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HOW TO BE A SUBSTANTIVALIST WITHOUT GETTING SHIFTY ABOUT IT*

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Abstract

According to substantivalism, spacetime points and regions are real entities whose existence is not dependent on matter. In this paper, I motivate and defend a version of substantivalism which takes the totality of spacetime as fundamental, and show how this position avoids certain problem cases, in particular the objection from static Leibniz shifts, and better conforms to how we think about space in physics. I argue that, even though the static Leibniz shifts do not show ordinary substantivalism is committed to in-principle undetectable physical structure (pace Dasgupta (2015a)), they do indicate something problematic about the modal profile of space-time and its constituents. While the problem is modal, the solution cannot be solely a matter of revising the substantivalist's modal claims. Rather, I argue, the substantivalist must revise her background ontology of space-time. I show how this can be done by developing substantivalist theory that rejects this picture in favor of an alternative ontology of space-time in the spirit of priority monism.

1. Introduction

Substantivalism about space-time is usually glossed as a thesis about what exists, or (better) what exists fundamentally. We can understand it as the view that the points and regions of space/space-time are concrete particulars whose existence does not depend on facts about bits of matter (specifically, the spatiotemporal relations *between* those bits of matter).[1] This is sometimes expressed as a slogan: "Substantivalists believe space-time is a substance!". Without reading too much into 'substance', we can (at least) say that, for substantivalists, the parts of space-time are concrete particulars and not, e.g., properties.[2] I'll sum up the spirit of the view in terms of what I'll call the "guiding conceit" of substantivalism:[3]

(Guiding Conceit) Our metaphysics of spatial/spatiotemporal points and regions should be close to, if not the same as, our metaphysics of concrete material entities/objects/etc.

Substantivalism is often defined in contrast to the opposing account, relationalism, according to which spatiotemporal relations between material physical objects are the fundamental facts concerning space and time, and space-time "exists" only insofar as it is grounded in facts about matter.

This paper concerns one of a very influential pair of objections to space-time substantivalism, which are collectively referred to as the "Leibniz Shifts". In what follows, I present both the "*Dynamic* Leibniz Shift" and "*Static* Leibniz Shift" objections, and discuss some contemporary responses to the latter. I examine an influential response due to Maudlin (1993), which says that the static shift objection fails to show that the substantivalist is committed to problematic actual physical structure. I defend this response from recent arguments by Dasgupta (2015a) and (2015b) that static shifts commit us to *in-principle undetectable* physical structure, but that our ignorance about that structure is inexpressible. However, I argue that, even though it involves no problematic actual commitments, the static shifts are still a problem for the substantivalist.

I maintain that static shifts are objectionable because of what they indicate about the *modal profile* of space-time and its constituents, not because of the substantivalist's commitment to positions in space-time. I argue that, while the problem is modal, the solution cannot be solely a matter of revising the substantivalist's modal claims. Rather, the substantivalist must revise her background ontology of space-time in such a way as to give rise to the right modal truths.

The second part of the paper motivates and develops a substantivalist position whose fundamental ontology and grounding structure avoids static shifts. According to this view, which I call "Space-time Globalism", the unique fundamental spatiotemporal entity is the *totality of space-time*. Points and (non-total) regions are derivative entities on this view. Their existence is grounded in the existence and fundamental nature of the total space-time, of which they are parts. This theory is a spatiotemporal analogue of priority monism, a view championed by Jonathan Schaffer (2010) according to which the fusion of all material objects is the one metaphysically fundamental material entity. I defend space-time globalism, showing how it avoids the static shifts and how the substantivalist can accept it without committing herself to priority monism about the material realm.

1.1. Leibniz shifts: dynamic and static

When I say that a theory of space-time "allows for" a Leibniz shift, what I mean is that, by that theory's own lights, a pair of so-shifted worlds

correspond to *distinct* possible state of the physical world. What are shifted worlds?

A pair of *dynamically shifted worlds* agree about all the relative velocities (relative motions) of material objects and the spatial distances between them at all times, but disagree about the *absolute* velocity of the world.

A pair of *static shifted worlds*, similarly, agree about the relative velocities (relative motions) of material objects and the spatial distances between them at all times, but disagree about the absolute *position* or *location* of those bodies.

The objection is that substantivalist theories allow for these shifts and that allowing for these shifts is bad because shifted worlds are observationally indistinguishable. Let's examine them a bit more closely.

The dynamic shift objection

The dynamic Leibniz shift is an objection to *Newtonian* substantivalist theories of absolute space and time. On Newton's account of absolute space (hereafter "Newtonian substantivalism"), all motion of material bodies is motion *relative to* a background of absolute space. In spatiotemporal terms, Newtonian substantivalism privileges a certain class of trajectories through space-time as "rest trajectories". One's absolute velocity is one's velocity *relative to* these trajectories.

The problem is that (by the theory's own lights)[4] only the relative velocities between objects, and the absolute *accelerations* of objects are directly observable.[5] There could be many worlds which agree about the relative velocities between the runner and the earth and their respective accelerations, but *disagree* about their *absolute* velocities (Fig. 1). In one world, W_1, the world's absolute velocity (big arrow) is $12^{\text{mi}}/_{\text{h}}$ to the right on the diagram, meaning the runner is at absolute rest (despite moving at $12^{\text{mi}}/_{\text{h}}$ relative to the earth) and in the other, W_2, he is in absolute motion of $312^{\text{mi}}/_{\text{h}}$ to the left.

According to Newtonian substantivalism, these two diagrams represent distinct possible states of the physical world. At most one of them accurately depicts the actual world at a given time. The dynamic shift objection is that these two scenarios should *not* be treated as distinct because W_1 and W_2 are *in-principle* observationally indistinguishable (no actual or possible observation could tell in favor of one over the other). Newtonian substantivalism, in accepting absolute velocities, is committed to the world having in-principle undetectable physical structure—that is, structure of which we are guaranteed to be ignorant.

The static shift objection

The static Leibniz shift concerns absolute spatial/spatiotemporal *position* structure instead of absolute velocity structure. For example: Suppose

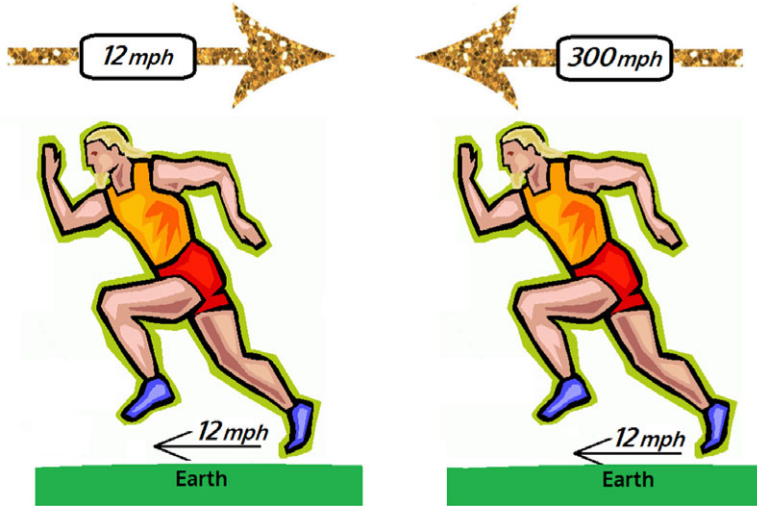

Figure 1. Two worlds with different absolute velocities. [Color figure can be viewed at wileyonlinelibrary.com]

that W_3 is the actual world, i.e. at W_3, all the positions of material bodies, relative and absolute, are as they actually are throughout history. The world W_4 agrees with W_3 about the *relative* position facts, i.e. the spatial distances between material bodies, at all times, but, at W_4, the *absolute positions* of everything in the universe are all shifted precisely 3 meters in the direction from New York to Philadelphia (whatever that direction is right now, as you read these words).

The thrust of the argument is the same. The substantivalist claims that points of space-time are entities that exist independent of material objects or the spatiotemporal relations between them. So worlds that differ in *which parts* of space are occupied by which bits of matter are, for the substantivalist, distinct possible states of the physical world. The relative positions and the relative motions (i.e. changes in relative positions) of the material objects are all the same, so these two worlds are observationally indistinguishable. Other things being equal, we should not accept a view that posits distinct possible states of the physical world that are observationally indistinguishable.

2. Responses to the Static Shifts

The focus of this section will be the static Leibniz shift objection, but it will behoove us to briefly discuss the dynamic shift and how the two relate. The dynamic shift has a very narrow range of application. It is only an effective objection against a very specific theory of space. Just about every

substantivalist agrees both that the dynamic shift objection shows absolute velocities to be (in principle) undetectable, and that this result is bad. The canonical substantivalist response to the dynamic shift objection is simply to reject Newtonian substantivalism, and adopt a substantivalist view that avoids commitment to absolute velocities.[6]

In the case of the dynamic shift, then, there's an answer available to the substantivalist that allows her to do away with the problematic absolute velocity structure, yet retain her substantivalism as well as the unproblematic *relative* velocity structure. No such response to the static Leibniz shift objection is available to the substantivalist. To make the analogous move means doing away with absolute *position* structure in favor of "relative position facts"—which is just to say spatiotemporal relations between bits of matter. But this amounts to a rejection of the substantivalist worldview.

While this makes the static shift objection more resilient, it has generally been considered the weaker of the two arguments. Very few substantivalists think that the static shift objection goes through, even though most agree that the dynamic shift objection is very strong. In what follows, I'll present one influential response offered by substantivalists as well as a recent criticism of this response by Dasgupta (2015a), who makes the case that the static shift arguments *are* as strong as their dynamic cousins, and should motivate us to give up absolute position structure.

2.1. Maudlin: no problem

Tim Maudlin (1993) argues that there's an asymmetry between the dynamic and static shift objections, and that this asymmetry means the latter does not threaten substantivalism.

First, a diagnosis. Maudlin argues that the dynamic Leibniz shift reveals that the Newtonian absolute space substantivalist is committed to *problematic actual spatiotemporal structure*. Specifically, the Newtonian substantivalist is committed to there being physical structure in the actual world which we have no epistemic access to, even in principle. Consider a question like "How fast are we going right now?" We might give a relative answer, talking about my body's speed relative to the earth, or the earth's velocity relative to the sun. According to Newtonian substantivalism, there is also a well-defined *absolute* answer to this question, but we're guaranteed to be ignorant of what it is.

(1) Is the absolute velocity of the universe $0^{m}/_{s}$ (i.e. absolute rest), or $12^{m}/_{s}$ in the direction from New York to Helsinki (right now), or some other velocity?

For the Newtonian substantivalist, at most one of these three disjuncts actually obtains, but the answer to which is unobservable and undetectable, not

just practically but *in principle*. Newtonian substantivalism, that is, posits *actual spatiotemporal structure* that is impossible to detect or observe. This, according to Maudlin, is what makes the dynamic shifts so problematic.

The same does not hold for the static shift objection. Distinguishing between static shifted possibilities does not entail that the *actual* world's position is in-principle undetectable. We cannot construct a question analogous to (1) about the universe's position. It's true that the substantivalist is committed to metaphysically distinct but qualitatively indistinguishable possibilities, but she is not committed to unobservable *actual* spatiotemporal structure. We can talk about how the world *would have* looked if everything had been shifted 5 feet in the direction from New York to Helsinki (right now), but this does not mean we are ignorant of the answer to a question about the *actual* world, like

(2) Is the universe absolutely positioned such that my desk is located *here*, or such that my desk is located 5 feet north-east of here?

The very formulation of (2) guarantees that we are comparing an actual scenario to a counterfactual one. As Maudlin argues, not only is ignorance about the answer to this question not guaranteed, often it's downright easy to determine the actual location of the world, given the formulation of the question.

> "Which is the actual state of the world? Now the answer is easy: In its actual state, my desk is here, not three meters north or anywhere else. So in the [dynamic] case, unlike the static case, sensible physical questions can be asked but cannot be answered by observations. *To even formulate the appropriate question in the static case one must indexically pick out a spatiotemporal location*, and it is then no great trick to observe what material body that location actually contains." (Maudlin 1993) [my emphasis]

It is, admittedly, very unclear what sort of moral we should draw from this result. At first blush, one might worry that it rests on a linguistic trick involving the use of indexical terms like 'here' and 'actually', or demonstratives like 'this location'. However, Maudlin's point is more robust than that. We can see this if we try to make the same move for the dynamic Leibniz shift.

Suppose we answer the question "How fast are we going?" with "We're moving at velocity, V_{Actual}", where 'V_{Actual}' is stipulated to denote the actual absolute velocity of the universe. In one sense, we have answered the question, but that doesn't mean our absolute velocity is detectable. There are still many questions about the *nature* of V_{Actual} which have determinate answers that, according to the Newtonian, are in-principle undetectable. For instance: "Is V_{Actual} non-zero?", "If it is non-zero, what is the angle between V_{Actual} and the

vector pointing from here to Philadelphia?", "Is V_{Actual}'s magnitude greater than $25^{\text{m}}/_{\text{s}}$?", etc.

In contrast, the analogous questions about the actual position of the world—e.g. "If the universe is positioned such that my desk is *here*, how far is *here* from my left hand?"—are perfectly in-principle detectable. Maudlin concludes that the static shift objection doesn't show that the substantivalist is committed to problematic *actual physical structure*. Rather, all the static shifts indicate is the existence of certain non-actual possibilities. The objection does not, therefore, threaten the substantivalist's account of how the world *in fact* is, viz. that space-time is a concrete entity independent of matter.[7]

2.2. Dasgupta: inexpressible ignorance

Shamik Dasgupta (2015a) and (2015b) has disagreed with Maudlin, arguing that the static Leibniz shift objections *do* reveal that the substantivalist is committed to actual spatiotemporal structure that is in-principle undetectable. He interprets Maudlin's argument as being ultimately about the nature of ignorance. For Dasgupta, the fact that static shifts can only be described using counterfactuals doesn't mean we fail to be ignorant of *something* about actual positions, it just makes our ignorance (or the fact of which we're ignorant) impossible to articulate.

> "Indeed in the case of position I appear to have two cognitive failings: a failure to know, and a failure to express that ignorance. Maudlin's view has the bizarre consequence that this double failure amounts to no failure at all!" (Dasgupta 2015a, p. 6)

However, the fact that we cannot articulate our ignorance doesn't mean that position facts are *detectable*. It just means absolute position structure saddles us with equally problematic, *inexpressible* ignorance.

For Dasgupta, the only way Maudlin's argument could serve as an adequate defense of substantivalism would be if we assume that all ignorance must be expressible. However, the view that all ignorance is expressible seems pretty suspect. Whether there is or isn't ignorance has to do with whether there are facts about the world that we don't have epistemic access to. But the extent and limitations of our *expressive* power ought to be entirely irrelevant to whether there are such facts (unless they're facts about our expressive power), or to whether these facts stand in the right relations to things we might detect.

Dasgupta thinks there are other plausible examples of inexpressible ignorance. One example involves a world with "one-way eternal recurrence", (ER−1), wherein "every 3 trillion years the history of the world repeats itself

in all qualitative respects" (p. 6). So, three trillion years after the first Big Bang, there is a Big Crunch, and then history proceeds in exactly the same way over the next three trillion years, starting with a second Big Bang and eventually ending with a second Big Crunch. Since each epoch is qualitatively indistinguishable from every other, we do not know whether we occupy the first epoch, or the second, or the third, etc. In ($ER-1$), this ignorance is expressible.

Dasgupta contrasts ($ER-1$) with ($ER-2$), a world with *two*-way eternal recurrence, so that there's no initial epoch as well as no final epoch. At ($ER-2$) we would be unable to express any ignorance about which epoch we occupy, since we cannot pick out an epoch except by way of an indexical or a demonstrative. I can talk about *this* epoch, or the epoch 7502 cycles after this one, but there's no question as to which one I inhabit (it's this one).

For Dasgupta, we are just as ignorant about which epoch we inhabit in ($ER-2$) as we are in ($ER-1$), even though we cannot express that ignorance. After all, how could it be that, by adding *more* epochs to the world, we could remove our ignorance as to which one we're in? For analogous reasons, the substantivalist is committed to there being inexpressible ignorance about our spatial/spatiotemporal location.[8] In order to avoid commitment to in-principle unobservable structure, the substantivalist must give up on absolute position just as she gave up on absolute velocity to avoid the dynamic shift objection. Insofar as this cannot be done without abandoning substantivalism about space-time, then so much the worse for substantivalism.

2.3. The rest of the paper

In the next section I evaluate these responses. I will disagree with Dasgupta, and argue against his claim that there is inexpressible ignorance of absolute position structure, and further argue that the objection does not identify anything problematic about absolute position structure *itself*. I will, however, agree that the substantivalist should respond to the static shift in a way analogous to how she responds to the static shifts, but I will deny that the only way to do that is to eliminate the offending structure.

Later, I will agree with Maudlin that the substantivalist is not committed to any in-principle ignorance about actual positions. However, I will reject his conclusion, that this means we do not need to change our account of space-time in response to this case, and argue that the static shifts *should* motivate the substantivalist to revise her metaphysics of space-time.

Section 4 makes the case that avoiding the static Leibniz shifts does not require doing away with position structure. Static shifts are objectionable because of what they indicate about the modal profile of space-time and its inhabitants. To remedy this problem, the substantivalist must revise the

fundamental ontology of space-time and its constituents in a way that gives rise to the right modal facts.

Section 5 develops and defends a position, Space-time Globalism, that accepts one such revised ontology of space-time. According to the view, the unique fundamental spatiotemporal entity is the totality of space-time, and points/regions exist in virtue of it. I show how this view avoids the static shifts and has the right modal consequences.

3. Evaluating these Responses

In this section, I argue that there is no ignorance, expressible or otherwise, revealed by the substantivalist's treatment of the static shift cases. Then, I make the case that, even so, the static shift objection is a real problem for substantivalism. This problem has to do with a background ontology of space-time that yields a proliferation of distinct physical possibilities.

In order for these claims to make sense, there are two important questions I will need to answer. If there's no ignorance, how can I maintain that the static shifts are a serious problem? Second, if the static shifts *are* a problem, how can we avoid them without eliminating the absolute position structure that *leads to* the shifts?

3.1. There is no in-principle ignorance

Dasgupta argues that, if substantivalism is true, we are ignorant of our position in absolute space, but this ignorance is inexpressible. I am not concerned with whether inexpressible ignorance is *ever* possible, just whether theories of space-time that distinguish between static shifted worlds commit us to such ignorance.

Let's return to Dasgupta's example of universes with recurring, qualitatively identical epochs. In the one-way recurring universe, ($ER-1$) (on which there is an initial epoch but no final epoch), I do not know which epoch I inhabit. I don't know whether I inhabit the *first* epoch, or the *second* epoch, or the *third*, and so on. Dasgupta argues that, if we do not know which epoch we inhabit in ($ER-1$), then we do not know which one we inhabit in the two-way recurring universe ($ER-2$). If this is right, then we are ignorant of which epoch we inhabit in ($ER-2$), but our ignorance cannot be expressed with a true instance of

(3) I do not know whether *P*.

Dasgupta notes that you do not need so drastic of a shift from ($ER-1$) to ($ER-2$) to make the argument. Consider the world ($ER-S$). ($ER-S$) is a

universe with two-way eternal recurrence, whose epochs are all qualitatively identical *with one exception*: the "special" epoch, e_S, "differs from the rest just in the fact that one electron is a little to the left of its counterparts in other epochs." (p. 7). With the exception of the position of that electron in e_S, ($ER{-}S$) is just like ($ER{-}2$).

In ($ER{-}S$), just like in ($ER{-}1$), we are *expressibly* ignorant of which epoch we inhabit. We can express this ignorance as an instance of (3): "I do not know[9] whether I inhabit the first epoch after e_S, or the first epoch before e_S, or the second epoch after e_S.." and so on. However, we would not be able to express this ignorance in ($ER{-}2$), since there would be no special epoch.

> "[Maudlin's] view[10] implies that, were that electron a little bit over to the right, I would not be ignorant of which epoch I inhabit. And this is hard to take seriously: surely my ignorance of which epoch I inhabit cannot be cured by minute changes in far-off epochs!" (Dasgupta 2015a, p. 7)

It's uncontroversial that, at ($ER{-}2$), we can no longer utter a true statement of the form "I do not know whether I inhabit the first epoch before e_S or not", since 'e_S' does not refer. But does this mean my ignorance isn't cured by the move from ($ER{-}S$) to ($ER{-}2$), and that the only difference is that I am unable to express that ignorance in the latter world?

It seems that Dasgupta is simply wrong here. There is no sense in which the change from ($ER{-}S$) to ($ER{-}2$) *merely* removes expressibility. Everything we are expressibly ignorant of in ($ER{-}S$) is either *false* in ($ER{-}2$), or is something we're also expressibly ignorant of in ($ER{-}2$). In ($ER{-}S$), I have properties like "is $2.634 \cdot 10^{5000}$ years away from e_S", or "exists before all epochs that differ qualitatively from the one I inhabit". Moving to ($ER{-}2$), it's not that I still have those properties, but can no longer denote them, I simply *do not have* those properties. And there's nothing strange about these properties being taken away by "minute changes in far-off epochs", because they're *relational* properties that concern minute facts about how I relate to *precisely those epochs*.

Any fact we can express ignorance about in ($ER{-}S$) but not ($ER{-}2$) isn't true-but-inexpressible in ($ER{-}2$), it's just *not a fact* at that world. If we're ignorant of anything in ($ER{-}2$), it's not one of *these*! At this point, the Dasguptan may prefer to bite the bullet and say that, in addition to our expressible ignorance, we're also *inexpressibly* ignorant of which epoch we inhabit in ($ER{-}S$), just as we are in ($ER{-}2$).[11] However, this claim requires justification, and Dasgupta's argument from expressible ignorance in ($ER{-}S$) to inexpressible ignorance in ($ER{-}2$) does not provide it.

The question at hand is whether or not there is anything of which we are in-principle ignorant at a substantivalist world. A negative answer to this question is perfectly consistent with there being *some* ignorance, in some domain or other, that is inexpressible.[12] The onus is not on the

substantivalist to show that inexpressible ignorance is impossible, but on the critic of substantivalism to provide some reason to believe there's inexpressible, in-principle ignorance *in this particular case*.

3.2. The static shifts are a problem

I have defended Maudlin's argument from Dasgupta's objection. Now I'll claim that Maudlin's argument doesn't imply what he thinks it does.

Maudlin's argument presupposes that the only way the static shifts could tell against substantivalism would be if they revealed that the substantivalist is committed to *problematic actual spatiotemporal structure*. This is a reasonable assumption to make. After all, this is precisely what the dynamic shifts do, and critics of substantivalism generally target position structure explicitly when making the static shift objection.

Given this assumption, a response which rescues the substantivalist's commitment to *actual* spatiotemporal position facts from the objection would render the static shifts toothless. And that's exactly what Maudlin's argument does. Maudlin argues that the substantivalist is *not* committed to any actual problematic spatiotemporal structure as a product of accepting absolute positions.

However, there are other ways that allowing for static shifts can reveal something problematic about substantivalism. The static shifts, I claim, indicate something objectionable about the *modal profile* of space-time and its constituents. We can evaluate the modal claims *themselves* for plausibility without needing to identify some first-order fact about the actual world as the culprit. If a theory of chairs gets everything about the actual world right, but implies that, even if the planet earth did not exist, the number and positions of all chairs throughout history would remain the same (hurtling through space in a vaguely spherical configuration), then our theory would be no good.

Even if the substantivalist is not committed to problematic *spatiotemporal structure*, she may still be committed to problematic claims about the actual world by accepting a background fundamental ontology of space-time which implies these modal claims. In the next section, I'll argue that the static shift objection should be understood as an objection to what spatiotemporal entities the substantivalist takes as metaphysically fundamental. Specifically, ordinary substantivalism takes points of space-time to be fundamental concrete individuals. Facts about those points, and the spatiotemporal relations they stand in, serve as the metaphysical explanations for facts about extended regions of space (like the region occupied by my hand) and or about space itself. Treating space-time points as fundamental opens the door for the static shifts, since changes to which fundamental entities are occupied results in a different possible world.

In what follows, I will argue that substantivalism *can* and *should* do away with this background ontology (section 4), and then show how this might be done (section 5) by developing a substantivalism that rejects this picture in favor of an alternative ontology of space-time in the spirit of priority monism.

4. Why Substantivalism is So Shifty

In this section, I defend two claims. First, that the background ontology of space-time points as fundamental spatiotemporal entities is an unnecessary commitment that goes beyond what's indicated in substantivalism's guiding conceit. Second, that we have good reasons to reject this ontology, and those reasons are not limited to the fact that it leads the substantivalist to distinguish between static shifted possibilities.[13] I'll run through a few such worries, and show why they tell against the ontology of space-time points as fundamental in particular, rather than substantivalism in general.

In section 5, I'll defend a third claim, closely related to the first two: We can do away with the background ontology of space-time points as fundamental constituents of space-time without sacrificing our commitment to positions as concrete individuals.

4.1. Can the substantivalist revise her ontology of space-time?

Later, I'm going to argue that we should reject the ontology of the ordinary substantivalist, on which space-time points are fundamental entities, and accept a view on which space-time points are derivative entities. You may already be feeling the worry that, by deflating the ontological status of space-time points, I'm violating the whole spirit of substantivalism. You may worry, that is, that the fundamentality of space-time points (or simple regions) is a necessary feature of any adequately substantivalist theory.[14]

To answer this worry, we need merely consider substantivalism's history. Not only is deflating the ontological status of your fundamental posits (so long as they remain concrete particulars) consistent with the spirit of the view, it's a key part in how the Newtonian substantivalist is able to avoid the dynamic Leibniz shifts. In section 2, I described the substantivalist response to the objection from dynamic shifts as involving just one step: the substantivalist, recognizing that absolute rest and motion are in-principle unobservable, does away with absolute velocities by adopting a substantivalist theory of space-time that does not posit them.

However, this is a modernized version of the story. The substantivalism of Isaac Newton was not an account of space*time* at all. Rather, it was an account of space *and* time. *Classic Newtonian substantivalism* posits absolute space, a 3-dimensional Euclidean space whose parts persist through absolute

time. On this view, an object is at rest during an interval of time just in case it occupies *the very same* (as in, numerically identical) point/region of absolute space throughout.

For the classic Newtonian, eliminating absolute velocities would require eliminating the structures in terms of which they are defined—viz. absolute space and absolute time. It would amount to abandoning the position entirely (much like the situation with respect to the static shifts). Luckily, the classic Newtonian had a very good argument in favor of the existence of absolute space: it's a necessary part of recapturing the observable effects of the bucket experiment. That is, the explanation for the observable behavior of water in a spinning bucket (receding from its axis of rotation) is that the water is spinning *relative to a background absolute space*. For the classic Newtonian, dynamic shifts are a necessary evil. We need space to explain observable physical effects, and we can define absolute rest and motion in terms of the fundamental ontology of that space (specifically, the numerical identity of its parts over time).

The substantivalist is only able to cleanly excise absolute velocity structure by transitioning from a space *and* time ontology to a *space-time* ontology. For the classic Newtonian, spatial points are fundamental individuals that persist through time, and "events" are abstract constructions of the possible goings on at some spatial point or region during some particular moment/span of time. The *space-time Newtonian* turns this on its head. For her, *space-time* points are fundamental time-bound individuals that, when occupied, are occupied by events, while *spatial* points are derivative entities, existing wherever a class of space-time points compose a trajectory instantiating the primitive spatiotemporal property "is a rest trajectory".

Only under a space-time ontology is the substantivalist able to reject absolute velocity without doing violence to the rest of her view. The resulting account is that of Galilean space-time, which, since it only distinguishes inertial (straight) trajectories from accelerated (curved) ones, lacks the machinery to distinguish a world at rest from a world in uniform motion in a straight line.

4.2. Should the substantivalist revise her ontology of space-time?

Here I illustrate how an ontology on which points or simple regions of space-time are fundamental gives rise to implausible consequences about the modal profile of space-time and its constituents.

What is needed to fully capture the facts?

What does one need to specify in order to fully determine the spatiotemporal facts at a world? Plausibly, it is necessary (if not sufficient) to

specify the *fundamental* spatiotemporal facts.[15] Consider a world consisting of a 3-dimensional Euclidean space, with no temporal extension, whose sole occupant[16] is a filled sphere of matter[17] precisely 2 meters in diameter. Does this description fully specify the spatial facts?

I want to say "yes". While there might be *non-spatial* facts about this world we could further specify (like the mass or mass density of the sphere), it seems like, when it comes to the spatial/spatiotemporal facts, this description is complete.

However, if the static shifts are possible, this is not correct. According to a space-time theory that distinguishes static shifted worlds, we need something beyond this description to fully capture the spatiotemporal facts. We need to add *where in space* the sphere is located. After all, if space-time points are fundamental concrete individuals, then it's a fundamental spatiotemporal fact that p is occupied and q unoccupied.

This, I claim, should strike us as very implausible—or, at least, seriously uncomfortable. One could try to make things more palatable by pointing out this decision about "where in space" we locate the sphere is arbitrary in a very strong sense. As such, for all practical purposes, we can safely suppress this unspecified fundamental fact without evoking any real confusion. However, there's no denying that, on a view that distinguishes static shifted possibilities, this additional specification is necessary to fully capture the fundamental spatial facts at this world.

The wrong questions

We can get at this worry in a different way. If space-time points are fundamental concrete individuals, then (by the guiding conceit of substantivalism) they *ceteris paribus* ought to admit of the same sort of modal profile as fundamental concrete individual objects. However, taking this claim seriously means granting legitimacy to counterfactual questions which, intuitively, should strike us as somewhere between confused and unintelligible. What would things be like if..

(i) ..the universe had been shifted such that my iced coffee is located 300 miles south of here?
(ii) ..p had been spatiotemporally related to all other space-time points exactly as q in fact is, and vice versa? (i.e. p and q "switch places")
(iii) ..every space-time point had been twice as distant from p as it in fact is?[18]
(iv) ..in a given general relativistic space-time, the metric and matter field in region R had been a different one, related to the actual metric and matter field by a hole transformation?

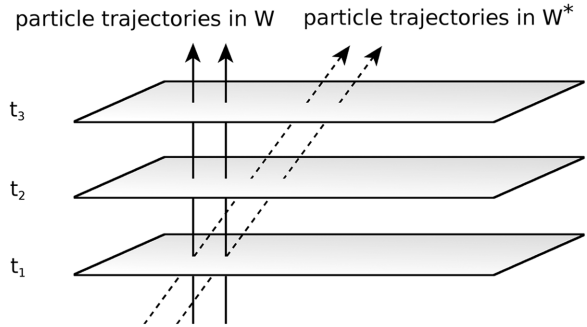

Figure 2. *W* and *W** each depict a pair of particles at a fixed distance apart, moving inertially through space-time.

The worst offenders seem to be (ii) and (iii). Question (ii) relies on the assumption that, in general, we can "rearrange" fundamental physical concrete objects. We can ask, for instance, what would happen if this electron and that positron were to suddenly switch places.[19] But the same question asked about a pair of *space-time* points sounds like a confusion bordering on category mistake. The same contrast holds for (iii), which is a more systematic and widespread version of the "switching" example, and its material analogue.

Question (i) is, of course, the static Leibniz shift, while question (iv) concerns a version of the hole argument, in many ways a more sophisticated cousin of the Leibniz shifts specifically focused on general relativistic space-time.[20] I feel like our reactions to these cases should differ in degree, not in kind. Whatever conceptual mistake is being made by some of these questions, the same sort of confusion is present in the others as well. For those still unconvinced, let me briefly present an example which will help to bridge the gap between questions like (ii)/(iii) and questions like (i)/(iv):

The Dasguptan tilt

Recall Galilean space-time, on which there is no absolute velocity structure. The theory only has the resources to distinguish between inertial (straight) trajectories and accelerated (curved) ones, so the two worlds depicted in figure 2, *W* and its dynamically shifted counterpart *W**, are physically equivalent according to Galilean space-time. One might, reasonably, think that this means substantivalist theories of Galilean space-times avoid the dynamic shifts. This is how the theory is most often presented. E.g. "So, if we postulate that physical space-time has a Galilean structure, [*W* and *W**] can be used to depict *exactly the same physical situation*," Maudlin (2012, p. 63).

Observe the difference between how W and W^* are treated in Galilean space-time and how static shifted worlds are treated. The ordinary substantivalist will readily admit that the static shifted worlds are distinct possible states of the world, pointing out that these shifted alternate possibilities are clearly non-actual (given that my desk is are located *here*, not 3ft north of here).

On the canonical way of interpreting diagrams of Galilean space-times, these two diagrams depict exactly the same physical situation. The "can" in Maudlin's statement is due to the diagrams having *more structure* then the space they represent, meaning they *could* be used as diagrams of *Newtonian* space-time, in which case (on the canonical way of interpreting diagrams of Newtonian space-time) they would depict *different* physical situations (namely one where the particles are at absolute rest in W and in absolute motion in W^*).

However, consider the following argument, meant to show that even Galilean substantivalism cannot avoid the dynamic shifts:

1. In W, the dashed trajectories *exist* but are unoccupied.
   Argument for 1: We could imagine a world with two additional particles following the dashed trajectories, which pass through the particles on the solid trajectories at t_1.
2. We could, at W, consider the possibility that the dashed trajectories be occupied by the particles which, in fact, occupy the solid trajectories.
3. This possible world would be non-actual, since it involves the occupation relation being distributed in a different way over the fundamental entities (points in space-time and particles/time-slices of particles).

This pair of possibilities would amount to spatiotemporal version of two "static" shifted worlds. The spatiotemporal relations between physical entities/events are as they actually are, but they occupy a region of space-time which they do not actually occupy. Dasgupta (2015b) calls this sub-variety the "Galilean tilts".

If we admit of the possibility of static shifts, we must admit the possibility of Galilean tilts. But distinguishing between such worlds runs counter to the entire point of Galilean space-time! How could it be that, at a world with only Galilean space-time structure, claims like "It's possible that the whole universe had been going 50-miles per hour faster in the direction from earth to Betelgeuse than it actually is" are *true*[21] and describe *genuinely distinct* physical possibilities? Could we really have gotten our own space-time theory so wrong? (Hint: no)

The problems with admitting Galilean tilts are especially striking if we consider what's necessary to fully specify the spatiotemporal facts. For Galilean space-time, the intuitive thought is that, in a world like W, we *only* need to specify that the two particles are moving inertially and stay at a

constant distance (of, say, 2*m*) from each other. But, if static shifts (and, therefore, Galilean tilts) are distinct possibilities, that won't be enough. We'll also need to say *which* pair of parallel inertial trajectories, 2*m* apart from each other, those particles follow.

The Galilean tilt, I claim, involves the same mistake that's behind questions (i) through (iv), above. Given the background ontology on which space-time points are fundamental individuals, static shifted worlds and Galilean tilted worlds both correspond to genuine differences in the fundamental spatiotemporal facts. A theory which treats such questions as intelligible is going wrong *even if* there's nothing problematic about the actual spatiotemporal structure it posits.

4.3. Why not a modal solution?

The moral of the static Leibniz shift objection, I've claimed, isn't that absolute position structure is problematic, but, rather, that the background ontology of most substantivalist theories, on which space-time points are fundamental concrete entities, commits them to a slew of implausible modal claims. Before we move on, however, it will be useful to address an alternative solution that has received some attention in the literature.

One might object that revising our fundamental ontology of space-time isn't necessary. If the problem is modal, then the substantivalist needn't change anything about her account of the *actual* world. She need merely revise her modal claims! The problem cases I discuss would not arise, for example, were we to stipulate that space-time points can not be freely recombined to produce new possibilities. Nor would they arise if we adopted an *anti-haecceitism* about space-time points (that is, deny that space-time points have any primitive identity or primitive *this*-ness), according to which they have no trans-world identity.

This family of responses—what Rickles (2008) calls "the modalist turn", and what Belot and Earman (1999) have called "sophisticated substantivalism"—offer various modal solutions[22] either to the static shifts or (more often) to the hole argument.[23]

Setting aside whether or not these moves would be successful,[24] there's a serious reason to doubt they, on their own, constitute a solution to the shifts. That is, these modal claims, if made in the absence of any corresponding change to the actual spatiotemporal facts (or to the ontological picture underlying those facts) would be little more than an *ad hoc* band-aid covering the most obvious symptoms without addressing their cause. Modal facts obtain in virtue of the natures of the actual. Nixon could not have been a ham sandwich, yet could have been a butcher, because of the kind of entity he actually was. "Substantivalism about the actual world but with different modal commitments for space-time points" is not a new theory, it's a

desideratum. There needs to be some difference in the substantivalist's account of actual space-time that could explain these changes to the modal facts.

In the next section, I will try to show how to be a substantivalist without taking space-time points to be fundamental concrete entities. I will develop an account of space-time that avoids the static shifts, as well as the other problems outlined in this section, without straying from the substantivalist's guiding conceit that space-time and its constituents (including space-time points) are concrete particulars.

5. The Priority of the Whole (Space-time)

The project is to come up with a fundamental ontology of space-time on which (1) points and regions are concrete individuals whose existence is independent of matter, *but* (2) there's no distinction between static shifted possibilities, Galilean tilted possibilities, possibilities wherein pairs of points "switch places", etc.

On ordinary substantivalism, space-time points are *fundamental* individuals. Their fundamental properties and relations ground the intrinsic features of the entities they compose, and we can sensibly ask about counterfactual scenarios in which those fundamental features are rearranged.

Things work differently for the non-fundamental. Consider a "switching" case with an ordinary material object, like an armchair. The oxygen atom, P, and the sulfur atom, Q, are parts of CHAIR—specifically, P and Q are parts of CHAIR's left arm and right arm, respectively. We can reasonably ask "What would things be like if P and Q were to trade places?" and, in doing so, consider the effect on (say) the atoms connected to P and Q by molecular bonds.

In contrast, the question "What if CHAIR's left and right arms traded places, but the positions of P, Q, and all the other atoms which make up CHAIR remained fixed?" seems, at best, somewhat confused. Whatever it means for CHAIR's left and right arms to switch places, it cannot happen if the objects which compose them do not change. If nothing changes about the fundamental state of the chair, or the fundamental entities which constitute it, then nothing can change about parts and properties of the chair which depend on them.

In this section, I will defend a view I call "Space-time Globalism", according to which space-time points are not fundamental. In slogan form, space-time globalism is the view that space-time points and (non-total) regions are more like CHAIR's left and right arms than they are like P or Q. More precisely, space-time globalism is the view that:

(i) The *total space-time* (the spatiotemporal region of which all actual spatiotemporal regions & points are sub-regions) is the unique metaphysically fundamental spatiotemporal entity.
(ii) The existence and nature of points and non-total regions are grounded in the existence and fundamental features of the total space-time.
(iii) The total space-time is a concrete individual.

How could it be that a composite whole, the total space-time, could ground the existence and nature of its own parts? This is, certainly, a non-standard position, but it's one that has been defended before, most notably by proponents of "Priority Monism", a theory of the material world championed by Jonathan Schaffer (2010) and (2009)). According to priority monism:

- The "cosmos" (i.e. the fusion all actual concrete objects) is the unique metaphysically fundamental object.
- The existence and nature of the *parts* of the cosmos are grounded in the existence and fundamental features of the cosmos.

On space-time globalism, we have an analogous picture. The total space-time is a complete spatiotemporal entity, and its fundamental organizational and structural properties are what determines the existence and nature of all other such entities.

5.1. Space-time globalism's predecessors

There have been other proposals which take a globalist stance towards the fundamental nature of space-time. However, many of them fall under the structuralist or structural realist heading, and (often by design) fail to qualify as suitably substantivalist.[25] One exception among those is the view defended by Esfeld and Lam (2006), which they call "moderate structural realism". According to moderate structural realism, objects like space-time points or regions genuinely do exist (and are not dependent on matter), but "instead of these objects having intrinsic properties, all there is to them are the [spatiotemporal] relations in which they stand" (Esfeld and Lam 2006, p. 8). The moderate structural realist hastens to add that points and the relations they stand in are "on the same ontological footing and are also conceptually [and ontologically] interdependent"(Esfeld and Lam 2006, p. 11).

This is interesting, since it means the only spatiotemporal entity that *isn't* dependent on another spatiotemporal object or relation, according to moderate structural realism, is the *total space-time*. On the interpretation of 'metaphysically fundamental' on which it means 'ungrounded' or 'not dependent on anything else', moderate structural realism takes on a distinctively monist hue.[26]

5.2. Can space-time globalism avoid the static shifts?

Yes. On this view, points and non-total regions are derivative entities (though they're still concrete individuals). According to Schaffer (2010), "Wholes are complete and concrete unities. Parts may be conceived of as aspects of wholes, isolated through a process that Bradley [(1893))] ... describe[d] as 'one-sided abstraction'." Without a change to the fundamental, there can be no change in the derivative. It doesn't make sense to say CHAIR's left right arms have switched places while their parts remained exactly the same. Similarly, facts about the *partial aspects* of the total space-time (incl. points & non-total regions) cannot change if the fundamental features of the whole are held fixed.

According to space-time globalism, I claim, the fundamental spatiotemporal facts would be unchanged in a universe and its static shifted counterpart. We can see this in our case of the 2m sphere of matter located in a 3-D Euclidean space with no temporal extension. The fundamental spatiotemporal facts at this world are:

Fundamental Entity:	The total space-time, *S*.
Fundamental Features:	*S* possesses the global spatiotemporal property "Is a 3-D Euclidean Space".[27]
Distribution of matter:	*S* has one occupant, a 2m-in-diameter (filled) sphere of matter.

These exhaust the fundamental facts necessary to completely determine the spatiotemporal facts at this world. This, recall, is precisely the intuitive result that, as we saw in section 4.2, ordinary substantivalism fails to vindicate. The fundamental spatiotemporal facts are the same under a static shift and, so, static shifted possibilities are not distinct possible states of the world.

5.3. Does space-time globalism commit us to priority monism?

No. Space-time globalism, I claim, is fully consistent with priority pluralism about non-spatiotemporal concreta. None of the considerations I present here should provide motivation for the substantivalist, *qua* substantivalist, to adopt a priority monist account of material entities.[28] That is, taking space-time points to be *fundamental* individuals—like the claim that space-time points persist through time—involves commitments beyond what is indicated in the spirit of substantivalism and its guiding conceit. The same goes for general priority monism. Likewise, the fan of priority monism is welcome to incorporate this into her view, but nothing I've said here demands it.

5.4. The nature of position and occupation

One snag with marrying space-time globalism with pluralism about material concreta is that it's unclear how spatiotemporal *occupation* is supposed to work. On ordinary substantivalism, occupation is usually understood as a fundamental relation between material objects and the specific regions that they *fully* overlap. How could this work, fundamentally, if non-total regions of space-time are derivative entities?

Here's one way to do it (not the only way): On space-time globalism, there is still an occupation relation. It's just non-fundamental. Occupation facts hold in virtue of facts about *how* objects are "positioned in" the total space-time, S. We introduce a family of "positioned-in" relations. Instead of saying "object a occupies some region, call it 'A', which has such-and-such spatiotemporal properties and stand in such-and-such spatiotemporal relations" we say that "object a is R-positioned at S" where 'R' refers to the same web of spatiotemporal properties and relations we ascribed to A. We can represent 'R' using an open formula constructed as follows: start with a sentence describing all of A's spatiotemporal properties and relations and remove reference to A, replacing every instance of its name with an open variable, x, and, finally, Ramsify out reference to any *other* space-time point or region.[29]

The positioned-in relation/family of relations (it depends on how you think of R) obeys the following fundamental axiom:

(Positioning Axiom) Concrete physical object, a, can be ***R*-positioned-in** S only if (i) S has a partial aspect (i.e. sub-region) which exhibits R, and (ii) no two partial aspects which exhibit R have mutually inconsistent spatiotemporal features.

We'll say a region, A, "exhibits R" just in case '$R[A/x]$' holds, where this term denotes the sentence produced by replacing every instance of the open variable, 'x', in 'R' with 'A'. Clause (i) requires that S have a part that can "fit" the material object or system in question, while clause (ii) requires that R have enough content to *fully* specify how a is positioned in S.

This picture is best illustrated with systems of point particles in a Euclidean space. The important step is this: we allow R to include spatiotemporal relations *to* particular material bodies. That is, 'R' does *not* Ramsify out reference to individual material objects in space (the way it does with individual space-time regions). So a may be R-positioned-in S where R="x is point-like $\wedge$ $D(x, b) = 2\text{m} \wedge D(x, c) = 7\text{m} \wedge \ldots$", and '$D(x, y)$' is a distance function.

Likewise, we include spatiotemporal relations to material bodies among the features relevant to clause (ii) of the Positioning Axiom, above. That

way, *R* will not distinguish a class of partial aspects with mutually consistent spatiotemporal features *unless* those aspects also agree about their situation relative to the extant material bodies.[30] So (for example) if *a* is positioned-in *S*, then *b* can only be *R*-positioned in *S* if *R* specifies *b*'s distance from *a*. Exactly how the positioned-in relation behaves will depend on the structure of the total space-time. The existence of *b* at a certain distance from *a* will, given the nature of distance and of Euclidean spaces like *S*, influence how *a* is positioned-in *S* (it will follow, that is, that *a* is the same distance from *b*).

This change to the fundamental story shouldn't alter our talk at the level of space-time's parts. After all, the thrust of the Maudlin argument is that we only ever pick out points and regions using indexicals and demonstratives based on their relations to material bodies we can observe.

6. Conclusion

The static Leibniz shifts do not indicate that the substantivalist's commitment to absolute position structure is problematic or unobservable. The source of this problem, I've argued, is what we take as fundamental (space-time points), and the solution is to take something else as fundamental (the total space-time). I've shown how this can be done, and argued that space-time globalism is able to avoid the static shifts and other problem cases without giving up on the core tenets of substantivalism about space-time.

I'll close by answering a "big picture" question: Is space-time globalism *really* a substantivalist theory? In short, yes. Earman and Norton (1987) are, quite simply, mistaken when they say static shift cases are the "acid test" about which all substantivalist theories must agree. Substantivalism is a thesis about space-time's *existence*, its *concreteness*, its *particularity*, and its metaphysical *independence from* matter and the relations between material bodies. Theories that allow for the static shifts are one kind of substantivalist view. Theories of temporally persistent absolute space (which allow for the dynamic shifts) are another. But these are not the only substantivalist options. Both involve commitments that go beyond substantivalism's guiding conceit, that the metaphysics of material bodies be close to the metaphysics of spatiotemporal entities.

I recognize that space-time globalism deflates the ontological status of space-time points, taking them from *fundamental* concrete simples to *derivative* concrete partial aspects of a fundamental whole. But so too does the move from Newtonian absolute space and time to Newtonian space-time deflate the ontological status of *spatial* points, taking them from *fundamental* simple entities that persist through time to *derivative* composites of space-time points that, together, form a rest trajectory. The important thing about both of these changes is that they retain the core of the substantivalist

worldview: the existence, concreteness, particularity, and independence from matter of space-time and its constituents.

Notes

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1. It might be that facts about the features of space-time regions—curvature, for instance—are grounded in facts about matter, especially on a view like GTR. I'm going to set that wrinkle aside and focus on classical space-times.
2. That is, on this understanding of substantivalism, someone who believes that *position* is an intrinsic quantitative *property* with a particularly rich structure, is *not* a substantivalist.
3. By 'close to' in the guiding conceit, I mean to encompass both the sense meaning 'similar to' and the one meaning 'intertwined with'. The latter allows this picture to include theories like *super*substantivalism (Cf. Sklar (1974)) where the metaphysics of spatiotemporal entities is very *dissimilar* to the metaphysics of concrete material objects, but the two are closely intertwined in that material bodies are identified with (or grounded in) spatiotemporal regions.
4. Cf. Newton's *Scholium*, (1689), Paragraph VII
5. Moreover, the relative velocities (and absolute accelerations) at a time are sufficient to determine, via the Newtonian laws, all the future relative velocities (and absolute accelerations).
6. One notable example (which will be important later on) of such a theory is *Galilean* (or "Neo-Newtonian") space-time, a classical space-time that doesn't privilege a class of rest trajectories. It only distinguishes inertial (unaccelerated) trajectories from accelerated ones. More contemporary spaces, like the Minkowksi space-time of the special theory of relativity, or the various space-times of the general theory of relativity follow Galilean space-time in this regard.
7. Leibniz could leverage this into an objection based on his Principle of Sufficient Reason: "Given that there are all these distinct possible worlds, if God were to create the world, she would have to pick between them. However, since they are observationally equivalent and physically symmetric, she would have to decide between them arbitrarily. But God does not make arbitrary decisions,". However, this is an argument whose premises are significantly less compelling to the contemporary substantivalist. Cf. Maudlin (1993).
8. At least in spaces like Euclidean 3-space, which extends infinitely in all directions and has the same structure everywhere. Non-standard spaces, like an Aristotelian universe on which space is a sphere, would be more like ($ER-1$) in that we would have run-of-the-mill expressible ignorance concerning our orientation relative to the privileged "edge" or "end" of space. And (see note 9) they would also resemble ($ER-1$) in that experiments could, in principle, be constructed to alleviate that ignorance.

9. Dasgupta actually writes that, in ($ER-S$) and in ($ER-1$), "I *cannot* know whether I inhabit *the 1st epoch*, or whether I inhabit *the 2nd epoch*, and so on." Dasgupta (2015a, p. 6) [my emphasis].

   This is a small point, but one worth making: It isn't right to say that we *cannot* know, in principle, what epoch we inhabit in ($ER-1$) or ($ER-S$). At best, we *do not* know our position relative to the initial epoch or the special epoch, e_S. There is, however, no *in-principle* obstacle to our coming to know. That is, the claim "Possibly, I come to know whether or not I occupy the *first* epoch, or the *second* epoch, or the... before the special epoch" is true at the world ($ER-S$).

   How does this work given that, at ($ER-S$), all of the epochs except e_S are qualitatively identical? Even though they are qualitatively identical *at that world*, they are not necessarily so. Suppose I believe that I am in $ER-S$, and decide to figure out which epoch I inhabit. It would be in principle possible for me to construct a small vessel durable enough to survive a Big Crunch and Big Bang, and then transport me to the region of the next epoch where the slightly shifted electron would be located. By passing this information on to my counterpart in this epoch, this process could be iterated. This strategy is not practically possible, but what's important to the analogy is that it's *in-principle* possible.
10. That is, the view Dasgupta attributes to Maudlin: "All ignorance is expressible ignorance". I take issue with this attribution (see note 12), but what is relevant here is just what the view implies (regardless of whether anyone actually holds it).
11. Cf. Dasgupta (2015a, p. 6-7).
12. This is why I dislike Dasgupta's interpretation of Maudlin, and others sympathetic to this substantivalist answer to the static shifts, as defending a position about the nature of *ignorance*. Despite its epistemic/linguistic trappings, Maudlin's response is an argument that there's no further fact of the matter to be ignorant *of*.
13. I am not the first to voice these concerns. Maidens (1992) and Hoefer (1996) argue that substantivalists should reject "the primitive identity of points". However, I will take issue with the positive accounts they (and other proponents of so-called "sophisticated substantivalism") provide as an alternative. See section 4.3.
14. Though the sentiment is clear, this expression of it can't be exactly right. After all, there are substantivalist theories about gunky space-times (cf. Russell (2008)) which have no points or simple regions. I wont say any more about gunky spaces if I can help it. Why not? I'm defending a close cousin of priority monism in this paper, and, if you ask me, too much of the appeal of that view rests on the shoulders of judgments about gunk.
15. Non-fundamental facts will be determined by the fundamental ones on which they depend (unless there's some kind of genuine emergence). Since fundamental facts don't depend on anything else, they need to be specified directly.
16. I'm assuming here that facts about occupation count as spatial.
17. This is sometimes called a "closed ball".
18. Assign (hyper-)spherical co-ordinates with p as the origin, then map all points, $\langle r, \theta_1, \theta_2, \theta_3 \rangle$, to $\langle 2r, \theta_1, \theta_2, \theta_3 \rangle$.
19. Even in the case with two electrons, it could make sense to ask this question. If, for instance, we were wondering whether instantaneous velocity is intrinsic, we

might ask whether these two electrons would change directions if they were to swap places.

20. I discuss some substantivalist responses to the hole argument in section 4.3.
21. Because Galilean space-time *is* able to capture relative velocities, we can, if given a trajectory in the actual world, determine which *other* (possibly unoccupied) trajectory is 50mph faster in the direction from earth to Betelgeuse.
22. Butterfield (1989) appeals to Lewis-style modal realism to deny trans-world identity to space-time points. Maidens (1992) offers (to the best of my knowledge) the first *anti-haecceitist* justification for a Butterfield-style response (suggesting that space-time points are analogous to qualitatively identical particles, and denying that models which "swap" them represent distinct situations). Hoefer (1996) further develops Maidens's proposal, and provides some general philosophical considerations against space-time points possessing "primitive identity". Rynasiewicz (1994) attempts to resolve the issue by modifying our account of when two mathematical models "represent the same situation". Brighouse (1994) argues that points obey a Lewis-style modal counterpart theory, on which qualitatively identical possibilities like the shifts correspond to a single possible world.
23. Most of the distinctive features of the hole argument turn on general relativistic theories of space-time and the mathematics we use to express and represent them; giving an adequate discussion of those would take us too far afield. The interested reader should see Earman and Norton (1987). For a more accessible presentation as well as a thorough survey of the many substantivalist answers to it (as well as some interesting comparisons between the hole argument and the Leibniz shifts), see Pooley (2012).
24. Skow (2008) has raised concerns that the Lewisian anti-haecceitism accepted by some sophisticated substantivalists—according to which there are no possible worlds that differ only in the identities of space-time points, even though there are still distinct *possibilities* that are static Leibniz shifted—does little to defuse Leibniz's objection.
25. Greaves (2011) makes the best, most thorough attempt to extract unambiguous positive theses from structuralist slogans. She surveys six precisifications of space-time structuralism and finds serious flaws in each.
26. Indeed, Schmidt (2010) has objected to Esfeld and Lam's view on the grounds that it seems to lead to priority monism about space-time, a position "rather hostile to structuralist metaphysics" (p. 510). The core commitments of structuralism—the denial of fundamental intrinsicality and the view that the "fundamental building blocks of reality are . . . relations"—go out the window if the total space-time is fundamental. Every spatiotemporal fact is an *intrinsic* quality of, and all spatiotemporal relations merely derivative aspects of, a fundamental individual.
27. It's an advantage of space-time globalism, compared to material priority monism, that it can appeal to fundamental properties that are more natural, less gerrymandered, and a better fit with our scientific practice. That is, for priority monism, the fundamental features of the most fundamental entity are the features of the cosmos, but those are exceedingly complicated. In contrast, we are quite used to thinking and theorizing in terms of global *spatiotemporal* properties—like "Is a three-dimensional euclidean space", "Is a 4D flat Minkowski space-time", etc. These properties are familiar, systematically specifiable, and relevant to the

practice of physical science. While global material properties, by contrast, would seem to be unfathomably complicated.

28. Schaffer (2009) defends a priority monism about space-time, but it is taken on as a by-product of two other theses: priority monism about the material world and super-substantivalism (the version where material objects are *literally identical* to regions of space-time, and the fundamental physical properties we typically ascribe to matter are instantiated by those regions). As such, the motivations offered for it are just the considerations in favor of those two theses. None of these considerations should motivate the substantivalist not already sympathetic to priority monism proper and super-substantivalism.
29. That is, we replace names of those points or regions with variables bound by existential quantifiers that we tack on to the front of the sentence (with widest possible scope).
30. It's occurred to me that, in many ways, this account of how bodies are "positioned-in" parts of a space-time is quite similar to how the "Ramsifying Substantivalist"—a hypothetical rogue substantivalist invented by Maudlin (1988) to demonstrate that there's room in logical space for a substantivalist position to which objections like the hole argument do not apply (the view is then summarily rejected)—treats mathematical representations of physical models. The Ramsifying substantivalist interprets what the *physical content* of a given mathematical representation is "by Ramsifying out reference to specific event locations" (Maudlin 1988). Ironically, one of the reasons Maudlin rejects Ramsifying substantivalism is that this method of interpreting mathematical models fails to distinguish between static shifted worlds (which, by Maudlin's lights, any genuine substantivalist theory should do).

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