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Philosophy of Space and Time: What is Space?

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Imagine that every object in the universe – you, your chair, Earth, everything else – moved one meter to your left.

Would you notice a difference?

Facts about relative distances, like how far my chair is from me, would remain the same before and after this shift. If such a shift causes no observable change, then we might wonder whether there is *any* meaningful difference between the universe before and after the shift.

The goal of this "shift" thought experiment, first proposed by Gottfried Wilhelm Leibniz (1646-1716)[1] in his correspondence with Samuel Clarke (1675-1729), is to argue against the view that *space exists independently of the stuff that's in it*. Instead, Leibniz says *space is merely a convenient way of thinking about the relationships between material objects*.

Here we'll articulate these two positions in the philosophy of space, which is a branch of the philosophy of space and time,[2] and consider key arguments for and against those positions.

1. Relationism

Relationists about space, like Leibniz, take space to consist of relationships between material objects such as planets, humans, and coffee mugs. Because shifting the universe one meter to your left doesn't change any distances between objects, relationists say that such shifts leave space unchanged.

Relationists say that the fact that no experiment we could do would tell us whether or not everything was moved one meter to our left shows that relationalism is correct.

If the shift argument is convincing, treating space as separate and independent from the material objects within it seems mysterious and unnecessary. Most of the things we believe exist (tables, electrons, tectonic plates, other people) are physical, material objects that we can observe or measure in some way. So, by making space just a way of understanding the relationships between physical objects, relationists ground their view of space in ordinary things we can sense and measure instead of some separate mysterious entity.

If we believe that, all other things being equal, we should prefer theories about objects we're familiar with from experience, like tables and planets, instead of theories that rely on arcane entities like spatial points (see below), then we have reason to believe the relationist's theory of space.[3]

2. Substantivalism

Substantivalists, however, take space to be something real, like a material object but not made of matter. Space, in their view, is made of many identical points, understood as infinitesimal, immaterial "containers" for matter.[4] Material objects, when they move, move from one spatial point to another.

Arguments for substantivalism typically identify some observable phenomenon that substantivalists can explain but relationists can't.

2.1. Argument from Acceleration

Some phenomena that substantivalists think they alone can explain are the observable effects of acceleration. If a car quickly accelerates, the driver feels pushed back in their seat. But a pedestrian, standing on the sidewalk next to that car, doesn't feel a similar sensation even though, from the driver's perspective, the pedestrian is the one accelerating.[5]

For a relationist, this might seem strange: if space is just distance relationships between objects, then saying "the car accelerates away from the pedestrian" and "the pedestrian accelerates away from the car" are equally correct. So why does only the driver feel pushed backwards? Substantivalists can explain this fact because only one person, the driver, is *really* accelerating through space, while relationists have a harder time explaining it.[6]

2.2. Kant's Incongruent Counterparts

In 1768, Kant (1724-1804) provided a novel argument against relationism based on what he calls *incongruent counterparts*. First, consider your left hand and your right hand:

All distances between two parts of my left hand (say, my left thumb and my left pinky finger) are the same as the distances between two parts of my right hand (my right thumb and my right pinky finger). So the relationist should say that the left and right hands are identical.

But have you ever tried to put a left-hand glove on your right hand? It doesn't work: our left and right hands, while reflections of one another, are just differently shaped.

Kant's point about incongruent counterparts like our left and right hands is that they are clearly not identical to one another, but the relationist can't explain the difference between them since all the spatial relationships within the parts of your left and right hands are the same.

But the substantivalist can explain this difference by appealing to the parts of space a right hand fills that a left hand doesn't and vice-versa. So, like acceleration, incongruent counterparts seem to be a phenomenon that substantivalists can explain but relationists can't, grounding another reason to favor substantivalism.

3. Relativity

The relationist/substantivalist debate changed with the advent of Einstein's theory of relativity in the early 20th century. Instead of talking about space and time separately, Einstein united them into a single, four-dimensional *spacetime*.

One feature of Einstein's general theory of relativity is that facts about the structure of spacetime depend on the distribution of matter in spacetime and vice-versa, which is captured by the Einstein field equations.

This may seem, at first, like a point in the relationist's favor since space seems to depend on matter, and there are many relationists that have used relativistic physics to advance their position.[7] However, one strange feature of the Einstein field equations that supports substantivalism is that there exist numerous distinct "vacuum solutions" to these equations: that is, according to these equations, there are multiple distinct spacetimes with different geometry compatible with a completely empty universe.

If we take this multiplicity of vacuum solutions seriously, then we have a feature of our best physics that the substantivalist can explain but the relationist can't. The relationists, however, can point out that we've never encountered an actual vacuum universe in nature; we've only encountered the one non-vacuum universe we live in. So while the theory of relativity has changed the relationist/substantivalist debate, it hasn't settled it.

4. Conclusion

Advances in physics have changed the conversation between relationists and substantivalists. As our best available physical theories change, we should anticipate new developments in arguments for both relationism and substantivalism, even if the physics alone cannot settle this debate.

Notes

[1] The simplified argument briefly reconstructed here isn't quite Leibniz's argument, or at least not a straightforward reading of the argument he provides in his third letter (LIII.5) to Clarke. A key premise I've suppressed is Leibniz's *Principle of Sufficient Reason*, which takes for granted that, for things to be one way rather than another, God must have reason to prefer them being the way they are to the way they could be. If absolute space exists and is a substance separate and apart from the matter within it, then all points within that space are assumed to be identical, and there could be no reason God could give for choosing to make a world with everything just where it is instead of making a world with everything one meter to the left. It is only once the Principle of Sufficient Reason is invoked that Leibniz draws his conclusion that space can't be a substance, or, in his terminology, that there is no absolute space. For an introduction to the Principle of Sufficient Reason, see Leibniz's Principle of Sufficient Reason by Marc Bobro.

[2] Why the philosophy of space *and* time? Why not treat these concepts separately? One answer is that many of our best physical theories treat space and time in a similar (if not identical) way – both space and time are dimensions that describe our physical world and provide us with a way to situate both ourselves and the events we care about. As a result, there are some puzzles in the philosophy of space that have analogues in the philosophy of time, and vice-versa.

But one of the best reasons to consider space and time together in one philosophical subfield comes from relativistic physics, which treats space and time as a single unified whole, spacetime, instead of as separate concepts. We'll cover some considerations from relativity later in this entry, but see Sklar (1977) for more on the philosophical ramifications of relativity.

[3] This stage of the relationist's argument relies on intuitions about simplicity and metaphysics, specifically the idea that we shouldn't assume the world to have more things in it than are necessary in order to explain the stuff we see in the world around us. For more on simplicity, see Baker (2022), especially his section titled "Ontological Parsimony," which discusses the claim that, all other things being equal, we should prefer theories that require us to believe in the existence of fewer things or types of things.

[4] The properties of spatial points may differ from one substantivalist account to another; for instance, substantivalists who believe that space is discrete may disagree with substantivalists who believe that space is continuous about whether, given any two points of space, another point of space must exist between them. But substantivalists about space typically agree on the following facts: 1) points of space are the smallest possible units of space, 2) points of space have well-defined metric properties that tell you the distance from one point of space to another, and 3) material objects and their parts can occupy points of space.

[5] Newton's famous example of the observable effects of acceleration comes not from cars but from a spinning bucket hung from a long cord. When the bucket is filled with water and spins, the water sloshes up onto the sides, which is observably different from how the bucket appears when at rest. Newton's example appears in his Scholium IV in his *Principia*.

[6] Some relationists have responded to arguments for substantivalism that rely on observable changes in accelerating objects by pointing out that one body is accelerating relative to the motion of many more bodies; for instance, in my example above, the car accelerates relative not just to me but to trees, houses, and all sorts of other objects in its vicinity, as well as the "fixed stars" beyond the earth. The pedestrian, however, is only accelerating relative to the car and is at rest with respect to all those other objects. See Section VI.4 of "The Principles of Dynamics" in Mach (1919) for a developed relationist response to acceleration along these lines.

[7] The most famous relationist argument that takes advantage of the general theory of relativity is the "hole argument": see Norton (2019) for details.

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