6
Space
Substantivalism and relationism

abstract entities vs concrete entities.

regions is commonly thought to be concrete but that isn't in the category of material objects.

realists would say regions or space do exist.

Anti-realists about space would say, regions are an unnecessary addition.

God creating the universe

The realist about regions thinks that God has first to make an enormous container – the regions – in order to put the objects in.

The anti-realist thinks that all God has to do to make the universe is make a bunch of objects, and then arrange them in a certain way.

Those who are realists about regions are called **substantivalists,** whilst those who are anti-realists about regions are often called **relationists**.

Newton's argument for absolute space

Dirction + Speed = velocity # Velocity + acceleration = innertial forces

Newton's bucket

Newton's argument for substantivalism –

if velocity has to be relative to something, and acceleration is a change in velocity, then acceleration has to be relative to something as well. But, says Newton, it's possible for one object to accelerate even though there's no *object* that the acceleration could be relative to. But, as it must be relative to *something*, it must be relative to something that was not an object: it must be relative to space itself; ergo, space must exist.

Stage 1*:* The rope is twisted but has not been let loose. The bucket and the water are at rest with respect to one another.

Stage 2*:* The rope has been let loose and the bucket has started to rotate. But the water is still at rest because the bucket hasn't yet started to churn it into motion.

Stage 3*:* The bucket is rotating, the water is now rotating as fast as the bucket and the water level is now concave.

as the water is going around and around, it changes direction; since velocity is not just speed but speed in a certain direction, as the water changes direction, it changes its velocity; as acceleration is just a change in velocity, the water is therefore accelerating; as the water is accelerating, inertial forces act upon it and it is those forces which cause it to be concave.

If Newton is right that acceleration always has to be relative to something, what can it be relative to in this case? The water can't be accelerating with respect to itself (its acceleration relative to itself is always zero – in the same way that you never end up leaving yourself behind, the water cannot accelerate away from itself!). But nor can it be accelerating with respect to the bucket. As the bucket is going as fast as the water, and its velocity is changing at exactly the same rate as the water, the two are at rest relative to one another.

It's at this stage that Newton adds in regions.

This largest region is what Newton calls **absolute space**.

Before the rope is twisted, and it is not rotating, the water and the bucket aren't accelerating at all with respect to absolute space. When we get to the third stage, the water may not be accelerating relative to the bucket, but it *is* accelerating relative to absolute space.

So, according to Newton, we need absolute space in order to account for the inertial forces.

Ernst Mach and the fixed stars

Mach supposed, contrary to Newton, that there was no absolute space; instead, the inertial forces were produced because of acceleration relative to the fixed stars. Even though the fixed stars are far away, this isn't entirely unreasonable. There are other forces that are produced when two objects interact, more or less regardless of their distance from one another.

Einstein's theory of **general relativity**.

Einstein aimed to produce a theory that, accounted for inertial forces by making them the result of the distribution of all of the matter in the universe. general relativity allowed for all of the matter in the universe to rotate in the same direction.

This is a problem.

If acceleration is the result of velocity changes relative to matter distributed across the entire universe, rather than relative to absolute space, then that doesn't allow for the matter *itself* to rotate. For it to rotate, it would have to absolutely accelerate,

but we are to imagine that **absolute acceleration** just is the relative acceleration something has to ***all of the matter in the universe***.

So for the matter to rotate, it would have to accelerate away from itself – and *nothing* can accelerate away from itself. For example, by definition you can never leave yourself behind!.

Brute accelerations

why is acceleration relative to *something* that brings about the inertial forces? and *how* does that mechanism take effect?

the brute truth in this case might help the relationist's case for anti-realism about regions. The relationist may say that acceleration is simply a fundamental property of the universe, irreducible to accelerations relative to other things.

every physical theory have to take some facts as brute,

e.g., the most fundamental particles instantiating the most fundamental properties. Call that brute fact X.

We could explain X by saying that the fundamental particles weren't actually fundamental and that there is an extra variety of particles: the **Uselessions**. We could say that the arrangement and organization of the Uselessions explained why the fundamental particles that have the properties they do. In this case, the existence of the Uselessions would be unverifiable.

Once you came up with the Uselessions, you can posit a theory that explains what the Uselessions do, in terms of the **Pointlessions**, and then a better theory that explains what they do in terms of **Irrelevantions**, etc.

So, the relationist might claim that Newton would be wrong to think that introducing absolute space brought with it any explanatory power, and that taking absolute acceleration to be brute is a superior option.

Leibniz's shift argument

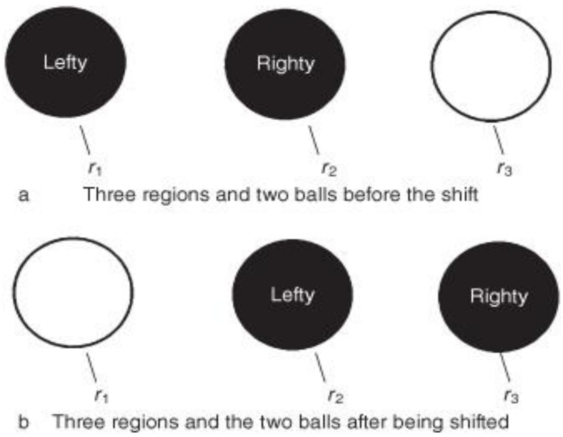
Gottfried Leibniz, a seventeenth-century philosopher, was a notable proponent of relationism and his **shift argument** was his main reason for endorsing it.

The argument is intended to be a *reductio ad absurdum* of being a realist about regions of space.

Start by imagining a universe with two balls in it, Lefty and Righty, plus absolute space. We'll concentrate on just three regions that make up that space. There's the region of space that Lefty is located at (call it r_1), the region of space that Righty is located at (call it r_2) – which is one metre to the right of r_1 – and finally an empty region of space one metre to the right of r_2 (call it r_3).

Figure 6.1a shows this set up. The problems arise when we imagine a second universe – one which was made differently, and where everything was shifted one metre to the right. Lefty would be where Righty was, i.e., located at r_2, whereas Righty would fill up what, in the other universe, was the empty space r_3. The place where Lefty was, r_1, would now be devoid of balls (see Figure 6.1b). As the places would be occupied by different things, these universes are two distinct possibilities.

Figure 6.1 Leibniz's shift argument



Leibniz had problems with such a possibility.

metaphysical principle: **the Principle of Sufficient Reason**: for everything that is the case, there must be a reason for why it is that way rather than some other way.

Given the Principle of Sufficient Reason, substantivalism has a problem, for what reason is there for Lefty being at r_1 (and Righty being at r_2) rather than Lefty being at r_2 (and Righty being at r_3)?

As there doesn't appear to be any reason for that, the Principle of Sufficient Reason is breached.

Relationism, on the other hand, solves the problem neatly.

Given relationism, there is no sense to be made of 'shifting' the objects. For the relationist, all there is to a universe are the objects in it, and the spatial relations between them.

so it’s impossible to shift Lefty and Righty one metre further to the right because they would both have to be one metre further to the right *of something else*.

With substantivalism, the ‘something else’ would be a part of absolute space, so we can have a difference between the universes.

There is no such parallel for relationism. So, given relationism, we don’t have two worlds which are different but where Lefty and Righty stand in the same relation to one another and we never have to ask the question about whether the situation depicted in Figure 6.1a holds or whether the situation depicted in Figure 6.1b holds – for the relationist, they are one and the same situation.

Leibniz also believed the **identity of indiscernibles**: if two things are indistinguishable – if they have the same properties – then they are one and the same thing.

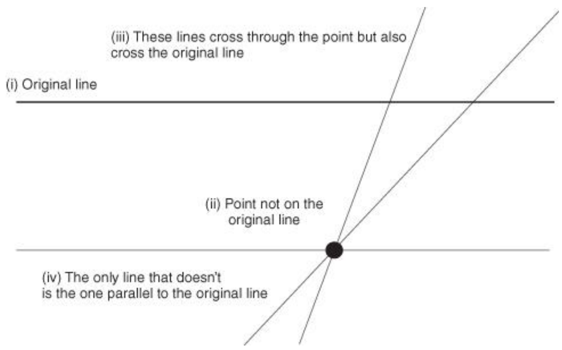
Leibniz thought, this favour relationism. As the two worlds posited by the substantivalist are indiscernible, then they must be identical. But that would be a contradiction, for substantivalists clearly thought they were distinct. So substantivalism must be false and relationism must be true.

Non-Euclidean geometries

So far, I have said that substantival space has no effects other than inertial forces and there is no way to distinguish between the two shifted universes that Leibniz imagines. But this is only true if Euclidean geometry, that is, the system of geometric axioms laid down by the ancient Greek Euclid, is true of our world.

In particular, it requires the truth of the **parallel postulate**: that for any line and any point not on that line, there’s only one line that can be drawn through that point that doesn’t cross the original line. That one line is, of course, the line *parallel* to the original line. Draw a line anywhere else, and it’ll cross the original one (see Figure 6.2).

Figure 6.2 The parallel postulate



For a long time, people thought the parallel postulate was incontrovertibly true. But then people developed **non-Euclidean geometries** where the postulate was false. The postulate only holds when we imagine **geometries on a flat surface**.

If we picture instead drawing lines on a surface that isn’t flat, the postulate turns out to be false. Imagine **a sphere** Euclidian geometrical principles fail. such as, triangles having to have interior angles that add up to 180 degrees.

Einstein’s theory of general relativity indicated that spacetime might be non-Euclidean – that is, that it might be curved.

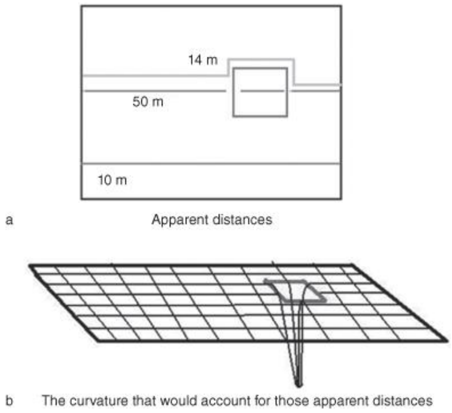
If it is curved, we’d notice differences because of this.

To see how it would make a difference, imagine the following situation. we’ll imagine that space is two-dimensional rather than three-dimensional. such a world is a **flatland**.

Imagine a room in flatland that is 10 metres across. In the centre of the room is a 4 m × 4 m area with a curtain around it. If our flatlanders walked from one side of the room to the other, they'd cross 10 m if they avoided the curtained area (as shown by the bottom line in Figure 6.3a). If they walked *around* the curtain area, they'd have to walk a bit further as they deviated from their straight line, say 14 m (as depicted by the top line).

But imagine that when a flatlander goes through the curtained area, he takes an awful long time to come out on the other side and, when he does, he insists that he was walking the whole time. Refusing to believe him, a fellow flatlander goes in with a long tape measure or metre wheel. The same thing happens and, when he emerges and reaches the other wall, he measures the distance he travelled from one wall to the other, not at 10 m but at 50 m!

Figure 6.3 Non-Euclidean space



If space were curved, we would have an excellent explanation for what has taken place. Imagine that the area curtained off was deformed rather than flat, making a deep dip in the fabric of space itself (see Figure 6.3b).

Now picture what would happen to the flatlanders who travelled through the curtain.

They'd have to go all the way down one side of space and then come out of the trough on the other side. It would, certainly, take them a lot longer to traverse from one side of the room to the other if they took this route. In such a world, the shape of space would have an explanatory role: the flatlanders would explain why it took them so long to travel certain places by saying that space existed and was shaped in a certain bizarre way in that region.

Einstein's theory of general relativity seems to indicate that the same is true of our world.

So it goes, spacetime can be deformed by the presence of things like mass, and if you deform spacetime correctly, then you end up with similar effects.

Whilst Einstein's deformations of spacetime are more complex than the above curtained-off area of flatland, the same idea holds – we might find that spacetime has an effect on us, and thus infer that it exists because of the shape it has in certain places. And, indeed, the predictions of Einstein's theory have been confirmed many times; although, there can be competing explanations to Einstein's.

The relationist still has options even at this stage. Whilst spacetime having a certain shape, and being warped, might explain certain phenomena, there are alternative explanations available.

Henri Poincaré offered such an argument. Returning to flatland, Poincaré would say that there are certain laws of nature which meant that ***any object travelling through the zone covered by the curtain ended up shrinking***. As it shrank, that would mean distances would *appear* to be larger even though, in fact, they were not. As you came out of the zone, the laws of nature would be such that objects expanded again until they were the same size at the other end. And as *everything* shrank and expanded when it went through the curtains, including light rays, even if you pulled the curtains away, you wouldn't see lots of tiny people;

Such a world of strange laws would be indistinguishable from one with a non-Euclidean geometry.

So we have two competing explanations: one that is compatible with a relationist's anti-realism about regions but invokes lots of brute laws of nature versus a substantivalist's realism about regions that invokes normal laws but adds warped spacetime into our ontology.

Ontological reductions

Reductions of regions

for substantivalism - we might commit to regions but reduce space to something else. Alternatively, we might reduce other things to space.

Some people say regions exist; but those are not in an ontological category of their own.

One way is to identify regions with sets. Start by introducing the notion of a **Cartesian coordinate system** which can be used to map space. What coordinates to use depends upon what dimensions we are considering. If we were considering three-dimensional space, we'd use three (one for each axis of the dimension). If we were considering four dimensions – say we were considering a spacetime which has **three dimensions of space and one of time** – we'd use four numbers.

Because it's easier, we'll again just imagine a two-dimensional flatland.

Each point in the flatland would be represented by two numbers – each number representing its position in one of the dimensions. One point is arbitrarily selected to be the 'origin' of the system, represented by 0,0. Places away from that origin are represented by positive or negative numbers giving their distance away from it, and you stipulate what each number represents.

So, we might stipulate that the unit of our coordinate system is the metre. So if a point was 2 metres in the eastwards direction of the origin, and 3 metres in the northwards direction, that point could be represented by 2,3. If it was 2 metres westwards of it and 4 metres north of it, that'd be represented with −2,4 (see Figure 6.4).

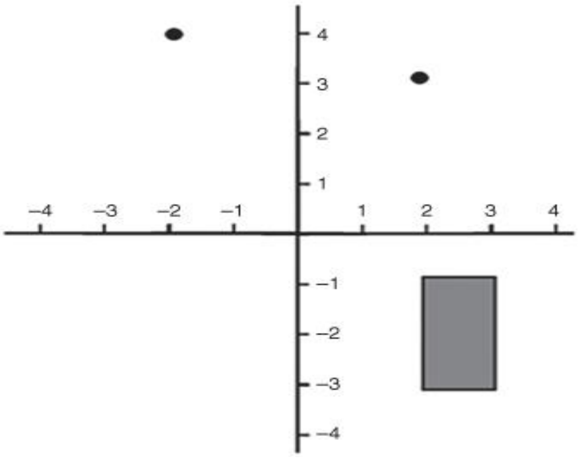


Figure 6.4 Cartesian coordinates

It's not hard to see how we might think a reduction of space to sets might proceed.

Each point in flatland corresponds to a coordinate of two numbers. We can identify the point with a set of those numbers. So the point at 2,3 is identified with the set of 2 and 3, and the point at −2,4 is identified with the set of −2 and 4

(actually, normal sets don't recognize order, so the point at 2,3 would end up being identified with the point at 3,2. Fortunately we can introduce a type of set that *does* recognize order – what are called **ordered sets**, represented by using < > instead of { }. So the point at 2,3 would be <2,3> and the point at 3,2 would be <3,2>. Unlike ordinary sets, as the members of the ordered set are in a different order, they end up being distinct).

With the points identified with sets, ***regions are identified with sets of points*** that fall within that region. So, the shaded region in Figure 6.4 is identified with the set of all of the points (infinite?) in that shaded region. So every point ends up being an ordered set of numbers ; which, as numbers might also be sets, might be an ordered set of other sets, and every region ends up a set of those ordered sets.

Regions, then, end up being mathematical objects.

Reductions to regions

We can also go the other way around and reduce other things to regions.

supersubstantivalism. This is the thesis that material objects – including things like you and me – are identical to regions.

reasons to believe supersubstantivalism - supersubstantivalist thinks that objects just *are* the regions they are located at.

We know,

- Objects always have the same size and shape as the region they occupy.
- Every object – every single one – occupies *some* region; none are left 'floating around', untethered from space and time.
- We tend to think that only one object can be located at a region at any given time.

We might take these facts as brute facts but we can 'up' the explanatory power of our theory if we accept supersubstantivalism. Now the explanation for the above is obvious:

- As objects just are the regions which they occupy, they must clearly have the same properties as it – including size and shape.
- As every object is a region, and an object is located at a region just in case it is that region, it follows that they *must* be in space and time.
- Clearly, two distinct objects cannot be in the same region as then two distinct things would be identical to the same thing, which is logically impossible.

people argue that **contemporary physics** demonstrates that supersubstantivalism is true, claiming that quantum physics or general relativity demand that objects are the regions that they inhabit.

Chapter summary

In this chapter, we have:

- introduced realism and anti-realism about regions of space and spacetime. These are substantivalism and relationism respectively.

- examined Newton’s bucket argument that acceleration must be relative to absolute space.
- examined Leibniz’s shift argument for relationism. According to Leibniz, substantivalism have no explanatory power.
- examined non-Euclidean geometries where substantival regions have explanatory power.
- looked at ontological reduction and regions, either of regions to something else, i.e., mathematical objects; or ‘something else’ to regions and material objects.