**A Solution to Some Grounding Problems for Relationism**

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**Abstract**

Let *wF*, *wC+*, and *wC–* be three distinct worlds, each of which contains only a single point-sized material particle, and in each of which spacetime is: uniformly flat, constantly positively curved, and constantly negatively curved, respectively. By the relationist’s lights, these worlds seem to be qualitatively identical. Nevertheless, for each world, there are propositions concerning possible arrangements of material points that are true in that world, but false in the other two. I argue that, surprisingly, the relationist can ground these differences in the distinct non-modal and intrinsic relations that are instantiated in each of *wF*, *wC+*, and *wC–*.

**Keywords**: metaphysics; spacetime; relationism; grounding; supervenience

**1. Geometric Possibility**

The *substantivalist* holds that spacetime itself, apart from the material objects occupying it, exists as an independent entity. The *relationist*, in contrast, denies this: nothing exists apart from material objects and their properties and relations (cf. Belot 2011: 1-2, 137-138; Field 1985: 33-34; Nerlich 1994: Ch. 1; and Sklar 1974: 161, 167).

Let *wF* be a possible world containing a single point-sized material particle, *pF*, and in which spacetime is Minkowskian (i.e., in which spacetime is a four-dimensional, uniformly flat manifold of spatiotemporal points). Let *wC+* be a possible world containing a single point-sized material particle, *pC+*, and in which spacetime is a four-dimensional manifold of spatiotemporal points standing in relations of constant positive curvature. Finally, let *wC–* be a possible world also containing a single point-sized material particle, *pC–*, and in which spacetime is a four-dimensional manifold of spatiotemporal points standing in relations of constant negative curvature.[[1]](#footnote-1) The substantivalist holds that *wF*, *wC+*, and *wC–* are distinct worlds: apart from *pF* in *wF*, *pC+* in *wC+*, and *p****C–*** in *wC–*,the actual arrangement of spatiotemporal points in each world differs from the actual arrangement of spatiotemporal points in the other two worlds. But if relationism is true, it might seem that *wF*, *wC+*, and *wC–* are not distinct: there is only one point-sized material object in each of these three worlds, and so *wF* = *wC+* = *wC–*.

Here is an initial reason for the relationist to think that *wF*, *wC+*, and *wC–* are nevertheless distinct. First, let a configuration of material point particles be *geometrically possible* with respect to a given world if the configuration is consistent with the spatiotemporal geometry of the world in question. Second, arrangements of material points are geometrically possible in each of *wF*, *wC+*, and *wC–* that are not possible in the other two worlds.[[2]](#footnote-2) To illustrate, consider the following propositions:

(*PF*) Possibly, the sum of the interior angles of any triangle whose vertices are spacelike separated from *pF* is 180 degrees.

(*PC+*) Possibly, the sum of the interior angles of any triangle whose vertices are spacelike separated from *pC+* is greater than 180 degrees.

(*PC–*) Possibly, the sum of the interior angles of any triangle whose vertices are spacelike separated from *pC–* is less than 180 degrees.

Why the restriction to triangles whose vertices are spacelike separated from *pF*, *pC+*, and *pC–*, respectively? Let us speak for the moment as substantivalists.Given that each of *wF*, *wC+*, and *wC–* are spacetimes of constant (i.e., flat, positive, and negative) curvature, we can foliate spacetime into “spacelike hypersurfaces” in each of these three worlds according to the reference frames of *pF*, *pC+*, and *pC–*. Such foliations allow us to specify the respective sets of spatiotemporal points, *AF*, *AC+*, and *AC–* that are “spacelike separated” from (i.e., simultaneous with) each of *pF*, *pC+*, and *pC–*. Let *AF2D* be a subset of *AF*, let *AC+2D* be a subset of *AC+*, let *AC–2D* be a subset of *AC–*, and let the members of each of *AF2D*, *AC+2D*, *AC–2D* be those points that form two-dimensional surfaces in *AF*, *AC+*, and *AC–*, respectively. Intuitively, as triangles are two-dimensional shapes, we want to distinguish what triangular arrangements of points are geometrically possible with respect to each of the two-dimensional surfaces of *AF*, *AC+*, and *AC–*.

The substantivalist has a straightforward explanation for *PF*’s, *PC+*’s, and *PC–*’s respective truth values in each of *wF*, *wC+*, and *wC–*. First, with respect to *wF*: that spacetime is flat explains why *PF* is true, and why *PC+* and *PC–* are both false. Second, with respect to *wC+*: that spacetime has constant positive curvature explains why *PC+* is true, and why *PF* and *PC–* are both false. Third, with respect to *wC–*: that spacetime has constant negative curvature explains why *PC–* is true, and why *PF* and *PC+* are both false.

Unlike the substantivalist, the relationist obviously cannot account for the various truth values of *PF*, *PC+*, and *PC–* by appealing to distinctive features of the respective spacetimes in *wF*, *wC+*, and *wC–*: according to the relationist, only one point exists in each world, and thus all three worlds seem to be qualitatively identical.

In broad outline, there are two relationist strategies available: on the one hand, the relationist can accept a primitive notion of geometric possibility, and thus insist that the difference in the respective truth values of *PF*, *PC+*, and *PC–* in these worlds is a brute fact; on the other, the relationist can attempt to show that these differences depend on the way things actually are in each of these worlds.

Though the first strategy has been common, it has also seemed unsatisfying (cf. Belot 2011: 51; Earman 1989: §6.12; and Field 1985). All else being equal, grounding modal claims is preferable to taking such claims as primitive, and so the relationist who accepts a primitive notion of geometric possibility is at an immediate disadvantage with respect to the substantivalist who is able to show that the respective truth values of *PF*, *PC+*, and *P****C–*** depend on the actual arrangements of spatiotemporal points in each world.

But if the first strategy is unattractive, the second appears hopeless for there seems to be no non-modal differences between *wF*, *wC+*, and *wC–* that could ground the relevant difference in the respective truth values of *PF*, *PC+*, and *PC–*. Thus the options for the relationist appear grim (cf. Belot 2011; Field 1985; Nerlich 1994: 20-22; and Sklar 1974: 171-173).

Understandably, some relationists will insist at this point (if not earlier) that the difficulty for relationism rests on a false assumption, which there is no non-question-begging reason to grant: namely, that *wF*, *wC+*, and *wC–* are distinct worlds. So, the objection continues, the best response to the so-called difficulty is to dissolve it by insisting that *wF* = *wC+* = *wC–*.

I have three reasons for thinking the relationist should not dissolve the present difficulty in this fashion. First, I think it is plausible to hold both that *wF*, *wC+*, and *wC–* are three distinct worlds, and that this is so independently of whether or not substantivalism is true: by Leibniz’s Law, if *wF* = *wC+* = *wC–*, then the same properties are instantiated in all three worlds; but *pF* instantiates the modal property *possibly being such that the sum of the interior angles of any triangle whose vertices are spacelike separated from pF is 180 degrees* (while *pC+* and *pC–*do not), *pC+* instantiates the modal property *possibly being such that the sum of the interior angles of any triangle whose vertices are spacelike separated from* *pC+ is greater than 180 degrees* (while *pF* and *pC–*do not), and *pC–* instantiates the modal property *possibly being such that the sum of the interior angles of any triangle whose vertices are spacelike separated from pC– is less than 180 degrees* (while *pF* and *pC+* do not); it follows that *wF*, *wC+*, and *wC–* are three distinct worlds.[[3]](#footnote-3) Second, if substantivalism can account for the difference between each of *wF*, *wC+*, and *wC–*, while relationism cannot, then, to the extent that one accepts the first reason, one should find substantivalism more attractive than relationism (cf. Belot 2011: 52). Third, responding to the difficulty for relationism by both granting that *wF*, *wC+*, and *wC–* are three distinct worlds, and providing an appropriate grounding for each of *PF*, *PC+*, and *PC–* (i.e., opting for the second, seemingly hopeless strategy mentioned above) is more interesting, and therefore more worth pursuing than the aforementioned *dissolution* (i.e., one which holds that *wF* = *wC+* = *wC–*) (cf. Belot 2011: 136).

I think these three reasons provide adequate motivation for at least *attempting* to resolve the relationist’s difficulties in the way I have described. Others may disagree. In particular, relationists who hold that *wF* = *wC+* = *wC–* can, of course, retain this commitment and reject all of the reasons just provided. I have no further arguments to convince them otherwise, and so the remainder of this paper is intended for those who, for one reason or another, think that *wF*, *wC+*, and *wC–* are all distinct, and that accounting for the respective truth values of *PF*, *PC+*, and *PC–* is a genuine problem for relationism.

**2. Some Grounding Problems for Relationism**

We are attempting to show that the respective truth values of *PF*, *PC+*, and *P****C****–* in each of *wF*, *wC+*, and *wC–* depend on the way things actually are in these worlds. It has not been uncommon to formulate such dependence claims in terms of supervenience (cf. Lewis 1992: 218-219; Sider 2001: 36). In particular, Gordon Belot (2011: 51-52) argues that truths concerning geometric possibility must supervene on the non-modal and intrinsic geometric properties or relations instantiated in that world. Specifically, for our purposes:

(*SF*) There can be no difference in *PF*’s truth value with respect to *wF*, on the one hand, and each of *wC+*, and *wC–*, on the other, without a corresponding difference in what non-modal, intrinsic geometric properties or relations are instantiated in *wF* on the one hand, and in each of *wC+*, and *wC–*, on the other.

(*SC+*) There can be no difference in *PC+*’s truth value with respect to *wC+*, on the one hand, and each of *wF*, and *wC–*, on the other, without a corresponding difference in what non-modal, intrinsic geometric properties or relations are instantiated in *wC+* on the one hand, and in each of *wF*, and *wC–*, on the other.

(*SC–*) There can be no difference in *PC–*’s truth value with respect to *wC–*, on the one hand, and each of *wF*, and *wC+*, on the other, without a corresponding difference in what non-modal, intrinsic geometric properties or relations are instantiated in *wC–* on the one hand, and in each of *wF*, and *wC+*, on the other.

Belot does not provide a definition of what makes a property or relation modal, and I do not have one to offer in his place. Nevertheless, an example should sufficiently clarify the intended import. I am human, and so I instantiate the property *being human*, which is a non-modal property in the relevant sense. On the other hand, I am not seven feet tall, and so I do not instantiate the property *being seven feet tall*. But suppose we grant that I am possibly seven feet tall. If so, then I instantiate the property *possibly being seven feet tall*, and this is a modal property in the sense that concerns us.

Intrinsic properties and relations, on the other hand, are somewhat easier to characterise (if not define) than modal properties. First, let objects be *wholly distinct* if they have no parts in common. Next, let us say that an *intrinsic* propertyis one that describes how an object is in and of itself, and apart from how everything wholly distinct from it is; similarly, an *n*-place intrinsic relation is one that *n* objects instantiate in virtue of how they are, and how they are related to each other, and apart from how everything wholly distinct from the *n* objects is (cf. Belot 2011: 51; Lewis 1983: 197; Skow 2007).

Clarifications aside, there is a problem with each of *SF­*, *SC+­*, and *SC****–***, which is that, according to a growing consensus, metaphysical dependence cannot be reduced to, or understood in terms of, supervenience. Instead, many have accepted an alternative *grounding* account of such dependence. Though there is some variation, many (perhaps most) grounders regard grounding as a relation that holds between facts (where a fact is a non-mereological complex that has, as constituents, one or more objects instantiating one or more properties or relations), and I assume this conception here (cf. Audi 2012; Raven 2012; Rosen 2010; Trogdon 2013).[[4]](#footnote-4)

Although grounding shares with supervenience the formal feature of being *transitive*,[[5]](#footnote-5) grounding nevertheless differs crucially in that it is both *irreflexive* and *asymmetric* (cf. Cameron 2008: 3; Raven 2012: 689; Rosen 2010: 115), whereas supervenience is *reflexive* and *non-asymmetric*.Furthermore, grounding is appropriately fine grained. A statue’s aesthetic properties are grounded in its physical properties, but it is not the case that every property that is necessarily instantiated is grounded in the statue’s physical properties. Unlike supervenience, grounding is not itself a relation of modal covariation, and so grounding is able to distinguish what mere supervenience cannot: namely, genuine cases of dependence (e.g., of the statue’s aesthetic properties on its physical properties) from spurious ones (e.g., of the property *being such that 2+2=4* on the statue’s physical properties).[[6]](#footnote-6)

Given that discussions of the relationist’s difficulties with grounding tend to understand the latter in terms of supervenience, I will also assume, as many do, that grounding, though not *reducible* to supervenience, nevertheless *entails* it.[[7]](#footnote-7) For instance, Jonathan Schaffer (2009: 364) writes: “There is an interesting question about the modal consequences of grounding. This opens up the prospect of using supervenience for *something* – the right sort of supervenience failure can show grounding failure” (emphasis in original). Given the aforementioned entailment, I will now show that it is precisely the seeming failure of supervenience that gives rise to a certain class of grounding problems for relationism.

As the relationist is attempting to ground the truth of *PF* in *wF*, *PC+* in *wC+*, and *PC–* in *wC–*, each of these propositions must be grounded in whatever non-modal, intrinsic geometric properties or relations are instantiated in each of *wF*, *wC+*, and *wC–*, respectively. Thus we have the following grounding theses:

(*GF*) That *PF* is true in *wF* is grounded in *wF*’s non-modal and intrinsic geometric properties or relations.

(*GC+*) That *PC+* is true in *wC+* is grounded in *wC+*’s non-modal and intrinsic geometric properties or relations.

(*GC–*) That *PC–* is true in *wC–* is grounded in *wC–*’s non-modal and intrinsic geometric properties or relations.

Each of the above grounding theses entails one of the corresponding supervenience theses mentioned earlier. That is, *GF­* entails *SF­*, *GC+­* entails *SC+­*, and *G****C–****­* entails *S****C–***. If this is so, however, there seems to be a straightforward problem. For example, given that *PF* is false in each of *wC+* and *wC–*, there must be some difference between the non-modal and intrinsic geometric properties or relations instantiated in *wF*, on the one hand, and such properties or relations instantiated in *wC+*, and *wC–*, respectively, on the other. But as *wF*, *wC+*, and *wC–* seem to be qualitatively identical, *SF* is false; if so, then *GF* is also false (by parallel reasoning, analogous conclusions follow for *SC+* and *GC+*, and for *SC–* and *GC–*). For my purposes, these are the three grounding problems for relationism with which we will be concerned.[[8]](#footnote-8)

**3. The Non-Modal and Intrinsic Natures of *RF*, *RC+*, and *RC–***

To preview: I first assume that there is a relation *RF* that is instantiated in *wF*, but that is not instantiated in either of *wC+*, or *wC–*; that there is a relation *RC+* that is instantiated in *wC+*, but that is not instantiated in either of *wF*, or *wC–*; and that there is a third relation *RC–* that is instantiated in *wC–*, but that is not instantiated in either of *wF*, or *wC+*; I then argue that each of *RF*, *RC+*, and *RC–* is non-modal and intrinsic. If these arguments are compelling, then the truths of *PF*, *PC+*, and *PC–*, respectively, are grounded in distinct non-modal, intrinsic relations that are instantiated in each of *wF*, *wC+*, and *wC–*. Furthermore, it follows that *GF­*, *GC+*, and *G****C–*** are true, that *SF*, *SC+*, and *S****C–*** are also true, and so that these grounding problems for relationism are solved.

I assume that, for each of *wF*, *wC+*, and *wC–*, any proposition *P* concerning the geometric structure of each of these respective worlds is either true or false. If so, then for each of *wF*, *wC+*, and *wC–*, there is a corresponding set *SGF*, *SGC+*, and *SGC–* of true propositions concerning the geometry of each of these three worlds. Specifically, the members of *SGF* are all of the propositions that are true of Minkowski spacetime, the members of *SGC+* are all of the propositions that are true of any spacetime of constant positive curvature, and the members of *SGC–* are all of the propositions that are true of any spacetime of constant negative curvature. Let us call *SGF* the *geometry of wF*, *SGC+* the *geometry of wC+*, and *SGC–* the *geometry of wC–*.

Let *RF* be the relation *representsF*, and let [*RF*] be the fact that *wF* stands in *RF* with *SGF*; let *RC+* be the relation *representsC+*, and let [*RC+*] be the fact that *wC+* stands in *RC+* with *SCC+*; finally, let *RC–* be the relation *representsC–*, and let [*RC–*] be the fact that *wC–* stands in *RC–* with *SGC–*.

I make the following assumptions about each of *RF*, *RC+*, and *RC–­*. First, I officially hold that each of *RF*, *RC+*, and *RC–­* are relations that hold between a world, on the one hand, and a set of propositions, on the other. But given that *wF* = *pF*, *wC+* = *pC+*, and *wC–* = *pC–*, and that the majority of the discussion that follows will be concerned with these one-particle worlds, I will frequently say that each of *RF*, *RC+*, and *RC–­* relates a material point-particle with a set of propositions. Other than affording a certain ease of expression, I trust that nothing substantive turns on this decision.

Second, if an entity *x* *necessitates* another entity *y*, then, necessarily, if *x* exists, then *y* also exists (cf. Armstrong 2004: 5-7; Merricks 2007: 5). Let a relation be *internal* if it is necessitated by the intrinsic properties of each of its relata; let a relation be *external* if it is not necessitated by the intrinsic properties of either of its relata; and let a relation be *mixed* if it is necessitated by the intrinsic properties of at least one, but not all, of its relata (cf. Armstrong 1978: 84-85; Armstrong 1997: 87-89). *RF*, *RC+*, and *RC–­* are mixed relations: on the one hand, and to take but one example, *RF* is necessitated by the intrinsic properties of *SGF*; on the other, *RF* is not necessitated by the intrinsic properties of *pF*.

Third, given that a fact is *fundamental* iff no other fact grounds it, and letting [~*RF*], [~*RC+*], and [~*RC–*] be the respective facts that *RF* is not instantiated, that *RC+* is not instantiated, and that *RC–* is not instantiated, each of [*RF*], [~*RC+*], and [~*RC–*] is fundamental in *wF*; each of [*RC+*], [~*RF*], and [~*RC–*] is fundamental in *wC+*; and each of [*RC–*], [*~RF*], and [*~RC+*] is fundamental in *wC–*.[[9]](#footnote-9)

I will now explain, for example, why *PF* is true in *wF*, and false in both of *wC+* and *wC–*. First, insofar as *PF* is a member of *SGF*, it follows that, in *wF*, [*PF* is true] is grounded in [*RF*]. Second, given that *GF* entails *SF* (§2), and that *PF* is true in *wF*, but false in both of *wC+* and *wC–*,there must be some difference between the non-modal and intrinsic geometric properties or relations that are instantiated in *wF*, on the one hand, and in each of *wC+* and *wC–*. Part of this difference consists in the fact that while *RF* is instantiated in *wF*, *RF* is not instantiated in either of *wC+* or *wC–*. That is, in *wC+*, [*PF* is false] is grounded in [*~RF*]; similarly, in *wC–*, [*PF* is false] is grounded in [*~RF*].

Given that *wF* stands in *RF* with *SGF*, it is plausible that this relation is not objectionably modal.[[10]](#footnote-10) Thus we have established both the first part of *GF* (i.e., that *PF*’struth in *wF* is grounded in the non-modal *RF*), and the first part of *SF* (i.e., that the difference in *PF*’s truth value with respect to *wF*, on the one hand, and to *wC+* and *wC–*,on the other, supervenes on whether the non-modal *RF* is instantiated in each of these latter worlds).[[11]](#footnote-11)

I turn now to the second parts of *GF* and *SF*: that *RF* is intrinsic. First, *pF* is the only material object in *wF*; second, regardless of what other necessary objects exist in *wF*, it is plausible that such objects have nothing to do with whether or not *pF* stands in *RF* with *SGF*; third, given these two points, it is plausible that *pF* and *SGF* instantiate *RF* in virtue of how they are, and how they are related to each other in *wF*, and apart from how everything wholly distinct from these two entities is. I conclude that *RF* is intrinsic (similar remarks apply to *RC+* and *RC–*).

Having established that each of *RF*, *RC+*, and *RC–* are non-modal and intrinsic, it follows that *GF­*, *GC+*, and *GC–* are true, that *SF*, *SC+*, and *SC–* are also true, and so that these grounding problems for relationism are solved.

**4. Some Objections to My Account**

I will now consider several objections to my account. The first is that, insofar as *wF*, *wC+*, and *wC–* are qualitative duplicates, it is implausible to regard *RF*, *RC+*, and *RC–* as distinctrelations.

In response, given that the relationist must help herself to *some* sort of primitive distinction between *wF*, *wC+*, and *wC–*, there is no general presumption against my claim that the relationist should accept a primitive distinction between *RF*, *RC+*, and *RC–*. Recall the common relationist strategy of accepting that *PF*’s truth in *wF* and falsity in each of *wC+* and *wC–* is a brute fact (§1).The problem with this strategy is not that it regards some claim or other as primitive; rather, the problem is that it regards the respective truth values of the *modal* claim *PF* in particular as primitive.But, as I have just argued, my account does not regard these truth values of *PF* as primitive, and so it avoids the objectionable feature of the common relationist strategy.

The second objection is that I am guilty of an adhoc solution to the relationist’s grounding problems. First, let an *abstract spacetime* be a mathematical object representing the spatiotemporal structure of a given world. It is standard for the relationist to assume that an abstract spacetime *A* represents by isomorphism: an arrangement of material points *M* in some world *w* is embeddable within *A* if and only if *M* is isomorphic to some *AS* (where *AS* is a subset of *A*) (cf. Friedman 1983: 219-221; and Mundy 1983, 1986). But my account is inconsistent with this standard assumption. To see why, first, suppose, as is plausible, that each of *pF*, *pC+*, and *pC****–*** is moving inertially.[[12]](#footnote-12) If so, then each of these particles is traveling along a uniform, continuous path (i.e., a one-dimensional line) that is indistinguishable from that of the other two. But then it follows that the path of any one of *pF*, *pC+*, and *pC–* is isomorphic to exactly the same regions of exactly the same abstract spacetimes as the other two particles. The upshot is that, as none of *RF*, *RC+*, and *RC–* can be understood in terms of isomorphism, my account seems desperately ad hoc. That is, I am positing three relations – *RF*, *RC+*, and *RC–* – whose sole purpose is to resolve outstanding problems for relationism.

By way of response, I will present an extended analogy to show that we should not regard the relationist’s acceptance of *RF*, *RC+*, and *RC–* as ad hoc. In brief, the relationist solution I am promoting here is relevantly like a distinctive solution that some presentists provide to a similar objection.

To begin, *presentism* is the thesis that it is always the case that the only objects that exist are those that exist at the present time, and the only properties and relations that are instantiated are those that are instantiated at the present time. A *wholly non-present* object is one that, roughly, exists at some past times or future times, but does not exist at the present time. Presentism entails that there are no wholly non-present objects.

Next, consider the following proposition:

(*PD*) Dinosaurs roamed the earth.

Presentists have well-known difficulties accounting for the obvious truth of *PD*. That is, in parallel with the grounding objection to relationism, there is a well-known grounding objection to presentism. First, we have the appropriate grounding claim:

(*GD*) That *PD* is true is grounded in what properties or relations are instantiated.

*GD* entails the following supervenience claim:

(*SD*)There can be no difference in *PD*’s truth value without a corresponding difference in what properties or relations are instantiated.

We motivate the grounding problem for presentism as follows. Consider the Russellian sceptical scenario where the world came into existence only a few minutes ago, and exactly as it then was. Given presentism, it follows that there is no difference between Russell’s world and ours in terms of what properties and relations are instantiated. But, given the sceptical scenario, *PD* is false: if the world came into existence only a few minutes ago, and exactly as it then was, then there would never have been any dinosaurs. Thus, given presentism, the truth of *PD* entails the falsity of *SD*, which, in turn, entails the falsity of *GD*. But surely *GD* is true, and so it follows that presentism is false. Let us call this *the grounding problem for presentism*.

Some presentists have responded to the grounding problem by endorsing *Lucretianism*. The Lucretian holds that the world is the totality of things existing at the present time, and this totality instantiates *Lucretian* (i.e., irreducibly past-tensed) *properties* (cf. Bigelow 1996; Crisp 2007; and McDaniel 2014). For an example of such a property, consider *was dinosaurian*, which is the property that the world was once inhabited by dinosaurs, and let [*was dinosaurian*] be the fact that *was dinosaurian* is presently instantiated. According to the Lucretian, the truth of *PD* is grounded in [*was dinosaurian*] which entails that the difference between our world and the Russellian one is that [*was dinosaurian*] obtains in our world, but not in Russell’s. Thus, *GD* is true, which entails that *SD* is as well.

There have been many objections to Lucretian properties. Most such objections argue that the supervenience base in *SD* should be restricted in various ways – e.g., to those properties and relations that are *categorical* (cf. Sider 2001: 40-41); to those that make an *intrinsic difference* (cf. Cameron 2010); to those that are *natural* (cf. Crisp 2007); etc. – and that such restrictions eliminate Lucretian properties. An objection that should *not* be made to Lucretian properties is that their acceptance by the presentist is an ad hoc response to the grounding problem. It is not difficult to see why this is so: *if* Lucretian properties are plausibly regarded as categorical, or intrinsic difference-making, or natural, etc., then insofar as the presentist already accepts other categorical, or intrinsic difference-making, or natural, properties into her ontology, there is (so far) no reason to reject Lucretian properties, and there is a very significant reason to accept them, which is their utility in solving the grounding problem for presentism.

Analogously, one should not object that the relationist’s acceptance of *RF*, *RC+*, and *RC–* is an ad hoc response to the grounding problems with which I am concerned here. Rather, one who objects to *RF*, *RC+*, and *RC–* should argue for an independently plausible restriction of the supervenience base for each of *SF*, *SC+*, and *SC–*that eliminates*RF*, *RC+*, and *RC–*. But we already have such a restriction, which is that the supervenience base must consist of only non-modal and intrinsic properties and relations. So if there is any problem with *RF*, *RC+*, and *RC–* it must be that they are objectionably modal or non-intrinsic. But I am in the process of defending my claim that these relations satisfy both of these constraints.

The third objection begins by recalling that the common relationist response to the three grounding problems accepts a primitive notion of geometric possibility. If my response is to be an improvement, then *RF*, *RC+*, and *RC–* themselves must not be objectionably modal. But each of *SGF*, *SGC+*, and *SGC–* seems to be essentially representational; if so, then each of *RF*, *RC+*, and *RC–* *is* objectionably modal: roughly, if *x* is essentially a representation of something or other, then *x* represents and so necessitates something or other.[[13]](#footnote-13) Thus, as *SGF* is essentially representational, it follows that *SGF* stands in *RF* with, and so necessitates, some material entity or other. Given *RF*’s status as a necessitating relation, it follows that *RF* is objectionably modal after all (similar objections apply to *RC+* and *RC–*).

I have two responses to this objection. First, I deny that *SGF* necessitates the existence of some material entity or other: *SGF* is a necessarily-existing object, and so there are worlds where *SGF* exists, but where no material entities exist; it follows that *SGF* is not essentially a representation of some material entity or other.

Second, in the current context, I assume that an objectionably modal relation is one that *reduces* to a paradigmatically modal relation, such as necessitation or supervenience. In contrast, if a relation merely entails, but does not reduce to, such a modal relation, it does not follow that the relation in question is thereby objectionably modal. This is a plausible assumption: the grounding relation *itself* entails, but is not reducible to, supervenience (§2). But the grounding relation is instantiated in each of *wF*, *wC+*, and *wC–* (§2), and, by hypothesis, grounding is not an objectionably modal relation.

Similarly, although I grant that *RF* entails necessitation, *RF* does not itself reduce to necessitation. Thus, *RF*, like the grounding relation, is not objectionably modal. Here is the argument. If *pF* stands in *RF* with *SGF*, it follows that, trivially, *pF* necessitates *SGF* (because *SGF* exists necessarily). But it is not the case that if *pF* necessitates *SGF*, then *pF* stands in *RF* with *SGF*: as *RF* is a mixed relation, it follows that *pF*’s intrinsic properties do not necessitate *RF* (§3); if so, there are worlds where *pF* exists, but where it does not stand in *RF* with *SGF*. So *RF* does not reduce to necessitation (similar remarks absolve *RC+* and *RC–*).

But doesn’t the relation between *RF* and *SGF* reduce to necessitation? No: although *RF* necessitates *SGF*, the latter does not necessitate the former. That is, assuming that a relation requires the existence of its relata, and, given *SGF*’s status as a necessary existent, there are worlds where *SGF* exists, but where no material entities exist, and so where *RF* is not instantiated.

A fourth objection finds fault with my disavowal of suspicious modality. Specifically, each of *RF*, *RC+*, and *RC–* seems to constrain what is geometrically possible in each of *wF*, *wC+*, and *wC–*, respectively. For example, with respect to *wF*, it is not possible that there exists an arrangement of three material objects that form the vertices of a triangle whose interior angles sum to greater than 180 degrees. But if this is so, then *RF* seems to be objectionably modal after all.

I reply by noting that, as grounding entails supervenience, the grounding relation itself constrains what is possible. In particular, and as I have already argued, given that *GF* entails *SF*, and that *PF* is true in *wF*, but false in both of *wC+* and *wC–*, the grounding relation constrains what is possible:there must be some difference between the non-modal and intrinsic geometric properties or relations that are instantiated in *wF*, on the one hand, and in each of *wC+* and *wC–* (§2). But, and to repeat, that the grounding relation entails a modal constraint in this way does not thereby make it an objectionably modal relation. Similarly, that *RF* entails constraints on what is geometrically possible with respect to *wF* does not thereby make it an objectionably modal relation.

My answers to the previous three objections invite a fifth objection, which is that *RF*, *RC+*, and *RC–* are mysterious. Perhaps, as I have urged, these relations are neither ad hoc additions to the relationist’s ontology, nor are they objectionably modal. Nevertheless, insofar as I hold both that *RF*, *RC+*, and *RC–* do not represent via isomorphism, and that these relations are not necessitated by the intrinsic natures of their respective material relata, I endorse a view that is deeply obscure.

I plead guilty to the charge, but deny its (comparative) seriousness. That is, I grant that accepting *RF*, *RC+*, and *RC–* is a cost, but maintain that the current context makes it bearable: insofar as the common relationist response to the grounding problems is committed to a primitive notion of geometric possibility, it too traffics in unilluminating mystery. So, if the decision is between my response, or the common one, then although one cannot avoid mystery, one *can* avoid primitive modality by endorsing my account.[[14]](#footnote-14) It is in this respect that my solution is an important advance over the common relationist variant.

A sixth objection is that the view I am defending is just substantivalism in disguise. For example, in my response to the third objection above, I admit that, as the spatiotemporal geometries *SGF*, *SGC+*, and *SGC–* are necessarily-existing, there are worlds where these geometries exist, but where no material entities exist; but then it looks as though I endorse substantivalism.

This objection misfires: the issue is not that *SGF*, *SGC+*, or *SGC–* exist in worlds where there are no material entities; rather, the question is, for any such materially-empty world, whether *SGF*, *SGC+*, or *SGC–* plays the role of the spatiotemporal geometry in that world. Substantivalism entails that every materially-empty world nevertheless has a spatiotemporal geometry. According to the view I am defending, however, no materially-empty world has a spatiotemporal geometry: if a world has a spatiotemporal geometry, then that world instantiates one or anotherof *RF*, *RC+*, or *RC–* (§3); as these relations require the existence of some material entity or other for their instantiation (§3), materially-empty worlds do not instantiate any of *RF*, *RC+*, or *RC–*; it follows that such empty worlds have no spatiotemporal geometry. So my view is not substantivalism in disguise.

The seventh and final objection I will consider is that, even if we grant that my view is not substantivalist, it is nevertheless the case that my view will be deeply unattractive to relationists. It is central to any relationist view that claims about the geometry of spacetime are ultimately grounded in the various relations between a plurality of material entities. But this is not so on my view. Rather, I hold that claims about the geometry of spacetime are – at least in cases involving one-particle worlds – ultimately grounded in the relation that a world consisting of a single material point-particle stands in with a set of propositions.

I have two responses. My first is that, in developing a relationist solution to grounding problems involving one-particle worlds, I was obviously not concerned to maintain – as the current objection holds – that claims about the geometry of spacetime in such worlds are ultimately grounded in the various relations between a plurality of material entities. Rather, my explicit goal has been to argue thatthe truths of *PF*, *PC+*, and *PC–*, respectively, are grounded in distinct non-modal, intrinsic relations that are instantiated in each of *wF*, *wC+*, and *wC–*, and to do so while avoiding any commitment to substantivalism. The current objection does not show that I have failed in my task.

Second, I am happy to grant that, insofar as standard relationist accounts hold that claims about the geometry of spacetime are ultimately grounded in the various relations between a plurality of material entities, my proposal is inconsistent with such accounts. But, in the current context, standard relationist accounts are noteworthy for being unable to solve grounding problems involving one-particle worlds. I am therefore also happy to grant that my account will only appeal to those relationists who are both bothered by these grounding problems, and have despaired of finding solutions from within the ranks of such relationist accounts.

**5. Conclusion**

The truth values of the geometric possibility claims *PF*, *PC+*, and *PC–* differ with respect to each of *wF*, *wC+*, and *wC–*. Though it is common for relationists to accept these truth values as primitive, such a commitment to irreducible modality has seemed unsatisfactory, but also unavoidable. If I am right, however, this conclusion is not forced on the relationist: the truth values of *PF*, *PC+*, and *PC–*, respectively, are grounded in three distinct, non-modal, intrinsic relations: *RF*, which is instantiated in *wF* (but not in *wC+* or *wC–*); *RC+*, which is instantiated in *wC+* (but not in *wF* or *wC–*), and *RC–*, which is instantiated in *wC–* (but not in *wF* or *wC+*).[[15]](#footnote-15)

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1. According to general relativity, spacetime curvature is due to the distribution of matter within the spacetime in question. As the only matter in *wC+* and *wC–*, respectively, is a single point-particle, I am not assuming that the curvature of the spacetimes in either of these worlds is due to their respective matter distributions. Nevertheless, I assume there is a clear sense in which such worlds remain genuinely possible (cf. Belot 2011: 52-53). [↑](#footnote-ref-1)
2. For more on why a distinctive notion of geometric (as opposed to merely physical) possibility is needed in this context, see Belot (2011: 49-51); Brighouse (1999); and Field (1985: §9). [↑](#footnote-ref-2)
3. Compare the well-known puzzle of the statue and the clay that composes it. It seems that there is only one object where the statue is located. But as the clay can survive being smashed, whereas the statue cannot, the clay has a modal property that the statue lacks. By Leibniz’s Law, it follows that the statue and the clay are distinct. What counts as the best *solution* to this puzzle is, of course, controversial; but it is widely agreed that there is in fact a *puzzle* here. [↑](#footnote-ref-3)
4. For alternative conceptions of grounding, see Fine (2012) and Schaffer (2009). [↑](#footnote-ref-4)
5. Schaffer (2012), however, denies that grounding is transitive. [↑](#footnote-ref-5)
6. The near-consensus is that grounding cannot be understood in terms of *any* modal notion (e.g., supervenience, necessitation, etc.). For an exception to this trend, see McDaniel (2019). [↑](#footnote-ref-6)
7. Though see Leuenberger (2014) for a dissenting view. [↑](#footnote-ref-7)
8. There are, of course, other grounding problems for relationism. I have only been discussing relationist attempts to account for (what the substantivalist would call) spacetimes of *constant* positive, negative, and flat (i.e., zero) curvature. But one can also consider spacetimes of *variable* curvature, in which the relationist attempts to distinguish one-particle worlds with such variably curved spacetimes from each other or from one-particle worlds with constant (positive, negative, or flat) curvature. As far as I can see, the solution to the three main grounding problems that I develop in this paper can be generalised so as to apply to these further grounding problems involving variably curved spacetimes. I will not, however, pursue this matter further here. [↑](#footnote-ref-8)
9. From the fact that, for example, *wF* instantiates *RF*, it does not follow that *wF* does not instantiate either of *RC+* or *RC–*. Thus, I have to regard each of [*RF*], [*~RC+*], and [*~RC–*], as fundamental facts (similar remarks apply to *wC+* and *wC–*). [↑](#footnote-ref-9)
10. Grant this assumption for now; I will defend it at length in the following section. [↑](#footnote-ref-10)
11. Straightforwardly analogous arguments establish both the first parts of *GC+* and *SC+*, and the first parts of *GC–* and *SC–*. I will not rehearse these arguments here. [↑](#footnote-ref-11)
12. Insofar as *pF*, *pC+*, and *pC****–*** are alone in their respective worlds, each particle is subject to no external influences (e.g., there is no reason to suppose that any of these particles is accelerating), and so it follows that each of *pF*, *pC+*, and *pC****–*** is moving inertially. [↑](#footnote-ref-12)
13. Note that, for any essentially representing entity *x*, the current objection does not assume that there is some particular represented entity *y* that *x* necessitates. [↑](#footnote-ref-13)
14. It might be thought that, with respect to the grounding problems of the present paper, I have pressed a false dilemma between my view and the common relationist response. For example, although Nick Huggett (2006) is not concerned with these grounding problems, he defends a relationist view that is both distinct from my own, and which might seem not to be committed to a primitive notion of geometric possibility. Nevertheless, given that Huggett (2006: 53) holds that “…geometric facts supervene on the history of [spatiotemporal] relations”, it is not at all clear that, with respect to one-particle worlds, he has the resources to solve such grounding problems without accepting such a primitive notion of geometric possibility. [↑](#footnote-ref-14)
15. Thanks to Geoff Goddu, Donald Smith, and multiple anonymous referees for very helpful comments on, and conversations about, this paper. [↑](#footnote-ref-15)