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Against relationalism about modality

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[Please note. The citations were messed-up by Springer's editing system, but I hope they remain sufficiently readable so as to not warrant a massive correction of the paper. --C.R.]

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Abstract
On a highly influential way to think of modality, that I call 'relationalism', the modality of a state is explained by its being composed of properties, and these properties being related by a higher-order and primitively modal relation. Examples of relationalism are the Dretske-Tooley-Armstrong account of natural necessity, many dispositional essentialist views, and Wang's incompatibility primitivism. I argue that relationalism faces four difficulties: that the selection between modal relations is arbitrary, that the modal relation cannot belong to any logical order, that to explain how the modal relation can relate properties of different adicities additional ideological complexity has to be introduced, and that not all modal constraints are relational. From the discussion, I will extract desiderata for a successor theory of modality.

Keywords Dispositionalism · Constraint · Primitive modality · Higher order

1 Introduction

On a highly influential way to think of modality, the modality of a state is explained, roughly, by (i) its being composed of properties, and (ii) these properties being related by a higher-order and primitively modal relation. Call this general notion, 'the relationalist scheme'. I will argue that the relationalist scheme suffers from four flaws. From the discussion, I will extract two desiderata for a theory of modality.

The focus of this paper will be objective—not epistemic, deontic nor doxastic—modality. More specifically, many relationalists aim to provide an account of physical modality: to account for the necessity of the natural laws, for example. Others aim to account for metaphysical necessity. The issue complicates a little because some relationalists believe that the necessity of the natural laws is metaphysical. On the other hand, one may doubt that metaphysical necessity is well-defined (Nolan, 2011), or that there is necessity beyond whatever necessity the laws of nature have

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(Priest, 2018). I prefer to not complicate the present discussion with these subtle matters. I assume that relationalists, as most other modal metaphysicians, want to account for *the broadest objective modality*, assuming that there is one (but see, e.g. Clarke-Doane, 2021).[1]

On one of the most familiar relationalisms, the Dretske-Tooley-Armstrong (DTA) account (Dretske, 1977; Armstrong, 1983; Tooley, 1988), the natural necessity of a state is explained by (i) its being composed of sparse universals and (ii) these universals being related by a higher-order relation of necessitation, *N*. In turn, states of the canonical form: *N*(*F*, *G*) are the laws, and they explain both the truth of the generalisations in law-statements, such as 'All *F*s are *G*s', and instances of lawful behaviour, such as *x*'s being *F* causing its being *G*.

The DTA account was originally intended to account for natural necessity, assumed by its champions to be metaphysically contingent. But it is more general than that: the restriction to natural necessity, and the concomitant one to sparse properties, may be lifted, so as to explain different objective sorts of necessity as deriving from different relations of necessitation. For example, *metaphysical laws* (e.g. Glazier, 2016; Schaffer, 2017; Wilsch, 2015) could, in principle, be understood from the postulate of a relation of metaphysical necessitation (Tugby, 2022). In what follows, I will assume that the DTA account can be understood as a general metaphysics of modality.

There are other ways to flesh out the relationalist scheme. We have (Jubien 2009, ch. 4) account, on which abundant properties stand in an internal relation of *entailment*, or Wang (2013) incompatibility primitivism, on which modality is explained by a polyadic relation of *incompatibility*. Many dispositional essentialist views of natural laws are also instances of the relationalist scheme. Many dispositional essentialists believe that natural properties are essentially modally related between them (e.g. Bird 2007; Ellis 2001; Jacobs 2010; for discussion, see Barker 2013; Jaag 2014). For example, Coulomb's law holds with necessity because the charge properties are dispositions: they are so constituted that for something to be charged is for it to be *disposed to* attract opposite charges and repel charges of the same sign, with a force directly proportional to the product of the charges and inversely proportional to the distance squared between them (ignoring the proportionality constant for the sake of the example). Because the modal relation is part of the properties' essence, the laws that they ground are metaphysically, not 'merely' naturally, necessary.

Not all dispositional essentialists are relationalists: some are primitivists. For example, those that postulate a primitive notion of 'pointing beyond itself' or Molnar (2003) 'physical intentionality' (and others have argued that this idea is worryingly utterly obscure Tugby, 2013). Another primitivist view associated with dispositional essentialism is the view of Anjum and Mumford (2011, 2018), for whom there is a primitive modality: *dispositional modality*, which 'sits between' contingency and necessity. I don't classify this view as relationalist: its fundamental posit is a *mode*,—the mode of tendency—not a modal relation.

[1] As most relationalists do not aim to account for logical modality, I will correspondingly ignore it here.

Some other views in the vicinity of dispositional essentialism don't seem to be obviously relationalist nor obviously primitivist. Some views are officially defined by means of certain syntactical operators, and there is a legitimate question as to whether or not they should be counted as cases of relationalism.[2] Examples of this could be the approaches of Vetter (2015), Bird (2007) and Yates (2013). I have reserved a detailed discussion of these views for the appendix; but, in short, and as far as I can see, it is not unfair to read Vetter as having a relationalist framework in mind, I would count Bird's theory as a case of relationalism, and the same for one of Yates' theories, but not the other.

There are many other cases of the relationalist idea (see for some references Barker, 2013; Jacobs, 2010; Kimpton-Nye, 2021). I hope that the examples above have elicited the intuition that there is a common pattern here—to be made explicit in the following section.

2 The relationalist scheme exactified

At the foundations of the relationalist scheme we find the *modal relations*, like *entailment* or *necessitation*, *stimulus–response* or *manifestation*, and *incompatibility*: each is supposed to explain why, when it relates properties, the resulting state obtains in a certain mode. Entailment and necessitation are supposed to directly account for necessity; incompatibility is supposed to account for impossibility; manifestation is supposed to account for counterfactuality. Other examples are Jubien's (p. 94 Jubien 2009) *compatibility*; or the ones noted by (p. 233 Jacobs 2010), including *probabilifies to degree x*, which would account for chance. I will use '$\mathcal{M}$' schematically for the modal relation that each relationalist theory postulates.

Some instances of relationalism are explicitly committed to a conception of properties: perhaps that they are (Aristotelian or Platonic) universals, or tropes, or that they are sparse (e.g. Armstrong, 1983; Tugby, 2013). But the relationalist scheme itself is not so committed. The only commitment is to the *reality* of properties: it is only required that they exist so that they can be related by a modal relation.

Most relationalists are modal primitivists.[3] To understand this, let us take the *real definition* of *A* to be the definition saying what *A* essentially is. Following Fine (1995) and others, I say that *A depends on B* if *B* appears in *A*'s real definition. I say that *A wholly depends on* $B, C, \ldots$ if the real definition of *A* is *exhaustively* given in terms of $B, C, \ldots$, where the real definition of anything *X* is exhaustive if it completely defines *X*: if it leaves no aspect of *X* undefined. Then, I think of *the fundamental* as that which does not wholly depend on something else: the fundamental does not have an exhaustive real definition: some aspect of it is primitive, i.e. really undefined. *The derivative* is what is not fundamental. For an example, consider the set {Socrates}. It has an exhaustive definition: it is the set (in some assumed ambient

[2] Thanks to a couple of referees for suggesting this discussion.

[3] An exception is Tugby's grounding theory of powers (see esp. pp. 11198–11201 Tugby 2021).

theory, say, ZF) the sole member of which is Socrates. Having an exhaustive definition, it's not fundamental but derivative, and it depends on Socrates.

Modal primitivism, then, is the thesis that some modal aspect of reality is fundamental. This 'modal aspect', in turn, might be a *difference in reality*—as in the *ideological* primitivisms examined by Sider (2011) and others—and/or a kind of entity—thus, an *ontological* primitivism.[4] Let's see.

An ideologically primitivist relationalism would take a modal difference as a fundamental aspect of reality and use it to (partly) define its relation: $\mathcal{M}$ 'embodies' the modality into worldly states. For example, understood this way, part of what defines *incompatibility* is that, if it relates two properties, then it is impossible for the same thing to instantiate both, or: part of what defines *entailment* is that, if it relates F to G, then necessarily whatever is F is also G.

An ontologically primitivist relationalism would assume $\mathcal{M}$ as a fundamental entity.[5] Such a theory may be combined with either a further ideological primitivism or with the rejection of ideological primitivism.

Conjoining ontological with ideological primitivism, $\mathcal{M}$ is partly defined by the fundamental modality, while remaining a fundamental entity because it is not exhaustively definable.

Combined with the rejection of ideological primitivism, the ontologically primitivist relationalism would not define $\mathcal{M}$ with an assumed primitive modality. But the link to modality has to come from somewhere. So, perhaps the thought would be that modal facts *just are* $\mathcal{M}$-states. $\mathcal{M}$ is not defined by a primitive modality: it is a basic, primitive entity, and modality enters the picture when $\mathcal{M}$ is instantiated. There would be an asymmetric explanatory arrow: modal facts simply *consist in* $\mathcal{M}$ -states.[6]

I don't think that relationalists are always sufficiently explicit so as to let us know which of the above options they mean. But my arguments, as we'll see, work either way.

Primitivist views need not take every modal fact as fundamental. Indeed, as I understand relationalism, it aims to explain modal facts with the introduction of the modal relation. Some relationalists differentiate between *basic* and *derivative* states (e.g. Wang, 2013), where the basic states explain the modality of the derivative

[4] There are also conceptual varieties of modal primitivism: some modal concepts are conceptually primitive. I am not engaging with them in this paper. Thanks to a referee for suggesting that I clarify matters here.

[5] I suppose a relationalist may coherently reject both ontological and ideological primitivism, by claiming that $\mathcal{M}$ is not fundamental, but that modality goes 'just as deep as $\mathcal{M}$ goes', so to speak. I will not further explore this option—my arguments apply all the same. However, see footnote 10, below, for a minor caveat.

[6] In the latter case, though, Lewis' objection to the DTA account (p. 366 (Lewis, 1983)) would be more appealing: the objection being that the relation's connection to modality cannot simply result from its name. Relationalists may respond that their relation need only be specified by what it *does*: by its theoretical role (Schaffer, 2016). In this dialectic, ideological primitivism seems to fare better: the connection to modality is simply that $\mathcal{M}$ is *defined* by modality. However, it's been argued (Romero, xxx) that essence cannot explain modality if essence is defined by modality, and I'd think an analogous objection could be posed to this sort of relationalism.

ones: the basic states are constituted by a modal relation; the derivative states may not be so constituted, but their modal status is explained by being related in some specified way to the basic states. Another project would use relationalist facts to provide truth-conditions for modalised language.

Now, $\mathcal{M}$ may be taken to essentially constitute properties, as in some powers ontologies,[7] or it may be external to them, as in the DTA account and other quidditistic metaphysics. Also, note that some relationalists aim to account only for *de dicto* modality (as Wang, 2013), while others extend their account to *de re* modality (Jubien, 2009), or even begin there (Jacobs, 2010; Vetter, 2015). I will ignore these distinctions. If my arguments are sound, they call into question the relationalist explanatory scheme itself, whether applied to every modal state or only to the basic ones, whether the relation is assumed to be internal or external to the properties, and whether applied to only *de re* modality, or only *de dicto* modality, or both.

Having explained which differences in relationalist theories are not relevant for our discussion, this is what I take to be the core relationalist thought, and what I will object to:

The Relationalist Scheme The modality of any state s is explained by:

1. s's either having properties (and/or relations) $P, Q, \ldots$, among its components, or being properly related to another state that does, such that:
2. There is a higher-order, relation between $P, Q, \ldots$, namely $\mathcal{M}$, where
3. We individuate $\mathcal{M}$ by its theoretical role: by how it relates properties and entails modal consequences by so doing.[8]

In this paper, I will argue that relationalism is confronted by four difficulties:

1. The selection between modal relations is arbitrary. So, they do not seem to be fundamental.
2. $\mathcal{M}$ cannot belong to any logical order. So, it could not be a relation.
3. To explain how $\mathcal{M}$ modally connects relations of different adicity, we require additional primitive modal ideology. So, relationalism is less ideologically simple than was previously thought, and $\mathcal{M}$ may even be redundant.
4. There are some unary constraints the modality of which cannot be explained by relationalist states.

[7] There are several views on the relation between properties and powers: one is that properties *are* powers, so that the relation is identity (Heil, 2003); another is that properties have their powers intrinsically related to them, perhaps by essential constitution (Bird, 2007; Yates, 2013); yet another is that properties ground their powers (Tugby, 2021).

[8] Relationalism so understood, its opposing views would reject either of 1, 2 or 3, above. But I take it that the main opposites of relationalism would claim that the modal status of a state is not explained by a relation: it is either not explained by anything else, or it is explained by something which is not a relation.

3 Arbitrariness

Jubien (2009), who grounds necessity in his primitive relation of entailment, grounds possibility in a relation of compatibility. He notes that compatibility and entailment are *dual*—'for example, for two properties to be compatible is for neither to entail the negation of the other' (p. 94)—and, so, that they are interanalysable. Relatedly, (p. 544, footnote 14 Wang 2013) notes that 'We could equally well take the primitive notion to be *compatibility*, but one primitive can do the work of two'.[9] Compatibility is the contradictory of her favoured primitive, incompatibility. The same can be said for every modal relation: given $\mathcal{M}$, there will be dual (schematically, $\neg\mathcal{M}\neg$), contradictory ($\neg\mathcal{M}$), and contrary ($\mathcal{M}\neg$) relations. If $\mathcal{M}$ explains the modality of a state, its dual does, too—as do its contradictory and its contrary.

This betrays a certain form of *overdetermination* in relationalism.

Clearly, given *any* member of the $\mathcal{M}$-family—$\mathcal{M}$ itself, or its dual, or its contradictory, or its contrary—all the others can be defined through negation. And there is no evident metaphysical asymmetry between them. It may be thought that, as the notation implies, $\neg\mathcal{M}$ is the contradictory of $\mathcal{M}$, which would make $\neg\mathcal{M}$ derivative. Nevertheless, the way we refer to those relations through notation and natural language is metaphysically irrelevant: for all we know, the metaphysical situation is not how we say and write it—we just happen to use our language and symbols in a non-metaphysically perspicuous way. Perhaps *incompatibility* is the basic relation and *compatibility* its contradictory; perhaps *necessitation* derives from *compatibility*, etc.

But then, choosing among $\mathcal{M}$, its dual, its contradictory, and its contrary, involves *arbitrariness*, because the theoretical roles that each plays exactly mirrors the others': if any member of the family does the explanatory job, so do the others. They are, in this sense, *metaphysically equivalent*. However, relationalism assumes that either the modality that constitutes $\mathcal{M}$, $\mathcal{M}$ itself, or both, are primitive. But the fundamental should not be arbitrary—that is part of what constitutes fundamentality, one would have thought.[10]

Consider a possible reply. Though it may be that all modal facts can be explained by $\mathcal{M}$ and by, say, $\neg\mathcal{M}\neg$, *all things considered*, the $\mathcal{M}$-theory may turn out to be more economical, systematic, unified, coherent with one's metaphysical views of

[9] Wang speaks here of primitive 'notions', which could perhaps suggest that her theory works at some conceptual level. That impression would be erroneous; her theory is an ontological theory about the modality of non-notional facts, see Sect. 5 of her paper, for example. Thanks to a referee for pointing out the need of this clarification.

[10] As I said in footnote 5, above, I suppose a relationalist may reject both ideological and ontological primitivism, claiming that $\mathcal{M}$ is a derivative entity, and that modality derives from $\mathcal{M}$-states. For such views, this objection loses some of its bite—but not all. The charge of arbitrariness in the selection of ontology and/or ideology is particularly pressing when applied to the fundamental, but it is also a problem even if the ontology and/or ideology in question is not fundamental. In general, arbitrariness is a defect of a theory.

other phenomena, etc. than the $\neg\mathcal{M}\neg$-theory, and this could justify the choice of $\mathcal{M}$ as basic.[11]

To this, I respond: *But how could that be?* By assumption, they are metaphysically equivalent: whatever one does, so does the other. So, whatever difference there is in their corresponding theories, it could not be a *metaphysical* difference: if it were metaphysical, there would be some metaphysical job that $\mathcal{M}$, but not (e.g.) $\neg\mathcal{M}\neg$, fulfils. That could not be because, for all we know, the metaphysics is such that $\neg\mathcal{M}\neg$ is the basic relation and $\mathcal{M}$ is the derivative one. So, for every job that $\mathcal{M}$ does, there is an equivalent one done by $\neg\mathcal{M}\neg$, such that considerations of fundamentality are 'screened-off' by the fact that we can't claim to know *which one* in the family is the fundamental one. So, whatever difference there is in their corresponding theories must be notational, epistemic, conceptual, or some such. And I fail to see why a conceptual, notational or epistemic difference between the $\mathcal{M}$- and $\neg\mathcal{M}\neg$-theories should entail a *metaphysical inequivalence* between $\mathcal{M}$ and $\neg\mathcal{M}\neg$ themselves.

Another reply could be that we can take *every* member of the family as metaphysically primitive. But that is redundant: given any one, the others are a free lunch (at least to the extent that logical operations are freely given). The fundamental should not be redundant.

A charge of economy can also be levelled here: one of the relations does the work and so, having also the others offends against Ockham's razor. The relationalists could reply that ideological economy should be evaluated by the number of kinds, and that they postulate a single kind of modal relations, having $\mathcal{M}$ and its dual, contradictory and contrary, as its species. However, *this* proposal is not relationalism anymore, as it is based on a *kind*, not on a *relation*.

Another conceivable alternative is to claim that one of the family is the one that exists and is fundamental; it is just indeterminate *which*. However, under an influential view (Sider, 2011), the fundamental is never indeterminate (see for discussion Torza, 2020),[12] Regardless, we would like a modal ontology that does not *require* ontic indeterminacy, if we can have one.

A final reply could be that one of them is fundamental, but not all, and that we do not know which is the case: there would be a definite fundamental fact of the matter, but we would not know which one it is. The indeterminacy would only be epistemic.[13]

Such a situation is not alien to us. Other theories (like haecceitism and quidditism, perhaps: see Black, 2000; Schaffer, 2005) also entail an insurmountable barrier of ignorance. But, though familiar, such ignorance-entailing metaphysics are not attractive: if we can do without the consequent ignorance, we should. Further, and

[11] I am very thankful to a referee for this reply.

[12] Admittedly, not every aspect of Sider's view fits comfortably with relationalism, as he takes the fundamental to be a-modal. However, in discussing relationalism, we are assuming that modal primitivism is well-motivated; further, it is unclear whether Sider's rejection of fundamental modality fits coherently with (1) his own meta-metaphysics (Torza, 2017) and (2) fundamental physics, which *is* modal (e.g. Hofer-Szabò et al., 2020).

[13] I thank a referee for this reply.

perhaps even more gravely, this reply courts with ad hocery. It involves postulating a profound sort of ignorance about a sort of facts, involving the basic postulate of the theory, that could be used to argue *against* the theory. To be worth this price, the credentials of relationalism should be correspondingly impressive.

Of course, this problem of arbitrariness is analogous to the problem of inter-definability for those views that take quantifiers (e.g. Sider, 2011) or modal operators to be fundamental ideology. This is unsurprising: quantifiers and modalities behave isomorphically with respect to negation (that is what allows both families of operators to be arranged in squares of opposition, and what underlies possible worlds semantics). The inter-definability of a family of operators or of relations entails the problem of choosing one among them to be the metaphysically fundamental one. But this type of problem is not limited to Siderian views—it could be extended to views which do not mention fundamentality at all. All that is needed is that constraints of simplicity and of non-arbitrariness are in place. If they are, and if the posits of the theory exhibit the kind of symmetry under negation (or a similar transformation) that is exhibited in squares of opposition, essentially the same problem will arise.

4 Extra-order

Some properties of different orders are modally related. We will take incompatibility primitivism as our sample theory, but the lesson carries over to every relationalism.

Consider *being an animal* and *being a biological property*. Being an animal is incompatible with being a property of any kind:

$$\text{Nothing could be both an animal and a property.} \tag{1}$$

Relationalists may try to account for this impossibility using their incompatibility relation, γ[14]:

$$\gamma(A, P) \tag{2}$$

At this point, it may be objected that many relationalist views are only intended to account for 'natural' modality, which is assumed to be less encompassing than 'metaphysical' modality. This, it may be thought, is why relationalism need not account for impossibilities like (1).

However, first, many relationalisms *do* aim to account for various metaphysical necessities—for example, dispositional essentialist views. Second, as mentioned before, the DTA account—perhaps the most important relationalism that was originally restricted to natural modality—can smoothly be extended to metaphysical modality (Tugby, 2022). But more important is that it is difficult to see why the impossibility of any animal being a biological property is not an impossibility *of*

[14] Here, I'm oversimplifying Wang's account, as she uses properties under variable listings. This detail is not relevant for this section.

Nature. Such an impossibility is a presupposition of all biological laws or mechanism descriptions. A metaphysics of the modality in Nature should explain those basic constraints.

Now, note that *being an animal* belongs to the first order, applying exclusively to individuals, while *being a biological property* belongs to the second order, applying exclusively to first-order properties. I call '*inter-order*' a relation that (purportedly) relates relations of different orders (let us include properties as relations of adicity 1). So, relationalists who accept views like (1), think that $\mathcal{M}$ is an inter-order relation.[15]

But could $\mathcal{M}$ be an inter-order relation? I will now argue that if it is, then it must also be an *extra*-order relation: a relation that cannot belong to any particular order.

Logical orders are indexed by the ordinals; we will use '${}^{i}R$' for properties and relations of order i. We want to know whether a relation can relate things from different orders. This question decomposes into these questions: Can it be that...

1. ...${}^{n}R({}^{m}R, {}^{k}R)$, for $m \neq k$ and $m < n$ and $k < n$?
2. ...${}^{n}R({}^{m}R, {}^{k}R)$, for $m \neq k$ and $m > n$ and $k > n$?
3. ...${}^{n}R({}^{m}R, {}^{k}R)$, for $m < n$ and $k > n$?
4. ...${}^{n}R({}^{m}R, {}^{k}R)$, for $m > n$ and $k = n$?
5. ...${}^{n}R({}^{m}R, {}^{k}R)$, for $m < n$ and $k = n$?

(For simplicity, I have considered only binary relations, without care for the ordering of the arguments.)

Questions 2, 3, 4 and 5 are easily answered in the negative: a relation could not relate relations from its own order or above it, because that is how orders are defined: a relation of order n only relates things of order $n - 1$; or, at the very least, of orders less than n.[16]

Only 1 could be answered positively. However, $\mathcal{M}$ has to relate relations of *any* order, because relations of any order can be incompatible with one another, or entail one another, etc. Consider, for example, any first-order property—say, *being an electron*—and any non-first-order property. Surely it *cannot* happen to a electron that it has any non-first-order property, because every non-first-order property is a property of *another* property, and therefore unfit to be a feature of an electron. (To remove a possible scope ambiguity, my claim here is, with X a non-first-order property: $\neg\Diamond\exists x(Ex \wedge Xx)$, not: $\neg\exists x(Ex \wedge \Diamond Xx)$, nor: $\neg\Diamond\exists x(Ex \wedge \Diamond Xx)$.)

However, assume that $\mathcal{M}$ were an nth-order property. *Being an electron* and every $n+1$th-order property are incompatible:

[15] A referee suggested that $\mathcal{M}$ need not obtain between properties of different orders, as relationalism can rule out properties of different orders applying to the same thing 'by fiat'. However, even assuming that philosophers can decree metaphysical reality to be as they see suit, this would entail abandoning the explanatory aims of relationalism, as the modal relatedness of those properties would not be explained by $\mathcal{M}$.

[16] Some believe that predications like 2–5 are ill-formed, while some believe that they are merely false (*cf* Linnebo & Rayo, 2012); either option comports with my diagnostic here.

$$\gamma(E, X) \tag{3}$$

with X a $n+1$th-order property. But this requires γ to relate things above its own order. We conclude that $\mathcal{M}$ should not belong to any particular order.

I am inclined to think that relations that do not belong to any order are not even conceptually possible. But some relationalists may want to claim that they are. If so, they must provide a theory of extra-order relations; as of today, such a theory is non-existent.

It could be speculated that $\mathcal{M}$ belongs to an order indexed by an infinite ordinal. Even if infinite orders make logical sense (for discussion, Linnebo & Rayo, 2012), the suggestion would be incorrect. *Every* logical order is defined by some constraints: a constraint on an order indexed by a successor ordinal o is that it must contain properties of relations of order $o-1$; a constraint on an order indexed by a limit ordinal l is that it must contain properties of relations of every order $o < l$. Relationalists analyse constraints, as every other modal fact, with relational states involving properties. Then, the constraints on the logical orders would relate the orders' properties. But like all properties, the orders' properties have to belong to a certain order. For *any* order o, its properties should belong to an order $p > o$. Therefore, the relation tying such properties, $\mathcal{M}$, has to belong to an order *above* p. But for any such order, there will again be constraints on it, and the argument applies again. $\mathcal{M}$ could not belong to any order, finite or infinite.

It may be argued that, for every order o, we have an ${}^{o}\mathcal{M}$ for that order, that can relate properties of orders $p < o$ (*cf.* p. 265 Dretske 1977): 'the modality at level n is generated by the set of relationships existing between the entities at level $n+1$').

Under this proposal, it's not that *being an animal* and *being a biological property* are incompatible *tout court*, but ^{n}incompatible, for some order n. Given that one of the properties is first-order and that the other is second-order, it is reasonable to think that their incompatibility relation is third-order, giving us that *being an animal* is ^{3}incompatible with *being a biological property*. In general, given any plurality of relations, $P, Q, \ldots$, their modal connections would be given by ${}^{o}\mathcal{M}$, of an order o immediately succeeding the maximum of the orders of $P, Q, \ldots$

Apart from inelegantly requiring the proliferation of modal relations, this invites the question of how modality, as traditionally understood, and modality *at an order*, as understood under this proposal, are related. Consider necessity. According to the relationalist view that we are considering, we have claims like:

$${}^{3}\Box(p),\ {}^{10}\Box(r),\ \ldots$$

each explained by a state like:

$${}^{3}N(F, G),\ {}^{10}N(X, Y),\ \ldots$$

The question is what does all of this have to do with claims like:

$$\Box(p),\ \Box(r),\ \ldots$$

If the relationalists deny any connection between modality *at an order* and modality *tout court*—perhaps claiming that there was not any modality *tout court* at all, to begin with —, then it is difficult to believe that they are not simply changing the topic. And, given that it would be arbitrary to identify modality with (say) ^{2573} modality, there remain two conceivable options: either the modalities at an order are somehow explained by modality *tout court* or the other way around. Given that we are considering relationalism, which has as one of its aims to *explain modality*, we will only consider the latter option.

So, the thought here is that modality *tout court* is somehow explained by the modalities at an order. But how? Perhaps:

$$\Box(p) \text{ is explained by } \exists n : {}^{n}\Box(p) \tag{4}$$

This surely requires principles of 'order harmony', like:

$$\text{If } {}^{n}\Box(p) \text{ for some } n, \text{ then } {}^{m}\Box(p) \text{ for all } m > n \tag{5}$$

Because, without (5), (4) would be compatible with:

$${}^{n}\Box(p) \wedge \neg {}^{m}\Box(p)$$

And in that case, there would be a question whether p is, or is not, necessary *tout court*.

I remain sceptical that the notion of *modality at an order* makes sense. At the very least, too many details remain to be understood, and it needs motivations beyond the defence of relationalism. But if the notion does make sense, it must be so in the context of a theory of modal relations at an order. So, those relationalists that aim to avoid the postulation of an extra-order relation, at the very least, have a non-trivial explanatory burden here.

One may try to evade these problems by questioning the presuppositions: that there *are* logical orders, and that there are modal relationships between them.[17]

The first escape route is *first-orderism*, which eschews higher-order metaphysics as a whole (gives an overview Skiba, 2021a). The thought is that higher-order quantification is somehow logically illegitimate, with the implication that there are no logical orders beyond the first one—and so, there is nothing but logical individuals. There could still be properties: tropes or universals, but they are also logical individuals, i.e. the first-order quantifiers also range over them, and so predicates do not refer to them. In this setting, the question whether $\mathcal{M}$ could be an extra-order relation simply does not arise.

However, this view is very unstable. As (pp. 812-3 Jones 2018) has argued, 'first-order realists need second-order quantification to capture their view's intended content'. Jones notes that, on realism, 'the existence of properties is supposed to be an objective matter that may outrun our linguistic and epistemic capacities', and so, it is not enough to accept only the instances of the first-order realists' core thesis,

Exist1 Necessarily, for any things that are Φ, there is some y that they instantiate such that, necessarily, any things that instantiate y are Φ,

[17] I am indebted to a referee for suggesting that I discuss these possible responses.

which is phrased in some particular language. Rather, Jones argues, the intended content should be that of the generalisation of **Exist1**—that is, with a higher-order quantifier over every condition Φ. If so, first-order realists ‘cannot consistently deny the intelligibility of the alternative second-order position’.

If Jones is right,—and I find it difficult to escape his argument—then one cannot consistently uphold first-order realism and the illegitimacy of second-order quantification, unless one introduces further additional premises—thus my claim of the instability of this sort of view. But with second-order quantification in place, one is led again to higher-order properties, and then to their modal relations with lower-order ones, and then the extra-order problem rears its ugly head.

Couldn’t one be a realist about first-order properties and a nominalist about the predicates and variables of higher-order logic? I suppose one could.[18] However, this leads again to an unstable view. Because first-order realists take their properties to be in the range of the first order quantifiers, we need a way to express how the objects relate between them and have their properties. The most common way to do so (p. 810 Jones, 2018, p. 3 Skiba, 2021a) is to introduce the variably polyadic predicate of *instantiation*, as we saw in **Exist1**. Different sorts of realism will interpret the instantiation predicate differently: ‘has’, ‘exemplifies’, ‘falls under’, ‘is a member of’, ‘is a member of the actual extension of’, ‘is a way that _ is’, are some of the examples Jones (note 5) provides. Once one has endorsed realism, it is very difficult not to think of each of those ideologies as referring to a specific relation: a relation between a thing and its property (or things and their relation). And this relation would seem to be not a first-order object, as indicated by the syntax. Other examples are the resemblance relation between tropes of Skiba (2021b) hybrid realism, or even $\mathcal{M}$ itself, given that it purportedly relates properties.

One may reject instantiation (perhaps against the background of Bradleyan worries). However, relationalism still requires that properties and relations be related by $\mathcal{M}$, and the canonical ways to express so require predicates. So, one may try to devise a syntactic framework to express relations between properties in a first-order language without any instantiation predicate, and indeed without any predicates at all. The only way I can think of doing so is using a two-sorted language, so that terms (variables and constants) are each subdivided into two sets: terms$_P$ is a subset of terms$_I$. Then, the syntactic constraints make it so that a string is a well-formed formula only if it has a form like:

$$\pi(\iota_1, \ldots, \iota_n),$$

such that π is a term$_P$ and the ι_i are terms$_I$. (We assume that each of the sets of constants and variables in the set of terms$_P$ are partitioned according to an assignment of a cardinal—adicity.) Terms$_P$ can now behave syntactically like predicates of ordinary first-order logic.[19] To incorporate what we formerly thought of as higher-order

[18] Skiba (2021b) proposes first-order tropes *and* second-order universals, so mixed views are not completely new.

[19] (p. 823 Jones 2018) considers using a many-sorted language to rule out predications of locative language to properties in a first-orderist setting, but this is different.

terms—$\mathcal{M}$ and their ilk—we only take them as further terms$_P$. Of course, lest we nonchalantly create a notational variant of the syntax of higher-order logic, we let any terms$_P$ combine with any terms$_I$ (as long as adicity constraints are satisfied). And so, what ordinary higher-order logic rules out as non-well-formed—predicating nth-order predicates to mth-order terms, where $m < n - 1$—here we accept as truth-evaluable: such (pseudo-)predications are only *false*, not *nonsensical*.

But why are they false?

I think it is because we still need a *hierarchy*: even if *being red* is a first-order entity (a trope, a universal, a set, or some such), it is a colour, so that *being a colour* should be classified distinctly. That is: we need sets of sets, properties of properties, tropes of tropes, and so on. They may be first-order entities, but they still organise into a hierarchy. (Hierarchies like this exist for different first-order objects. For example, in set theory, the levels in question are defined in the cumulative hierarchy in terms of the notion of *rank*: (p. 64 Jech, 2003).) That is why, for example, $\mathcal{M}$ cannot relate Obama and Biden, even if the three entities are first-order: $\mathcal{M}$, Obama, and Biden belong to different levels in this hierarchy, and $\mathcal{M}$ can only relate things in a level higher up than the level of Obama and Biden. This classification better explains why $\mathcal{M}$ does not *simply happen to not relate* Obama and Biden: there is a constraint to the effect that it *couldn't* relate them.

But then, as long as this hierarchy is organised into *levels* such that (i) these levels form a total order, (ii) every property or relation belongs to at least one of the levels, and (iii) properties or relations of properties and relations of level n belong to a level $m > n$, we again have the same form of problem: $\mathcal{M}$ again seems to be required to belong to no specific level.

I have argued that first-orderism is an inhospitable setting for relationalism: the constraints it imposes make it an unstable foundation on which to develop the very basics of relationalism. If there's another way to do this, it requires a theory much more developed than what we have seen at this point.

Here's another way in which relationalists may try to evade the extra-order problem: *order-dissonant* sentences like

$$\text{Nothing could be both an animal and a property} \tag{1}$$

are not even meaningful. Explicitly put, the view would be this:

Noncumulativism Sentences of the form of '$R(a_1, \ldots, a_n)$' are well formed only if the type of each 'a_i' is j and the type of 'R' is $j + 1$.

One way to be a noncumulativist is to follow Frege's (1891) semantic insights, as developed by Trueman (2020) and by Button and Trueman (2022); there may be other ways. If Fregeanism or any other form of noncumulativism is true, (1) does not make sense and there is no need for extra-order modal relations.

Indeed, (Sect. 9 Trueman 2020) considers a sentence neighbouring (1):

$$\text{No property is an object} \tag{6}$$

and notes that 'Frege himself asserted (6) all the time' (p. 114). However, under the Fregean implementation of noncumulativism, the literal reading (6) is not false, but *nonsense*. In the end, Trueman argues, the *official*, *philosophically strict* thought that we (and Frege) mean to express with sentences like (6) has more to do with the impossibility of building a Fregean thought by combining the senses of phrases in the form of '( ) is an object' with senses of phrases in the form of '( ) is a property' and the sense of the existential quantifier. (For the exact definition of this view, and Trueman's case for it, see Trueman, 2020).

So, a relationalism set in the environment of Fregean noncumulativism rejects the notion that there is modality *tout court*: there are only modal relations at an order, governing the states of the preceding type (i.e., logical order). Above, I expressed doubts about this claim. But noncumulativism is controversial in further ways.

Linnebo and Rayo (2012) argue against noncumulativism and motivate *cumulative type theory*, which counts as well-formed formulas like ${}^{\beta}x({}^{\alpha}y)$ iff $\beta > \alpha$. One argument takes from Gödel's (1933) argument that noncumulativism imposes unnecessarily strong requirements. They also develop an argument against noncumulativism from the theses of *absolute generality*,—that first-order quantifiers can range over absolutely everything—of *semantic optimism*,—that every language can be given a theory of all its possible interpretations—and the thesis that variables of limit type can apply to variables of the preceding successor types. (For discussion of this argument, see Sect. 6 Button & Trueman, 2022).

Apart from Linnebo and Rayo's Gödelian discussion, noncumulativism entails an error theory about large swaths of seemingly innocent predications.

Note that it is not difficult to produce an indefinitely long list of order-dissonant predications. Consider an object and one of its properties, P. P instantiates the second-order property *being a first-order property*, call it 'F'. Consider its complement: *not being a first-order property*, '$\neg F$'.[20] Surely, $\neg F$ is had by everything which is not first-order: objects and higher-order properties. But what order is $\neg F$? One would think that complementary properties belong to the same order, so that $\neg F$ is second-order; but if so, $\neg F$ gives rise to an indefinite number of seemingly meaningful order-dissonant predications: 'Biden is $\neg F$', '2 is $\neg F$', and so on. Noncumulativism entails that all of these seemingly natural predications, literally interpreted, are meaningless.

Indeed, Fregeanism could be seen as a kind of *reference magnetism* directly opposing the philosophy behind the most popular brand of reference magnetism: the one advocated by the Lewisians. According to Lewisian reference magnetism, the fundamental properties and other parts of metaphysical structure are *reference magnets* in the sense that, as a matter of an external constraint on the reference of our language, joint-carving structure is by default selected over less joint-carving structure in semantic interpretation (see Sect. 3 Lewis, 1984; Sider, 2011). According to Fregeanism, the type structure is a reference magnet: as a matter of an external constraint on the reference of our language, logical orders are by default selected such that the senses of the predicates never incur in order dissonance. And as with

[20] I am indebted to a referee for discussion of this case.

Lewisian reference magnetism, *Fregean* reference magnetism is not imposed by our use of language, but by metaphysics: it is an external constraint on interpretation.[21] Our language automatically 'scouts for' metaphysical structure and latches onto the appropriate type. In some cases—at least with order-dissonant predications—the scouting does not find the correct structure, and then what we thought were the literal meanings of our language are not so: the real meaning turns out to be Trueman's sophisticated thoughts about the impossibility of building other thoughts.

The metasemantic constraint of Lewisian reference magnetism opposes the skeptical and error-theoretical consequences of denying that there are external constraints. However, Fregeanism entails an error theory about large swaths of seemingly natural predications. Far from helping to explain how we are successful at our referential endeavours, Fregean constraints *promote* skepticism about the literal interpretation of our language.

There is a much simpler route, and that is to accept that sentences like (1) and Trueman's (6) are meaningful. Even more, (1) and (6) are counted as *obviously and literally* true: it is obviously and literally true that no animal could simultaneously be a biological property, and it is obviously and literally true that no property is an object, nor could it simultaneously be an object. Because they are true, they cannot be ill-formed.[22]

So, as they say, one person's modus ponens is another person's modus tollens: I take sentences like (1) and (6) as counterexamples to any view which entails that order-dissonant predications are meaningless, as I think it is *obviously and literally true* that nothing could be an animal and a property, and that nothing could be a thing and a property. And I know that I may be accused of begging the question—*It cannot be true if it cannot be assigned a sense!* But this reply seems to me to be putting the theory first and the data second—the datum is that the sentences are true, and our theories should aim to account for it. I am aware, however, that this sort of dispute is hardly ever settled with this kind of argument: one side offers a datum, the other claims that it's not a datum but an assumption that their theory is wrong. Sadly, to adjudicate between these views and move the discussion forward, we would need a deeper examination of their relative theoretical virtues. Such a task, as I hope it is evident, cannot be carried out here.

I am content enough if we accept the following conclusion. There remain two clear ways for relationalists to defend their view. Given the difficulties with first-orderism, they need a plausible theory of extra-order relations. Or they may refuse to accept order-dissonant predications, accepting the particularly strong constraints of *noncumulativism* and having to explain away our semantic intuitions. None of these tasks seem trivial, and so I hope to have advanced the discussion here by noting how much work remains to be done in this aspect.

[21] It may flow from the Fregean assumption of a 'mirroring principle', see (Textor, 2010; Valdivia, 1984, 2015).

[22] See (Magidor, 2009) for a related discussion.

5 More primitive modality

Relationalism assumes primitive modality in its modal relation $\mathcal{M}$. The fundamental hypothesis of relationalism is that using this modality we can explain all modal facts of Nature. In this section, I argue that this fundamental hypothesis is false: relationalism needs to assume previously unnoticed modal ideology, such that there are some modal facts that are neither those pertaining to $\mathcal{M}$'s essence, nor can be explained by $\mathcal{M}$.

If I am correct that relationalism needs further primitive modal ideology, how grave is that? In part, it depends on what view is relationalism contrasted with. If it is contrasted with a reductivist or anti-realist view which requires *no* primitive modality, relationalism was already worse off in that respect. But if we contrast relationalism with other contenders, it is important to know which view is ideologically simpler. However, I'm tempted to think that the problem is even graver. For if we already accept the previously unnoticed primitive modal ideology that, I'll argue, is required by relationalism, one may argue that no further modal ideology is needed—in particular, that $\mathcal{M}$ is not needed. We'll see more about this below.

That $\mathcal{M}$ is a relation means, platitudinously, that it is part of its nature to relate. And as we saw, some relationalists used to represent this relational aspect by formulas like this: '$E(P, Q)$', which are to be interpreted as representing the fact that P entails (necessitates) Q. So, the relational nature of $\mathcal{M}$ is, in this framework, easily understood: $\mathcal{M}$ is a higher-order relation that relates lower-order properties and relations, and that's all.

Unfortunately, though, that's not all. To explain how $\mathcal{M}$ establishes modal connections between properties it will not do to merely display sentences like '$E(P, Q)$' and claim that they represent (for example) that P *entails* Q. This is because the $\mathcal{M}$-relations relate not only monadic properties, but also polyadic relations. Let's see.

Relationalists introduce their relations by the modal connections they are supposed to underpin: E is supposed to underpin necessary connections, γ is supposed to underpin incompatibilities, and so on. This means that, minimally, $\mathcal{M}$-facts should imply the corresponding modal facts. For example, as (p. 185 Turner 2010) noted for Jubien's theory, 'the most natural gloss of entailment' should entail:

$$\text{if } E(R, S) \text{ then: } \Box \forall x_1, \dots x_n \left[R(x_1, \dots x_n) \rightarrow S(x_1, \dots x_n) \right] \tag{7}$$

Analogously, incompatibility primitivism (for example) should entail:

$$\text{if } \gamma(R, S) \text{ then: } \neg \Diamond \exists x_1, \dots x_n \left[R(x_1, \dots x_n) \wedge S(x_1, \dots x_n) \right] \tag{8}$$

However, as Turner (p. 185) notes, (7)—and (8) and their ilk—don't say what happens if R and S relate different numbers of things and in different orders, as in Turner's examples (p. 185):

Necessarily, if x is between y and z, then x and y are co-linear. (T1)

Necessarily, if x is between y and z, then x and z are co-linear. (T2)

Moreover, although it'd perhaps be natural to think that (T1) is to be accounted for by the fact that *betweenesss entails co-linearity*, relationalists should be careful when picking formal representations of the idea, like:

$$\text{if } E(B, C) \text{ then: } \Box\forall x, y, z\big[B(x, y, z) \rightarrow C(x, y)\big],$$

because we also need to account for (T2), which would require this different form:

$$\text{if } E(B, C) \text{ then: } \Box\forall x, y, z\big[B(x, y, z) \rightarrow C(x, z)\big].$$

Then, relationalists must be clearer about how $\mathcal{M}$-facts explain modal facts, when $\mathcal{M}$ relates relations of different adicities and/or with different orderings of their argument places. This is Turner's objection to Jubien, but it clearly generalises.

Developing her own brand of relationalism, Wang (2013) introduced the following insight: properties and relations are sometimes *coordinated* at one or more of their places (see also pp. 229–230 Armstrong, 1996). To represent this, she introduces the notion of a *property P under variable listing* $(v_1, \dots, v_n)$, written '$P(v_1, \dots, v_n)$' and defined by an *n*-ary relation symbol *P* and a vector of variables $(v_1, \dots, v_n)$. Then, some properties under variable listings are *coordinated at their ith place* iff each of those properties is of adicity at least j, $i \leq j$, and the same variable appears at each of the properties' variable listings at their *i*th place. For example, $P(y, z, t)$, $Q(x, z, y, u)$ and $R(x, z)$ are coordinated at their second place.

Wang's syntactical apparatus is both powerful and useful for relationalism in general. With it, the relationalists can clearly state how $\mathcal{M}$ modally connects relations of different adicities, taking into account the fact that those modal connections may vary with the order of their argument places. So, for example, Turner's examples of modal facts, (T1) and (T2), are accounted for by relationalist facts of the form:

$$E(B(x, y, z), C(x, y)) \tag{T1-W}$$

$$E(B(x, y, z), C(x, z)) \tag{T2-W}$$

(taking $\mathcal{M} = E$ for the sake of the example; this generalises in an obvious way.) Let us call formulas like these 'Wang formulas'. Wang formulas allow the relationalists to completely and precisely state *how* is it that $\mathcal{M}$ modally connects properties and relations: not by linking the 'plain' properties, so to speak, but by connecting them *at their places*.

Unfortunately, however, this comes at a cost. Metaphysics does not reduce to syntax. Philosophers must specify what their formalisms represent: the metaphysical flesh is in the semantics, not in the mere formalism, which most of the times can be interpreted in different ways, some of them metaphysically irrelevant. We must ask, then, how are we to understand Wang formulas: what does a formula like '$E(B(x, y, z), C(x, z))$' mean?

'We've just said it!'—you might say—'It means that *B* and *C* are linked through *E* at their specified argument-places.' Well, yes, but what does *that* mean?

The most direct unpacking of this idea is that properties have *slots*—the ontological correspondents of the syntactic argument-places, see (Dixon, 2018; Gilmore, 2013)—and Wang formulas represent the modal linking of these slots. So, if two properties are linked at certain specific places through (say) the incompatibility relation γ—represented by a Wang formula like '$\gamma(P(x, y), Q(y, z))$'—this means that P-at-its-second-slot is incompatible with Q-at-its-first-slot.

The cost is that slots require primitive modal facts.

First, slots are themselves defined modally. A slot is something that is in a relation and that *can* be *occupied*. A slot could not be simply defined as the ontological counterpart of a syntactical argument-place, because fundamental metaphysics should not depend on syntax—a very derivative endeavour. And a slot should not be simply defined as a place that *is* occupied, because uninstantiated relations have their slots unoccupied. Even if one thinks that (necessarily?) a relation exists only if it is instantiated, so that u exists only if u's slots are all filled, still, it should be part of the definition of a slot that it *can* be occupied—the slot 'allows' the property to have further instantiations, beyond those that it *does* have. As (p. 196 Dixon 2018) says (my emphasis): 'Like the slot theorist, the pocket theorist posits entities (pockets) in properties and relations that *can* be occupied', and: 'slot theory is the view that a property or relation is n-adic if and only if there are exactly n slots in it, and that each slot *may* be occupied by at most one entity'. So, clearly, slots are characterised as occupi*able* entities in a property, and I take it that the '*may*' here has a modal import, so that the sentence means: *necessarily, if x is a slot and y occupies x and z occupies x, then $y = z$.*[23] Slots and pockets are occupi*able* entities in properties; then, they have a modal definition, and the modality has to be ontological: it has nothing to do with our epistemic state or with any other non-ontological modality.

Second, the relation between universals and their slots, such that a slot is *in* a universal, also requires modal axioms, as acknowledged by (pp. 195–198 Gilmore 2013).[24] One of these may be that the relation is necessarily asymmetric (p. 195).

The modal constraints defining slots and their relation to universals are not explained by more fundamental $\mathcal{M}$-facts. Rather, as I have argued, if relationalists want to explain how is it that $\mathcal{M}$ can underpin modal connections between relations of different adicity, and such that the order of their arguments is important—if relationalists want to dispel Turner's worry—the appeal to slots (or pockets or some such) is a very natural route to take, and those entities require ontological modality of their own. Because slots are part of the explanation of how $\mathcal{M}$ modally connects relations, the modal status of those slot-theoretical principles are not to be explained by $\mathcal{M}$-facts, on pain of circularity. So, relationalism needs more primitive modal ideology than the one defining the modality of $\mathcal{M}$: that which corresponds to the primitive modal facts of slot theory and which helps to explain not the modality, but the *relationality* of $\mathcal{M}$.

[23] These statements should be complicated in a variety of ways, but my basic point remains *mutatis mutandis* Dixon's *pocket theory* generalises slots to *pockets*, but these are also modally defined: see p. 196 and p. 206.

[24] Gilmore poses this as a possible objection to slot theory, but acknowledges that 'In the end, this objection may be correct' (p. 195), although he argues that the brute necessities that slot theory requires may be reasonable and independently motivated.

Third, even ignoring the modal ideology defining slots, Wang formulas require us to quantify over what could or could not fill the slots of the linked properties. Consider again (T1) and (T2). As we saw, it is not enough to say that *B* is linked to *C*: we need to say *which* of the three things related by *B* are also related by *C*. Otherwise, the relationalists won't be able to differentiate between (T1) and (T2). So, it's not enough to track the number of slots of each of *B* and *C*, and it's not enough to track their order. It's also that the slots *have* to have certain occupation patterns: that is why, in (T1-W), *C* is displayed with the variable listing (*x*, *y*), while it is displayed with (*x*, *z*) in (T2-W).[25] While the slots of *C* remain the same—they are the only two slots in *C*—the Wang formula displays the pattern of occupation of those slots: in (T1-W), *C*'s second slot is occupied by whatever occupies *B*'s second slot; in (T2-W), *C*'s second slot is occupied by whatever occupies *B*'s third slot. Again, *C*'s slots remain the same: they are only two things. But Wang formulas *implicitly quantify over slot-occupiers*; that's how they can represent the occupation patterns. And they cannot be only actual occupiers: Wang formulas must quantify over *possible* occupiers. They must say that (T1-W) every possible thing that occupies *B*'s second slot occupies *C*'s second slot, and that (T2-W) every possible thing that occupies *B*'s third slot occupies *C*'s second slot. To interpret the formulas, the implicit quantification over *possibilia* is needed: not just the quantification over the actual slots of the properties, but also over their possible occupiers. Without this—without enforcing links between the slot-occupiers—there is no other way, at least no other apparent way, to recover the distinction between (T1) and (T2).

And the problem is that the most direct interpretation of this is in terms of further modal ideology, that of quantification over *possibilia*. Again, this is the most direct interpretation of the Wang formulas. If there is another one, it is on the relationalists to present it. But,—and this is my main worry—if this argument is correct, then *it is unclear why would we need* $\mathcal{M}$ at all. For, if we already have *possibilia*, or if we have the primitive possibility that partly defines slots, or the primitive necessity that partly defines the relation between relations and their slots—then, what would prevent us to think that any of the primitive modal aspects of reality that these ideologies represent are what underlie the modal facts that the relationalists wanted to explain in the first place? It could not be that $\mathcal{M}$ explains those aspects: as we have seen, $\mathcal{M}$ *presupposes* them for its relationality.

At this point, relationalists may want to backtrack: *Are slots really required?*

The relationalists may try to avoid using the formalism that suggests the interpretation in terms of slots. This leads, quite naturally, to predicate functor logic (PFL). PFL has been applied to views like generalism (Dasgupta, 2009) and ontological nihilism (Turner, 2011), but we ignore debates about these views here.

In PFL, we have:

- A denumerable set of basic *terms*;

[25] The formulas are invariant under uniform substitution of variables (p. 547 Wang, 2013), but the point is not about the variables, but about the coordination that they need to represent.

- A function $\hat{a}$ assigning a finite cardinal to each term, such that if $\hat{a}(A) = n$, we say that A is an n-ary term and we write it as 'A^n';
- The following six functors: &, $\sim, c, p, \iota, \sigma$, which create new terms from the basic ones as explained by (appendix Dasgupta 2009).

Relationalists could use PFL so as to have $\mathcal{M}$ respect the places of the relations it relates.[26] The aim is to have formulas so that, e.g., $\mathcal{M}(R, S)$ is true while $\mathcal{M}(R,$ converse of $S)$ is false. Also, with the algebraic operations of PFL, relationalists could construct suitable relations for their basic modal facts, taking care for the arity of the terms. For example, the fact that B^3 holding between a first, a second and a third object entails C^2 holding between the first and the second, could then be represented by a formula like: '$E(B^3, C^3)$', where C^3 is constructed from a dyadic term C^2 using the PFL functors, such that C^2 represents a dyadic relation that holds between x and y iff C^3 represents a triadic relation that holds between x, y and z. The thought is that we then evade quantifying over slots and their occupiers, making $\mathcal{M}$ directly relate the properties, represented by the PFL terms.

However, actually, what we have done is used PFL to simulate reference to the syntactic argument places that are explicit in the matrices of classical first order logic (FOL) and in Wang's properties-under-variable-listings. The number of argument places is simulated in PFL by the $\hat{a}$ function assigning numbers to terms, and we have to assume that these terms are handed down to us with a settled order in what corresponds to FOL variables—so that in the FOL-PFL translation, the FOL matrices '$C(x, y)$' and '$C(y, x)$' can be assigned different PFL terms (indeed, the second one to a functorial operation on the first). Without this predetermined order, PFL would be blind to the difference between the two FOL matrices, there would not be a 1-1 translation between FOL and PFL, and PFL would be useless to represent the different facts (T1) and (T2).[27]

And when the time comes to provide an interpretation of the formalism—which is going to be required if there is a claim that this formalism *represents* metaphysical facts—it's almost inevitable to think of PFL as simply a notation that, with baroque contortions, allows us to represent predicates with their argument places and order. And we have already seen what this entails—most naturally, the representation of slots. And, further, we are also are going to need to think of those slots not only as capable of being filled, but as being such that *any of their possible fillers* are going to be modally linked, just as we argued for Wang's formalism.

Ultimately, this result should not be surprising at all. The fact is that we *need* modal links between what could simultaneously instantiate relations: we need to account for facts like the fact that, necessarily, if a is between b and c, then whatever a is, it is co-linear with b and also co-linear with c. Wang formulas do this explicitly;

[26] I am indebted for the following suggestions to an anonymous reviewer.

[27] This is only a necessary condition. Another is the correspondence between the functor 'c' and '∃', which motivates Turner's (Sect. 6 Turner, 2011) argument that 'c'-statements in PFL are as committing as '∃'-statements in FOL. I do not require Turner's metasemantic principle (*) (p. 17 Turner 2011), the major premise in his argument, for my argument; I am not relying on such a generalisation, but on what the relationalists could use PFL for. For discussion of Turner's (*) principle, see Diehl (2018).

with PFL, the representation may be more roundabout, but it is there. And the ontological implications are the same.

Relationalists may want to evade these issues by backtracking even further. Above, I said that if they want to tell us that $\mathcal{M}$ relates properties and relations, they need to tell us exactly how. They may prefer to remain silent about this question: they may insist that their canonical formulas—'$N(F, G)$' and so on—are all that is needed: they may argue that Turner's questions are somehow illegitimate, and that their quietism is justifiable. This would deepen their primitivism: not only is the *modal* nature of the modal relation not exhaustively definable, so is its *relational* nature. $\mathcal{M}$ relates properties, but in a way that cannot be further explained.

I believe that this quietist thesis makes relationalism unacceptably obscure. I would urge relationalists to reject quietism, and to try and do better than what here I have been capable of.

6 Unary constraints

Not every modalised state is relational: some *single* properties are constrained: there are *unary* constraints in Nature. These unary constraints are not obviously explainable by relational states. The fact that there are unary constraints has also been noted by Wilhelm (2020), who uses it to argue against interventionism about explanation. Here, we ignore interventionism.

Our first example is one that Wilhelm presents. As usual, we regard fields as physical quantities: scalar-, vector-, or tensor-valued properties of spacetime points. Then, consider the magnetic field, $\mathbf{B}$, of Maxwellian electrodynamics.[28] Gauss's law for magnetism says that the divergence of $\mathbf{B}$ must be zero (at every point):

$$\nabla \cdot \mathbf{B} = 0 \text{ everywhere.} \tag{9}$$

'How is this not relational?', you may ask, 'There is an identity sign right there!' There is, but (9) says that it is physically necessary that the divergence of $\mathbf{B}$ be zero: it does not say that the field entails or is entailed by another property, or that two properties are incompatible, etc. The constraint rules the property $\mathbf{B}$ to be, as mathematicians say, a *solenoidal* field.

There are many unary constraints on properties: there are many cases in which a *single* property is constrained to take a value, or to take a value in a specified interval, or constrained from having a value higher or lower than a certain bound, or in general to be of a specific form. We have seen Gauss' law, we may also mention systems solving a constrained optimisation problem, where there are constraints ruling a single degree of freedom to have a certain value; or the other examples of Wilhelm (2020): the Past Hypothesis, principles of conservation, and the Wheeler-DeWitt equation. Is the modality of these states explained by relationalism?

[28] Note that $\mathbf{B}$ is a frame-dependent property, which does not affect the argument here.

The relationalists may insist that there are relational states that explain the modalities in question. (p. 110 Jubien 2009) suggests that statements of the form '$\Box(Pa)$' have as truth-conditions facts whereby entailment relates *a*'s essence—understood as a property, *A*—and *P*: the relationalist fact that $E(A, P)$ would explain the modal fact (or make true the corresponding sentence) that $\Box(Pa)$.

However, some constraints may be merely physically necessary; others could even be metaphysically necessary, but not flow from the essence of a property. In our case, the constraint that **B** be solenoidal is not part of its nature: **B** is usually introduced through the Lorentz law (e.g. pp. 238–239, 278 Purcell & Morin, 2013), and (9) is taken as a constraint *on* the field, not as part of its definition.[29] The thought is that **B**'s nature is *compatible* with magnetic monopoles—electrodynamics could be true even if (9) wasn't—but they are ruled out by (9). Then, the necessity of (9) is not due to the essence of **B**.[30]

For another idea, consider this proposal:

$$E(\textit{Being a magnetic field}, \textit{Being solenoidal}) \tag{10}$$

Note that (10) does not directly explain the fact that **B** is solenoidal. Rather, it (purportedly) explains the (potential) fact that every magnetic field is solenoidal.[31] What is problematic about this proposal is that Gauss' law for electromagnetism does not say that being a magnetic field *per se* ensures being solenoidal: it is not a higher-order law about the property of being a magnetic field; rather, it is a constraint on the actually existing magnetic field. Put in the language of worlds for illustration, the idea is that Gauss' law does not claim that *at every possible world, every magnetic field is solenoidal*; rather, it claims that *the magnetic field that exists at this world is solenoidal at every physically possible world.*

We may evade this problem modifying (10) with the identity property of the field, so as to read:

$$E(\textit{Being } \mathbf{B}, \textit{Being solenoidal}) \tag{11}$$

In general, the idea would be to have each constrained property (P) to be $\mathcal{M}$-related to its constrained form ($C(P)$).[32] So, *to be P* is incompatible with *not being* $C(P)$, or *to be P* entails *being* $C(P)$, or some such variation. The necessity of the constraint

[29] The Lorentz force law:

$$\mathbf{F} = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$$

defines the electromagnetic force **F** on a particle of charge q with velocity **v** perpendicular to a magnetic field **B** in the presence of an electric field **E**.

[30] For example, (p. 531 Purcell and Morin 2013) note that, although matter is actually such that the magnetic field is solenoidal, it could also not be. Given this contingency, solenoidality cannot be part of **B**'s nature. (p. 242 Griffiths 2013) notes that the existence of magnetic monopoles 'remains an open experimental question'. But if it were part of **B**'s definition that it is solenoidal, such a definitional fact could not be refuted by experiment.

[31] I owe this point to a commentary of a referee for a relevantly similar case.

[32] For example, an anonymous referee suggested that the necessity that a property be invariant may be accounted for by the fact that being-the-property-*P*-in-a-situation-*S* entails being-the-property-*P*-in-a-situation-$T(S)$, where T is a symmetry transformation.

would be explained by the property's identity-property being modally related to the property in its constrained form.

However, this would not work: as we saw, the necessity of (9) is not due to the essence of **B**. But the identity property of anything is a part of its essence.

It may be objected that (9) does invoke **B**, and so it seems to refer to **B**'s identity property. Regardless, the source of the necessity is not **B**'s identity property. Again, **B** is not *defined* by (9), because it is agreed by physicists that **B** is compatible with magnetic monopoles. So, (9) refers to **B**, but the source of its necessity is not **B**'s definition. In contrast, facts like (11) are assumed by the relationalists to explain the necessity of laws like (9). So, if (11) explains (9), and as (11) is a fact about **B**'s identity property, then a fact about **B**'s identity property would explain (9)—which, as we have seen, is incorrect.

So as to evade reference to the field's identity property but still manage to individuate it, let's stipulate that a **B**-*esque field* is one that satisfies the definitions and laws of **B** in Maxwell's theory minus Gauss' law. Then, this is the new proposal:

$$E(\textit{Being } \mathbf{B}\textit{-esque}, \textit{ Being solenoidal}) \tag{12}$$

However, this proposal would directly explain only this modal fact:

Necessarily, for all X, if X is a **B**-*esque field then X is a solenoidal field.*

But this is not what (9) says. It says that necessarily **B** is solenoidal—**B** itself. But (12) does not ensure reference to a single **B**-esque field. There are different conceivable **B**-esque fields. And, as we saw, being **B** is compatible with solenoidality and with non-solenoidality; so, being a **B**-esque field should be, too. So, there could be non-solenoidal **B**-esque fields, contrary to (12).

We may try to append context. Perhaps what is related to solenoidality is *being a* **B**-*esque field given how everything actually is*. The problem with this proposal is that this property depends on every actual thing, making the modal fact depend on *actualia* extrinsic to the constrained property and in many cases dependent on it. We would like to claim that **B** would still be constrained even if many of the things that do not actually exist, existed, and even if many of the things that actually exist, did not.

The problem in this case is that the law refers directly to a property, but it's not true in virtue of the essence of the property: the property is defined *first*, and *then* a non-essential constraint is imposed on it. So, a relationalist fact purportedly explaining the law should *not* establish the modal connection between the property's essence (including its identity) and its constrained form, because the essence itself does not imply, is not incompatible with, etc., the constrained form. But the relationalist fact cannot, either, be one which refers to a property 'like' the one constrained, because that does not ensure the uniqueness that is present in the constraint.

In cases like that of Gauss' law, the constraint is imposed on a previously defined property. There may be other cases in which the constraint *defines* (at least partly) the property. Among these, there may be cases where the constraint is, furthermore, fundamental. For example, it is an open scientific question whether or not there are fundamental constraints in the form of conservation principles or the symmetries of an hypothetical final theory. Those fundamental constraints would not be defined in terms of the properties—rather, *the properties would be defined by the constraints*: part of what defines the physical property is that it is necessarily conserved, for example. This theoretical possibility has been considered seriously in science, and it is *not* for philosophers to decide whether or not that is correct.[33]

If there are fundamental constraints defining a property *P*, then, facts about *P*—including facts about its relations to other properties—cannot be ontologically prior to those constraints. For example, perhaps energy is conserved:

$$\frac{dE}{dt} = 0$$

But how could this constraint be more fundamental than *E* if it is *defined* in terms of *E*?

It may be that the fundamental constraint is that the fundamental properties are conserved, so the fundamental law would be one of form, not about a specific property; like so:

$$\frac{dX}{dt} = 0,$$

and energy would just be so that it satisfies this law. Be that as it may, fundamental constraints are by definition not explained by further ontology. A fundamental unary constraint may essentially constrain a single property to be a certain way, so that the property is essentially such that it necessarily takes that form, but the essence is not explanatorily prior to the necessity: rather, the necessity is imposed by the constraint, and the essence is partly constituted by the constraint.

In both of the types of cases we have examined—cases of property-defining fundamental constraints, and cases where the constraint is imposed on an already defined property—the source of the necessity is not a fact about the essence of the property, but the constraint itself. *A fortiori*, the source of the necessity is not a fact about a relation between the essence of the property and something else. But not all unary constraints may fall under these cases. For example, there may be property-defining non-fundamental unary constraints. Perhaps in those cases, it is plausible to take the explanation of *P*'s being necessarily of a form *C* to be the fact that *being P* is modally related to *being C*.

[33] For example, (p. 80 Weinberg (1987)) suggests the possibility that 'at the deepest level, all we find are symmetries and responses to symmetries. Matter itself dissolves, and the universe itself is revealed as one large reducible representation of the symmetry group of nature'. (p. 14256 Gross (1996)) notes that 'Einstein's great advance in 1905 was to put symmetry first, to regard the symmetry principle as the primary feature of nature that constrains the allowable dynamical laws.' And Wigner (cited by (p. 64 Lange (2017))) said that for the conservation laws 'which derive from the geometrical principles of invariance it is clear that their validity transcends that of any special theory'. The possibility that the symmetry constraints are ontologically fundamental has been explored in metaphysics, see e.g. French (2014) and Schroeren (2021). Of course, differentiable symmetries correspond to conservation laws by Noether's theorem.

I have argued that there are at least some cases of unary constraints which are not plausibly explained in terms of relationalist facts. As before, the relationalists can read this as an invitation to expand, and perhaps modulate the parameters of, their theory. I, for one, read this as a fourth reason to remain sceptical of relationalism.

7 Conclusion

Though many objections have been posed before to different specific relationalist views, I have argued that the very *idea* underlying relationalism faces four non-trivial problems. Realising that such problems exist provides a couple of valuable lessons, in the form of desiderata for a modal metaphysics.

The first one is this: *The basic postulate of the theory should not be a relation*. I consider this to be a desiderata because it would allow us to simultaneously evade the problems of extra-order relations and of unary constraints, and the problem of explaining how relations of different adicites are modally related. These three problems originate in the postulation of a relation as the explananda of modal facts: because it is a relation, it must relate at least two properties, it must belong to an order, and it must relate those properties in a specific way.

A second desiderata would be this: *The basic postulate of the theory should not be metaphysically equivalent to another possible postulate*. This would allow us to block the problem of arbitrariness for relationalism and for the theory that one of the classical modalities is fundamental.

After relationalism, there is room for optimism about modal primitivism if we can devise a theory that satisfies these desiderata. I think that we can; but that is for another time.

Appendix

Here, I explore the question whether three influential views—Bird's, Vetter's, and Yates'—which are officially defined by means of certain syntactical operators, should be counted as cases of relationalism.

Bird

According to (p. 45 Bird 2007), the fundamental natural properties are *potencies*: properties with a *dispositional essence*. And the dispositional essence of a potency *P* is defined by a formula of this form:

DEp $\square(Px \rightarrow D_{(S,M)}x)$

where '$\square$', the operator of metaphysical necessity, governs a formula meaning: *if any possible x is P*, *then x is disposed to manifest M under the stimulus S*—where the disposition is necessarily equivalent to the familiar counterfactual analysis (p. 43). But Bird explicitly takes his formalism to represent a *manifestation relation*:

> Dispositional monism is the view that all there is to (the identity of) any property is a matter of its second-order relations to other properties. [...] In dispositional monism the second-order relation in question is the relation that holds, in virtue of a property's essence, between that property and its manifestation property—which we will call the *manifestation relation*. (p. 139 Bird (2007))

We see that, while the theory is syntactically presented by means of operators, these pieces of syntax are interpreted in terms of relations. Bird's theory is a case of relationalism.

Vetter

Vetter's view (Vetter, 2015) is defined with a syntactical operator, 'POT', which expresses potentiality:

> POT must therefore be a predicate operator which takes a predicate—specifying the potentiality's manifestation—to form another predicate, which can then be used to ascribe the specified potentiality to an object. [p. 145]

Then, formally, if F is an n-ary predicate and $t_1, \ldots, t_n$ are terms,

$$\mathrm{POT}[F](t_1, \ldots, t_n)$$

is a well-formed sentence, meaning that the objects $t_1, \ldots, t_n$ have the (joint) potentiality to F. Vetter's view is that potentiality-ascriptions like the above can be used to explain modal facts.

First, I hope we can agree that operators and formulas are *syntactic devices*: whatever metaphysical flesh they have must be in their intended interpretation. One may, for example, want to say that a modal syntactical operator refers to a *modal operation* (this was an example offered to me by a referee), but then one must say how operations are to be defined. In the standard, set-theoretical setting, operations are relations (see e.g. p. 11 (Jech, 2003)): 'An n-ary operation on X is a function $f : X^n \to X$'; of course, every function is a relation). One might have another notion of 'modal operation' in mind, but it is clear that specifying it requires a *theory*—which leads to my point. Syntax is not enough: we need an interpretation, if we are to be presented with a metaphysical theory.

Back to Vetter. Although, ultimately, a simplification (p. 96), she accepts as approximately true that potentialities are individuated by their manifestation conditions. Vetter argues that they are definitely not individuated by a pair of a stimulus and a manifestation. This takes us to the question of *what is* a potentiality.

And I don't think that the answer to that question is obvious. Ignoring the distracting nuance, assume that potentialities are individuated by their manifestation properties. But *are* potentialities properties? Yes: 'Potentialities are, moreover, properties of individual objects' (p. 145 Vetter, 2015). But the potentiality is not its manifestation condition: 'Potentialities are potentialities to...' (*ibid.*)—there is something more. There must be, because we need to have a modal 'oomph' that makes a potentiality be a modal entity, the truthmaker of possibility ascriptions and a graded or determinable possibility (p. 95).

Vetter's formalism suggests that potentialities are constituted by whatever is represented by the operator 'POT'. I can see three possible interpretations of this.

One is that Vetter thinks of *potentiality* as Anjum and Mumford (2011, 2018) think of *tendency*: as a primitive mode in which states can obtain. Another possibility is that potentialities are monadic properties of facts: $\mathrm{POT}[F](t_1, \ldots, t_n)$ iff that $F(t_1, \ldots, t_n)$ is possible to some degree. If either of these options is true, potentialism is not a relationalism but a monadicism. However, these ideas do not make it true that potentialities are properties of individual objects.

But if we take the formalism and the interpretational clues at face value, it would seem that potentialities are constituted by the POT-operation on manifestation conditions. If so, potentialism *is* a kind of relationalism: there is a modal relation, denoted by the operator 'POT', relating properties to objects that have potentialities with those properties as manifestation conditions. A potentiality would be a property like *being able to walk*, constituted by the property of *being walking*, related to the subject of the potentiality by POT. Some of what Vetter says in her 2015 book seems consistent with this relationalist framework, like:

> I have a potentiality to walk; I have no potentiality to lay eggs. Thus I am differently related to the property of walking than I am to the property of laying eggs. [...] the contrast is between having and lacking a potentiality. [p. 151]

Also, responding to Giannini and Tugby (2020), she says that (p. 215; my emphasis Vetter, 2020):

> The Aristotelian picture I suggest is one on which objects, by being some way or another, ground their properties. But they do not ground them one by one. Rather, *on the dispositionalist picture, we can think of properties as nodes in a vast network held together by the manifestation relation*.

While she accepts that this description has a 'metaphorical nature' (*ibid.*), she stands by it.

Yates

Yates presents two theories (p. 26 Yates 2013):

Orthodox Dispositional Essentialism (ODE) The individual essence of P is a set of dispositions it bestows in virtue of its nature, and which no other property bestows.

Finean Dispositional Essentialism (FDE) The individual essence of P is a set of Physical laws that are true in virtue of its nature, and which aren't true of any other property.

Now, Yates' ODE is clearly a relationalist view: properties are necessarily linked by their essence to dispositions, and properties and other properties are modally linked through the manifestation relation that constitutes dispositions. What about FDE?

In FDE, the individual essence of a property is directly given by a law. Sometimes, from those laws, 'certain disposition-defining subjunctive conditionals' follow (p. 29 (Yates, 2013)), and 'It's natural to identify the dispositions a Physical property bestows essentially as those that are derivable [...] from laws true in virtue of its nature'. However, crucially, 'FDE entails neither that every Physical property essentially bestows dispositions, nor that those that do have dispositional individual essences' (p. 30). This would seem to entail that Yates' FDE is a mixed view: partly relationalist, partly essentialist. However, I think it is ultimately purely essentialist (as was, seemingly, pointed out to Yates by a referee: footnote 61): the fundamental modal posit is the essence of a property, and laws get to be necessary by being essential to properties (through an essentialist explanation like that investigated by Glazier, 2017). From these necessary facts, certain subjunctive conditionals follow, but their modal status would seem to be completely explained by the necessity derived by the essentiality in question. (Some reject that necessity can be explained by essence, e.g. (Leech, 2018; Romero, 2019); I will not discuss this issue here.) So, I count FDE not as a relationalist, but an *essentialist* view.

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