Newman's Objection and the No Miracles Argument

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1 Introduction

Structural realists claim that we should endorse only what our scientific theories say about the structure of the unobservable world. But according to Newman's Objection, the structural realist's claims about unobservables are trivially true. In recent years, several theorists have offered responses to Newman's Objection. But a common complaint is that these responses "give up the spirit" of the structural realist position.

In this paper, I will argue that the *simplest* way to respond to Newman's Objection is to return to one of the standard motivations for adopting structural realism in the first place: the No Miracles Argument. Far from betraying the spirit of structural realism, the solution I present is available to any theorist who endorses this argument.

I will begin in section 2 by providing an overview of structural realism and Newman's Objection.

2 An overview of structural realism

Perhaps the most powerful argument for scientific realism is the *No Miracles Argument* (NMA). According to the NMA, the novel predictive success of our scientific theories would be a miracle if those theories were not at least approximately true. One of the most compelling arguments for scientific antirealism is the *Pessimistic Induction* (PI). According to the PI, we can look to the history of science to find many examples of predictively successful theories that we now reject. It seems that we could have run the NMA in support of these past theories, even though they turned out false. Why, then, should we be more optimistic about our current best theories?

Worrall (1989) cites Fresnel's theory of the ether as a paradigmatic example of a predictively successful theory turning out false. Despite its falsity, Worrall thinks that there is a non-miraculous explanation of why Fresnel's theory enjoyed novel predictive success. He observes that Fresnel's equations describing the behavior of light traveling between two media were wholly preserved by Maxwell's electromagnetic theory. According to Worrall, this shows that while Fresnel may have misidentified the *nature* of light, he correctly identified its *structure*. On the basis of this and other examples, Worrall concludes that we should endorse only what our scientific theories say about the structure of the unobservable world. Worrall's *epistemic structural realism* is able to respect the force of the NMA: our theories enjoy novel predictive success because they make true claims about the structure of unobservables. But it is also able to avoid the PI, given that the structural elements of successful theories have been preserved across theory change.

Epistemic structural realism (i.e., the view that all we can know about the unobservable world is its structure) is often contrasted with *ontic structural realism*: the view that there is nothing more to the unobservable world than structure.[1] In the arguments ahead, I will exclusively discuss ESR.

2.1 The Ramsey sentence

What does the structural realist mean when she says that we should endorse what our scientific theories say about the structure of the unobservable world? Many structural realists cash this claim out as follows: instead of using our theory's interpreted predicates to describe unobservables, we should instead endorse our theory's *Ramsey sentence*.[2]

We construct a Ramsey sentence as follows. Assume that a scientific theory is finitely axiomatizable in a formal second-order language. First, one divides the predicates of the theory in question into an "interpreted" set $\{I_1, \ldots, I_m\}$ and a "Ramsified" set $\{J_1, \ldots, J_n\}$, depending on whether we have grounds for endorsing the interpretation our theory assigns the given predicate. According to the structural realist, we should leave only observable predicates interpreted. We can represent our theory as a single sentence $T(I_1, \ldots, I_m, J_1, \ldots, J_n)$. To obtain the Ramsey sentence T^*, one replaces all J_i with X_i, where X_i is a variable in the second-order language. One then existentially quantifies over all of the second-order variables to obtain $T^* \equiv \exists X_1, \ldots, \exists X_n(I_1, \ldots, I_m, X_1, \ldots, X_n)$.

To make this concrete, I'll give an example from Maxwell (1970). Consider a one-sentence theory: if a radium atom decays radioactively, there will be a click in a suitably placed Geiger counter. We capture this theory with the sentence $\forall x((J_1x \wedge J_2x) \rightarrow \exists y I_1 y)$, where '$J_1x$' means '$x$ is a Radium atom', 'J_2x' means 'x decays radioactively', and 'I_1x' means 'x is a click in a suitably placed Geiger counter'. The Ramsey sentence will be $P \equiv \exists X_1 \exists X_2[\forall x((X_1x \wedge X_2x) \rightarrow \exists y I_1 y)]$. P asserts that there exist two properties X_1 and X_2 such that if a given unobservable entity is within the extension of X_1 and X_2, then there will be a click in a suitably placed Geiger counter. This example shows how a theory's Ramsey sentence is weaker than its interpreted axioms. P doesn't say anything specific about the nature of unobservable relations; it characterizes these relations purely in terms of the set-theoretic relations among their extensions.

2.2 Alternatives to the Ramsey approach

In 2.3, I will show how Newman's Objection arises for structural realists who adopt the Ramsey approach to structure. But it should be noted that many contemporary structural realists do not use Ramsey sentences; instead, they cash out the notion of

[1] See Ladyman (1998).

[2] I discuss alternatives to the Ramsey approach in 2.2.

structure in terms of *models*.[3] Here, the relevant notion of a model is a mathematical structure (i.e., a domain with relations defined upon it) that can be used to represent the unobservable world.[4] To provide dialectical context for the paper, it will be useful to briefly discuss some of the differences between these two approaches.

(1) *View of theories*: When Maxwell (1970) introduced the Ramsey approach to structure, he was working under the traditional "syntactic view" on which scientific theories are identified with collections of sentences. But today, many theorists instead endorse a "semantic view" on which theories are viewed as families of models.[5] Proponents have argued (see French & Ladyman (2003, 33-34)) that the semantic view best accounts for the role of models and idealizations in physics as well as the ways in which our theories represent the world.

If one views theories as sets of sentences, the Ramsey sentence is the natural way to conceive of structure. But if one endorses the semantic view, it is more natural to cash out structure directly in terms of the theory's models. So one perceived advantage of the models approach is its compatibility with a more refined view of scientific theories.[6]

(2) *Ontological discontinuity*: It has been argued (see Ladyman (1998, 411-415)) that a Ramsey sentence always refers to exactly the same entities as the original interpreted theory. If this argument is successful, then the Ramsey approach will fail to accomodate cases of ontological discontinuity across theory change, and therefore will not help the structural realist escape the PI.

(3) *Ontic structural realism*: While many structural realists are motivated by epistemic concerns, many are also motivated by metaphysical concerns raised by contemporary physics. According to *ontic structural realists*, phenomena like quantum entanglement motivate a view on which individual objects are (in some sense) ontologically dependent on the world's relational structure.[7] It has been argued that, by being isomorphic to this wordly structure, models are best able to represent the metaphysical picture of OSR.[8]

Despite the potential advantages of the models approach, I focus on the Ramsey approach in the discussion ahead. This will allow me to more easily engage with the recent literature on Newman's Objection, which has focused on the Ramsey approach. It is worth emphasizing, however, that the solution I present should be available to *any* structural realist who accepts the NMA, not just those who use Ramsey sentences.[9]

[3]See, e.g., Ladyman (1998).

[4]See Frigg & Votsis (2011, sections 2 and 3.4.2) for discussion.

[5]For discussion, see Suppe (1974).

[6]See Ladyman (1998, 416-418).

[7]In fact, there are many versions of OSR (see Frigg & Votsis (2011, 4.1)), and not all proponents would endorse the characterization just given. But this intuitive characterization will suffice for the purposes of this paper.

[8]See French & Ladyman (2003, 33-34).

[9]Some theorists, such as French & Ladyman (2003, 33), have argued that moving to the models approach is itself a response to Newman's Objection. But Ainsworth (2009, 150-152) and Frigg & Votsis (2011, 255-256) argue that versions of the objection arise for either approach.

2.3 Newman's Objection

Newman (1928) launched what many consider to be a devastating objection to Russell's (1927) early version of structural realism. Demopolous & Friedman (1985) showed that Newman's Objection can equally be directed at structural realists who make use of Ramsey sentences. The Ramsey sentence specifies the set-theoretic relations among the extensions of certain unobservable relations. According to Newman's Objection, if unobservable relations are given this purely extensional characterization, then the Ramsey sentence is trivial because the unobservable domain U cannot fail to have the posited set of relations so long as there are sufficient elements in U. This is because every set A determines a structure containing all subsets of A, and hence every extensional relation on A (Psillos (1999, 64)). For concreteness, I'll apply this objection to a simple example. Suppose our Ramsey sentence is $Q \equiv \exists X_1 \exists X_2 \exists x \exists y \exists z \exists t(X_1xz \wedge X_1yz \wedge X_2zx \wedge x \neq y \wedge y \neq z \wedge x \neq z \wedge I_1t]$. Here is what Q says about unobservables: there exists an unobservable relation X_1 whose extension includes $\{\langle x, z\rangle \, \langle y, z\rangle\}$ and there exists an unobservable relation X_2 whose extension includes $\{\langle z, x\rangle\}$, where x, y, and z are distinct unobservable entities. But this claim is trivial because, for any domain of unobservable entities with at least three members, we can simply define relations satisfying the above characterizations by putting the unobservable entities into ordered tuples in the appropriate way.

Strictly speaking, we should not say that a theory's Ramsey sentence is trivial. First, I note that the relations posited by the Ramsey sentence can only be defined on a domain with a sufficient number of elements. For example, Q implies that there are at least three distinct unobservable entities. Furthermore, it can be proved that a theory's Ramsey sentence has the same observable consequences as the original fully-interpreted theory (for detailed discussion, see Ketland (2004)). For example, Q says that some entity t instantiates the observable property I_1. It may sound strange to label the Ramsey sentence "trivial" given that it captures all of this empirical content, but one should remember that even a scientific anti-realist (such as a constructive empiricist) will agree that the observable consequences of the original theory are true. What separates the structural realist from the anti-realist is the further claim that there are certain extensionally-characterized relations that are instantiated in the unobservable world. Newman's charge is that this *further* claim is trivial, given that every possible set of n-tuples on U determines an extensional relation. For this reason, Newman's Objection is commonly paraphrased as follows: the Ramsey sentence is "trivially" (i.e., automatically) true so long as:

(i) the observable content of the Ramsey sentence is true and
(ii) we quantify over a domain that meets a certain cardinality constraint.

3 Constraints

In recent years, several theorists have offered responses to Newman's Objection. A common complaint is that, for one reason or another, such attempts give up the spirit of the structural realist position.[10] But in this paper, I will argue that a simple solution to Newman's Objection is available to the structural realist. The key to this response is to return to one of the standard motivations for endorsing structural realism — the NMA.

Before presenting this response, it will be useful to mention two obvious constraints any response to Newman's Objection must satisfy if it is to "uphold the spirit" of structural realism:

(1) **PI Constraint**: Any proposed response to Newman's Objection must not introduce content that is itself threatened by the Pessimistic Induction (i.e., it would be illegitimate for the structural realist to introduce content threatened by the PI given that one of the original motivations for adopting structural realism was to avoid the PI)

(2) **Grounding Constraint**: In responding to Newman's Objection, the structural realist cannot rely on the interpreted content of her scientific theory (i.e., it would be illegitimate for the structural realist to deflect Newman's Objection in a way that requires her to endorse the very content she means to eliminate when Ramsifying her theory)

To intuitively illustrate these constraints, I will consider how they might be used to challenge two responses to Newman's Objection from the recent literature. The goal of this section is not to conclusively demonstrate that these proposals fail; in fact, I think each proposal deserves further attention. Instead, the dialectical aim of this section is to provide support for the concern commonly expressed in the literature that these proposals give up the spirit of structural realism (see footnote 10). This, in turn, should motivate us to look for a simpler, less controversial solution to Newman's Objection, which I provide in section 4.

3.1 The intensional operator approach

Melia & Saatsi (2006) observe that the relations described by our theories are often taken to stand in certain intensional relations to each other. For example, some properties counterfactually depend on others, some properties are independent of others, some properties are strictly necessarily correlated with others, etc. Melia & Saatsi claim that, by using operators to express these higher-order relations in her Ramsey sentence, the structural realist can avoid Newman's Objection. I'll illustrate this strategy by considering Melia & Saatsi's own example (in adjusted notation).

Suppose we have a simple theory $\forall x(J_1x \leftrightarrow I_1x)$ whose Ramsey sentence is $R \equiv \exists X_1\forall x(X_1x \leftrightarrow I_1x)$. As it stands, R's structural content is trivial by Newman's Objection. Now suppose our theory asserts that there is a lawlike connection between the properties expressed by the predicates I_1 and J_1 in the interpreted theory. Melia & Saatsi suggest that we can then amend the Ramsey sentence R to $R^* \equiv \exists X_1 \mathrm{L_P}\forall x(X_1x \leftrightarrow I_1x)$,

[10]See, e.g., Psillos (1999, 65), Ainsworth (2009, 161-162), and Frigg & Votsis (2011, 251-254))

where $\mathrm{L_P}$ is an intensional operator that expresses "it is physically necessary that". Melia & Saatsi claim that, with the introduction of the $\mathrm{L_P}$ operator, purely mathematical relations no longer trivialize the Ramsey sentence (581).

The intensional operator approach faces a difficult question: if a structural realist isn't willing to endorse her theory's interpreted claims about unobservable relations, why would she be willing to endorse interpreted claims about the *higher-order* relations holding between these unobservables? This puzzle seems to be the reason why many theorists have found the intensional operator approach unsatisfactory.[11] To make this worry more precise, I'll now consider how the PI and grounding constraints might be used to challenge this proposal.

PI constraint: To assess whether the current proposal satisfies the PI constraint, consider the shift from Newtonian mechanics to relativity. Worrall (1989, 121) observes that, while many of the basic theoretical assumptions of Newtonian mechanics were discarded with the advent of general relativity, many of its mathematical equations (such as the law of universal gravitation) survived as *limiting cases* of relativistic equations. So Worrall claims that the shift from Newtonian mechanics to relativity is a case where structural content has been preserved across theory change. Of course, Worrall is not claiming that Newtonian structure has been *exactly* preserved: even when we consider medium-sized objects, Newtonian equations only approximate relativistic equations. Still, Worrall thinks that the correspondence between the equations is enough to support the claim that structure has been preserved.

But unfortunately for the intensional operator proposal, this is a case where claims about nomic necessity were actually *discarded* across theory change. Before relativity, Newton's law of gravitation was thought to apply to any two massive bodies. After relativity, we now understand that Newton's law breaks down when we consider extremely massive bodies. In other words: to the extent to which Newtonian claims about structure were approximately preserved across theory change, they were *only* approximately preserved for a restricted domain that excludes extremely massive bodies. But it is very plausible that there are no such domain restrictions for any true physical law.[12] So while it may have seemed appropriate to introduce an $\mathrm{L_P}$ operator to the sentence expressing Newton's law of gravitation before relativity, we now recognize that the introduction of such an operator is inappropriate. This example shows that the non-structural content that Melia & Saatsi want to introduce to the Ramsey sentence is itself threatened by the PI.

Melia & Saatsi also mention the operator "[...] is correlated in a lawlike manner with [...]", which I will symbolize as 'L_C' (579). I think the counterexamples arising for L_P also arise for L_C, since claims about lawlike correlation between F and G are plausibly equivalent to claims of the form $L_P \forall x(Fx \leftrightarrow Gx)$. But might there be ways to precisify/modify L_P or L_C that avoid the PI worry? (Thanks to an anonymous referee for this suggestion.)

[11] See, e.g., Ainsworth (2009, 162) and Frigg & Votsis (2011, 252).

[12] See Lange (2009). If one is worried by this assumption, the examples in the subsequent paragraph and the optics example in footnote 13 do not require it.

We might try: "[...] lawfully correlates with [...] at the observable limit". But worries about the PI arise for this operator as well. To return to Worrall's original example: Fresnel's equations were once thought to be physically necessary at the observable limit. But with the advent of non-linear optics, we now know that Fresnel's equations cannot account for the behavior of light in observable contexts where the intensity of the incident light very high (for discussion of the limitations of Fresnel's equations, see Wright (manuscript)).

We might try: "[...] lawfully correlates with [...] subject to certain ceteris parabus conditions". But the PI arises here as well. As discussed by Wright (manuscript), the ceteris parabus conditions for Fresnel's equations have been revised across theory change; for example, it is now recognized that these equations only hold for certain types of media and light conditions.

There are other possibilities we might try, but in the next paragraph I explain why it is unnecessary to consider further examples.

Similar problems arise for other of Melia & Saatsi's examples.[13] Before relativity, space and time were thought to be objectively *independent* dimensions of reality. But after relativity, we now understand that how spacetime is divided into spatial and temporal dimensions depends on the observer and her state of motion. Similarly, before quantum mechanics, it was thought that measurements of a particle A did not *counterfactually depend* on measurements of a particle B outside A's lightcone. But after quantum mechanics, we now think that such counterfactual dependence is exhibited in entangled systems.[14]

Of course, the above examples do not show that problems arise for *all* intensional operators. But these examples *are* enough to raise the spectre of the PI: why should we think that our current theory's intensional claims are true given that these intensional claims have often been mistaken in the past? While further responses may be available to Melia & Saatsi, the PI constraint seems to support the common concern that their proposal gives up the spirit of structural realism.

Grounding constraint: I mentioned before that, on Melia & Saatsi's proposal, different intensional operators will be appropriate for different theoretical contexts. For example, if we have a sentence expressing the relation between the spin of electrons and the force they feel in a magnetic field, it would seem appropriate to introduce an operator asserting that these properties are lawfully correlated (581). But if instead we have a sentence expressing the relation between the properties *being* H_2O and *being water*, we could introduce an operator that expresses a relation of strictly necessary correlation (581).

The fact that Melia & Saatsi allow for different kinds of operators prompts the following question: for any given theoretical context, how are we able to judge which operator can be appropriately introduced? It seems that the only way we could make

[13]Since Melia & Saatsi only provide details on L_P, I may not interpret the other operators in exactly the way they intended. But regardless, this discussion will show that intensional claims have often been discarded across theory change.

[14]See Maudlin (2011, ch. 5) for discussion.

such a judgment is by relying on the interpreted content of our scientific theory. To see why this is plausible, suppose that we were given only the original Ramsey sentence (without intensional operators) for some unknown scientific theory T. When we are given this Ramsey sentence, we thereby learn the structural and observable content of T. But it doesn't seem that we would then be in a position to judge which intensional operators to apply to a given sentence of T; for example, we wouldn't be in a position to judge whether we should apply an L_P operator or instead an operator expressing that the two properties are strictly necessarily correlated. This example suggests that we cannot decide which specific operators are appropriate just on the basis of the structural and observable content of our theory.

But then how *do* we decide which operators are appropriate? The most plausible story seems to be that, in making these judgments, we are relying on the interpretations that our theory assigns to its unobservable predicates. The problem is that the structural realist explicitly denies that we have epistemic grounds for endorsing this interpreted content. So it would be illegitimate for the structural realist to rely on this content when deciding which intensional operators to introduce.[15]

In response, Melia & Saatsi might claim that general philosophical considerations give us reason to endorse claims about intensional relations.[16] But there are two problems for this proposal. First, this proposal seems to conflicts with the earlier observation that intensional claims are often discarded across theory change. If we revise intensional claims in this way, it seems unlikely that such claims are justified by any general philosophical considerations. Second: it doesn't seem that general philosophical considerations would allow us to make judgments about which *specific* operator is appropriate in a given theoretical context (as in the argument I gave above).

Summary: Perhaps the above arguments can be resisted. But at the very least, the PI and grounding constraints seem to justify the concern expressed in the literature (see footnote 11) that the intensional operator approach does not uphold the spirit of structural realism. Given that the structural realist does not endorse her theory's interpreted claims about unobservable relations, it is not clear why she would be willing to endorse interpreted claims about the higher-order relations holding between these unobservables.

3.2 The domain restriction approach

I will now (much more briefly) explain how analogous concerns arise for a second proposed response to Newman's Objection.

The structural realist claims that the unobservable world satisfies a certain abstract structure. Newman responds that this is trivial: at the very least, there are purely

[15] *N.b.*: the current objection does not apply to *all* versions of structural realism since, e.g., some structural realists are not motivated by concerns about the interpreted content of our theories (thanks to an anonymous referee for this observation). Will this objection arise for any structural realist who endorses the Ramsey approach? This remains to be seen; I consider a second version of the Ramsey approach in 3.2.

[16] Thanks to an anonymous referee for this suggestion.

mathematical relations that instantiate the posited structure. Instinctively, the structural realist may object that these aren't the relations she had in mind. An obvious suggestion is to restrict the domain for the second-order language so as to exclude Newman's mathematical relations. For example, we might try to restrict the domain to "natural" properties.[17]

Like the intensional operator approach, the domain restriction approach faces a difficult question. If a structural realist isn't willing to endorse her theory's interpreted claims about unobservable relations, why would she endorse interpreted claims about the higher-order properties of these unobservables? This basic concern seems to explain why theorists have not found the domain restriction approach convincing.[18] To make this worry precise, we can again consider the grounding and PI constraints.

PI constraint: Melia & Saatsi (2006) observe that many properties that our theories once considered to be natural (*being green*, *being hot*, etc.) have instead turned out to be disjunctive. But then we should worry that future scientific developments may show that properties like *being an electron* or *having a mass* are also disjunctive, even though we currently consider them to be natural properties (576). So Melia & Saatsi argue that, by restricting the domain to natural properties, the structural realist becomes vulnerable to the PI.

Melia & Saatsi's argument assumes that disjunctive properties are not natural. But there are conceptions of natural properties on which this is not the case (thanks to two anonymous referees for this observation). One alternative worth considering is Schaffer's (2004, 92-93) *scientific conception*, on which natural properties are just those properties "invoked in our scientific understanding of the world." But this proposal also seems to violate the PI constraint, since the properties invoked in our scientific understanding of the world have changed across theories. For example, properties of an ether are no longer invoked in our scientific understanding of light. (As it happens, this proposal also violates the grounding constraint: see footnote 21).[19]

Of course, the structural realist might try to restrict the domain in some other way: perhaps a restriction to *qualitative* properties or a restriction to *non-mathematical* properties would work better. But Melia & Saatsi (2006, 5.2-5.4) consider these and other proposals and conclude that they are too weak: they cannot rule out certain trivial interpretations of the Ramsey sentence.

Grounding constraint: It would seem inappropriate for the structural realist to merely *stipulate* that the properties in her theory are natural, just because it helps avoid Newman's Objection. If the structural realist is going to be justified in restricting the domain

[17] To be clear: when I speak of natural properties, I am speaking of the type of fundamental, non-disjunctive properties discussed by Lewis (1983), not about natural kinds (though there may be important connections between them). I consider other conceptions of natural properties in footnotes 20 and 22.

[18] See, e.g., Psillos (1999, 66), Ainsworth (2009, 168-169), and Frigg & Votsis (2011, 253).

[19] A second alternative is Ladyman & Ross's (2007, ch. 4) account of *real patterns*. Roughly speaking, a pattern is real if it (i) is projectible on some physically possible perspective and (ii) encodes information about worldly structure with a certain efficiency. Because the reality of a pattern depends on what is physically possible, this proposal is *prima facie* threatened by the fact that claims about physical possibility have been discarded across theory change (see 3.1). But this issue is complex; I think Ladyman & Ross's account deserves further consideration.

in this way, it seems that she should be able to provide some epistemic grounds for thinking that the properties posited by her Ramsey sentence are natural. But what could these epistemic grounds be? Psillos (1999, 66) argues that the only way a structural realist could judge that the posited properties are natural is if she looked to the interpretations that her theory assigns to its predicates: "Having specified these *natural* relations, one may abstract away from their content and study their structure. But if one begins with the structure, then one is in no position to tell *which* of the relations one studies and *whether* or not they are natural." So there is a worry that the domain restriction strategy cannot satisfy the grounding constraint.

To respond, the structural realist could try to provide *extra*-theoretical grounds for believing that the properties discovered by physics are natural.[20] For example, Lewis (2009) associates fundamental, non-disjunctive natural properties with fundamental causal powers. On the assumption that physics discovers properties with fundamental causal powers, this supports the claim that physics discovers fundamental natural properties. But this conclusion is controversial. For example, Schaffer (2004, 93) argues that we do *not* have reason to think that physics discovers fundamental natural properties. This conclusion also seems to conflict with Melia & Saatsi's (2006) above observation that many properties referred to by our theories have turned out to be disjunctive.[21]

Summary: It is outside the scope of this paper to fully settle this dispute. Suffice to say that there is at least a worry that the domain restriction approach does not uphold the spirit of structural realism. Given that the structural realist isn't willing to endorse her theory's interpreted claims about unobservables, it is not clear that she should be willing to endorse interpreted claims about the higher-order properties of these unobservables.

3.3 Summary

In this section, I've illustrated the PI and grounding constraints by considering how they might apply to two recent responses to Newman's Objection. These constraints provide support for the concerns found the literature that extant responses to Newman's Objection give up the spirit of structural realism.

I think the above proposals deserve fuller discussion; perhaps they can be adequately defended from the above objections. But instead of examining these proposals further, my aim for the remainder of this paper will be offer a simpler, less-committing response to Newman's Objection. This proposal — the *NMA approach* — makes no claims about naturalness or about higher-order relations. By avoiding these controversial assumptions, the NMA approach represents a more "minimal" approach to structural realism, one that

[20] Thanks to an anonymous referee for this suggestion.

[21] What about other ways of conceiving of natural properties? Schaffer's scientific conception also seems to violate the grounding constraint: it would be illicit for the structural realist to restrict the domain to those properties invoked in our scientific understanding of the world, given that the structural realist denies that we have grounds for endorsing the properties identified by our scientific theories. It is more difficult to assess whether Ladyman & Ross's real patterns proposal satisfies the grounding constraint; this question deserves further discussion.

is available to any structural realist who endorses the NMA.

4 Deflecting Newman's Objection with the NMA

Consider a structural realist in Fresnel's time who endorses the Ramsey sentence of Fresnel's theory. This Ramsey sentence claims that there exist various unobservable relations that satisfy a certain structure S. Why does the structural realist believe that these unobservable relations exist? The answer given by Worrall (1989) and many other structural realists is: the No Miracles Argument. Fresnel's theory successfully predicted certain observable phenomena, such as the bright spot at the center of a shadow cast by a small disk. But this predictive success would be a miracle if the observable phenomena in question were not causally explained by the instantiation of unobservable relations satisfying S. Put another way: it seems very unlikely that Fresnel's theory would correctly predict the spot of light if there didn't exist unobservable relations satisfying S whose instantiation causally explained the spot of light.

This example sets up the key claim I want to make in this paper. The above case reveals one definite, concrete example of a non-structural claim about the unobservable relations satisfying S that (many) structural realists will endorse: *the instantiation of these relations is supported by the NMA*. But if the instantiation of these relations is supported by the NMA, they cannot be the types of relations typically thought to trivialize the Ramsey sentence. After all, these trivializing relations have nothing to do with the novel predictive success of our theories.

From this we see that structural realists who accept the NMA do not merely endorse the (almost) trivial claim that certain unobservable relations satisfy a certain structure S. Instead, they endorse the substantive claim that:

(a) certain unobservable relations satisfy a certain structure S and
(b) the instantiation of these relations is supported by the No Miracles Argument

We know that any structural realist who accepts the NMA will endorse (b). And insofar as she is committed to (b), it is clear that the structural realist's position is not trivial.

Stepping back, it should seem completely obvious that structural realists like Worrall (1989) would endorse (b). After all, at the beginning of this paper, I cited (b) as Worrall's original motivation for adopting structural realism. But far from being an objection to the NMA proposal, the obviousness of (b) is actually the proposal's main advantage. In effect, it shows that a solution to Newman's Objection is available to any structural realist who endorses the NMA. And because the NMA is one of the standard motivations given for the view, there is no risk that the current proposal gives up the spirit of structural realism. In particular, there is no need to appeal to controversial assumptions about the naturalness of unobservable relations or the intensional relations holding between them.

I have argued that, insofar as a structural realist accepts (b), her position is not trivial. So if the Ramsey sentence is trivial, it is a problem with the Ramsey sentence as currently formulated, not a problem with structural realism. Does this mean the structural realist should abandon the Ramsey sentence?

In fact, I will argue in 4.1 that it is possible to *amend* the Ramsey sentence to reflect claim (b) and thereby deflect Newman's Objection. This proposal satisfies the PI and grounding constraints and so, at least to this extent, will uphold the spirit of structural realism. (Of course, there may be *independent* reasons for structural realists to abandon the Ramsey sentence – see 2.2.)

But it should be emphasized: I think the above response to Newman's Objection should be available even to structural realists who don't use Ramsey sentences at all. The key claim is that, so long as the structural realist accepts the NMA, we can identify a positive claim about unobservable relations that the structural realist will endorse. This claim, by itself, shows that structural realism is not trivial.

4.1 Amending the Ramsey sentence

To present the amendment to the Ramsey sentence, I will examine a toy three-sentence theory of Mendelian genetics. The first sentence asserts a simple inheritance rule: each parent plant passes on one of its two genes to the offspring plant; there is an equal chance that either one of a given parent's genes will be passed on. The second and third sentences say that a plant with a tall gene will be tall and that a plant with two short genes will be short (i.e., the tall gene is the dominant allele). I'll express this theory formally using the predicates below:

Interpreted Predicates	**Ramsified Predicates**
$Pxyz$: x and y are the parents of z	G_1xy: x has y as its first height gene
Ax: x is a tall pea plant	G_2xy: x has y as its second height gene
Bx: x is short pea plant	Tx: x is a tall gene
	Sx: x is a short gene

The theory will be formulated in a language with probability assignments. For any sentence A, '$Ch(A) = p$' says that the objective chance of A is p.[22] The language will also contain singular terms denoting facts. For any formula P, the expression $[\![P]\!]$ denotes the fact that P. For example, $[\![Tx]\!]$ denotes the fact that x is tall, $[\![G_1xy]\!]$ denotes the fact that x has y as its first height gene, etc.

The sentences of the original theory are below:

(1) $\forall a\forall b\forall c\forall p\forall q\forall s\forall t\{(Pabc \wedge G_1ap \wedge G_2aq \wedge G_1bs \wedge G_2bt) \rightarrow [(Ch(G_1cp) = 0.5) \wedge(\neg G_1cp \rightarrow G_1cq) \wedge (Ch(G_2cs) = 0.5) \wedge (\neg G_2cs \rightarrow G_2ct)]\}$

(2) $\forall x\forall y\forall z[(G_1xy \wedge G_2xz \wedge (Ty \vee Tz)) \rightarrow Ax]$

(3) $\forall x\forall y\forall z[(G_1xy \wedge G_2xz \wedge Sy \wedge Sz)) \rightarrow Bx]$

[22] For simplicity of presentation, I'm assuming an account of objective chance according to which objective chances are defined relative to some reference class or other; on such an account, objective chances need not be time-dependent. See, for example, Hoefer (2007). This choice has no bearing on my arguments; it merely allows me to present the theory with shorter sentences.

According to Newman's Objection, the structural content of the Ramsey sentence formed from (1)-(3) is (almost) trivial.[23] But I argued in the last section that the position of structural realists who accepts the NMA is not trivial: such theorists accept the further claim that the instantiation of the structurally-characterized unobservable relations is supported by the NMA. The question is how to amend the Ramsey sentence to express this substantive commitment.

To this end, I'll introduce a new one-place predicate $\mathcal{N}$ ("the NMA predicate") to both the first-order and second-order languages. The predicate is interpreted as follows:

> $\mathcal{N}x$: x is such that the NMA provides (direct) evidence for x[24]

The rules for amending the Ramsey sentence with the $\mathcal{N}$-predicate are very simple. Let $\forall x...\exists y...(P)$ be a sentence in prenex normal form from the original theory, where P is an expression involving Ramsified predicates. The first step is to amend each sentence of this form to $\forall x...\exists y..(P \wedge \mathcal{N}[\![P]\!]\}$. The second step is to Ramsify the theory as normal, *leaving the $\mathcal{N}$-predicate interpreted.*

Here is how this procedure works on the Mendelian genetics theory. First, we add the bolded $\mathcal{N}[\![P]\!]$ expression to sentences (1)-(3) to form (1′)-(3′) as follows:

(1′) $\forall a\forall b\forall c\forall p\forall q\forall s\forall t(\{(Pabc \wedge G_1ap \wedge G_2aq \wedge G_1bs \wedge G_2bt) \rightarrow [(Ch(G_1cp) = 0.5) \wedge(\neg G_1cp \rightarrow G_1cq) \wedge (Ch(G_2cs) = 0.5) \wedge (\neg G_2cs \rightarrow G_2ct)]\}\wedge \mathcal{N}[\![(\mathbf{Pabc} \wedge \mathbf{G_1ap} \wedge \mathbf{G_2aq} \wedge \mathbf{G_1bs} \wedge \mathbf{G_2bt}) \rightarrow [(\mathbf{Ch}(\mathbf{G_1cp}) = \mathbf{0.5}) \wedge (\neg \mathbf{G_1cp} \rightarrow \mathbf{G_1cq}) \wedge(\mathbf{Ch}(\mathbf{G_2cs}) = \mathbf{0.5}) \wedge (\neg \mathbf{G_2cs} \rightarrow \mathbf{G_2ct})]]\!])$

(2′) $\forall x\forall y\forall z\{[(G_1xy \wedge G_2xz \wedge (Ty \vee Tz)) \rightarrow Ax] \wedge \mathcal{N}[\![(\mathbf{G_1xy} \wedge \mathbf{G_2xz} \wedge (\mathbf{Ty} \vee \mathbf{Tz})) \rightarrow \mathbf{Ax}]\!]\}$

(3′) $\forall x\forall y\forall z\{[(G_1xy \wedge G_2xz \wedge Sy \wedge Sz)) \rightarrow Bx] \wedge \mathcal{N}[\![(\mathbf{G_1xy} \wedge \mathbf{G_2xz} \wedge \mathbf{Sy} \wedge \mathbf{Sz})) \rightarrow \mathbf{Bx}]\!]\}$

Next, we form a new Ramsey sentence by adjoining (1′)-(3′), replacing the unobservable predicates with second-order variables, etc.[25] Importantly, the $\mathcal{N}$-predicate is left interpreted. The new Ramsey sentence will be just like the old except for the addition of the bolded $\mathcal{N}[\![P]\!]$ expressions. So the new Ramsey sentence expresses both of the claims about unobservables that the structural realist is willing to endorse: (a) the original claim that there exist certain unobservable relations satisfying a certain structure,

[23] The Ramsey sentence formed from (1)-(3) will be: $\exists X_1\exists X_2\exists X_3\exists X_4(\forall a\forall b\forall c\forall p\forall q\forall s\forall t\{(Pabc \wedge X_1ap \wedge X_2aq \wedge X_1bs \wedge X_2bt) \rightarrow [(Ch(X_1cp) = 0.5) \wedge (\neg X_1cp \rightarrow X_1cq) \wedge (Ch(X_2cs) = 0.5) \wedge (\neg X_2cs \rightarrow X_2ct)]\}\wedge \forall x\forall y\forall z[(X_1xy \wedge X_2xz \wedge (X_3y \vee X_3z)) \rightarrow Ax] \wedge \forall x\forall y\forall z[(X_1xy \wedge X_2xz \wedge X_4y \wedge X_4z)) \rightarrow Bx])$.

[24] I will explain the qualification "direct" in note (viii) of 4.2.

[25] The new Ramsey sentence will be: $\exists X_1\exists X_2\exists X_3\exists X_4(\forall a\forall b\forall c\forall p\forall q\forall s\forall t(\{(Pabc \wedge X_1ap \wedge X_2aq \wedge X_1bs \wedge X_2bt) \rightarrow [(Ch(X_1cp) = 0.5) \wedge (\neg X_1cp \rightarrow X_1cq) \wedge (Ch(X_2cs) = 0.5) \wedge (\neg X_2cs \rightarrow X_2ct)]\}\wedge \mathcal{N}[\![(\mathbf{Pabc} \wedge \mathbf{X_1ap} \wedge \mathbf{X_2aq} \wedge \mathbf{X_1bs} \wedge \mathbf{X_2bt}) \rightarrow [(\mathbf{Ch}(\mathbf{X_1cp}) = \mathbf{0.5}) \wedge (\neg \mathbf{X_1cp} \rightarrow \mathbf{X_1cq}) \wedge (\mathbf{Ch}(\mathbf{X_2cs}) = \mathbf{0.5}) \wedge (\neg \mathbf{X_2cs} \rightarrow \mathbf{X_2ct})]]\!]) \wedge \forall x\forall y\forall z\{[(X_1xy \wedge X_2xz \wedge (X_3y \vee X_3z)) \rightarrow Ax] \wedge \mathcal{N}[\![(\mathbf{X_1xy} \wedge \mathbf{X_2xz} \wedge (\mathbf{X_3y} \vee \mathbf{X_3z})) \rightarrow \mathbf{Ax}]\!]\}\wedge \forall x\forall y\forall z\{[(X_1xy \wedge X_2xz \wedge X_4y \wedge X_4z)) \rightarrow Bx] \wedge \mathcal{N}[\![(\mathbf{X_1xy} \wedge \mathbf{X_2xz} \wedge \mathbf{X_4y} \wedge \mathbf{X_4z})) \rightarrow \mathbf{Bx}]\!]\})$. I've bolded the added $\mathcal{N}[\![P]\!]$ expressions.

and (b) the additional claim that the NMA provides direct evidence that this structure obtains.[26] (I will explain the qualification "direct" in note (viii) of 4.2.)

I've illustrated the use of the $\mathcal{N}$-predicate with the Mendelian theory, but the simple rule given above for the introduction of these predicates will be available in any context where our theories make claims about unobservable structure. This is because, whenever our theories make claims about unobservable structure, structural realists who endorse the NMA will claim that such structure is supported by the NMA.

4.2 Clarifying the NMA approach

In this section, I will address some questions about the use of the $\mathcal{N}$-predicate.

(i) *"Why is the $\mathcal{N}$-predicate left interpreted when Ramsifying the theory?"*

Response: If the $\mathcal{N}$-predicate was Ramsified, then the Ramsey sentence would merely assert: (a′) there exist certain unobservable relations satisfying a certain structure, and (b′) facts involving these unobservables instantiate a certain property. But this is trivial: we could simply define relations and a higher-order property that satisfy the characterization in (a′) and (b′). To successfully deflect Newman's Objection, we need the Ramsey sentence to express the *interpreted* claim that the NMA provides direct evidence for certain unobservable structure.

(ii) "*Since a Ramsey sentence with $\mathcal{N}$-predicates makes claims that go beyond structure, doesn't the introduction of $\mathcal{N}$-predicates give up the spirit of structural realism*?"

Response: This objection takes the slogan "structural realists are only willing to endorse claims about the structure of unobservables" much too literally. If a theorist only qualifies as a "structural realist" if she refuses to endorse *any* claim about unobservables that goes beyond structure, then structural realism can't be saved. But this is attacking a strawman. When we consider how (many) structural realists actually argue for their position, it is obvious that they *do* endorse a claim about unobservables that goes beyond structure: they believe that the unobservable structure is supported by the NMA. So, far from betraying the spirit of structural realism, the NMA proposal is in fact built into one of the standard motivations given for the view.

(iii) "*It would be inappropriate for the structural realist to simply stipulate that the Ramsey sentence should include $\mathcal{N}$-predicates. What justifies the introduction of these (interpreted) expressions?"*

Response: $\mathcal{N}$-predicates aren't introduced to the Ramsey sentence by mere stipulation. Nor are they introduced on the basis of the interpreted content of our scientific theories. $\mathcal{N}[\![P]\!]$ expressions assert that certain unobservable structure is supported by the NMA. So the reason these interpreted expressions can be included in the Ramsey sentence is because the structural realist accepts the NMA. I discuss this issue further when discussing the grounding constraint in 4.3.

(iv) "*The new Ramsey sentence explicitly makes claims about the No Miracles Argument. But this seems strange: our scientific theories may be supported by the NMA, but*

[26] For example, the part of the Ramsey sentence corresponding to (2′) will say: all pea plants with a certain unobservable property are tall, and that the NMA provides evidence for the fact that all pea plants with this unobservable property are tall.

they do not make claims about the NMA."

Response: The current proposal should not be interpreted as claiming that $\mathcal{N}[\![P]\!]$ expressions are part of the content of our scientific theories. In the above example, the structural realist introduced $\mathcal{N}[\![P]\!]$ expressions to the original theory's sentences in order to generate (1′)-(3′). But in introducing this predicate, the structural realist isn't claiming that (1′)-(3′) are part of the content of our scientific theory itself. The $\mathcal{N}$-predicate is introduced to form (1′)-(3′) only so that we eventually form a Ramsey sentence that expresses a certain positive, non-structural claim about unobservables: the claim that the instantiation of certain unobservable relations is supported by the NMA. The structural realist doesn't accept this non-structural claim because it is a part of her scientific theory; she accepts it because she accepts the NMA. So we should think of $\mathcal{N}[\![P]\!]$ expressions as extra-theoretical claims that the structural realist endorses about the unobservable relations posited by her theory.

It might at first sound strange to say that the structural realist's Ramsey sentence expresses additional content that wasn't a part of her original scientific theory. But this worry passes when one realizes that on the current proposal, the Ramsey sentence is no longer used to isolate the part of the content of our scientific theory endorsed by the structural realist. Instead, we are adding extra-theoretical content to the Ramsey sentence in order to reflect the structural realist's full epistemic commitments.

(v) "*But if we allow in extra-theoretical content, does the Ramsey sentence still perform its original function? Originally, the Ramsey sentence was merely supposed to express the theoretical claims that the structural realist is willing to endorse.*"

Response: To respond to this question, I will re-emphasize that what is ultimately at stake with Newman's Objection is whether structural realism is a trivial position. I have argued that, because the structural realist claims that certain unobservable structure is supported by the NMA, structural realism is definitely not a trivial position. This crucial point stands independently of whether or not we include the $\mathcal{N}$-predicate in the Ramsey sentence. So long as the structural realist is also willing to grant (extra-theoretically) that the NMA provides direct evidence for the instantiation of certain unobservable relations, her position is not trivial. Indeed, the NMA approach should be available even to structural realists who don't use Ramsey sentences at all.

(vi) *"If one accepts that the structure described in the NMA is trivial, then saying the NMA provides evidence for that structure doesn't make it less trivial. Compare: the fact that the self-identity of my computer supports the law of self-identity hardly makes the law of self-identity any less trivial."*[27]

Response: With the NMA proposal, it remains trivially true that Newman's trivializing relations satisfy structure S. But as discussed above, it is *not* trivially true that the NMA provides evidence for the existence of unobservable relations satisfying S; this shows that the relations described by the Ramsey sentence cannot be the trivializing relations that Newman had in mind. Since this non-trivial claim has been introduced to the amended Ramsey sentence via the $\mathcal{N}[\![P]\!]$ expressions, the Ramsey sentence's claims about structure are no longer trivial.

[27] Thanks to an anonymous referee for providing this example.

(vii) *Clarifying the $\mathcal{N}$-predicate*: Throughout this section, I've appealed to the intuitive idea that the NMA provides support for $[\![P]\!]$. To make this more precise, here is one way we might formalize the structural realist's No Miracles Argument:

1. If theory T does not correctly identify '$\forall x ... \exists y ... (P)$' as expressing the structure of the unobservable world, the novel predictive success of T is a miracle.
2. The novel predictive success of T is not a miracle.
3. Therefore: T correctly identifies '$\forall x ... \exists y ... (P)$' as expressing the structure of the unobservable world.
4. $\forall x ... \exists y ... (P)$

The above argument helps clarify the interpretation of the $\mathcal{N}$-predicate: in asserting that the NMA provides evidence for $[\![P]\!]$, the structural realist is asserting that there is an argument of the above form.

(viii) *"Direct" evidence*: To explain the restriction to "direct" evidence in the interpretation of the $\mathcal{N}$ predicate, consider the following argument[28]: "It would be a miracle for our theory T to have novel predictive success if it didn't even correctly state at least how many unobservable entities there are. So the NMA provides evidence that the unobservable world has a certain cardinality c. But if the unobservable world has cardinality c, it is trivial to infer that $[\![P]\!]$ obtains, since we can simply *define* relations satisfying this structure. So even with the added NMA clause, the Ramsey sentence is satisfied so long as its observable content is true and the unobservable domain has a certain cardinality."[29]

This argument shows that there are two senses in which the NMA might be said to provide evidence for $[\![P]\!]$. In one sense, the NMA provides evidence for $[\![P]\!]$ *in virtue of* providing evidence that the unobservable domain has cardinality c; this is the sense operative in the previous paragraph. But the structural realist will also say that there is a sense in which the NMA provides more *direct* evidence for $[\![P]\!]$. This can be seen from the fact that, according to the structural realist, it is *because* the NMA provides evidence for $[\![P]\!]$ that we can infer, by logical entailment, that the unobservable domain has cardinality c.[30] Compare: it is *because* the NMA provides evidence for a certain spatial arrangement of planets that we are able to infer (by logical entailment) that there are eight planets. (Of course, once we infer that there are eight planets, it is trivial to define relations over them; this is the sense in which the NMA provides indirect evidence for unobservable structure).

[28] Thanks to an anonymous referee for pressing this point.

[29] This "trivial" interpretation of the NMA is incompatible with the argument as presented in note (vii). The trivial interpretation supports the existence of *many* structures, since there are many ways to define relations on the unobservable domain. But in note (vii), premise 1 presupposes that T identifies a unique structure.

This incompatibility may be enough to exclude the trivial interpretation, since the $\mathcal{N}$-predicate is explicated in terms of the argument version given in note (vii). But in this note, I will further clarify the $\mathcal{N}$-predicate in a way that excludes the trivial interpretation.

[30] Thanks to Matthew Kotzen for the suggestion to distinguish these two senses of evidential support in terms of their different orders of explanation.

The latter, more "direct" sense of evidential support is what interests the structural realist, which explains the qualification in the interpretation of the NMA predicate.[31]

(ix) *Modes of presentation.* Here is a final objection: "Consider the arbitrary theory $\hat{T} \equiv \forall x(J_1 x \to I_1 x)$, where J_1 and I_1 are unobservable and observable predicates, respectively. After following the NMA proposal, the structural realist obtains the Ramsey sentence: $\hat{R} \equiv \exists\Phi(\forall x(\Phi x \to I_1 x) \wedge \mathcal{N}[\![\forall x(\Phi x \to I_1 x)]\!])$. The NMA proposal faces a dilemma based on whether there is one or more variable assignments satisfying the $\mathcal{N}$-clause in $\hat{R}$.

Suppose first that there is a *unique* variable assignment satisfying the $\mathcal{N}$-clause; for example, suppose the variable assignment in question is the one that assigns the unobservable relation J_{17} to "Φ". Then the only way that $\hat{R}$ as a whole could be true is if J_{17} is such that the NMA provides evidence that the instantiation of *it* is sufficient for the instantiation of I_1. But this seems tantamount to abandoning structural realism. The structural realist denies that we can know the nature of the properties filling the structural roles outlined by our physical theories. But this horn requires that the NMA provides evidence that J_{17} *in particular* plays this role.

Now suppose instead that there are variable assignments satisfying the $\mathcal{N}$-clause *other* than the one just mentioned. Then Newman's Objection strikes again, since the only such assignments will be ones that assign Newman's trivializing relations to "Φ". (This would only fail to be the case if the structural realist postulated multiple properties that could map to "Φ", which would seem completely unmotivated.)

So the dilemma is: either the NMA proposal is incompatible with structural realism, since the $\mathcal{N}$-clause supports beliefs about J_{17} in particular. Or else it presents no escape from Newman's Objection, since the $\mathcal{N}$-clause is also satisfied by Newman's trivializing relations."[32]

Response: We can think of the above dilemma as a choice over whether the $\mathcal{N}$-operator is factive or not (i.e., whether the truth of $\mathcal{N}$x requires that x actually obtains). I'll now show that the structural realist can respond to either horn of the objection.

Horn 1: Intuitively, the structural realist's motivation for endorsing $\hat{R}$ over $\hat{T}$ is to leave open a larger set of epistemic possibilities about the nature of the unobservable property in question. With $\hat{T}$, this property is specifically identified as J_1. But with $\hat{R}$, it is epistemically possible that *other* properties fill the role in question. Perhaps Φ is J_1, but perhaps it is J_2, or J_3, or J_4, etc.

Now, on a factive reading of the $\mathcal{N}$-operator, there will be only one variable assignment satisfying the $\mathcal{N}$-clause in $\hat{R}$. This is because the structural realist denies that the NMA provides (direct) evidence for *more than one* (actually instantiated) unobservable property. But intuitively, it does not follow that the structural realist can identify J_{17} *in particular* as the property supported by the NMA. After all, we just saw that $\hat{R}$ leaves open which member of the set $\{J_1, J_2, J_3, ...\}$ is supported by the NMA.

[31] *N.b.*: in using the term "direct", there is no need to assume that any *specific* proposition is the conclusion of the structural realist's NMA. The important point is that the NMA's support for $[\![P]\!]$ in the intended interpretation is comparatively more direct than its support for $[\![P]\!]$ in the trivial interpretation.

[32] Thanks to an anonymous referee for pressing this objection.

So what has gone wrong? The objection on this horn fails because the sense in which the NMA provides support for J_{17} is not a sense that allows the structural realist to identify J_{17} *as* J_{17}. Here, it is important to recognize the different modes of presentation under which the structural realist might form beliefs about J_{17}. In endorsing $\hat{R}$, the structural realist cannot infer: 'The NMA provides direct support for the fact that J_{17}'s instantiation is sufficient for I_1's instantiation'. Instead, the structural realist is only justified in inferring sentences such as: 'The NMA provides direct support for the fact that the instantiation of the property satisfying the open sentence $\forall x(\Phi x \rightarrow I_1 x) \wedge \mathcal{N}[\![\forall x(\Phi x \rightarrow I_1 x)]\!]$ is sufficient for I_1's instantiation'. This latter mode of presentation does not put the structural realist in a position to identify the nature of the unobservable property; this property could be any member of the set $\{J_1, J_2, J_3, ...\}$.

Horn 2: Of course, the structural realist can grant that there is also a sense in which the NMA might be said to incrementally confirm the hypothesis '$\forall x(J_i x \rightarrow I_1 x)$' for *each* member of $\{J_1, J_2, J_3, ...\}$ (including those members which are not actually instantiated). On this nonfactive reading, there will be many variable assignments satisfying the $\mathcal{N}$-clause, such as the ones assigning the properties J_1, J_2, J_3, etc. to "Φ". Of course, since only one of $\{J_1, J_2, J_3, ...\}$ is actually instantiated, only one of these properties will satisfy the first conjunct[33] of the Ramsey sentence — this ensures that the Ramsey sentence as a whole is not trivial.

Because, on this horn, there are many properties satisfying the $\mathcal{N}$-clause, it is not the case that the NMA supports belief about the role of one unobservable property in particular. So the alleged problem with horn 1 is avoided. But nor is the structural realist acting desperately in adopting this stance, since on the non-factive reading of the $\mathcal{N}$-operator, the properties satisfying the $\mathcal{N}$-clause need not be actually instantiated. For this reason, the structural realist is not forced to say (in accordance with referee 1's suggestion) that Newman's trivializing relations must satisfy the $\mathcal{N}$-clause. So adopting this horn of the dilemma does not land the structural realist back in Newman's Objection.

4.3 Satisfying the constraints

I'll now show that the NMA approach satisfies the two constraints from section 3.

Grounding constraint: With both the intensional operator and domain restriction approaches, there is a worry that the structural realist needs to rely on her theory's interpreted content. But there are no such worries for the NMA proposal. To endorse a certain $\mathcal{N}[\![P]\!]$ expression, the structural realist only has to accept the corresponding instance of the NMA. So we see that the epistemic grounds for $\mathcal{N}[\![P]\!]$ expressions are *extra*-theoretical.

PI Constraint: In 3.1 and 3.2, I explained why the domain restriction and intensional operator approaches may be threatened by the PI constraint. Each of these proposals introduces non-structural content to the Ramsey sentence, but it is not clear why this

[33] Here, we should regard $\hat{T}$ and the first conjunct of $\hat{R}$ as implicitly claiming that some unobservable entity instantiates the unobservable relation in question. Otherwise, the first conjunct of $\hat{R}$ (and $\hat{T}$ as well) would be trivial for a completely unrelated reason: its being an empty universal generalization.

non-structural content isn't itself threatened by the Pessimistic Induction. Understanding the link between the $\mathcal{N}$-predicate and the NMA explains why the NMA proposal does not fall prey to the same objection. Whenever a structural realist introduces a $\mathcal{N}$-predicate, it is in a context where certain unobservable structure is supported by the NMA. So if the PI threatens $\mathcal{N}$-predicates, the PI directly threatens the NMA. But if the NMA has no force, this is an independent worry for structural realists like Worrall, not a worry that has anything specifically to do with Newman's Objection.

4.4 The NMA approach vs. alternative approaches

As described in 3.1 and 3.2, many theorists have found the intensional operator and domain restriction approaches unconvincing. This is because these responses require controversial assumptions about the naturalness of unobservable relations or the higher-order relations instantiated by these unobservables. It is not clear that the structural realist should be willing to endorse these assumptions. The comparative advantage of the NMA approach is its epistemic humility. Endorsing the NMA approach only requires that a theorist endorse the No Miracles Argument. In this sense, the NMA solution is built into the standard motivations for adopting structural realism. Because of its minimal commitments, the NMA approach is able to satisfy the PI and grounding constraints.

Now, it may be the case that the worries raised for the alternative responses to Newman's Objection can be overcome. For example, perhaps the structural realist can successfully argue that the posited unobservable relations are natural or that these unobservables stand in certain intensional relations.[34] Even so, there would still be an important dialectical role for the NMA proposal. Given the skepticism expressed towards the domain restriction and intensional operator strategies in the literature, it is valuable to have a response to Newman's Objection that doesn't rely on these controversial assumptions. We can think of the NMA response as creating space for a kind of minimal version of structural realism that doesn't require commitments to claims about naturalness or the higher-order relations between properties. This is why, in the introduction, I referred to the NMA approach as a "simpler" response to Newman's Objection.

It is also interesting to consider whether the NMA approach could be combined with one of the alternative approaches. For example, perhaps one could deflect Newman's Objection by restricting the second-order domain to "properties whose instantiation is supported by the NMA". Or perhaps one could introduce an sentential operator expressing the relation of "NMA support". If these strategies were successful, we could view the NMA proposal as a specific form of the approaches considered in section 3 — a version that requires weaker assumptions and that is guaranteed to satisfy the PI and grounding constraints. Whatever the structural realist decides, the No Miracles Argument is what does the substantive work in responding to Newman's Objection.

[34]One might even try to use the NMA to support these positions. For example, one might try to argue that the NMA justifies us in believing the properties posited by our theories are natural. I think the arguments from 3.2 show that this isn't the case, but this is at least a possibility worth considering.

4.5 Reliance on the NMA

I've argued that the NMA proposal avoids a variety of controversial assumptions. But the proposal does not avoid all controversy since the NMA in closing, it is important to acknowledge one potential cost: the NMA is *itself* controversial. For example, van Fraassen (1980, 40) claims that the success of our scientific theories is not explained by their truth, but is instead explained by the fact that only empirically successful theories survive the competition of scientific practice. As a second example: Howson (2000, ch. 3), Lipton (2004, 196-198), and Magnus & Callender (2004) each argue that a theory's empirical success does not suggest its approximate truth since there is no independent way of knowing the base rate of approximately true theories.

Proponents of the NMA have offered responses to these and other objections. For example, Musgrave (1988, 242) argues that, while van Fraasen's Darwinian account explains why (generally speaking) only successful theories survive, it does not explain why a certain *particular theory* has been successful. Worrall (2009) provides a response to the base rate arguments.

It is outside the scope of this paper to assess these arguments. So one can view this paper as establishing the following conditional: *if* the NMA argument is sound, then the structural realist can successfully deflect Newman's Objection. Since it is very common to cite the NMA as a motivation for structural realism[35], this conditional thesis is an important result.

5 Conclusion

In this paper, I've argued that the structural realist can respond to Newman's Objection by appealing to the No Miracles Argument. If a structural realist acknowledges the force of the NMA, she does not merely accept the trivial claim that certain unobservable relations satisfy a certain structure. She will also accept the substantive claim that the instantiation of these relations is supported by the NMA. But if this is the case, then it cannot be the case that these unobservable relations are the trivializing relations cited by Newman.

I've argued that the NMA approach is able to satisfy two constraints on responses to Newman's Objection: the PI and grounding constraints. Another advantage of the proposal is its epistemic humility: the NMA solution is built into one of the standard motivations for adopting structural realism in the first place. I showed how the structural realist might amend her Ramsey sentence using the $\mathcal{N}$-predicate so as to reflect her full epistemic commitments.

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