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Prizewinning Essays

First Prize

Is structural realism the best of both worlds?

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Introduction

Structural realism is the view that we should accept not scientific theories' descriptions of unobservable entities (electrons, waves, genes, etc.), but their structural contents (Ladyman 2002, p.261). Worrall argues that structural realism is the 'best of both worlds' in the scientific realism vs. anti-realism debate: it reconciles the realist's view that scientific theories have been so empirically successful that they cannot possibly be miraculous accounts of phenomena, with the anti-realist view that even the most successful theories have come to be rejected over time. Is structural realism the best of both worlds? I answer this question with a qualified 'no'. While it undoubtedly captures salient features of both sides, it fails to account for others.

1. Structural Realism

The scientific realist's No Miracles Argument (NMA) may be formulated as follows:

(1) The predictive success of science does not have satisfactory explanations in the absence of realist interpretations of theories.

(2) Realist interpretations provide adequate explanations of scientific success.

(3) By abduction, scientific realism is probably true.[1]

In other words, theories have historically yielded such strong, novel, and unexpected predictions that were not "built into" their central doctrines that it would be a miracle if natural phenomena were *not* as these theories describe. For instance, it could not have been a coincidence that Newtonian mechanics predicted the existence of undiscovered planets, nor could it have been sheer luck that Fresnel's wave model of light predicted that a bright spot would appear at the center of a circular shadow if a parallel beam of light were shone on a round object. Inferences to the best explanations suggest that these theories are true rather than miraculous, which, in turn, indicate that unobservables exist.

Anti-realists, however, counter that NMA cannot explain why new theories often reject and radically depart from their predecessors. Kuhn argues that theory changes sometimes occur within radical paradigm shifts—scientific revolutions wherein entire groups of theories, laws, formulas, terms,

[1] Dawid and Hartmann 2017, pp.4063-4064

instruments, methods, assumptions, standards, and theoretical entities that constitute a new paradigm replace the current (and often incommensurable) paradigm wholesale, such as when Ptolemy's geocentric model of the universe was overthrown by Copernicus' heliocentric model. Theory changes are 'changes in world view' (1996, p.111) and akin to 'religious conversions' (p.154) wherein the acceptance of one theory logically entails the rejection of another. Laudan, another anti-realist, gives the examples of how aether and phlogistic theories were once seemingly accurate but were eventually discarded, especially their 'evidently non-referring' central theoretical terms (1981, p.33). Based on these cases, the anti-realist's pessimistic meta-induction argument goes, there are inductive grounds to expect that even our best theories at present will eventually suffer the same fate and therefore cannot be true either (Rosenberg 2012, p.152).

To this objection Boyd replies that at least new theories 'resemble current theories with respect to their accounts of causal relations among theoretical entities' (1973, p.8). Worrall complains that this principle can arbitrarily be taken too far. Maybe some theories vaguely overlap in some respects, but not all. Surely some theories are so fundamentally different that no amount of 'rational reconstruction' can establish resemblance between them (1989, pp.115-116). He does, however, concede that theories *do* retain certain aspects across theory change, but these are matters of *form* rather than content. He gives the example of how Fresnel's wave theory was replaced by Maxwell's electromagnetic theory. Even if Fresnel's characterization of the nature of light was rejected, his differential equations were preserved by the latter, which explains why his wave theory enjoyed predictive success (pp.117-118). Although Fresnel mischaracterized light, he correctly described its mathematical *structure*: that light consists of vibrations at right angles through a mechanical medium in the direction of the transmission of light through the medium. Hence, while Fresnel did not correctly describe the nature of light, he accurately described relations between optical phenomena (p.119).

Structural realism has the advantage of explaining both horns of the dilemma. On one hand, it preserves NMA by explaining that theories have been successful not because scientists have serendipitously divined the nature of unobservables, but because they have adequately explicated mathematical relationships that scaffold reality. Thus, unlike the full-blooded realist who is committed to (i) the metaphysical thesis that unobservables objectively exist as described, (ii) the semantic thesis that terms like 'electron' are genuinely assertoric and referring, and (iii) the epistemic thesis that mature theories about unobservables are true or approximately true, the structural theorist carries a lighter burden. On the other hand, structural realism accounts for theory change without explaining how unobservables were carried over from older to newer ones. Unlike the full-blooded realist, who must justify why we had reason to believe that older theories were true, she must simply elucidate how theories share mathematical structures. For instance, she need not explain where gravity figures into a curved spacetime, only how Newtonian mechanics can be absorbed or remain 'continuous' with Einstein's theory of relativity, which is more feasible. This is how Worrall concludes that structural realism represents the best of both worlds.

2. Three Objections

Despite structural realism's success, I find it wanting in three respects. Firstly, structural realism does not capture the fact that scientists are more ambitious than it depicts them to be. Like Van Fraasen, Worrall seems committed to the view that science merely 'saves the phenomena' or 'aims to give us theories which are empirically adequate' (van Fraasen 1998, p.1069). Unfortunately this does not always square with scientific behavior. Oftentimes, scientists not only explicate the empirical structures of phenomena, they also probe into the nature of unobservables underlying them. For instance, as early as 1964, Higgs, Englert, and four other scientists posited the existence of unobservable entities to explain why certain particles have mass. They did not merely try to express the relationships between them in mathematical terms; in fact, they even theorized about these entities' properties, such as their spin and physical composition. It took nearly forty years' worth of experiments for them to arrive at their crowning, Nobel-winning achievement, the discovery of the Higgs boson particle, which signaled the existence of the Higgs field—an invisible energy field throughout the universe that imbues other particles with mass. If structural realism is true, then why did these scientists act not only as if they could establish empirical adequacy, but a kind of entity realism that full-blooded realists accept?

Secondly, speaking of entity realism, structural realism occasionally comes close to collapsing into some limited version thereof. Worrall writes that the structural realist, unlike the entity realist, 'insists that it is a mistake to think that we can ever "understand" the *nature* of the basic furniture of the universe' (p.122). This may be so, but entity realists distinguish between the epistemological claim that unobservables can be understood from the ontological claim that they exist. Hacking, who is of the latter group, argues that their existence can at least be validly inferred. In particular, he states that 'experimental entities' (e.g. electrons) must exist because they can be manipulated like tools to study other phenomena—including the very relationships the structural realist investigates. If a structural realist is studying the structure of the electron cloud model, for example, it is a short distance for him to ask the next question: what is causing this cloud? There must be *something* that exists, even if unobservable. Additionally, Hacking writes, 'The experimenter is convinced of the reality of entities some of whose causal properties are sufficiently well understood that they can be used to interfere *elsewhere* in nature' (1998, p.1157). Therefore, the cleavage between entity and structural realism may be so thin in some cases that the latter may implicitly entail the former. Thus, Worrall misconstrues NMA: the "miracle" to be explained is not just that theories accurately describe structures, but that they allow us to deduce sufficient basic truths and properties that we can instrumentalize them.

Finally, structural realism underestimates the force of the anti-realist's argument from theory change. Worrall claims that the general structure of theory T_N may be preserved by theory T_{N+1}, albeit in different terms. Perhaps this holds in some cases, but it becomes significantly harder to illustrate when multiple theory changes have occurred within a scientific field. The structural realist must also show that T_{N+1} and T_N retain the same structure from T_{N-1}, T_{N-2}, and so on, otherwise, a break in the line of theories risks conceding that some previously widely accepted link in the chain *was* wrong. For instance, it might be possible to show that Einstein's mechanics retained something from Newtonian mechanics, but can it be shown to have also existed in the mechanics of Descartes, Galileo, Philoponus, all the way back to Aristotle (or wherever the regression ends)? This seems dubious and unlikely.

Conclusion

Structural realism reconciles *some* aspects of both worlds, but to say that it marries the *best* of them is a misnomer because it gives up too much of either. Maybe some contemporary formulation of structural realism will enjoy more success, but that is beyond our scope today.

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