Realism and Its Representational Vehicles*

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Introduction: The Hegemonious Semantic Approach

Accoridng to Halvorson, echoing Suppe from almost thirty years ago (Suppe 1989, p. 3), '[w]ithin a few short decades, the semantic approach [SA] has established itself as the new orthodoxy' (Halvorson 2012).[1] Part of the reason why the SA has come to be seen as so well entrenched is that it has proved itself adaptable to both realist and anti-realist stances. Here I want to focus on its adoption by structural realists, including myself, who have done so on the grounds that it wears its structuralist sympathies on its sleeve (Ladyman 1998). Despite this, the SA has been identified as standing in tension with the ontological commitments of the so-called 'ontic' form of this view and so I plan to explore that tension before discussing the usefulness of the SA in framing scientific representation before concluding with a discussion of the implications of the ontological status of theories and models themselves.

The Semantic Approach and Structural Realism

The debate over structural realism is extensive and a number of more or less stable positions have now crystallized. So-called 'epistemic' structural realism states that all that we can *know* is the structure of the world and that we must remain agnostic about the nature of things over and above, or 'behind' that structure (Worrall 2012). This faces the criticism that insisting on the epistemic inaccessibility of the nature of things runs counter to the scientific ethos of the last few hundred years (Psillos 2001) or, at the very least, sounds suspiciously Kantian. The alternative 'ontic' form argues that in addition to the above claim, we should accept that all that there *is*, is the structure of the world (Ladyman 1998; Ladyman and Ross 2007). Thus, in effect, the nature of things gets cashed out in entirely structural terms.

This stance has twin motivations: first, as a response to the infamous Pessimistic Meta-Induction (PMI) and the supposedly problematic nature of inter-theoretic ontological continuity in general (and here the partial structures form of SA has been deployed to capture 'diachronic' inter-theory relations as well as 'synchronic'); secondly, as a way of accommodating the implications of quantum

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[1] However, whereas Suppe's intention was to praise the semantic approach, Halvorson's is to damn it! For a response see van Fraassen, 2014.

physics which render the metaphysics of objecthood problematic (French and Ladyman 2003).

This ontic structural realism (OSR) then divides into two sub-forms: 'Moderate' OSR, which retains a notion of object but only as metaphysically 'thin' or as having 'contextual' identity, sufficient to allow them to function as relata in the structure (Esfeld, and Lam, 2011; Ladyman, 2009; French and Ladyman 2011); Eliminativist OSR, which eliminates objects in favour of what it claims is a wholly structural metaphysics (French, 2014). Note, first of all, that the SA is deployed in this context to *represent* structure at the level of the philosophy of science, as it were, whereas said structure is *presented* within the theory (for example, via group theory in the case of modern physics) at the level of the science itself (see French 2014 Ch. 5 for further discussion). Of course, insofar as the SA is set-theoretic, what we have is an exemplification of Suppes' famous exhortation that we (philosophers) should use the same representational devices as science itself – that is, mathematics. Here the distinction is only between the way structure is presented within a theory, for scientists' purposes, and how that structure is then represented, for the purposes of the philosophy of science.

The second point to note is that in the case of both Moderate and Eliminativist OSR we adopt an iterative approach towards the elements of the set within the SA (that is, the A in $<A, R>$). The idea is as follows: we begin by designating the relevant set in 'everyday' scientific terms, as the set of hadrons for example. We then argue that all the properties of the hadrons must be understood in structural terms (drawing in the way that spin and mass drop out of the Poincaré group of space-time symmetries, for example), thereby effectively reconceptualising the particles as elements or features of the relevant structure(s). The moderate structural realist then insists that we can still retain a notion of objecthood here, only that it is metaphysical 'thin' in that the very identity of the particles qua objects is given in 'contextual' or structural terms. The eliminativist, on the other hand, pushes the line that with all that there is about the particles, including even their identity, cashed out in such terms, there is no need to retain a notion of object; thus, particles-as-objects are eliminated in favour of particles-as-features-of-structure. Note further that such a metaphysical move does not block physicists, or us, from *talking about* hadrons etc., as there are further metaphysical devices that allow us to continue to do that, while denying that we are talking about objects (again see French 2014).

But how can we use set theory to represent the structure that Eliminative OSR takes ontologically seriously? Here I shall consider two answers: the first insists that we simply can't and so we have to shift to a new representational framework; the second maintains that we can, as long as we adopt a particular manoeuvre that can be traced back to Poincaré.

The first answer admits that the formal framework of SA must be abandoned when it comes to eliminativist OSR, since it still retains objects as the A. If one were to accept that, then perhaps the most obvious alternative is category theory, as advocated by Bain, Landry, Rickles and others (see Bain 2013; Landry 2007). The overall strategy is then as follows: we take the objects of the category to represent the models of theory and thus the structure we are interested in. The definition of

an element (of an object of the relevant category) within the category theoretic framework then eliminates explicit reference to such elements, that is - physical objects. There are then two possible sub-strategies that one can adopt:

Representation: translate all set-theoretic descriptions into category theoretic terms, thereby yielding a reformulation of the set theoretic notion of element of set in such terms.

Presentation: construct the relevant category theoretic models of physics 'directly' (see, for example, Baez, 2006).

Adopting the first, we obtain a description of the relevant physical structure at the level of the philosophy of science that does not contain reference to objects; adopting the second, we achieve the same but at the level of the science itself.

Unfortunately, however, there are serious concerns with this alternative. The first is that category theory in effect operates at too high a level of abstraction to serve our realist purposes. In particular, it is too abstract to be of use in responding to the PMI or in capturing inter-theoretic relations in general (see French 2014 Ch.6). Now the advocate of category theory may respond along the following lines: '… we are discussing an equivalence between two theories, whose models will generally have different types of mathematical structures respectively, and thus do not live in the same category.' (Teh, forthcoming). However, although this may be true when it comes to quantum gravity, say, it is surely not the case for other examples such as the shift from Fresnel's theory of light through to Maxwell's electromagnetism (Worrall 1989). And even if we grant, as we should, that a thorough-going structuralism needs to accommodate a range of mathematical structures, such as topological spaces, vector spaces, differentiable manifolds, Boolean algebras, groups and so on, which 'live' in different categories, one might insist that the partial structures form of SA can capture the relevant inter-relationships between mathematical and physical structures perfectly adequately (see Bueno, French, Ladyman 2002).

A further and perhaps more biting worry is that the above category theoretic strategies do not actually eliminate the relevant objects (see Lam and Wuthrich, 2014; Teh, op. cit.). Thus it has been argued that objects are eliminated from only some 'models' of the translated theory or they are eliminated in name only.[2] Furthermore, relations (as usually understood) are eliminated also, which is not quite what the ontic structural realist wants. And finally, whatever notion of structure we end up with is not unproblematic, as category-theoretic structure is basically characterised in terms of category theoretic morphisms holding between category theoretic objects and these are not the same as relations between elements (of such category theoretic objects) which is what the structural realist is concerned with (so in effect we return to the first concern above).

[2] However, this point does not bite so hard, as it obviously depends on what one means by 'in name only'. If that means, eliminates objects in a metaphysical sense but not in the everyday physicists' sense of particle, then the advocate of OSR may cry 'That's good enough for me!'.

Of course, further developments may assuage these concerns. Certainly, a core issue is whether the notions of relata and relations that we are concerned with here must be seen as fundamentally set-theoretic in a way that underpins the SA but undermines eliminativist OSR.

Let's consider the second answer. We recall that the general issue for eliminativism is how to talk about that which one ultimately eliminates from one's ontology (here we might look at eliminativism in the philosophy of mind; see Rosenberg, forthcoming). Again, one might adopt an iterative strategy: we begin with a particular domain of discourse, namely the elementary particles. As a first iteration, we represent the situation set theoretically (broadly and simply, of course) as follows: <*A, R*>, where *A* designates the set of particles and *R* the relations that we take to hold between them. In a second iteration, we then reconceive that representation in structuralist terms by effectively reading <*A, R*> ontologically from right to left, taking the *A* to be entirely characterised – their properties and even their identity – in terms of the *R*; or to put it another way, taking all the features of the *A* to be 'grounded' in the *R*. The eliminativist then maintains that the *A*, *as objects*, can then be dispensed with from our metaphysics. So, we write the <*A, R*> from left to right, of course, but we are invited to read it, ontologically, from right to left. Note two things: first, that this iterative approach retains the 'two-sorted' conception inherent to set-theory but effectively divides the sorts across iterations or levels. And secondly, it is not only the *A* that are reconceptualised but also the *R*, as these have to be conceived of not as relations that hold 'between' the *A*, with the implication that the *A* have some prior or independent existence from the *R*, but as features of the structure (of the world), such as laws and symmetries, that yield the properties that are then associated with (and outwith the structuralist framework, said to be possessed by) the *A*. The point is, we introduce something for representational purposes that we then ontologically reconceive and eliminate altogether.

One might well ask at this point whether such a manoeuvre is acceptable. Thus, as part of a broadly nominalist response to claims that mathematical entities are indispensable in scientific explanations, Melia has argued that we can regard such objects as offering a kind of explanatory scaffolding that can then be dismissed ontologically (Melia, 2000). Furthermore, and more generally, it is not the case that our ontological commitments must be read off the representation as written. As Azzouni has urged, even if we follow a Quinean reformulation, with its associated mantra of 'to be is to be the value of a variable', it is not necessary to take quantifier commitment to yield ontological commitment – the former supports at best only a 'thin' form of commitment, whereas much more is required to underpin the kind of commitment sought be the realist (see Azzouni and Bueno, forthcoming). Again the general point is that representational form is not necessarily the appropriate guide to such ontological commitment.

So, coming back to the manoeuvre itself, one can still avail oneself of the set-theoretic resources of the SA, while avoiding commitment to the elements of the set *as objects*. Hence, there may be no need to seek an alternative representational framework for structural realism. Nevertheless, there are other concerns associated with the SA in the realist context more generally.

Realism and Representation

The origins of the SA lie in Tarskian model theory of course and this has led to concerns about the dual use of formal, set-theoretic models to both underpin truth (as correspondence) and to represent theories and models in science (Chakravartty, 2001; Thomson-Jones, 2006). One way of responding to such concerns is to adopt Suppes' strategy of distinguishing between the 'extrinsic' perspective, from which theories can be characterised as families of (set theoretic) models (related via partial isomorphism etc.) and the 'intrinsic' one, from which theories are seen as objects of epistemic attitudes, such as belief (da Costa and French 2003). On the former, the role of the models is *representational* and as the well-known slogan of the SA goes, to *present* a theory is to define its class of models directly. On the latter view, the role of models is that in terms of which relevant sentences are satisfied yielding truth à la Tarski. Thus, as van Fraassen puts it, models 'look in two directions at once'.

Now it is only if theories are *identified* with set-theoretic models that we have a problem but unfortunately this is a common assumption regarding the SA (consider the title of Halvorson's critique, for example). The whole debate that followed is shaped by this assumption that the SA takes theories *to be* set-theoretic, an assumption that has perhaps drawn strength from van Fraassen's famous claim:

'... if the theory as such, is to be identified with anything at all - if theories are to be reified - then a theory should be identified with its class of models.' (van Fraassen, 1989, p. 222)

But note, that's a big 'if' (see the discussion in da Costa and French 2003)! And one option is to deny the antecedent and refuse to identify theories with anything – but I'll get to that shortly.

So, if one adopts Suppes strategy, the question arises, what *is* a theory then? If both the set-theoretic and propositional characterisations are merely different perspectives, useful for different purposes, what exactly are theories themselves? This is a question that is sharpened in the current context where the realist's traditional reliance on reference has given way to the invocation of representation as the appropriate framework for describing the relationship between theories and the world. Accounts of this framework have drawn heavily on examples from the philosophy of art, particularly in painting and depiction more generally and perhaps that has helped strengthen the idea that representation requires some*thing* that represents, with that thing being the depiction when it comes to art, and the theory, as an object, in science.

So, what kinds of things might a theory or model be? Here are two well-known examples.

Theories as Abstracta

So, if a theory is a family of models according to the SA, how should we conceive of the latter? Giere argues that models should be taken to be abstract entities that satisfy a certain theoretical definition and are related to their target systems via a theoretical hypothesis (Giere 1988, p.80ff).. And they are abstract in two ways: first, they are abstract insofar as they are not physically realized. So, in this sense they are like mathematical entities. Secondly, they are abstract in that they are only partially specified; so, Newton's Laws refer to forces, masses, accelerations, velocities, positions, and times, but not to any specific objects or quantities. (Giere 2008, p.5).

Now there are well-known problems with abstract entities, not least how it is that we come to *know* them. Here those problems have a particular hue, as theories are standardly regarded as the sorts of things that scientists discover. But if they are ultimately abstract entities, *how* are they discoverable? Does our scientific mind's eye traverse the (Platonic) realm in which they exist, lighting on certain ones that can then be developed heuristically and subjected to confirmation or falsification? And in that case, are they there eternally, just waiting to be discovered?

Popper, for example, thought not. Famously he consigned theories to his 'World 3' which was distinct from the worlds of material entities and minds. But this world was open to two-way causal interaction; theories could affect us (Popper's claims on this score are less than convincing) and we can effect them – we can create and change theories, for example (Popper 1978). Also in World 3 are works of art like *Hamlet* and Beethoven's *Ninth Symphony* and Popper's view foreshadows that of Thomasson who suggests that such artworks can be regarded as 'abstract artefacts' in the sense that although they lack a spatio-temporal location, they are still created, come into existence, change, and may cease to exist (Thomasson 1999; Thomasson 2004). It is through their creative activities that artists bring such artworks into existence, and their continued existence depends on the artists' intentionality.

At this point a number of questions pop up: does the artwork come into existence at the moment the artist thinks of it? Or does it come into existence in proto-form at that point and is subsequently changed as the artist develops her conception (think of Beethoven composing his 9th over 6 years!). Related questions arise if we export this conception to the philosophy of science: are we to conceive of Einstein's General Theory of Relativity as coming into existence over a period of years, emerging from the shadows in some sense, or as a sequence of theory-stages that develop into the full blown entity through the force of Einstein's intentions? Perhaps these questions can be answered satisfactorily, but here is the fundamental problem with this sort of account: how does engaging in a certain practice, artistic or scientific, or following a certain heuristic move, *create* an artefact that is abstract? In the case of a concrete artefact, such as a painting or a physical model, like Crick and Watson's tinplate and wire model of DNA, one can answer this question, not least because the practices and moves considered will embody certain causal relationships that one can understand as effecting the final product, namely the painting or model. How is that effecting established in the case of abstract artifacts? Here we face the problem again of how the abstract can be related to the concrete in such a way that the latter can effect changes in the former and Thomasson and Popper owe us some account of how we can bridge that gap, between the practice

and the entity (for further exploration of these concerns and possible responses, see French forthcoming).

Theories as Fictions

Continuing the exploration of connections between the philosophy of art and the philosophy of science, some have suggested that theories and models should be seen as akin to works of literature and thus should be regarded as *fictions* (see Frigg and Hartmann, 2006). This view is motivated not just by the claim that models are creations of human imagination, just like novels and plays, but also by the thought that like the latter, models have a 'life' or rather, internal structure, of their own which can be explored and developed and which can yield surprising results.

Thus Frigg takes models to be objects in the sense that Sherlock Holmes or Frodo are objects – namely objects of our imagination (Frigg 2010). Drawing on Walton's view of literary fictions as representational in the sense of functioning as a props in certain games of make believe, (Walton 1990), model descriptions should also be seen as props, with the relevant rules given by that description, together with the relevant background theory, the assumed mathematics and so on (Frigg 2010). This description, and the associated rules, may become fleshed out or otherwise developed as time goes on, so this account can accommodate the shift from a partially baked idea to a more solid suggestion to something about which the question can be asked, 'does this correspond to the target system?' (ibid., p. 260).

However, Toon argues that Walton's antirealism about fictional characters sits uneasily with Frigg's account (Toon 2012, pp. 57-59). Consider: according to the latter, model $\mathcal{M}$ represents some real system $\mathcal{S}$ if and only if $\mathcal{M}$ denotes $\mathcal{S}$ and there is some 'key' that tells us how facts about $\mathcal{M}$ can be translated into facts about $\mathcal{S}$. But if one imports Walton's anti-realist stance and applies it to models, then, strictly speaking, there can be no facts about $\mathcal{M}$, and no relevant relation can be established between models and target systems.

Now Toon sees Frigg as offering an 'indirect' account of modelling, whereby scientists modelling a system are taken to be describing an imaginary model system, which can then be compared to a fiction. Toon, by contrast, argues for a 'direct' approach, according to which scientists simply imagine things about real systems. So, consider what is involved in modelling a bob on the end of a spring, undergoing simple harmonic motion (Toon 2012, pp. 38ff): idealisation yields a 'prepared description' of the spring which *represents* it – following Walton's view – by prescribing imaginings about it (ibid.). Just as the passage from HG Wells' novel *The War of the Worlds* that imagines St Paul's cathedral having been blasted by the Martians represents St Paul's by requiring us to so imagine certain things about it, so the prepared description of the spring, plus the associated equation of simple harmonic motion, represent it by virtue of requiring us to imagine that the bob is a point mass, air resistance is zero, the spring exerts a linear restoring force, and so on. Hence, statements such as 'the bob oscillates sinusoidally' should be understood not as assertions about some model-system ('the bob and spring system') but as about what the model prescribes us to imagine and when we make such utterances we are engaging in certain acts of pretence.

This is an interesting account that deserves more consideration than I can give it here (see again French forthcoming). Nevertheless, there are a number of concerns with it. First of all, how are we to understand representation on this account, standardly understood in terms of a relation holding between a theory or model and the target system (see French 2003)? On Toon's account, *M* is a model-representation if and only if *M* functions as a prop in a game of make-believe (2012, p. 62) and thus prescribes the relevant imaginings (see also pp. 81-82). Thus, to state the obvious perhaps, his view of representation in science draws on representation in works of fiction, rather than on representation in paintings, and consequently moves away from the standard relational view. But then this loses many of the advantages of such a view: in particular, it allows us to characterise and grasp the way inferences can be drawn within the model and then exported across to the target system, allowing us to draw conclusions about the latter (Bueno and Colyvan 2011).

Secondly, and more generally, there is the worry that fictions, as the product of imagination, are arbitrary in a way that scientific theories are not – after all, not just anything goes (cf. Nolan, 2011). Of course, one can say the same about literature – genres and sub-genres have rules and conventions that authors may defy at their peril. Likewise, when it comes to models, adopting Toon's schema, not any old story will serve as the model fiction, as there are heuristic constraints that shape the model in certain well-known ways. Note here the importance of such constraints and practice which in effect carry the burden, from our perspective, of delineating acceptable models within Toon's framework. A broader, related concern runs as follows: if there had been no Conan Doyle, there would have been no Sherlock Holmes; more generally, if there were no humans, or sentient creatures, there would be no stories at all. If models are fictions, then it would follow that we would have to say something similar: if there were no Einstein, there would be no General Relativity and if there were no humans in general, there would be no theories.

Now, of course, this does not imply that there would be no curved space-time or whatever. We are not talking about whatever it is that theories purportedly refer to or represent but rather whether the theories themselves would exist or not. So, if there had been no Einstein, would there have been no GR? Famously Hilbert was supposed to have been on the verge of publishing his version of General Relativity, when Einstein 'got there' before him and in general the phenomenon of multiple discovery might provide some reassurance that even if certain individuals had not existed, the relevant theories would still have been imagined (on the fictionalist account). Nevertheless one might be sceptical of multiple discovery as a phenomenon within the history of science, noting that, for example, Wallace's theory of evolution was not, in fact, the same as Darwin's, nor were Lorentz's or Poincaré's accounts the same as Einstein's Special Theory of Relativity. As for Hilbert and GR, setting aside the contentious priority issue, it has been claimed that although Hilbert 'had' the field equations, he and Einstein not only proceeded via very different trains of thought but developed their accounts along very different philosophical and epistemological lines, so that the former's theory, insofar as it was a unification of gravity with electromagnetism, was not, in fact, the same as GR (see for example Brading and Ryckman 2008). What is at issue here is whether a theory

just 'is' the relevant equations, as Hertz is supposed to have said about Maxwell's electromagnetism, or, more generally, what the identity conditions for theories might be. As we'll see shortly, I feel no compunction to address this issue.

And of course, the fictionalist will surely agree that indeed, if Einstein had not existed, GR may not have been proposed, either not in the form by which we know it or, perhaps, not in any form – science may just have halted with classical physics, for all sorts of reasons. Likewise for the more general question: if there had been no human beings, then there would have been no novels, no literature and similarly, no scientific theories, since these are all regarded as products of human imagination. Of course on this view one has to be careful with talk of scientific discoveries – features of the nature of the world may be discovered (if one is a realist) but theories are created and insistence on discovery here runs the risk of begging the question.

But finally, there are further concerns to do with the nature of human imagination and whether it can in fact be extended to theories as the fictionalist insists. As Weisberg remarks, '… while it is relatively easy to imagine the content of finite, deterministic, individualistic models like a population of genes undergoing assortment, it is unclear that this procedure could generalize to more complex cases.' (2013 p. 63). In particular, how might probabilistic interactions be imagined, when any given fictional scenario can only be a single instantiation of such interactions (ibid.)? Given the prevalence of probabilistic features in many models in current science, from physics to the social sciences, this appears to be a real problem. The notion of imagining brought over from the philosophy of literature and specifically Walton's ideas of props in games in make-believe appears heavily biased towards *visual* imagination, not surprisingly. But now a concern arises whether this is appropriate for the scientific context, especially when we move away from the more straightforward examples such as simple pendula or weights on a spring. One might appeal to some kind of distinction between 'sensory' and 'conceptual' imagination, with the former associated with forming a mental image and the latter with entertaining certain possibilities but it is not clear how helpful this is – how is conceptual imagination distinct from the kinds of conceptual explorations that advocates of alternative approaches will also acknowledge? And what would be the role of 'props' in such imagination? Could it really be characterised in terms of a game of make-believe?

These are questions that fictionalism will have to answer if it is to be more widely accepted as a way of understanding the nature of theories but as I've briefly indicated, the abstract artefacts view also faces challenges. It may well be that these challenges can be met but elsewhere Vickers and I have proposed a way forward that cuts straight through this knotty tangle of issues and it does so by appealing to a form of eliminativism again.

Theory Eliminativism

The core slogan here is "There are no such things as theories!" (French and Vickers 2011; see also Vickers, 2013).

The view derives from a double-importation: first from metaphysics into the philosophy of music, then from there into the philosophy of science. We've already

touched on the ontological status of musical works, and views range from insisting that they are abstract artefacts to the claim that they should be regarded as the sum of all their performances (see the relevant section on ontology in Kania 2014). Cameron (2008a) presented a novel way of cutting through all the arguments and counter-arguments in this debate by drawing on metaphysical nihilism which offers a framework within which one can effect a reduction in one's ontological commitments. There are two crucial features to note. The first concerns the introduction of a form of 'truthmaker' theory, which draws our attention to what it is for a proposition to be true. On the standard understanding of this account, the truthmaker for the claim '*x* exists' is always x. However, Cameron's approach allows for the truthmaker of the sentence to be something other than '*x*', so the claim that '*a* exists', for example, might be true according to some theory without *a* being an ontological commitment of that theory (Cameron [2008b], p. 4).

The second feature urges us to take these truthmakers to lie at the most fundamental level of our ontology – namely, that characterises how the world is at its most fundamental level. One may then draw a distinction between two different types of statement: those of everyday English, say, and that describes the world at its fundamental level (the language here is sometimes referred to as 'Ontologese; Cameron [2008a] p.300f.). Thus the statement, '**there are statues**', uttered as one that purportedly describes the fundamental level, is false, because at that fundamental ontological level, there are no statues. However, the everyday claim, 'there are statues' is true, but not in virtue of the fact that **there are statues**, again at the fundamental level, but in virtue of the fact that there are elements of our fundamental ontology that are arranged in such a way as to yield what we refer to, at the everyday level, as statues (*ibid*., p.301). And of course, we can also apply this distinction to OSR: thus the eliminativist structural realist might insist that '**there are particles**' is false, because at the most fundamental level there are no particles *qua* objects, only structures, whereas 'there are particles' is true, in virtue of the fact that there are structures 'arranged' such as to yield the features we associate with particles (that is, 'via the relevant symmetry groups for example; see French 2014 Ch. 8).

This nihilist move can then be applied to theories themselves (French and Vickers 2011) and to ease the reader into such a stance, let me return to fictionalism.

Thus with regard to the issue of whether a character in a novel – Sherlock Holmes for example – exists, Thomasson writes,

'Our literary practices . . . definitively establish the existence conditions for fictional characters—that is to say, they establish what it takes in a given situation for there to be a fictional character. … (A. Thomasson 2003)

Thus, worries over whether Sherlock exists or not are misguided, for what it is for him to be is given entirely by the relevant literary practice. Cameron then adapts this to his nihilism: 'we appeal to something to do with the literary practice rather than the fictional character itself when specifying the truthmaker for claims concerning the existence of, and properties of, the fictional being.' (Cameron

forthcoming). And in particular he insists that if '*a* exists' is made true by some truthmaker *x*, then metaphysical concerns about the nature of *a* should simply evaporate. The only issue now is whether we admit *x* into our fundamental ontology. When it comes to novels, this fundamental ontology concerns the afore-mentioned literary practices (ibid, p. 6).

We can then make a third importation and adopt such a nihilist stance within the philosophy of science and towards theories, *qua* entities of some kind or other: '**there are theories'**, asserted in the language of the fundamental level, is false, although 'there are theories' uttered by scientists and philosophers of science is true and it is made so by the relevant truth-makers. The question then, of course, is what exactly are the features of the world that ultimately make true our talk of theories? And the answer, by analogy with fictional characters, is scientific practice; so (paraphrasing Cameron and following Thomasson) we appeal to something to do with the scientific practice rather than the theory itself when specifying the truthmaker for claims concerning the existence of, and properties of, that theory. The task then is to pinpoint those features of practice that we are happy to accept as elements of our 'fundamental ontology' that can give an adequate grounding to our talk about the existence of, and properties of, theories.

So, consider claims that are true *of* theories, such as 'Quantum mechanics is an extremely successful theory'. This is made true by the practices involved in deriving novel predictions, testing etc. and, crucially, it should not be understood as requiring commitment to some entity, whether abstract artefact or fiction, that is called 'quantum mechanics'. Or consider the claim, 'Quantum mechanics is an elegant theory' – this is made true by those features of theoretical practice determined to possess or be associated with the relevant aesthetic quality. Now consider claims that are true *in* theories, such as 'According to standard quantum mechanics, undisturbed systems obey a linear dynamic'. This is made true by certain features of theoretical practice that are determined to possess certain mathematical features. Again, there is no commitment required to 'quantum mechanics' as an entity, however conceived.

What about the worry that if there were no people, there would be no practices, and hence no theories? Well, of course my answer is blunt: there never were any theories! But a more sensible worry might be, if scientific work stops, in a certain area, so there were no (current) practices, could we still talk about theories, in that area – an obvious answer would be to turn to the history books an insist that such talk is made true by past practices. That is how we can continue to make claims about 'the theory of phlogiston' for example, even though the relevant practices have long since ceased.

The primary virtue of this account is that we don't have to worry about how we have access (creative or otherwise) to theories as abstract entities, nor whether our imaginations can be reasonably said to stretch to the 17-dimensional spaces and complex stochastic models. We can pull in our ontological horns as philosophers of science and still continue to make all the claims about theories that we always have, *and*, furthermore, this account encourages us to look closer to the actual practices of science, which is surely a good thing!

But now lets return to the theme of realism, whether structural or otherwise

– how can we accommodate the kinds of claims made in that context?

Realism without Theories

So, what about statements like 'theory T is true (or approximately so)'? What would be the truthmakers in the relevant practice that make such claims true? Here we have to be a little careful as such statements are some of the core claims of realism and a constructive realist would not accede to them. Thus, the relevant practice can't be scientific practice alone but must include those inferential moves that realists appeal to in order to justify their claims. Hence we can say that such claims as the above are made true by certain truthmakers in scientific *and* philosophical practice, where such practice might include the No Miracles Argument, for example. However, it has been argued that realists and anti-realists differ over the elements that can be taken to be included in such practice – to such a degree that they can be regarded as effectively adopting different stances. Thus there may be acute differences in what constitute the truthmakers for such claims as the above. But that's ok, because, as just noted, constructive empiricists, at least, are going to insist that we should not make such claims to begin with. Recent stance oriented approaches to the realism-antirealism debate are hence only going to be a problem if they imply that different kinds of realist adopt radically different perspectives on what constitutes the relevant set of truthmaker practices, and certainly that has not yet been demonstrated.

Of course one might now balk at this extension of eliminativism to the truth of claims about the truth of theories! Not just anti-realists but some realists will argue that it is just not appropriate to take a philosophical position such as realism to be itself true – or at least not in the standard, correspondence sense, for what would this position correspond to? Or, thinking of representation again, if theories are said to be true, or approximately so, by virtue of the fact that they represent certain features of the world, what is it that realism could be said to represent in this way? One option here might be to take a pluralist view of truth itself, with truth-as-correspondence appropriate for certain domains of discourse but not others (see Wright 1999). In that domain of discourse that concerns the realism-antirealism debate, in which realist claims about the truth of theories are themselves taken to be true (by realists) by virtue of certain elements of philosophical practice, perhaps the appropriate notion of truth is something much more deflationary, like warranted assertibility.

Now, what about representation? Here, it would seem, we can make similar moves: statements such as 'Theory T is a good/accurate/faithful/whatever representation of target system S' are made true by certain features of the relevant practices, where again, these will cover both scientific and philosophical practices, insofar as 'faithful' representation, for example, goes beyond empirical adequacy. Again we might wonder whether the framework of truth as correspondence and truthmakers are entirely appropriate for this domain of discourse. But there is a further concern: talk of representation suggests, at least, there is a that which is doing the representing; that is, some*thing* that stands at one end of the representational relationship. And eliminativism about theories denies this.

One option would be to insist that there is strictly nothing standing in the representational relationship; theories are not like paintings, from which so many examples and counter-examples have been drawn; and representation is an inappropriate device for capturing the kinds of claims we want to make. An alternative line would be to suggest that what is standing in that relationship is a meta-level construction that we, as philosophers of science (or scientists when they are in philosophical mode), deploy when we endeavour to make sense of scientific practice and its implications for our understanding of the world. The idea then is that when we, philosophers (or again, scientists or others thinking philosophically), talk (seriously) about theories representing some target system, we have in mind, if perhaps only implicitly, some way of 'representing' theories themselves and these systems. If one is an adherent of the syntactic approach, then the theory can be said to be 'represented' logico-linguistically and a referential relationship with the relevant elements of reality established in those terms. If one is an advocate of the SA, then, likewise, one 'represents' the theory at the meta-level of the philosophy of science in terms of set theory and also 'represents' the way the theory latches onto the world via the formal notion of (partial) isomorphism, which of course then relates to the formal representation of the target system (in order to sidestep protests that set theoretical notions cannot relate mathematical structures and physical ones). However, I've put the word represent in scare quotes because there is nothing for either the logico-lingustic set of propositions or set theoretical structure to actually represent. Instead, these devices should be understood as constructions that we philosophers of science use to do our jobs. Thus, the object-level relation of representation does not hold between the relevant features of the world and theory, per se, but between those features and our logico-linguistic or set-theoretic or whatever, *construction*. Furthermore, statements about *that* representation are made true by the appropriate features of history and philosophy of science practice.

Conclusion

As philosophers of science, we deploy various resources, such as the SA, in order to do what we want to do as philosophers and thus to achieve our aims. These resources come with various benefits and disadvantages and one can argue for a pluralistic view that suggests we deploy whatever available resources are most appropriate for the job at hand. When it comes to capturing inter-theoretic or theory-data relations, like many people I think the SA offers the best set of tools for the job. But it would be a mistake to move from that view to the claim that theories *are* set-theoretic in some sense.

Furthermore, new developments in realism put pressure on those resources, as in the case of ontic structural realism and representation. However, there are ways of resisting or, at least, sidestepping that pressure via the appropriation of further resources, including some that are metaphysical or methodological. We can for example cut through concerns about what sorts of things theories are and end that particular debate by importing a form of nihilism and associated truthmaker theory from metaphysics. This allows us to continue talking about theories without

being committed to them as abstract entities or whatever. From this perspective the SA can be see as no more than a construction, deployed by us as philosophers of science to achieve our own ends and certainly not as constitutive (either of theories or the structure of the world). The focus then shifts back, as it should, to the practices that ground the truth of the claims we make about theories, rather than on the ontological nature and identity conditions of the latter. Just as ontic structural realism frees us from a dependence on outdated metaphysics, so this view of theories themselves should free us from relying on often inappropriate comparisons with artworks and encourage us to pay more attention to the issues that really matter.

References

Azzouni, J. and Bueno, O. True Nominalism: Referring versus Coding. British Journal for the Philosophy of Science, forthcoming

Baez, J. (2006). Quantum Quandaries: A Category-Theoretic Perspective. In D. Rickles, S. French & J. Saatsi (Eds), The Structural Foundations of Quantum Gravity, (pp. 240-265) Oxford: Oxford University Press

Bain, J. (2013). Category-theoretic structure and radical ontic structural realism. Synthese, 190, 1621–1635

Brading, K. and Ryckmann, T. (2008), Hilbert‟s "Foundations of Physics": Gravitation and electromagnetism within the axiomatic method. Studies in the History and Philosophy of Modern Physics 39, 102-153

Bueno, O. and Colyvan, M. (2011). An Inferential Conception of the Application of Mathematics. Nous, 45, 345–74.

Bueno, O., French, S. and Ladyman, J., (2002). On Representing the Relationship between the Mathematical and the Empirical', Philosophy of Science 69, 452-473.

Cameron, R. (2008a). There Are No Things That Are Musical Works. British Journal of Aesthetics, 48, 295-314.

Cameron, R. (2008b). Truthmakers and Ontological Commitment.Philosophical Studies, 140,1-18.

Cameron, R. (forthcoming), How to be a Nominalist and a Fictional Realist', In C. Mag Uidhir (Ed) Art and Abstract Objects, Oxford: OUP

Chakravartty A. (2001) The Semantic or Model-Theoretic View of Theories and Scientific Realism. Synthese, 325-345

Da Costa, N. and French, S., (2003), Science and Partial Truth, New York: Oxford University Press

Esfeld, M.and Lam, L. (2011). Ontic Stuctural Realism as a Metaphysics of Objects. In A. Bokulich and P. Bokulich (Eds), Scientific Structuralism. Boston Studies in the Philosophy of Science. (pp. 143–59) Dordrecht: Springer.

French, S. (2003). A Model-Theoretic Account of Representation
Philosophy of Science, 70, 1472-1483.

French, S. (2014) *The Structure of the World*, Oxford: OUP 2014

French, S. (forthcoming), *There Are No Such Things as Theories*

French, S. and Ladyman, J., (2003). Remodelling Structural Realism: Quantum Physics and the Metaphysics of Structure: A Reply to Cao. Synthese 136: 31-56

French, S., Ladyman, J., (2011), 'In Defence of Ontic Structural Realism. In Bokulich, A. and Bokulich, P, (Eds), Scientific Structuralism, (pp. 25-42) Dordrecth: Springer,

S. French & P. Vickers, (2011). Are There No Such Things as Theories?. British Journal for the Philosophy of Science 62, pp. 771-804

Frigg, R. (2010). Models and Fictions. Synthese 172 pp. 251 – 268

Frigg, R. and Hartmann, S. (2012). Models in Science The Stanford Encyclopedia of Philosophy (Fall 2012 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2012/entries/models-science/>.

Giere, R. N. (1988). *Explaining Science: A Cognitive Approach*. Chicago:
University of Chicago Press.

Giere, R.N. (2008). Models, Metaphysics and Methodology. In S. Hartmann, C. Hoefer, and L. Bovens, (Eds) Nancy Cartwright's Philosophy of Science. London: Routledge, pp. 123-126.

Halvorson, H. (2012). What Scientific Theories Could Not Be. Philosophy of Science 79. 183–206

Kania, A. (2014). The Philosophy of Music. The Stanford Encyclopedia of Philosophy (Spring 2014 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2014/entries/music/>.)

Ladyman, J. (1988). What is Structural Realism? Studies in History and Philosophy of Science 29. 409–24

Ladyman, J. (2009) Scientific Structuralism: On the Identity and Diversity of Objects in a Structure. The Proceedings of the Aristotelian Society 81. 23–43

Ladyman, J. and Ross, D. (2007). *Everything Must Go*, London: Routledge

Lam, L. and Wuthrich, C. (2014). No categorial support for radical ontic structural realism. British Journal for the Philosophy of Science. doi: 10.1093/bjps/axt053

Landry, E., (2007). Shared Structure Need not be Shared Set-Structure. Synthese 158. 1-17.

Melia, J. (2000). Weaseling Away the Indispensability Argument', Mind 109 : 455-479

Nolan, D. (2011). Modal Fictionalism, The Stanford Encyclopedia of Philosophy (Winter 2011 Edition), Edward N. Zalta (ed.), URL = http://plato.stanford.edu/archives/win2011/entries/fictionalism-modal/

Popper, K.R. (1978). *Three Worlds: The Tanner Lectures on Human Values*, Utah: University of Utah Press.

Psillos, S., (2001), Is Structural Realism Possible? Philosophy of Science, 68: S13–S24.

Rosenberg, A. (forthcoming). Eliminativism without Tears.

Suppe, F. (1989) The Semantic Conception of Theories and Scientific Realism. Urbana, University of Illinois Press.

Teh, N. (forthcoming), Categorical Generalization and Physical Structuralism' British Journal for the Philosophy of Science

Thomasson, A. (1999). Fiction and Metaphysics. Cambridge: Cambridge UP.

Thomasson, A. (2003). Fictional Characters and Literary Practices. The British Journal of Aesthetics 43: 138-57

Thomasson, A. (2004), The Ontology of Art. In P. Kivy (Ed) The Blackwell Guide to Aesthetics. Oxford: Blackwell.

Thomson-Jones, M. (2006) Models and the Semantic View. Philosophy of Science 73 524-535

Toon. A. (2012) Models as Make-Believe, Palgrave-Macmillan.

van Fraassen, B. (1989), Laws and Symmetry, OUP

van Fraassen, B. (2014). One or Two Gentle Remarks about Hans Halvorson's Critique of the Semantic View Philosophy of Science, 81. 276–283

Vickers, P. (2013) Understanding Inconsistent Science, OUP

Walton, K. (1990) Mimesis as Make-Believe, Harvard University Press

Weisberg, M. (2013) Simulation and Similarity, OUP.

Worrall, J., (1989) Structural realism: The Best of Both worlds? *Dialectica*, 43: 99–124. Reprinted in Papineau, D., (Ed.)., *The Philosophy of Science*, Oxford: Oxford University Press, 139–165.

Worrall, J., (2012) Miracles and Structural Realism. In Landry, E., and Rickles, D., (Eds.), Structural Realism: Structure, Object and Causality, (pp. 77-98) Springer

Wright, C. (1999). Truth: A traditional debate reviewed. Canadian Journal of Philosophy, 24: 31–74