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Semi-realism, Sociability and Structure

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Abstract Semi-realism offers a metaphysics of science based on causal properties. Insofar as these are understood in terms of dispositions for specific relations that comprise the concrete structure of the world it can be regarded as a form of structural realism. And insofar as these properties are 'sociable' and cohere into the groupings that comprise the particulars investigated by science, it captures the underlying intuition behind forms of entity realism. However, I shall raise concerns about both these features. I shall suggest that dispositionalism is not an appropriate metaphysics for modern physics and that 'sociability' should be understood in terms of the coherence revealed by symmetry principles. I hope to show how we can retain the virtues of semi-realism while dispensing with the problematic elements by recasting it in more thoroughly structuralist terms.

1 Introduction

A Metaphysics for Scientific Realism brings together the core elements of 'entity' and 'structural' realisms, and underpins the resulting 'semi-realism' with a 'metaphysics of science' based on causal powers. The kinds of structures we should be realist about are concrete and conceived of in terms of relations holding between first-order, causal properties of objects (2007, p. 41). Those that are 'causally linked to the regular behaviours of our detectors' are the 'detection' properties (ibid., p. 47), which are to be distinguished from the 'auxiliary' properties. The former are those '… in whose existence one most reasonably believes on the basis of our causal contact with the world.' (ibid.); whereas the latter have an unknown ontological status, since detection based grounds are insufficient to determine whether they are causal or not. It is in terms of the detection properties that we come to identify the entities that are the focus of the

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'entity' realist, and it is these properties that provide the minimal interpretation of the mathematical equations favoured by the structural realist.

As Busch notes (Busch 2009, p. 369), Chakravartty has been prominent in helping to shape the debate over structural realism and my own work in this area has hugely benefitted from and been shaped by, his criticisms and suggestions (see for example French 2006 and forthcoming b). In what follows I shall focus on certain central aspects of the above metaphysics and use these to further develop the differences between semi-realism and ontic structural realism (OSR).

The bridge between the first two parts of the book—that which sets out semi-realism and that which develops an appropriate metaphysics underpinning this stance—is represented by the following passage:

> Causal properties are the fulcrum of semirealism. Their relations compose the concrete structures that are the primary subject matters of a tenable scientific realism. They regularly cohere to form interesting units, and these groupings make up the particulars investigated by the sciences and described by scientific theories. The continuous manifestations of the dispositions they confer constitute the causal processes to which empirical investigations become connected, so as to produce knowledge of the things they study. (2007, p. 119).

Hence, it is not just that we can infer the natures of things from the structure but that the latter is encoded in the former (2007 p. 43). This is the case because the above first-order causal detection properties should be understood in terms of dispositions for specific relations which comprise and are recognised as the above concrete structures. I shall try to indicate that this dispositional element is both problematic and unnecessary.

The second aspect concerns the regular coherence that leads to those groupings we designate as scientific kinds and particulars. This is captured by the suggestive notion of 'sociability' and I shall argue that although this gives semi-realism an advantage over other attempts to elaborate a metaphysics for science, it should be further articulated in structural terms.

2 Doing Away with Dispositions

Let's begin with the question why we should ascribe dispositions to objects in general and the objects of physics in particular. Many accounts begin with the standard example of a glass vase or window having the disposition of being fragile, leading to an obvious worry that a metaphysics appropriate for macroscopic objects is being illegitimately imported into the micro-realm. Thus consider reductive moves that insist that to say something is disposed to give a response to some stimulus is just to say that it possesses a property that would cause it to give that response if it were to undergo that stimulus. These are seen as open to standard objections such as 'finkishness', which hinge on the introduction of non-permanent dispositions such that the relevant counterfactual remains true in the absence of the disposition in question (see Martin 1994). Such moves crucially depend on the

intuition that objects may gain or lose their powers but it is, at the very least, not at all clear that this holds for the fundamental objects of physics and their equally fundamental properties. Similar considerations apply to the deployment of so-called deviant processes whereby the relevant response is obtained by means other than those related to the stimulus cited in the conditional (Smith 1977); again there appears to be little scope for such deviance in the micro-realm.

Semi-realism cannot be held guilty in this regard but nevertheless we can ask whether we need to introduce dispositions in order to understand physical properties and, in particular, whether an alternative account might retain the virtues of semi-realism without them. Chakravartty asks,

> Why and how do particulars interact? It is in virtue of the fact that they have certain properties that they behave in the ways they do. Properties such as masses, charges, accelerations, volumes and temperatures, all confer on the objects that have them certain abilities or capacities. These capacities are dispositions to behave in certain ways when in the presence or absence of other particulars and their properties. (2007, p. 41).

Thus the property of mass, for example, confers the disposition on a body to be accelerated under applied forces. And it is via the linkage between such dispositions that causal activity is produced.

The crucial move in the above passage is from the claim that the explanation for the behaviour of particulars is the properties they have, to the assertion that these properties confer upon these particulars certain 'abilities or capacities'. Indeed, according to the dispositional identity thesis (DIT) that Chakravartty supports, the identity of causal properties is given by the dispositions they confer. If dispositions were to be eliminated in favour of categorical properties, then something over and above such properties would have to be sought to underpin the relational links so crucial for semi-realism.

One option would be to take laws as providing such an underpinning, where the laws are understood realistically. In this case, it would be the laws that would function as the ultimate explanans for the behaviour of particulars, in the sense of governing the latter. Mumford (2004) has raised concerns about such a view and in particular has pointed out that in order to govern, there must be some kind of metaphysical 'gap', as it were, between the laws and the relevant properties, such that the identity of the latter cannot be given in terms of the former.[1]

If, on the other hand, laws are taken to be 'internal' to the properties in some way, or supervenient upon them (see for example Bird 2007), then Mumford insists, they cannot be said to govern appropriately. In that case, it is unclear what role the laws have and Mumford insist they should be dispensed with. On his view, the relevant regularities should be understood as determined by modally informed properties that can be conceived of as bundles of powers and it is these that provide the relevant necessary connections (2004).

[1] This assumes that quiddity based accounts are metaphysically abhorrent. Psillos (2006) attempts to make these more palatable by allowing properties to acquire and lose powers, but this suggestion is also problematic, as we shall see.

Chakravartty wants to maintain a neutral stance in such metaphysical debates, in order to keep semi-realism as broad and attractive as possible (2007, p. 142). With regard to the relationship between laws and properties, he takes them to be 'flipsides of the same coin' (ibid. p. 147): the laws are effectively encoded in the dispositions conferred by the properties and the identity of the latter is given in terms of the laws they participate in. At this point, however, a worry may emerge as to whether this 'package' can be stable. Mumford, again, would insist that if the laws really are encoded in the dispositions then, qua metaphysically substantive entities, they should be dispensed with. That would undermine the aims of semi-realism, or at the very least, result in a position that is not quite so broad or attractive.[2]

Alternatively, if they are retained, as metaphysically substantive, over and above the properties and the dispositions they confer, then the metaphysical gap re-appears and one may wonder how laws can determine the identity of the latter properties and dispositions. One way of evading this kind of dilemma is to adopt a structuralist perspective on laws that sets them as primary and the relevant properties as emergent, in a sense (see Cei and French, forthcoming); however, my focus in this paper lies elsewhere.

Let's return to the question of the grounds for introducing dispositions. One suggestion is that these are provided by the physics:

> Physics tells us what result is apt to be produced by the having of gravitational pull or of electromagnetic charge. It does not tell us anything else about these properties. In the Standard Model the fundamental physical magnitudes are represented as ones whose whole nature is exhausted by their dispositionality: that is, only their dispositionality enters into their definition. Properties of elementary particles are not given to us in experience: they have no accessible qualitative aspect or feature. There is no 'impression corresponding to the idea' here. What these properties *are* is exhausted by what they have a *potential for doing*, both when they are doing it and when they are not. (Molnar 1999, p. 13).

There are a number of claims being made here. The first has to do with what physics 'tells us'. This is not straightforward of course. First of all it is not clear what it is that is doing the 'telling'. Typically, claims that, for example, theories tell us about objects are made on the basis of an explicit Quinean reconstruction and it is open to debate whether such reconstructions should be taken as canonical. Secondly, it is not at all clear that under such a reconstruction the theory could be said to tell us that said objects possess dispositions. Of course, they do not tell us much more about properties than that they are inter-related in certain ways and they certainly do not tell us that they have quiddities or whatever (not least, in both cases, because the language of theories is metaphysically 'thin') but further interpretation is required to go from such inter-relationships to the possession of dispositions.

[2] Mumford is entirely happy to dispense with scientific laws, arguing—in addition to the above metaphysical considerations—that the wide diversity of laws, law-like principles and so forth in science cannot be captured by an unitary account of them (2004).

One could adopt the same perspective as operationalism: thus one might say that since we can only measure or even detect charge, say, by bringing in a test charge, the most appropriate way of understanding this property is in terms of the disposition to manifest (the Coulomb force) when presented with the appropriate stimulus (the bringing in of the test charge). Indeed, one could try to justify such a move by insisting that we should tailor our metaphysics to fit our epistemology. However, although I am generally in favour of such cloth-cutting, I think there's a difference between using it to push such items as hidden 'natures' or, indeed, quiddities, out of our ontology, and using it to bring in another particular set, such as dispositions. In particular, a structuralist ontology arguably provides a more tight fitting set of metaphysical clothes.

The second claim made in the above quote is that the 'Standard Model' of elementary particle physics—that is the currently accepted model of the electro-weak and strong nuclear forces—represents the relevant fundamental physical magnitudes in entirely dispositional terms. Again, it is not clear how this might be justified. One thought might be that over and above what was just said about what theories 'tell' us, the Standard Model, by incorporating quark confinement, tell us that certain elementary objects and their associated properties cannot be 'observed' or accessed, even in the extended sense in which electrons etc. might be said to be observed or accessed. Hence, even more so than in the latter case, we can only detect such objects via the effects they produce. But, again, it is not clear what this 'even more so' amounts to here. Quarks, just like electrons, are only accessible via long (defeasible) chains of effects and all that quark confinement tells us is that we cannot detect or access single quarks. It is not at all clear that this provides any additional grounds for dispositionalism.

Furthermore, if one were to let quark confinement tell us something metaphysical, there appear to be just as strong grounds for saying that it tells us to do away with the underlying objects; thus again, an alternative interpretation of this theoretical feature can be given. Finally, even granted that properties of elementary particles are, of course, not given to us in experience, further steps are required to warrant the claim that what they *are* is exhausted by what they have a *potential for doing*.

There is a further concern with dispositionalism in this context that I shall mention here and return to below. This has to do with the role of symmetry principles in physics, which is absolutely fundamental. Thus, to take again the example of the Standard Model, this is typically defined in terms of the local $SU(3) \times SU(2) \times U(1)$ gauge symmetry. One certainly cannot talk of what physics 'tells us' without taking into account such symmetries. However, this may present problems for a dispositionalist account. Dispositional essentialists in particular appear to be stymied, since their essentialism leaves no metaphysical room for the kinds of constraints on properties and laws that symmetry principles represent (see Cei and French forthcoming). Many don't mention symmetry, even while they're happy to draw on other aspects of current science in support of their view. Bird, at least, does face up to the issue (2007) but he tries to eliminate symmetry by taking it to be part of the background structure that he sees modern physics as rejecting (e.g. time and quantum gravity). This is clearly a problematic move but fortunately I

think semi-realism is better placed to respond to this challenge, through the notion of 'sociability', although, as I shall indicate below, I think it pushes the semi-realist even further towards structuralism.

If we grant that physics does not tell us straightforwardly that there are dispositions, it may be argued that the alternative is deeply unsatisfactory. Typically this is taken to be that the relevant properties should be understood as first-order, monadic, and categorical (Molnar op. cit., p. 14). However, what then accounts for the behaviour of the elementary objects? One option is to take this behaviour as a 'brute fact', but then the properties appear to have instrumental value only (Molnar op. cit. p. 15) and if physics tells us that the fundamental properties of elementary particles are all dispositional, then, the argument goes, 'this instrumentalism about the properties will carry over into anti-realism about the particles themselves.' (ibid.) And if we accept a realist ontology of macroscopic objects and their dispositions, then we end up with a strange kind of dualism. If we further take the history of physics to support a compositional framework for both objects and properties, then incoherence threatens: physical systems would be composed of non-existent parts and their properties would be ontologically dependent on non-existent fundamental properties. To avoid this, we are urged to adopt either full-blown realism or anti-realism, with the former embracing dispositions all the way down, as it were.

I think this is mistaken and not just because the issue of compositionality is problematic in this context, or because one might reject a dispositional account of the properties of macroscopic objects and hence adopt a coherent realism that does not involve fundamental dispositions. My concern is with the initial supposition that without dispositions, the behaviour of objects must be taken as brute. One could of course explain this behaviour in terms of the relevant laws, taken as 'governing' in the appropriate sense. Again we would have to face Mumford's dilemma, but as indicated, a structuralist account sidesteps this (see again Cei and French forthcoming). In particular, on such a view we could avoid the inference 'If there is no electric charge (but only 'electric behaviour'), then there is no electron.' (Molnar op. cit. p. 15) and in general the worry that instrumentalism about properties carries us to anti-realism about the objects since, according to OSR, we can still be scientific realists about both but deny that they constitute metaphysical entities in any robust, non-dependent sense.

Nevertheless, I agree that the framework of monadic, categorical properties is problematic.[3] And my reason has to do with an underlying assumption to the effect that although physical properties feature in our theories as inter-related, via laws etc., we can conceive of them as monadic and 'intrinsic'. Typically we are invited to get an initial handle on what is meant here by considering a given object and then conceiving of a world in which there is just that object; the properties of the object that are retained in such a possible world where there are no other objects are those that we might take to be monadic and 'intrinsic'. Such exercises in conception can

[3] Dorato also argues that quantum mechanics supports dispositionalism because quantum states are best seen as relational and indefinite (Dorato 2007). However, being relational does not imply being dispositional and equating the disposition-manifestation relationship with that which holds between being indefinite and being definite, at the very least extends the meaning of dispositional beyond that which is being considered in this paper (see McKitrick 2008).

be problematic in the current context insofar as they abstract away the relevant physics in order to achieve an appropriate state of affairs on the basis of which metaphysical judgment can be passed on the status of certain properties, this judgment then being held to remain in force when we shift back from the aforementioned state of affairs to that which is fully clothed with the relevant physics.

This raises general issues about the relationship between metaphysics and science but the central point is that when it comes to such conceptions, as Hacking said in a related context, 'bland assertion is not enough.' (Hacking 1975, p. 251). What else one needs to specify obviously depends on the project one is engaged in; at the very least some form of spatio-temporal background might be introduced (French 1995). Likewise, if the project is to establish whether a property such as mass, for example, should be counted as intrinsic, then abstracting away the framework of General Relativity is tantamount to metaphysical bland assertion and leaves the project open to the sorts of charges levelled by Ladyman and Ross (2007). (And of course how we should understand mass in the context of General Relativity is a delicate issue.)

The point, again, is that conceiving of a possible world in which there is a 'lonely' object and simply asserting that such an object has any of the standard physical properties is not enough to establish that such properties as they feature in *this* world are intrinsic, monadic or whatever. Indeed, the attribution of these standard physical properties in an appropriate manner—that is, one that respects their role within our best theories—may undermine this notion of 'lonely objects' and in general the possible world conceptions it is associated with. The question now is, if one is going to carry over the relevant panoply of physical theory into one's possible world conceptions, why even bother trying to abstract out the supposed intrinsic properties? Why not simply 'read off' the metaphysics of properties from the theoretical context?

Thus consider charge for example: it is obviously completely straightforward to 'conceive' of a possible world in which there is a single charged particle and no other objects. So, we have a situation of metaphysical loneliness and we may be tempted to conclude that charge can thereby be considered an intrinsic and monadic property. But in this context, what features does this property have? In particular, does it have any that we standardly attribute to charge? Can we say, in this physically attenuated situation, that the charge on this lonely object is either positive or negative, or that it obeys Coulomb's Law, or that it is the generator of the U(1) symmetry of electromagnetism, with an associated conserved current?[4] Of course, we *could* say, were we to bring in a test charge (suitably designated as either positive or negative) from infinity, but then we are no longer so lonely.[5] If we want

[4] I am grateful to Kerry McKenzie for discussions on this and related points.

[5] Unless we were to take a further step up the ladder of modality and insist that the introduction of such a test charge is not to introduce a further feature of the possible world we have conceived but is merely a further modal exploration of that world that allows us to add to our conception of it; so the idea would be that the $1/r^2$ feature associated with Coulomb's Law can be held to be a feature of our lonely situation but that as a matter of epistemology (in that possible world) it cannot be detected. At this point one might counter-insist on bringing one's metaphysics into line with the relevant epistemology and that if our only access to the features of charge are through its effects on other charged bodies, then ascribing such features to lonely charges that by stipulation or bare assertion are not able to have any such effects amounts to the elaboration of illegitimate metaphysics.

to ascribe to charge those features that it is standardly taken to have, and that 'make' it *charge*, at least as far as the physics is concerned (irrespective of whether we take properties to have quiddities or not), then we need to consider it in the appropriate theoretical context. But if we do that then it seems much harder to maintain that charge is intrinsic or monadic in the relevant sense; indeed, if we are undertaking such a consideration, then we might just as well 'read off' the metaphysics from the appropriate theory.[6]

Related concerns arise with regard to the motivation for introducing dispositions, and not just because they are typically taken to be intrinsic themselves. Thus charge is argued to be dispositional because it entails certain subjunctive conditionals; that is, an object is taken to be charged only if the object would produce the appropriate manifestation—such as a repulsive or attractive force (although we shall come to the issue of what counts as a manifestation below)—when subject to the appropriate stimulus conditions—namely in the presence of another charged body (see Mellor 1974, p. 171). This accommodates the above kind of scenario but it invites us to ascribe charge on the basis of considering what an isolated object would do, if under the appropriate conditions, and constructs a metaphysics on that basis. Such a characterisation of dispositions in terms of the entailment of conditionals faces well-known problems, not least of which is that by rendering all physical properties dispositional it effects a kind of *reductio* [see the debate between Averill (1990) and Reeder (1995)]. One response is to strengthen the entailment with conceptual necessity: dispositional properties are those that play, as a matter of conceptual necessity, a certain causal role that is best captured in conditional terms (Mumford 1998). Thus charge is dispositional because as a matter of conceptual necessity it plays the causal role it does in repelling or attracting other charges in accordance with Coulomb's Law. The obvious question now concerns the grounds for asserting such conceptual necessity and this pulls us back, once more, into the broader theoretical context (and again the issue is whether we need to advance beyond that context to metaphysically construct isolated dispositions).

More importantly, for my purposes, however, this characterisation still seems too broad and fails to distinguish between a dispositional analysis of physical properties and the kind of structuralist conception that I favour. In drawing the relevant line (and urging the semi-realist to cross it), it is helpful to look at Cartwright's consideration of the distinction between dispositions and capacities (Cartwright 2007). Thus, she too rejects drawing the line on conditional grounds since she holds capacities to be more akin to human dispositions, characterised by Hampshire as 'essentially various'; that is, although there is 'constancy of tendency', in the sense that a given charge is always striving, as it were, to attract other charges, the outcomes that occur due to the electromagnetic 'capacity' are indefinitely various. It is this essential yet indefinite variety of outcomes that underpins Cartwright's

[6] All this is not to say that physicists should not consider lonely scenarios involving, say, universes with single masses for example (think of the Schwarzchild solution of Einstein's equations). These are fine for helping to pin down and explore certain physical features but the point, again, is that this does not amount to an appropriate (meta-metaphysical) methodology for establishing the metaphysical nature of properties that features in this, the actual world.

'patchworks' in which laws are only locally applicable in the context of what she calls 'nomological machines' (for a critical review, see Chakravartty 2003a).

Capacities, for Cartwright, differ from dispositions in being 'open-ended', in the above sense that the effect associated with a given capacity is not guaranteed—it all depends on the relevant circumstances. Furthermore, dispositions, unlike capacities, may not always be on 'display'; that is they may be latent. They are also more malleable than capacities, in that unlike the latter they can be triggered and enhanced or retarded; what the two share, however, is their ability to be 'interfered with'—indeed, Cartwright takes this to be the 'central feature' of capacities (2007). More importantly perhaps, for what I shall say below, both dispositions, and capacities, have a 'two-sidedness' to them, in that the articulation of these notions involves a distinction between the occurrence of the disposition or capacity and its manifestation. Cartwright takes this to be the 'central criterion' that distinguishes both dispositions and capacities from categorical properties. Of course, pinning down what counts as a manifestation is tricky but, Cartwright insists, what it is not is what is recorded in experimental results.

Rather than conditionality then, it is malleability that brings dispositions and capacities together. But of course, there is the 'constancy of tendency' mentioned above: unlike dispositions, capacities are always switched on, as it were (and the tendency here is to cause, something that Chakravartty would agree with of course). These tendencies will produce the canonical manifestation, *unless they are interfered with*. Spelling out what counts as interference in order that the relevant conditional is not vacuous is notoriously problematic, but Cartwright insists that whether a capacity is interfered with in a given situation is both a matter of fact and one that we can know about, albeit not mechanically (but then, as she says, we should not take science to be mechanical anyway).

This is a useful 'compare and contrast' exercise. However, MacArthur has argued that, '… the open-ended nature of capacities does little to distinguish them from dispositions in the context of a nomological machine.' (MacArthur 2006, p. 238). This is because in that context (which underpins the content of science) capacities must operate in a sufficiently regular manner as to be quantified. Furthermore, with open-ended and indefinitely various capacities out of the picture, '… we are left with the view that science defines its objects of study in terms of their dispositions for causal regularities or the law-like relations that its objects of study obey.' (ibid., p. 243). And this, as MacArthur notes is just the view that Chakravartty advocates, with the relevant dispositions understood as occurrent and not latent.[7]

Furthermore, it is not clear that capacities are in fact any less malleable than dispositions. Here the issues of distinguishing between a capacity or disposition and its manifestation intrude (see McKitrick op. cit.). If the manifestation of the gravitational capacity, say, is taken to be the gravitational force, then there are good grounds for insisting that it does not get either 'triggered', or altered (as long as the relevant masses remains constant). But then what's the difference between the capacity and the force? As McKitrick asks 'Do we really need two things instead of one: gravitational

[7] McKitrick (op. cit.) also presses on this supposed distinction, using the example of 'stability' in an office building, which Cartwright would not count as a capacity but can hardly be regarded as latent.

capacity, which is always manifesting, and its manifestation, the force of gravity?' (ibid.) If, on the other hand, the manifestation of gravitational capacity were taken to be the motions of relevant objects, then the capacity looks as malleable as a disposition: 'The manifestation could be triggered if something gets close enough to something to get it to move, diminished by a force pulling the object in the opposite direction, and enhanced by an additional force pulling the object in the same direction.' (ibid.). Now, Cartwright's comment about not identifying manifestations with what is included in experimental reports, suggests an inclination towards the first option but that leaves us wondering what is to be gained ontologically from including capacities in our pantheon. A similar conclusion applies to dispositions.

We recall that within semi-realism dispositions are conferred by causal properties and manifest, continuously, as causal processes. The typical playing out of the contrast with categorical properties—whether dispositions reduce to the latter, whether this distinction even applies to properties and so on—is taken to involve open issues, the answers to which will all be consistent with the underlying picture. But even granted this last point, the nature of the distinction itself is crucial here. As Chakravartty notes, it is usually explicated in terms of the manner in which dispositions and categorical properties are described: 'the former in terms of what happens to objects under certain conditions, and the latter without reference to any happenings or conditions' (ibid., p. 123). It is this distinction which undergirds this metaphysical picture and perhaps the fundamental difference between semi-realism and OSR lies with the issue of the extent to which that most basic metaphysical picture needs to make reference to these happenings and conditions.

It is not just that the underlying metaphysics of the semi-realist is object-oriented and particularist, but that it is one in which we are invited to conceive of such particulars and their properties as being '… disposed to behave in certain ways in the presence and absence of other particulars and properties…' (2007, p. 120), where it is these properties and resulting causal processes that scientific theories describe. Thus underlying this account is something akin to the 'loneliness' assumption touched on above, namely that particulars may exist in the absence of others and hence may not manifest the requisite behaviour, but by conceiving of what that behaviour would be in the presence of the further particular we come to ascribe a disposition to behave in such a way. As should be clear, this is an assumption and picture fundamentally at odds with OSR (cf. Ladyman and Ross 2007, p. 3) and, as indicated above, is not pressed upon us by the fundamental physics.

Let us return to our initial question, but now re-frame it to ask why should the *semi-realist* incorporate dispositions into her metaphysics? Chakravartty gives both positive and negative reasons. First of all, dispositions help explain why causal processes evolve the way they do (ibid. p. 125). Secondly, although realists may adopt a deflationary account of dispositions, attempts to reduce disposition talk to conditional sentences are famously problematic (ibid.).

With regard to the first reason, the success of dispositions as an explanans obviously depends on how we characterise the explanandum. If causal processes are conceptualised in terms of objects, properties and behaviour that is dependent on the presence or absence of other objects and their properties, then dispositions may well seem an appropriate explanation of the evolution of such processes. If, however, we

eschew such a picture and adopt an alternative view of both processes and dynamics, then the need for this kind of explanans evaporates. Obviously, within OSR, an account of the dynamics of structure must then be developed. Bain, for example, has drawn attention to the significance of 'dynamical' structures which must supplement the group-theoretic representations that OSR incorporates (Bain forthcoming; French 2011). Again, however, there is little scope and no need for the introduction of a metaphysics of dispositions in such supplementation.[8] With regard to the second reason, since I reject such talk to begin with, I don't feel compelled to provide any reduction of it. (At best, the structuralist may view such talk along 'as if' lines: we sometimes talk as if there are dispositions that confer behaviour, but at the most fundamental level, our ontology does not include such entities. For a useful way of accommodating apparently ontologically laden talk with the absence of the given ontology, see Cameron 2008).

Furthermore, without the happenings and conditions, DIT can be metaphysically 'reverse-engineered' and read both reductively and ontologically. If what makes a causal property the property that it is, are the relations that it enters into with other such properties, with the conjunction of the laws comprised by these relations specifying the natures of all the causal properties there are, then reading this identity chain from right to left, as it were, and ontologically, we can take the laws (understood structurally of course) as fundamental and the powers and properties as emergent from the relevant relations, with no need for dispositions. Indeed, the kind of holism that the dispositional view entails with regard to the natures of causal properties meshes well with a structuralist stance (Chakravartty 2007, p. 140). As in the case of the natures of objects presupposed by 'epistemic' structural realism, the natures of properties get cashed out in relational (and hence structural) terms. And as Chakravartty states, the network of properties and relations comes as a package or not at all (ibid., p. 147). Indeed, if properties and laws are merely flipsides of the same coin, then we can take the law side as ontologically basic, as a straightforward reading of the physics would suggest anyway. In addition, given that the dispositions are genuinely occurrent, if their manifestations are causal processes, then as with gravitational capacity, when it comes to the most fundamental dispositions, McKitrick's question arises once more: do we really need both the causal power and the process it manifests?

There is more to say here, particularly with regard to 'ceteris paribus' and 'vacuous' laws. With regard to the latter the above holism comes into its own, with relations acting as the truthmakers of the relevant law statements (ibid., pp. 146–147). Setting aside the element of potentiality associated with dispositions, it would seem that structuralism could incorporate this aspect as well. Being able to give an account of the former on a par with 'traditional' laws is typically taken to be one of the advantages of the dispositional view.[9] But as Chakravartty notes, if

[8] So, for example, the dynamics of Yang-Mills theories, considered by Bain, is encoded in both the relevant invariants and in the geometric structures defined over the projective carrying space.

[9] Drewery argues that certain ceteris paribus laws are not subject to this type of account, namely those that state that other things being equal a member of a kind is like other members in possessing a certain property (Drewery 2001). However, Chakravartty understands the traditional counterparts to such statements as 'definitional generalisations' and one could extend this to treat Drewery's examples as ceteris paribus descriptions of objects (and as such would not apply to the fundamental objects of physics anyway).

ceteris paribus law statements are accurately formulated to describe causal laws, then they can be understood as 'partial maps' of relations (ibid., p. 149). This can also be made consonant with the structuralist perspective, although instead of saying that they hold partially because in formulating them one does not specify all of the potentially relevant dispositions, one would have to say that—ultimately—they so hold because in formulating them one does not specify all the relevant features of the fundamental structure. Thus both the semi-realist and the structuralist can agree that, if correct, ceteris paribus law statements are accurate descriptions of possible relations (ibid.), but whereas the former takes these relations to be between causal properties, the latter takes them ontologically simpliciter, and the sense of possibility here is grounded, not in dispositions and their stimulation under different conditions, but in the modal abstraction of certain aspects of structure.

The crucial difference between semi-realism and OSR remains the status of objects (Chakravartty 2003b). For the semi-realist, objects fill the crucial role of acting as the 'seat' of causal powers. Elsewhere I have tried to respond by insisting that structure, or aspects thereof, can also fill this role (French 2006) but here I would like to suggest that, again, certain particularist assumptions might be at work behind the scenes: if one thinks of powers as the sorts of things that can be brought into play, or manifested, under certain conditions, where those conditions are typically articulated in particularist terms—that is, in terms of objects interacting with other objects—then it becomes natural to see these powers as grounded in the objects. Natural, but not necessary.

In addition, properties cluster: we see a certain charge, observed at a particular spatio-temporal location, always associated with a certain (rest) mass and a certain spin and we infer that we have observed an electron, for example (Chakravartty op. cit.). Again I have indicated how we might accommodate such observations within a group-theoretic understanding of structure (op. cit.) but what I'd like to consider further is the explanation of this coherent clustering in terms of the 'sociability' of properties.

3 Being Sociable

Let's begin with kinds, the analysis of which forms a central pillar of *A Metaphysics for Scientific Realism*. The account is appropriately inclusive, embracing both what are traditionally seen as 'essence' kinds and also so-called 'cluster' kinds, associated with biological species for example. As Chakravartty notes, this generates a dilemma: if, on the one hand, one takes the former to be the only genuine natural kinds, then one must explain the nature and role of the latter; if, on the other, one embraces both, then one must give an account of successful inductive practice in the latter case, in the absence of the kinds of law-like generalisations that we see in the former (op. cit., p. 168). Chakravartty grasps the second horn and asks if we can find anything that '… deserves credit, metaphysically speaking, for supporting scientific generalisations and predications in both cases …' (ibid.). His response is to generalise from the case of essence kinds where it is ultimately the causal properties (mass, spin, charge etc.) that explain why the relevant generalisations hold. In all

cases, essence and cluster, it is facts about causal properties that underwrite the relevant inductions: 'Law-like behaviours obtain not merely as a consequence of the possession of essential properties by members of essence kinds, but as a consequence of the possession of *any* causal property by *any* sort of object.' (ibid., p. 169).

But, as he notes, instances of these properties are not randomly distributed across space–time; rather, they cluster together, a phenomenon that is described in terms of 'sociability'. Furthermore, sociability comes in degrees, and it is this that distinguishes 'essence' from 'cluster' kinds:

> The highest degree of sociability is evidenced by essence kinds, where specific sets of properties are always found together. In other cases, lesser degrees of sociability are evidenced by the somewhat looser associations that make up cluster kinds. (ibid. p. 170)

But in either case, it is the sharing of causal properties that underwrites the relevant inductive generalisations and predictions.

A crucial question is whether this notion of 'sociability' should be taken as primitive or not. As Chakravartty notes, it can certainly be analysed further in the case of cluster kinds, through Boyd's 'homeostatic clustering' for example. However, such mechanisms are not robust enough to account for the co-instantiation of the so-called intrinsic properties of elementary particles and in the case of such 'essence' kinds, sociability must be admitted as a 'brute fact' (ibid., p. 171).

Now it is precisely these latter kinds that I am concerned with and I shall focus on the supposedly brute nature of sociability. Clearly this notion captures an important feature of the physical world and by introducing it Chakravartty's account scores over that of Mumford, for example, which allows for entirely promiscuous property clustering. However, it seems only to attach a metaphysical label to the physical explanation of this feature. And the relevant explanans is symmetry.

So, just to rehearse a familiar point: if we begin with some very general kinds in physics, namely fermions and bosons (about as fundamental a distinction as it gets), these are understood physically in terms of the appropriate symmetrisation of the wave-function (symmetric and anti-symmetric respectively; other forms are also of course possible, at least theoretically). This in turn can be seen as a manifestation of 'Permutation Invariance' and is represented mathematically by the permutation group. How we then understand Permutation Invariance is a further issue. Huggett draws on a useful parallel between permutations and covariant spatial transformations and suggests that this allows us to see quantum statistics as '… a natural result of the role symmetries play in nature.' (Huggett 1999, p. 346). This can then be further articulated in a structural context: the permutation group mathematically describes a profound feature of the structure of the world (French and Rickles 2003).[10] The relevant 'sociable' aspect of fermions and bosons is thus articulated by the relevant symmetry (as represented by the permutation group) and what is doing the explaining here is that symmetry appropriately understood in structural terms.

[10] For further discussions of symmetry in this context see Lyre (2004) and Kantorovich (2009).

Now one might claim that this focus on symmetry extends further than an approach based on sociability, since the latter is primarily concerned with the sociable nature of *properties*, and that's not what we seem to have here, at least not the so-called intrinsic or state independent properties such as mass, charge and spin. If we can be said to have properties at all, they are those of the relevant aggregates, reflected by the appropriate statistics. However, the spin-statistics theorem does relate these latter properties to one of the intrinsic set listed above; the issue then is whether one can take the statistics and related distinction into kinds as a result of a purportedly more fundamental distinction between half-integral and integral spin (see French 2000). There are continuing debates over what counts as an adequate proof of this theorem (see Sudarshan and Duck 2003), but the semi-realist can certainly use it to argue that the reach of symmetry does not extend further than that of causally empowered properties.

Fermions, in turn, divide into sub-kinds of leptons and quarks, with the former including electrons, muons, tauons and their associated neutrinos. These most basic kinds are also captured via symmetry considerations, as represented by group theory. Wigner famously established the connection between the relevant characterising properties and the irreducible Hilbert space representation of the (restricted) Poincaré group [the 10-dimensional non-compact Lie group of isometries of Minkowski spacetime; for technical details see McCabe (2004), which also includes consideration of the issues involved in extending Wigner's programme to curved space–time], or, better, the associated Lie algebra. In addition to these space–time symmetries there are the so-called internal symmetries,[11] such as that associated with colour (in quantum chromodynamics) as represented by SU(3), the irreducible representations of which famously underpin the classification of hadrons in the so-called 'Eight-Fold Way'.[12] Again, the relevant properties that characterise both the kinds and their inter-relationships are tightly linked to the relevant symmetries as represented via group theory. Indeed, the meaning of physical quantities such as angular momentum and spin[13] can be understood as deriving from their being eigenvalues of the generators of the relevant Lie algebras and the (second-order) properties of these quantities is given by the associated structure (Mirman 1995).

Now, although semi-realism is not hampered by essentialist restrictions that block the incorporation of such symmetry considerations, it is not clear what explanatory work the notion of sociability is doing. If the explanandum is the clustering of certain fundamental physical properties (forming both kinds and objects), then what the above brief outline suggests is that the relevant explanans is

[11] Impossibility proofs and associated so-called no-go theorems exist which prevent the construction of a theory appropriately combining space–time and internal theories. For a critical discussion that argues that the relevant theorems are physically irrelevant, see Mirman (1969); these theorems do not apply to supersymmetric theories.

[12] My understanding of both the history and philosophical implications of the relevant physics has been significantly enhanced and deepened by the work of Kerry MacKenzie, who has pointed out that the above considerations yield an ontological picture that is significantly different from the so-called 'bundle' theory of objects since these symmetry relationships specify both kinds of particles and the compositional relationships that hold between these kinds (cf French 2006, fn 11).

[13] Morrison takes the group-theoretical representation of spin to block the possibility of a realist interpretation of it (Morrison 2007); for a response, see French (2012).

the appropriate symmetry consideration, as represented group-theoretically. Now one might argue that this gives us only the physical explanans as it were, and that what we need is the appropriate metaphysical correlate. But then 'sociability' (like its trope-theoretic kin of 'founding' or 'saturation'), seems merely to label the phenomenon itself, taking it close to functioning along the lines of 'dormative virtue'. In this sense, the above symmetry considerations can be said to explain sociability, and embedding the former in a structuralist metaphysics provides a 'deeper' metaphysical explanation—not least because these considerations reflect a fundamental aspect of the structure of the world.[14] Of course, Chakravartty only intended 'sociability' to act as a metaphor, but if it is to be more than a figure of speech, if it is to be what is called a 'conduit' metaphor, then I suggest that it needs to be supplemented (if not supplanted) by a structural understanding.[15]

Furthermore, introducing these considerations allows us to respond to a problem that arises for such 'cluster' views, namely that of 'free mass' (Schaffer 2003). On such a view of particulars, the question arises as to what prevents one or more of the properties—mass, for example—'breaking free', as it were, from the others, so that we have a one property 'cluster' of, in this case, just mass. The possibility of such a 'free mass' has been taken as a *reductio* of the property cluster view of particulars and a typical response is to introduce certain property interdependencies such as 'founding' or 'saturation' relations (to which one could add sociability). Schaffer rejects such metaphysical interdependencies on the grounds that they involve 'occult' and 'brute' necessities; that there is no plausible way to specify exactly *which* interdependencies hold, and that it seems possible to obtain respectable property-clusters in ways that preclude interdependence (ibid. p. 132). I am not particularly bothered by the first or third issues, since it is not clear to me how a metaphysical necessity that is underpinned by its physical counterpart counts as 'occult' or 'brute'; nor, relatedly, do I think the kinds of combinations Schaffer constructs correspond to anything we find physically. But we can specify which interdependencies hold, at least at the level of physical relationships, in precisely the ways indicated above.

Schaffer's (sub-) conclusion is:

> An explanation for why properties cluster remains elusive. All attempts to explain the impossibility of free masses, whether in terms of the relation between *object* and *property*, or in terms of principles internal to *property*, look to fail. Perhaps it was all along a mistake to think of free masses as impossible. (ibid., p. 133)

Again the issue of what counts as an adequate explanation arises. Perhaps the difficulty here is that if one looks only to metaphysics for such an explanation then there is nothing for whatever principle one proposes—founding, saturation, sociability …—to get any purchase on. And insisting that free properties are

[14] For criticisms of this kind of 'group-theoretic structural realism' see Roberts (2011); and for a response, see French (2012).

[15] This can then yield a unified account of the sociability of particulars and kinds, citing the relevant symmetries and group-theoretic features as explanans in both cases. In this sense, OSR offers a stronger explanatory framework than that based on object-oriented metaphysics (cf. Chakravartty 2003b).

impossible because of some object-property or property-property relation that ties them into a cluster looks like little more than repeating the insistence. The alternative, as I have suggested above, is to articulate an explanation on physical grounds and then embed the explanans in an appropriate metaphysical framework.

This then allows us to account for the contingent lack of free properties as acknowledged by Schaffer (ibid., p. 134), and in a clearer way than the analogy he suggests with quark confinement. It also allows a response to Schaffer's 'positive' argument for free masses, based on subtraction: for any particular, we can construct a 'near twin' sub-duplicate of it by subtracting any property, following which 'it seems clear' that we still have a particular.[16] Hence we obtain the 'generalized subtraction premise': for any n-propertied object, it is possible for there to be an n-1 propertied sub-duplicate (ibid., p. 136). This is taken to garner further support from the apparent lack of necessity of any particular property and as Schaffer notes, we are now merely iterations away from a free mass (or any other property). The problem of course is that although this argument applies to particulars regarded in an abstract, metaphysical sense—namely as clusters of properties—it does not apply to the contingent particulars of the actual world. Here, if one strips away charge, for example, from a certain cluster, one no longer has an electron[17]; and more importantly, recalling what was said above, only certain clusters make up the kinds and particulars we observe around us, as determined by the relevant symmetry considerations. Perhaps Schaffer might counter that he is precisely concerned with the notion of particular in the abstract or metaphysical sense and there is nothing in that notion that blocks the subtraction argument. Well of course, but that is because of the kinds of considerations already touched upon: at this level of abstraction there is nothing that could act as such a block that doesn't have the look and feel of something akin to a 'dormative virtue'.

4 Conclusion

Semi-realism is rightly regarded as offering a moderate form of realism that is metaphysically informed, scientifically attuned and incorporates the central elements of entity and structural realisms. What I have tried to do here is indicate how we can retain certain of its virtues while dispensing with some of its metaphysical commitments. Dispositions, as articulated in this context, are tied to a problematic metaphysical picture and although Chakravartty remains unconvinced by the underdetermination arguments for dispensing with objects (see, again, his 2003; my 2006), I hope to have indicated how robust disposition talk is at best unmotivated and at worst undermined by considerations from physics. More positively, semi-realism's metaphysics is in better shape than, say, dispositional essentialism, when it comes to the accommodation of symmetry principles in science. Nevertheless, if

[16] As Efird and Stoneham note, this 'clear' intuition is surely question begging (2010).

[17] Efird and Stoneham make a similar point: if we take a certain object such as a post box then it is not at all intuitive that there could be a 'near twin' *of a postbox*, yet lacking colour and shape. Their conclusion is that Schaffer's argument is either invalid or fails to be independently suasive (ibid.).

'sociability' is to function as less of a metaphor and more as a metaphysical explanans, then it needs to be further articulated, and the most appropriate way of doing that, I suggest, is through structural considerations. Certain of these already lie at the heart of semi-realism and what I am suggesting is that this commitment be extended to yield not only an even more sophisticated realism, but one that is informed by a more coherent and compelling metaphysical stance.

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