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French, S (2018) Between Factualism and Substantialism: Structuralism as a Third Way. International Journal of Philosophical Studies, 26 (5). pp. 701-721. ISSN 0967-2559

https://doi.org/10.1080/09672559.2018.1542275

Factualism, Substantialism and Structuralism*

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Introduction

According to the substantialist, substances should be regarded as the fundamental ontological category. It is substances that are the bearer of properties, that are causally efficacious and that compose the things we see and touch around us. Cumpa has argued that this metaphysics fits poorly with classical physics (2014) and Buonomo has extended this argument into the quantum realm. After reviewing their claims, I shall argue that simple reflection on the form of the Standard Model also undermines substantialism. I will then explore Dasgupta's qualitative factualism in this context before suggesting that modern physics does not compel us to adopt such a stance. The alternative is to adopt a form of structuralism which, although it may be rendered compatible with factualism, can also stand as a 'third way' between these stances.

Substantialism

According to the substantialist, 'Substance and properties are basic, indeed *the* basic ontological categories.' (Heil 2012, pp. 3-4). Indeed, they may be thought of as complementary categories, so substances are the bearers of properties and properties are the way that substances are (ibid.). If you add the requirement that whatever ultimately bears properties must be metaphysically simple (ibid., p. 20), you must conclude that substances are metaphysical simples. Substances, on this view, are the metaphysical 'fundamental building blocks' (ibid. p. 41). If you then argue that whatever one takes to be *metaphysically* fundamental should align with that which we take to be *physically* fundamental, you will further conclude that the fundamental building blocks of physics – whether they are taken to be particles, or fields, or superstrings or whatever – must be substances (ibid., p. 5).

Thus, on this view the electron, for example, is a substance that possesses certain properties, such as (rest) mass, charge and spin. A particular (rest) mass, charge and spin is the way the electron, as a substance, is. What this yields is a 'bottom-up' account, according to which we start, ontologically, with these fundamental simples as substances and work our way up through the various 'levels' of reality, from the fundamental to the 'everyday'. So, if we further conceive of properties as powers, or dispositions, the fundamental substances come to be seen as the 'seats' of such powers – an electron, for example, is the seat of an assortment of causal powers as expressed through the above properties (one might hesitate at regarding spin as causal but the recent development of spintronics could be deployed to assuage such doubts). Working our way up, we can then appeal to suitable accounts of composition or emergence or some such, to arrive at the entities that we take to populate the 'everyday' level.

* I'd like to thank Javier Cumpa in particular for helpful comments on this paper. Of course he is not to blame for any of its deficiencies!

To many this is an appealing picture but Cumpa raises the following criticism (2014) based on a proposed criterion for fundamental categories that runs as follows:

For every x, x is the fundamental category of the world if and only if x has explanatory power to account for the relation between the ordinary world and the physical universe. (Cumpa 2014: p. 320)

This requires that any candidate for fundamentality must be 'cross-sectional' in the sense of crossing or bridging the two levels – that of the 'ordinary world' and that of the 'physical universe'. Unfortunately, Cumpa argues, the above substantialist account fails to meet this criterion, essentially because it fails to be cross-sectional. Thus, consider this table at which I am sitting: we might think that the solidity of the table is a property of it. But according to the above account, only fundamental simples can be considered to be substances and only these truly possess properties. The solidity of the table is not a property per se, it is merely a consequence of the arrangement of fundamental substances; that is, '… what you get when you arrange these substances in this way.' (Heil 2012, p. 7). Thus by virtue of situating substances and properties only at the fundamental level, this sort of account cannot satisfy Cumpa's criterion. As Buonomo puts it,

… if ordinary substances and ordinary accidents are nothing but substances and properties by courtesy, this kind of explanation of the fundamental level of the world consists in the elimination of the ordinary level of things as far as the fundamental categories are concerned. As a consequence, if the ordinary world is omitted by the categorial discourse, it is hard to see how the category of substance may account for the complex world. (Buonomo 2017; published online, no page numbers)

Furthermore, according to Buonomo, things get worse for the substantialist account when we take quantum physics into account. So, consider quantum 'entanglement', which arises, for example, when we have two particles that interact - quantum mechanics will ascribe a state to the system as a whole, such that the two particles cannot be said to have distinct states. This form of 'holism' results in certain non-classical correlations being exhibited between measurements made on the particles (e.g. of their spin) and these correlations have now been experimentally verified in various ways. This forces some revision of the rather simplistic substantialist metaphysics above, whereby the particles are the fundamental property possessing substances that then compose various wholes, running through the levels from atoms to molecules and eventually to tables ... The extent of such revisions may be debatable. But if we take entanglement to imply that, for example, the state of the whole cannot be said to supervene on those of the particles (Teller 1986) or, at the very least, that the former cannot be said to *depend* upon the latter, then it is clear that standard notions of composition, for example, insofar as they metaphysically ride on the back of such dependence, are going to have difficulty in accommodating this feature of the quantum world.

As a result, some substantialists have taken what some might see as a rather drastic position and adopted a form of monism, according to which, '[p]articles would be abstractions in the sense that a billiard ball's redness would be an abstraction, a way the billiard ball is …' (Heil 2012: p. 48; cf. Schaffer 2010)[1] However, Buonomo identifies a number of difficulties with such a move: first, it yields a conflict between classical and quantum metaphysics, wherein according to the former electrons, say, are substances but according to the latter they are not – indeed they are regarded as properties, with the holistic, entangled state understood as substantival.[2] Of course, the substantialist could simply give priority to the quantum account but the worry then, is that to dismiss the classical view in this way would further clash with the way that classical physics continues to be used at the macroscopic level in all sorts of ways. Furthermore, quantum physics cannot be taken as our 'Theory of Everything', not least because of the well-known issues regarding its unification with General Relativity.

The second difficulty is that, in general, '…the substance-property division recognized by a substantialist ontology has unclear results when applied to quantum physics.' (Buonomo 2017) So, for example, if we take the monistic version of substantialism sketched above, the universe as a whole, understood quantum mechanically, would be the (only) substance but then it is not clear what are this substance's properties. If these are taken to be the particles themselves, then how are we to understand what we usually take to be the properties of *these*, such as (rest) mass, charge, spin etc.? If we take these not to be properties then we have another clash with the classical view. If we take them to be properties of properties, then the substantialist owes us an account of how to make sense of this idea. Perhaps we should regard them as 'pseudo-'properties like the solidity of my table, but they certainly do not feature at the 'everyday' level in the way the latter does (ibid.).

However, even if the substantialist could respond to the above problems, there is a final objection that is taken to be 'lethal': such a monistic account fails to meet Cumpa's cross-sectionality criterion above, since, again, the category of substance and its complement, that of property, refer to only one level, that of the scientific universe, and hence fail to bridge the gap between that and the everyday world (Buonomo 2017).

Now, the substantialist may have the means to respond to these concerns, more or less straightforwardly. Consider again the purported conflict between the classical and quantum accounts. Given the naturalistic demand that we tailor our metaphysics to fit our science, and given the apparent conflict between classical and quantum *physics*, it is hard to avoid the conclusion that some consideration will have to be given as to the relationship between the two metaphysical pictures. So, one option would be for the substantialist to accept that classical mechanics 'works', in some sense, at the macroscopic level (however that is defined) and thus can be considered pragmatically true or partially true or whatever (da Costa and French 2003) at that level, but that this does not justify rejecting the quantum substantialist metaphysics. Indeed, one might expect the emergence of an appropriate metaphysics for the level of 'everyday' objects to follow the broad contours of the shift from truth in the

[1] Alternatively one might adopt some form of emergence and argue that entangled systems are emergent entities (Humphreys 2016).
[2] Cumpa (2019) argues that the substantialist position faces the threat of losing internal coherency on this point: either electrons, say, are genuine substances or genuine properties.

standard sense at the fundamental level to pragmatic or partial truth at that of the everyday.

Alternatively, she could follow Cartwright (1999) in adopting a 'patchwork' form of realism, according to which classical and quantum physics are both true, but in distinct domains. If the latter are taken to correspond to these levels we've been talking about then the substantialist could propose a 'patchwork' metaphysics according to which both entities to which classical mechanics is taken to apply – such as tables – and those to which quantum mechanics is taken to apply – such as electrons – are deemed to be substances, where this category is acknowledged to be domain or level specific. That's obviously quite a radical suggestion and one that perhaps doesn't sit so comfortably with the overall idea of fundamentality.

A further alternative would be to simply insist that even though classical mechanics 'works' in some sense at the everyday level, this does not preclude one arguing that quantum mechanics actually applies across the board and hence the metaphysics associated with classical physics can, in fact, be dismissed. Note first of all, that it is not the case that quantum physics is only confined to the 'microscopic' level, however that is defined. There are a number of very well-known and quite striking quantum phenomena at the macroscopic level, involving superconductivity or 'superfluid' behaviour, in general. Note also that we can give some account of how we can recover apparently classical behaviour on quantum mechanical grounds via the physics of decoherence (Bacciagaluppi 2016). Given all of that, the substantialist could maintain that the metaphysics associated with quantum mechanics is, in fact, the fundamental one and that it can accommodate apparently classical behaviour in a context dependent way – by, for example, allowing that we obtain the appearance associated with a classical substantialist metaphysics through the decoherence mechanism.

As for the concern about quantum mechanics not being the final Theory of Everything, that surely is a sweeping concern that would apply to *any* theory at this stage of the development of physics. And granted the problems associated with unifying it with General Relativity, it remains by far the best theory we have at this level. Plus, of course, whatever theory we eventually end up with, we would expect it to degenerate into quantum mechanics in the relevant domain, e.g. at distances greater than the Planck scale and for which gravitational effects can be ignored.

The second difficulty above can be dealt with by cutting out the metaphysical middleman, as it were. We recall that the worry is that by taking the universe, understood holistically, as the (quantum) substance and particles as non-substances, or properties, it becomes unclear how we are to regard what we would typically take to be the properties of these particles. However, if we regard particles as nothing but particular clusters of such properties then the worry about how we are to understand properties-of-properties simply evaporates. Of course, there remains the issue of why those specific properties happen to cluster together in the way that they do; that is, why that specific (rest)mass, charge and spin associated with the electron, say, happen to occur together. But its not clear how invoking substance at this level helps with that – after all, we can still ask what is it about that substance that leads those specific properties to cluster together. Of course, we can always answer that this is a primitive feature of our metaphysics (Heil 2012) but if we drop the idea of particles as substances, and take them to be clusters of properties, we could appeal to something like Chakravartty's notion of 'sociability' (2007) to metaphysically explain why those specific properties appear together as they do. On this picture, then, we have the universe as one substance, with properties that cluster together in certain ways to give what we call 'particles'. Of course, appealing to 'sociability' may seem an ad hoc move but perhaps this is where we reach the limits of our naturalism.

The final difficulty above repeats Cumpa's concern. Let us recall its origin in the insistence that for something to be a fundamental category, it must be able to account for the relation between the ordinary world and the physical universe. The requisite notion of 'cross-sectionality' can then be expressed in 'strong' and 'weak' forms:

'Strong' cross-sectionality: something is a fundamental category if it can account for the relation between the 'ordinary world' and the 'physical universe' by virtue of appearing, as a category, in both the 'ordinary world' and the 'physical universe'.

'Weak' cross-sectionality: something is a fundamental category if it can account, *in some manner*, for the relation between the 'ordinary world' and the 'physical universe'.

Substance is not strongly cross-sectional because in the quantum mechanical context it cannot feature in both the 'ordinary world' and the 'physical universe'. However it is weakly cross-sectional insofar as an account can be given of the relation between the physical universe and the ordinary world, where that account, as metaphysics, rides naturalistically on the back of the relevant physics, in terms of decoherence or whatever (for additional concerns, however, see Cumpa 2019).

Unfortunately, there is a further argument that can be deployed and which I think is decisive. This draws on the role of symmetries in modern physics, as exemplified by the so-called 'Standard Model' in elementary particle physics.

Substance and the Standard Model

Let us quickly review the Standard Model: famously, it encompasses the electromagnetic, the weak nuclear and the strong nuclear interactions (but not, crucially, gravity) and classifies all known elementary particles. At its heart sits certain kinds of symmetries that have become a prominent feature in the development of physics over the last hundred years or so. Indeed, Weinberg writes, in reflecting on the development of the Standard Model,

> … we did have a valuable key to nature's secrets. The laws of nature evidently obeyed certain principles of symmetry, whose consequences we could work out and compare with observation, even without a detailed theory of particles and forces. There were symmetries that dictated that certain distinct processes all go at the same rate, and that also dictated the existence of families of distinct particles that all have the same mass. Once we observed such equalities of rates or of masses, we could infer the existence of a symmetry, and this we thought would give us a clearer idea of the further observations

that should be made, and of the sort of underlying theories that might or might not be possible. (Weinberg 2011)

Thus symmetries serve a crucially important heuristic role and, partly as a result, have been cemented into the fabric of the model itself.

Now what does this have to do with substantialism? Well, recall the picture outline in the previous section: classically, it's a 'bottom-up' account in which we begin with elementary particles as the fundamental substances that possess the relevant properties. However, the Standard Model gives a very different picture, in which the relevant properties 'drop out' of the symmetries. Lets see how it works.

We begin with Permutation Symmetry, which lies at the very core of quantum theory and is associated with the so-called indistinguishability of quantum particles. It is represented mathematically by the permutation group (see French and Krause 2006) and divides up the space of states in quantum mechanics (the Hilbert space) into distinct sectors, each corresponding to a certain fundamental kind of particle, the two most well known being fermions, which obey Fermi-Dirac statistics and bosons, obeying Bose-Einstein statistics. The former includes electrons and protons etc., the latter includes photons, for example, and their behaviour in aggregate is very different: putting it crudely, bosons tend to cluster together, whereas fermions tend to stay apart. There are other kinds that are possible, corresponding to so-called para-particles but although it was suggested that quarks could obey parastatistics, this idea was eventually dropped (French 1995). The point is, the most fundamental kinds into which elementary particles can be divided, effectively 'drop out' of the imposition of this symmetry.

The Standard Model also incorporates the global Poincaré symmetry that is a feature of all relativistic quantum field theories and which is a symmetry of Minkowski space-time. As Wigner famously showed, this generates a classification of all elementary particles in terms of their mass and spin. Hence these fundamental properties can also be said to 'drop out' of this particular symmetry. Finally, there is the local SU(3) x SU(2) x U(1) gauge symmetry that effectively characterises this particular model and covers the fundamental interactions of the strong, weak and electromagnetic forces, respectively. Gauge symmetry refers to the way in which the mathematical expression of the system's dynamics remains invariant under a group of transformations, where the 'gauge' aspect denotes certain redundant degrees of freedom in that expression. The generator of this group of transformations represents a field and when such a field is quantised, we get certain gauge particles (bosons) that 'carry' the interaction. Thus, in the case of electrodynamics, the relevant gauge symmetry group associated with the property of charge is U(1) and the requirement of gauge invariance yields the photon as the corresponding gauge boson. Thus, again, certain kinds of particles 'drop out' of a symmetry principle.

Notice how this is very much a 'top-down' sort of framework: it is the symmetries that yield the properties of the particles – from the kind of particle they are to their specific properties like spin – rather than thinking of them as possessed by the particles as substances. Now, of course, the substantialist view of quantum theory is also top-down in the sense that all such monist accounts are: here, we begin with the universe as a whole, understood as a quantum system in an entangled state, which is then taken to possess certain properties. But of course, the latter picture does not incorporate these symmetries, nor the manner in which properties 'drop out' from them.

With regard to that first point, the substantialist could argue along the following lines: the universe, as an entangled quantum system, evolves according to Schrödinger's equation, understood as the overall fundamental law of quantum theory and the symmetries can then be taken to be constraints on the derivative laws formed from that equation by plugging an expression of the relevant dynamics into it. However, it remains unclear how the properties concerned can be said to both 'drop out' of the symmetries and be possessed by the universe *qua* quantum system. Of course, how this 'dropping out' of kinds and properties and particles is to be captured in terms of some metaphysical framework remains to be discussed (see Cumpa and French, forthcoming). One option is to deploy the language of determinables and determinates, so that the symmetries would be the determinables of which the properties are the determinates (see French 2014). But again it is not clear how this would be of any use for the substantialist.

Factualism

Cumpa and Buonomo take the rejection of substantialism to make metaphysical room for factualism. This is the view that, as the name suggests, facts, or states-of-affairs are the most fundamental category. There is, of course, a huge literature on the relationship between facts and objects with their properties but here I will just note that a constitutional relationship immediately allows for the criterion of cross-sectionality to be met:

Consider once again the brown table in front of us. It seems to me that we could regard the perceptual entity as a fact, namely, the fact that this table (the table in front of us) is brown. We can consider the arrangement of particles of which the table consists and its perceptual properties as the two constituents of the fact. Since I grant ontological status to the ordinary world and the physical universe, I think that it is clear that the division between facts and constituents is cross-sectional in character. We could perfectly call "emergent fact" the category of entity that emerges from the reconstruction of the relation between the scientific level of physical arrangements of particles and the ordinary level of emerging properties. (Cumpa 2014, p. 322)

Furthermore, empirical rules can be given that establish the existence of relationships between the constituents of facts 'in' the manifest and scientific images (Cumpa 2019, p. 18). So, taking the example of the table, we have:

(1) Iff there is an arrangement of electrons behaving in a certain way, there is a table
(2) Iff there is an arrangement of photons behaving in a certain way, there is the colour brown.

As Buonomo remarks, this amounts to a form of 'constructive factualism', according to which facts are scientific reconstructions of their constituents: 'It is by recognizing the reconstructive nature of facts that we can understand the explanatory power of this category to account for the relation between the ordinary world and the physical universe …' (Buonomo 2017). Thus we should not situate the fact that 'the table is brown' at the level of the everyday, since although the colour brown belongs to that level, the table, as an arrangement of particles, should be regarded as sitting at the level of the 'physical universe' (ibid.). It is this distinction between the respective constituents that allows this fact to bridge or intersect the two levels.

Now there is an obvious worry that arises at this point: if it is on the basis of our scientific knowledge that we take an object such as a table to be an arrangement of particles and thus situated at the level of the physical universe, why should we not apply the same methodology to the colour brown? Of course, colour science is a complex field and the colour of an object is not a simple matter of light of a certain wavelength being reflected from it, but involves not only the surface and reflecting properties of an object but also, in some cases, its emitting properties, the relevant context, including the colours of nearby objects (the presence of which can generate numerous well-known 'illusions') as well as certain features of the optical system and the brain. But the point is, such a story can be given and with the relevant details filled in, it will be an appropriately explanatory story, thereby satisfy the underlying demand of the cross-sectionality criterion (see Cumpa 2019). Of course, one could insist that aspects of what we call colour, or even colour itself, remain outwith such an account, insofar as they concern sensations or qualia or whatever. In that case, however, one might hesitate to situate these aspects at the level of the 'everyday' and certainly such a move would represent a significant cost for this sort of broadly factualist account.

Here's another example that further illustrates the concern and sharpens it in the context of the discussion of the Standard Model above. Consider a different property of the table, one that is tactile and just as important as its colour, if not more so, namely its solidity. The full explanation of this is also complex, involving, of course, the chemical composition of the table, the nature of the constituent molecules, the relationships between them and so forth. But a crucial factor in this explanation is the Pauli Exclusion Principle, credited with accounting for the stability of matter in general (see Massimi 2005). The principle is often stated as requiring that electrons in an atom must be assigned different 'quantum numbers' reflecting the fact that they occupy different states. More generally, it is a manifestation of the requirement that the wave-function applicable to fermions – the particle kind that includes electrons – must be anti-symmetric under particle permutations. But this in turn is just one representation of Permutation Symmetry, another being that wave- functions applicable to bosons – such as photons – must be symmetric under permutations (and there are an infinite number of other representations, corresponding to para-statistics as mentioned above).

Thus, the ultimate explanans, as it were, in this explanatory story is a fundamental symmetry principle. Adopting the same methodology as in the case of the table as an object, we can conclude that its property of solidity can also be explanatorily grounded in a feature of the scientific universe. Remaining within the factualist conception this raises an immediate concern about the status of the 'ordinary world', which is supposed to anchor one side of the bridge furnished by the relevant facts. There are a number of options then open to us: one is to maintain a form of reductionism along the following lines (Cumpa 2019). Consider the fact of the table being brown. This has constituents in both the scientific and 'everyday' worlds: in the case of the table, the two relata of the reduction can be identified, since the 'everyday' table and the scientific one belong to the 'scientific' world. And of course, this identification requires the existence of both relata. However, although the colour brown is reducible to the photons and the chemical make-up of the table and so forth, it is not identical with all that, since colours do not belong 'in' the scientific world (ibid.). The crucial point here, is that as far as the factualist is concerned, the property of being brown is a constituent of the fact of the table's being brown, not of the table itself. If the latter were the case, then the colour brown would have to belong to the same 'world' as the table and we would lose cross-sectionality.

Note the assumption of the existence of both relata, situated in the 'everyday' and 'scientific' worlds respectively. It is this that requires the criterion of cross-sectionality and the associated compex, albeit nuanced, considerations of the constitution of facts. Can we find an alternative that this metaphysically less costly? Indeed we can: a form of eliminativism tied to an iterative methodology that assumes both relata to begin with and then shows that one can actually be dispensed with.

Thus we can argue, on the back of the above explanatory story, that the 'ordinary world' or 'everyday' level can be *eliminated* in favour of the scientific, or fundamental (French 2014): we begin with an 'appearance', such as solidity that we take, at first iteration, to be situated in the 'ordinary world' or at the 'everyday' level; we then apply the above science based and hence naturalistic methodology of metaphysics and explain this appearance in terms of, ultimately, Permutation Symmetry; we then take this explanation to licence the elimination of solidity as a feature in our metaphysical pantheon. Compare this to the explanation of rainbows, for example: we begin with the appearance of multicoloured entities in the sky, regarded at the 'everyday' level as things of some kind; we then explain this appearance in terms of the reflection and refraction of light, when the eye and the sun and water droplets are in a certain alignment; and we may go on to appeal to further features of geometrical optics or catastrophe theory or whatever (see Bueno and French 2018, pp. 189-191) to flesh out the details of our explanans and deepen the explanation; but at the end of that process, we end up with a scientifically based explanation that effectively removes 'rainbows' from our list of physical 'things'. This may appear extreme but it offers a number of meta-metaphysical advantages, not least in that it reduces the number of levels (obviously) and therefore also eliminates the need for a criterion of cross-sectionality, as there are no distinct levels to 'bridge' or cross.

Of course, eliminativism is not cost-free. The identification and hence elimination of 'solidity' in favour of Permutation Symmetry implies certain robust modal claims, to the effect that there could be no such property in the absence of this symmetry. But in fact that is what modern physics tells us (modulo theory change under which this symmetry may be recovered 'in the limit', say). There is also the concern how to make sense of statements apparently about 'everyday' things. Fortunately there are a number of metaphysical devices on hand that we can use (see French 2014 Ch. 11), such as a form of truth-maker theory according to which statements about *y* are made true by *x*, without having to take *y* to exist. It may appear that we have retained the 'everyday' world, in some sense, but the purpose of such devices is not to 'bridge' the two worlds but to make sense of statements that are *apparently* about one of them. By virtue of this, there remains no need for such a criterion as cross-sectionality.

I'll come back to eliminativism as I want to press a further point that has to do with the inclusion of such features of the scientific world as symmetry principles as *constituents* in facts. Now, on the face of it, there may not seem to be any in-principle objection to such a move. After all, Buonomo, in defending and extending Cumpa's approach, accepts that the superposition of the quantum states of the universe may be included as such a constituent. However, you might have qualms about accepting symmetry principles on the grounds that the constituent 'slot' in this case has to be filled by an element of the physical universe that is *fundamental* and only the so-called 'basic building blocks' of the world, such as particles or fields can be fundamental in this sense. Here perhaps we might draw on alternative understandings of 'fundamentality' (see French forthcoming).

Thus, Tahko, for example, has argued that we should adopt such an understanding based on the idea of 'ontological minimality', in the sense that the fundamental level should simply be taken to consist of ontologically minimal elements, with no commitment to any mereological 'building' arrangement (Tahko 2018). In the absence of such a commitment, some other framework needs to be appealed to in which symmetry principles can be accorded the relevant metaphysical priority. It turns out that relations of supervenience and dependence are not up to the job (Wolff 2012, McKenzie 2014) but we might appeal to the determinable-determinate relation again (French 2014 Ch. 10) and argue that this satisfies the cross-sectionality criterion. Some might balk at the inclusion of determinables in our fundamental level but Wilson (2012) has argued that such balking is question begging and that there is no principled obstacle to such a move. There is more to say (again, see French forthcoming) but hopefully I've indicated how symmetry principles can be regarded as fundamental constituents of facts.

However, a further issue is whether such constituents in general can be *qualitative*. Thus, it might be argued either that *all* fundamental facts must be individualistic facts in the sense that they are about or concern individuals or, at least, that the facts that we are concerned with here, namely facts that satisfy the cross-sectionality criterion, must be individualistic facts. The former seems a very broad claim and here I'll focus on the second. The argument could run as follows[3]: as (many of) the entities we are typically concerned with in the 'ordinary world' are individuals, so the constituents of the facts we are concerned with in cross-sectional situations should be individuals. Thus because the table at which I am sat is an individual, so the constituent entities that are arranged to compose it must be individuals. Particles are individuals, so they satisfy this particular desideratum, whereas symmetry principles are not and so they don't.

[3] As Cumpa has emphasised, the criterion itself does not require that the constituents of facts be individuals (email).

Now that isn't a particularly strong argument to begin with and one might want to insist that when it comes to quantum mechanics, the desideratum straightforwardly fails because quantum particles are non-individuals in some sense. On this point, however, we have to tread carefully, since as is now well-known it is perfectly compatible with quantum physics to adopt the view that particles are individuals – there is in effect a kind of metaphysical underdetermination of these two views by the physics (French and Krause 2006). Thus someone determined to defend the claim that the relevant facts must be individualistic facts could insist on adopting the view of quantum particles as individuals and simply accept that this, in effect, goes 'beyond' the physics. But of course, someone who adopts the alternative view – attributed originally to the likes of Born and Heisenberg – that quantum particles are non-individuals could question the argument itself and maintain that as long as we can give an appropriate account of how non-individual quantum particles, suitably arranged, compose in some sense the table at which I am sat, there is no obstacle to entertaining facts that have non-individuals as their constituents.[4]

More generally, Dasgupta (2009) has argued for a 'revisionary metaphysics' that he calls 'generalism', involving qualitative – that is not individualistic – facts. The core of his argument is that 'primitive individuals' are what he calls 'danglers' in physical theories, by analogy with absolute velocity in classical mechanics and as physically redundant and empirically undetectable elements they should be removed. Instead we should adopt a generalist metaphysics according to which facts are constructed out of properties alone (cf. Paul 2013). Now there's an obvious problem with such a metaphysics, which has to do with the formal language in which it can be expressed, given that the standard understanding of the quantifiers that feature in classical logic is that they range over a domain of individuals (Dasgupta 2009, p. 50). This of course is a problem that many revisionary forms of metaphysics have had to face: the view that holds that quantum particles are non-individuals, for example, cannot avail itself of standard set-theory for similar reasons and hence alternative formalisms such as quasi-set theory and qua-set theory have been developed (French and Krause 2006).[5]

Dasgupta opts for an algebraic framework in which certain functors express the relevant features of the structure instantiated by the domain of properties (of general adicity, so including relations): so, for example, some of them express the conjunction and negation of properties, others express the permutation of properties, another captures the idea of partially 'filling' a property as in instantiating its first position and so on. This allows him to express a generalist metaphysics in which the fundamental facts of the world have the form P^0 obtains, where P^0 is a 0-place property that may be formed from more basic terms through the application of the above functors (2009, p. 53). As he says, 'The generalist and the individualist therefore paint radically different pictures of the material world. The individualist tells us that there is a domain of individuals propertied and related in a certain way; while the

[4] Providing such an account is a non-trivial task. Granted that facts might be taken to have a non-mereological form of composition (Cumpa 2019), there remains the issue of articulating that form such that it tracks both the scientific and non-standard set-theoretic details.

[5] Indeed, much of the discussion surrounding Dasgupta's proposal retreads issues that have previously appeared in considerations of identity and individuality in quantum physics.

generalist tells us that there are states of affairs that obtain, where these states of affairs are composed purely out of properties. ' (ibid., p. 54) And just how radical the generalist picture is can be seen once we appreciate what Dasgupta calls its 'holistic' flavour (which may be compared with certain forms of monism):

'When I see my laptop and my cup on the table, I intuitively see the situation as being composed of many facts: my laptop being on the table, my cup being on the table, and so on. Add these facts up, I naturally think, and you get the entire situation. But according to generalism this is an illusion: the situation is fundamentally speaking a single whole. Indeed, generalism implies the striking claim that, fundamentally speaking at least, there is only One Great Fact that captures our entire world all at once! ' (ibid., p. 56)

What about statements that apparently refer to individuals, such as those we typically make about entities in the 'everyday' world? As Dasgupta notes, there are various options: a form of error theory, according to which such statements are strictly false, or fictionalism, according to which they are true of the fiction that there are individuals, or reductionism, according to which they actually refer to more fundamental facts, such as those expressed in the generalist picture, and so on (ibid., p. 54). As in the case of the truth-maker theory briefly touched on above, Dasgupta insists that the cost of deploying such devices is more than compensated for by the ontological parsimony that results from eliminating primitive individuals (ibid., p. 57; cf again Paul 2013).[6]

Let us consider the core idea that 'primitive individuals' are 'danglers' in the sense of being physically redundant and empirically undetectable. A little care needs to be taken here: first, with what is intended by 'primitive individuals' and secondly with the physical context in which they are taken to be redundant.

So, to begin, if by 'primitive individuality' is meant something like primitive thisness or haecceities or, to relate back to our earlier discussion, some form of substance, then the idea that these are explanatorily idle, as Turner (2014) characterizes it, represents nothing new, as similar claims have been made in the past (for a historical overview, see French and Krause 2006). And of course this should come as no surprise insofar as terms like haecceity, primitive thisness or substance do not (typically) feature in our scientific theories, alongside terms like 'electron' or 'electromagnetic field' or 'charge' and so on. The former count as metaphysics, unlike the latter, although of course where to draw the line can be a tricky proposition. Indeed, even if it is granted that physics does not care whether we explicate the notion of individuality via that of primitive thisness or some account or substance, or whatever, it is generally accepted that, as far as classical physics is concerned anyway, electrons, say, are individual objects. Dasgupta's argument is that even in the classical context, the notion of individuality that is appealed to here is explanatorily idle and is thus a 'dangler'. Lets briefly consider how the argument proceeds.

It begins with an analogy with absolute velocity. Thus, he writes, '…I think we should reject primitive individuals for the same reason that contemporary orthodoxy rejects absolute velocity: our best physical theories imply that they

[6] There are further costs associated with the algebraic language that Dasgupta proposes (Turner 2014).

are physically redundant and empirically undetectable.' (op. cit., p. 37). Rehearsing a line of argument that according to the laws of Newtonian mechanics no measuring device could be constructed that would detect absolute velocity, he concludes that it is empirically undetectable. Furthermore, it is part of that argument that differences in absolute velocity at one time do not give rise to any other differences at later times and hence it is physically redundant as well. Thus absolute velocity counts as a 'dangler' (Turner prefers the term 'idler'; 2014).

Dasgupta then mounts a similar argument to conclude that primitive individuals are also danglers. He begins by noting that according to the laws of Newtonian mechanics, two particles with the same mass, charge and so on, launched from the same spot with the same initial velocity and subject to the same forces will follow the same trajectory. Hence he concludes that differences in individualistic facts at a certain time do not give rise to any differences at later times – in particular they do not give rise to any differences in general facts. But of course this is simply because the laws of Newtonian mechanics do not pertain to, latch onto or however you want to put it, the individuality of the particles – it is only their relevant properties that matter.

Furthermore he argues that primitive individuals are empirically undetectable, beginning by noting that if, unbeknownst to us, a certain individual were permuted with another with exactly the same properties we could not tell the difference. And given the laws of physics it is impossible to build any device that could distinguish between these two situations, precisely because primitive individuals are physically redundant (ibid., pp. 42-43; this is why Dasgupta reverses the order of consideration as compared to absolute velocity, beginning here with physical redundancy). Now you might think that again, empirical undetectability simply follows from the metaphysical nature of primitive individuality – of course it is redundant and undetectable because as a piece of metaphysics it is not related to the empirical substructures of our theories in the way that theoretical terms are.[7] However, further care needs to be taken at this point. Suppose we include among our physical theories, classical statistical mechanics (as we should!)? In that case, Dasgupta's permutation argument does not go through: even though the objects concerned are indiscernible such that we could not *tell* the difference, the permutation *makes* a difference – indeed, putting things rather crudely, it is the counting of such permutations that lies at the heart of so-called Maxwell-Boltzmann statistics that underpins thermodynamics.

Things look different in the quantum context, of course. There – again, putting it crudely – permutations are not counted, a feature that is expressed by means of the principle of Permutation Symmetry as discussed above and which leads to very different kinds of particle statistics, such as the Bose-Einstein and Fermi-Dirac cases already mentioned. It was on the back of this that physicists argued that individuality must be abandoned in the quantum context. This could

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[7] Turner raises concerns about the algebraic formalism that Dasgupta employs to express his generalism, to the effect that it is more complex than standard logical formalisms and hence there is a trade-off in choosing to eliminate danglers/idlers (2014). We might useful compare this concern to similar worries about choosing the non-individuals + quasi-set theory 'package' over individuals + standard set theory in the quantum context. For further discussion see Dasgupta and Turner (2014).

be taken to vindicate Dasgupta's generalist thesis but note, first of all, that the thesis in this case would not be based on a misguided analogy with absolute velocity but would be grounded in the specifics of quantum statistics.[8] Secondly, however, as we've just noted, quantum statistics *is* compatible with regarding the particles as individuals – you just have to understand Permutation Symmetry a certain way (French and Krause 2006). Of course, Dasgupta might insist that such compatibility does not mean that the notion of individuality is not a 'dangler' in this context; indeed, the very fact that there is this metaphysical underdetermination between quantum particles-as-individuals and quantum particles-as-non-individuals suggests that it really does not matter which we choose as far as the physics is concerned, and hence individuality is physically redundant.

Nevertheless, picking the other 'horn' of the metaphysical dilemma also comes with costs – namely that of, first, explicating metaphysically what one means by 'non-individuality' and secondly, elaborating an appropriate formal framework for this 'package' (French and Krause 2006; cf. Turner's concerns, again, about the costs of generalism; 2014). The appropriate response, I would suggest, is to avoid having to entertain such 'danglers' and also having to pay such costs by rejecting both packages and withdraw from object-oriented metaphysics entirely. I'll come back to that shortly when I introduce structuralism.

Before I do, its also worth noting the further point that dismissing individuality as redundant in the quantum context is a little quick. It might seem plausible if we're only thinking in terms of haecceities or substance or the line, but a 'physics-appropriate' form of individuality can be constructed in this context by means of the (Quinean) notion of 'weak discernibility' (Muller and Saunders 2008). The idea is that two individuals can be said to be weakly discernible if they enter into irreflexive relations of the form '… has different P from …', where P is some predicate. Since two fermions in a singlet state, say, must possess different spins (one will have spin 'up', the other spin 'down') they can be said to enter into such a relation and hence are weakly discernible and individuals in this sense. One can understand this approach as offering a further means of articulating the quantum particles-as-individuals package but insofar as the individuality is grounded not in some metaphysical notion of primitive thisness or whatever but in certain relations holding between the particles in a certain state, one might struggle to claim that it is physically redundant.

Now, this obviously suggests some form of 'bundle theory' of individuals, which takes them to be nothing other than bundles of properties, typically conceived of as universals, including, in this version, relations (and it is because the relevant relations are manifested in physical situations such as the singlet state that this account evades Dasgupta's arguments to do with physical redundancy and empirical undetectability). Dasgupta rejects the bundle theory (2009, pp. 47-49), but here again, some care must be taken. The reason for this rejection has to do with the Principle of Identity of Indiscernibles, required by

[8] Saunders has argued that the Gibbs Paradox shows that individuality should be abandoned even in the context of classical statistical mechanics (2006). Alternatively one could take the paradox as a kind of 'footprint' within the latter of the forthcoming 'new' quantum statistics (French and Krause 2006). For a truly physics based form of generalism, see Saunders 2018.

bundle theories as a metaphysical guarantor against the possibility of two individuals sharing the same bundle of properties. As Dasgupta notes, the Principle restricts the scope of possibilities that we may entertain (indeed, that was its original purpose as far as Leibniz was concerned!) and, as usually expressed, it clashes with quantum mechanics (French and Krause 2006). However, as usually expressed the scope of the Principle does not extend to the kinds of irreflexive relations appealed to in the above account and it turns out that a form of the Principle, as suitably extended, can be constructed that is compatible with modern physics (Saunders 2003). Thus the bundle approach should not be dismissed quite so quickly.

Having said all of that, Dasgupta's approach does open the door to a kind of qualitative factualism that, with a little work, can be made to mesh nicely with modern physics. Pushing the door open even further we might then include symmetry principles such as those canvassed above in our fundamental qualitative basis. Indeed, this is what recent forms of structuralism have suggested.

The Structuralist Perspective

In very general terms, structuralism has been characterised as advocating a shift from thinking about the world in terms of objects to thinking about it in terms of *structures* (Ladyman 2014). As so characterised, albeit quite crudely, it can obviously be understood as standing in opposition to substantialism. What powers the shift to structures, at least in part, is reflection on the above metaphysical underdetermination between the two 'packages' of particles-as-individuals and particles-as-non-individuals, understood as motivating the ejection of objects from our fundamental metaphysical pantheon (Ladyman 1998). Further reflection on the nature of the theories of modern physics and in particular on the role of symmetry principles then helps us get a grip on what is meant by structure in this context. Thus, following Cassirer (1936) the structuralist can say that it is the interlocking 'Parmenidean sphere' of symmetries and laws, with specific measurement outcomes acting as 'existential witnesses' in Wilson's sense (Wilson 2012), pinning down the range of possibilities covered by such principles to this one, the structure of the actual world (French 2014).

So, to be more specific, Permutation Symmetry is a feature of the structure of all physically possible worlds, covering those that include paraparticles, but the structure of *this* world is delineated by Bose-Einstein and Fermi-Dirac statistics, yielding the most fundamental kinds, namely bosons and fermions respectively. The latter act as 'existential witnesses' in the above sense and their relationship to the symmetry that lies in the fundamental base can be described in terms of that of determinates to determinables.

Such a stance can easily be seen to be compatible with (qualitative) factualism, as hinted at above. Instead of particles as constituents, however, we would have symmetries and laws. Furthermore, cross-sectionality can still be satisfied, insofar as the other constituent 'slot' in the fact could be filled by 'everyday' properties, such as solidity for example. As indicated previously, the latter is explained, ultimately, by Permutation Symmetry (see French and Saatsi 2018) and so the fact <Permutation Symmetry, solidity> bridges the scientific and 'everyday' worlds in a way that satisfies Cumpa's Criterion.

However, it is certainly not necessary for the structuralist to also be a factualist. She could resist such an identification, on the well-ground grounds but in particular for reasons of ontological economy. The eliminativist structuralist especially, might insist that having eliminated the 'everyday' world, she is in no metaphysical mood to entertain 'facts' as further elements of her metaphysical pantheon. Indeed, she may well ask what it is that they 'bring to the table'! Standardly the factualist response is to emphasise the role of facts in explanations and the way they function as the locus of modality. I don't have space to go into the details of the relevant debate but the non-factualist structuralist can argue that what is doing the explaining when it comes to the solidity of my table, say, is not Permutation Symmetry as a constituent of a fact but simply Permutation Symmetry as a physical feature of the world. That is what is cited as the explanans in the usual scientific accounts. Couching it in terms of a 'fact' appears to add little to such accounts; at best, such a move only adds a further descriptive gloss from which we cannot straightforwardly infer ontological significance.

As for modality, the Humean structuralist will join her fellows in maintaining that any modality is 'in' the models. The non-Humean may argue that it is 'in' the world but again it is not necessary for her to ascribe it to 'facts', taken as features of her ontology. She may, for example, extend a 'primitivist' account of laws to symmetries and argue that these are likewise 'modally informed' (French 2014). We can illustrate this with, yet again, Permutation Symmetry, which, as we've noted, allows for options other than the standard forms of quantum statistics. Taking this mathematical 'surplus structure' as representing possible physical features of the world we can ascribe a certain 'power' or 'potentiality' to the symmetry, drawing on recent analyses of these notions (Vetter 2015). In this respect the modal structuralist account bears a certain resemblance to the kind of dispositionalism favoured by the substantialist, but of course with the 'seat' of modality shifted from objects to structures.

Finally, it is also this aspect of symmetries that underpin the counterfactual considerations appealed to in explications of the explanations they play a role in: the different possibilities encompassed by these symmetries allow us to entertain 'what if things had been different?' scenarios that track the metaphysical dependencies relating the explanans and explanandum as physical features of the world (French and Saatsi 2018).

In this manner, then, among others, structuralism may offer a 'third way' between substantialism and factualism. There is of course much more to be said, some of which will involve very general issues going far beyond the scope of this essay. However, I would argue that this is an avenue worth exploring, both for its contrasts and comparisons with the alternatives.

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