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ARE DISPOSITIONS REDUCIBLE?

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I. DEMISE OF THE OLD ANALYSIS

According to an old tradition of analysis, to attribute to an object the disposition to behave in a certain way is just to say that the object would behave in that way if it were appropriately stimulated. I shall call this the naïve conditional analysis:

NCA. x is disposed at time t to give response r to stimulus s iff, if x were to undergo stimulus s at time t , then x would give response r .

Although this definition is open to decisive objections, most of which are not new, NCA is not yet dead. There are still those of us who ask, on the presupposition that NCA or something very similar is the correct analysis of dispositions, whether dispositions can explain their manifestations, or whether the bearers of nothing but dispositional properties can fill space, or whether colours are mere dispositions in the objects to create sensations in viewers. The main difficulty of NCA has always been to see how the simple non-material conditional in the *definiens* describes a genuine intrinsic property at all. The conditional does not seem to be saying anything about what it is, *in the object*, that makes the response follow upon the stimulus. Dispositions, on this account, appear to be descendants of Malebranche properties (x has a Malebranche disposition iff, if the stimulus event occurs, then God directly brings about x 's response). Secular occasionalism, although familiar from the bad old days when behaviourism ruled in the philosophy of mind, is not confined to psychology. It arises whenever an

analysis of dispositional concepts, physical or psychological, is modelled on NCA.

Many philosophers who to their credit find it impossible to believe in Malebranche dispositions have adopted a functionalist analysis that is both a conditional *and* a causal analysis. It tries to meet the challenge of accounting for the powers of objects as genuine intrinsic properties. Here is a representative formulation of it:

CCA. x is disposed at time t to give response r to stimulus s iff x has some property G that would cause x to give response r if x were to undergo stimulus s at time t .

CCA inherits some of the problems faced by NCA, as well as having distinctive difficulties of its own due to the requirement that all dispositions must have a causal base. I shall mention three objections to CCA.

Finkishness. There is a refutation of the conditional analysis due to C.B. Martin.¹ Objects can acquire or lose non-permanent powers. These acquisitions and losses usually have causes. Let there be a non-permanent disposition D with s the stimulus and r the response appropriate to D . Now if when the stimulus s occurs it causes the stimulated object x to acquire D , and the same occurrence of s also triggers D and so brings about the response r , then at some time t , at which time s does not occur, the conditional 'If s were to occur at t then x would respond by doing r ' is true, although x does not have D at t . Such dispositions are finkish, and they falsify one half of the conditional analysis.

Conversely, if the occurrence of s causes an object x that has D to lose that disposition, then r does not occur despite the occurrence of s . Then at some time t , at which s does not occur, the conditional 'If s were to occur at t then x would respond by doing r ' is false although x has D at time t . Such dispositions are also finkish, and they falsify the other half of the conditional analysis.

Martin's argument does not apply only to NCA. The causal base, the 'property G ' in CCA, is included in the refutation. A disposition is finkish if the occurrence of the stimulus determines the acquisition or the loss, respectively, of the causal base. A non-imaginary example is an electrical safety cut-out switch which turns off the current in a wire when an earthed conductor touches the wire, thus preventing anybody getting a shock from the wire. At time t it is true that the wire is live, although the conditional 'If one were to touch the wire at t one would get an electric shock' is false, thanks to the safety switch.

¹ C.B. Martin, 'Dispositions and Conditionals', *The Philosophical Quarterly*, 44 (1994), pp. 1-8.

Deviant process. This is a problem for CCA suggested by A.D. Smith.² For an object to have a disposition to respond in a certain way, it is *not enough* that the response should be conditional on the occurrence of the definitionally appropriate stimulus. Suppose knocking some object causes ‘Z-rays’ to be beamed on it, which in turn causes it to shatter in the way fragile things shatter when knocked. Here a stimulus–response sequence occurs which satisfies the *analysans* of CCA, yet the shattering is not a manifestation of the fragility but of a deviant process. This objection draws attention to the fact that dispositional dependence contains something over and above conditional dependence.

Causality. One might say that the causal base of a disposition is a ‘causally operative sufficient condition for the manifestation’.³ Two consequences flow from adopting such a ‘complete cause’ concept. Dispositions are intrinsic properties of their bearers. This is one of the crucial appearances which has to be saved by an analysis. Now the causally operative sufficient condition for almost any manifestation is complex, and its parts are bound to include circumstances that are extrinsic to the bearer of the disposition. The first consequence of equating the causal base of the disposition with the complete cause of the manifestation is that we lose intrinsicity.

The second consequence is that we make the manifestation of the disposition into something unpreventable given the occurrence of the stimulus. For if to have the disposition *D* is to have a causal base which is the causally operative sufficient condition of *D*’s manifestation, then there cannot be another disposition *D** such that the exercise of *D** prevents *D* from manifesting itself. *D** would then be a disposition whose exercise, in Mark Johnston’s terminology, ‘masked’ the presence of *D*.⁴ Such masking dispositions exist, but the use of a complete cause concept in CCA rules them out.

The alternative to saying that the causal base is the complete cause of the manifestation is to say that it is part of the cause. But which part? There is no obvious answer to hand.

II. A REFORMED ANALYSIS AND ITS DIFFICULTIES

David Lewis agrees that CCA is refuted by finkishness. He has proposed a reformed conditional analysis (RCA) which is meant to be immune to Martin’s counter-example, *and* allow dispositions to be reduced to something

² A.D. Smith, ‘Dispositional Properties’, *Mind*, 86 (1977), pp. 439–45.

³ E.W. Prior, R. Pargetter and F. Jackson, ‘Three Theses about Dispositions’, *American Philosophical Quarterly*, 19 (1982), p. 251.

⁴ Mark Johnston, ‘How to Speak of the Colours’, *Philosophical Studies*, 68 (1992), pp. 221–63.

else.⁵ I stress the last point. Lewis' explicit intention in reformulating CCA is to show us how to avoid having to adopt irreducible dispositions. His analysis is of strong philosophical interest, in my opinion, precisely because it is part of this larger programme of saving the reducibility of dispositions.

RCA. Something x is disposed at time t to give response r to stimulus s iff, for some intrinsic property B that x has at t , for some time t' after t , if x were to undergo stimulus s at time t and retain property B until t' , s and x 's having of B would jointly be an x -complete cause of x 's giving response r .

The meaning of ' x -complete cause' is as follows. Starting with the idea of the complete cause of a manifestation event, ' x -complete cause' is obtained by restriction – 'a cause complete in so far as havings of properties intrinsic to x are concerned' (Lewis p. 156). RCA makes the having of the disposition independent of circumstances that are extrinsic to x .

How does RCA deal with the problems that beset CCA?

Finkishness. This is the refutation of the old analysis that RCA was specifically designed to meet, and I think it successfully blocks finkish cases for dispositions that have a causal base. A possible weakness of the treatment is that it cannot be extended in any obvious way to ungrounded dispositions. An analysis of ungrounded dispositions as conditionals, along the lines of NCA, say, is open to Martin's refutation. This will not worry those who think that there are no dispositions without causal bases.

Deviant process. Lewis rejects this line of criticism, because he denies (p. 154) 'that dispositional concepts generally have built-in response-specifications requiring a direct and standard process'. The example of HIV is given to show that the concept of a lethal virus does not require a direct and standard process. HIV, unlike ordinary viruses that attack vital systems, works by weakening the body's immunity against other pathogens. Its *modus operandi* is non-standard; nevertheless we call HIV 'lethal'. Any disposition D can be a cause (though not the complete cause) of various effects, depending on the presence or absence of other dispositions that partner D in jointly producing the effects. It does not follow from this that there is no limit to the *ways* in which a disposition can bring about its manifestation. Smith's case requires there to be a certain process peculiar to fragility, so that an object counts as fragile, not simply if it breaks on being gently knocked, but only if it does so as a result of that causal process. I think that a finitely disjunctive process-specificity is built into *all* dispositions. The example of HIV shows that for a virus to have the disposition to kill there does not have to be a *unique* process which leads from the infection to the victim's death. What the

⁵ David Lewis, 'Finkish Dispositions', *The Philosophical Quarterly*, 47 (1997), pp. 143–58.

example of HIV does *not* show is that any process whatsoever which leads from infection to death entails that the virus involved is lethal. A cautious tyrant decrees that whenever a hitherto unknown virus infects someone, the infected person is to be killed forthwith for the protection of the rest. Then we have stimulus (= entry of the virus), intrinsic causal base (= the body's hosting of the virus) and response (= death). Although all the elements of the *analysans* of RCA are satisfied, the virus may be harmless. It is the tyrant's decree lying on the causal path from stimulus to response that is lethal. The process leading to death is deviant *for a virus*, although it is not deviant for a certain system of infection control. For every disposition there are *limits* to what counts as the right process, and therefore for every disposition there are possible cases that lie outside the limits. In these possible cases the appropriate response is produced by a deviant process and not as a manifestation of the disposition.

What if 'dispositional concepts generally' were not process-specific? We could say that there are dispositions that are unconstrained in what, for them, counts as the right process leading to the response. That only divides dispositions into those that are not process-specific and those that are. RCA, however, does not merely *permit* process-unspecific dispositions, it ensures by definition that every disposition *has to be* process-unspecific. So even if 'lethal' as applied to viruses were unusual (or unique) in having some degree of process-specificity, it would still count against RCA. You need only a single effective counter-example to refute an analysis.

Causality. Under CCA there were two objections to the causal base as the complete cause. One was loss of intrinsicity. RCA meets this objection perfectly.

The second was unpreventability, or the ruling out of masking. Here RCA does something to help, but not enough. RCA allows a disposition of the object x to be masked by a disposition extrinsic to x . This covers a lot of the usual cases, such as the inflammability of the match masked by lack of atmospheric oxygen, etc. But RCA still rules out intrinsic maskers. By this I mean that if an object has two dispositions D_1 and D_2 , then according to RCA it cannot be the case that the manifesting of D_2 prevents D_1 from manifesting, or *vice versa*. The Greeks seem to have had a fascination for such cases: Tantalus, whose ability to drink was masked by his disposition to cause all fluids he approached to evaporate; King Midas, whose disposition to turn everything he touched into gold unfortunately masked his ability to nourish himself. Other common examples include the power of ingested poison masked by the power of ingested antidote, and an object's attractive power masked by a repulsive power it has, or *vice versa*. Intrinsic maskers are everywhere once you start looking for them.

What, then, is the difference between having the power of seeing, and having the power of seeing provided one's eyes are open and one is not asleep? The former is a simple but maskable disposition. It has several intrinsic maskers. The latter is a more complicated disposition and (let us assume) is not maskable. Lewis briefly hints (p. 153) that in cases like this we want to say that the simple maskable disposition and the complicated unmaskable disposition both exist. I agree that there are both maskable and unmaskable dispositions. But how can it be open to Lewis to accept both types, if the nature of the simple disposition, with its intrinsic maskers, refutes RCA?

III. RESTRICTED QUANTIFICATION AS A WAY OUT?

The objections so far canvassed to old and new causal conditional theories of dispositions depend on the (implicitly) universal quantification of the definitions. To have a disposition is to have an intrinsic property which (jointly with the stimulus) has a regular (i.e., unrestrictedly general) causal connection with a response. Making this explicit we get:

RCA₂. *For all times t*, something *x* is disposed at time *t* to give response *r* to stimulus *s* iff, for some intrinsic property *B* that *x* has at *t*, for some time *t'* after *t*, if *x* were to undergo stimulus *s* at time *t* and retain property *B* until *t'*, *s* and *x*'s having of *B* would jointly be an *x*-complete cause of *x*'s giving response *r*.

Restricting the scope of the definition is one way to avoid the counterexamples so far considered. Lewis once analysed the dispositional state of being unlocked, in cylindrical combination locks for bicycle chains, as the causal role of that state, which is

the syndrome of its most typical causes and effects: namely, that setting the combination typically causes the lock to be unlocked and that being unlocked typically causes the lock to open when gently pulled.⁶

This restricted quantification yields the following revision to RCA:

RCA₃. *For typical times t*, something *x* is disposed at time *t* to give response *r* to stimulus *s* iff, for some intrinsic property *B* that *x* has at *t*, for some time *t'* after *t*, if *x* were to undergo stimulus *s* at time *t* and retain property *B* until *t'*, *s* and *x*'s having of *B* would jointly be an *x*-complete cause of *x*'s giving response *r*.

⁶ Lewis, 'An Argument for the Identity Theory', in his *Philosophical Papers*, Vol. 1 (Oxford UP, 1983), p. 100.

‘Typically’, the word used here to indicate restricted quantification, is seriously ambiguous. In one of its senses it is a usefully vague probabilifying device, cut from the same cloth as ‘commonly’, ‘frequently’, ‘more often than not’, ‘in most cases’, ‘for the most part’, etc. In this sense it indicates sub-universal statistical quantification. In a second sense ‘typically’ is an indicator of defeasibility. Other words that can function as defeasibility indicators are ‘normally’ and ‘standardly’. In this sense ‘It is typically the case that p ’ means ‘Other things being equal, p ’.

To disambiguate RCA_3 we should make two quantifier substitutions. First we replace ‘for typical times t ’ by ‘for most times t ’. The result of this substitution is RCA_4 . Then we replace ‘for typical times t ’ with ‘for all times t at which other things are equal’, resulting in RCA_5 . Both RCA_4 and RCA_5 are immune to refutation by finkish cases, by stimulus–response sequences that result from deviant processes and by intrinsic maskers. Unfortunately, they generate other problems, as examination of each reveals.

RCA_4 . ‘For most times, unlocked locks are caused to open by gentle pulls’ is a frequency statement. It carries existential import. It implies that the disposition must be exercised more than once, because there are no statistical truths about null populations or singletons. It also implies that the number of times at which gentle pulls cause the unlocked lock to open must exceed the number of times at which gentle pulls fail to cause an unlocked lock to open. RCA_4 violates the ontological non-dependence of dispositions on manifestations by ruling out unmanifested dispositions as impossible, and by placing *a priori* constraints on the ratio of responses to stimuli. Such statistical facts about dispositions as the ratio of the occurrence of responses to the occurrence of stimuli are evidently contingent facts, to be learned *a posteriori*; they are not facts that ought to be derivable from a definition. So one cannot write a correct definition of dispositions in the form of RCA_4 .

RCA_5 . From a reductionist point of view, the trouble with RCA_5 is that a *ceteris paribus* clause occurs in it essentially. This makes RCA_5 circular, and there is no known way of removing the circularity.⁷ The circularity does not destroy the usefulness of such definitions in ordinary life or in the context of scientific investigation. For example, when we are testing for the presence of a disposition in an object we use our results in combination with background knowledge about the disposition in question. Such empirically obtainable background knowledge can put us in a position to say that on a given occasion other things relevant to the disposition are equal (or not, as the case may be). This in turn enables us to make a determinate interpretation of the test results. There is no conflict between the circular analyses and

⁷ Martin pp. 5–6; Lewis pp. 157–8; also George Molnar, ‘Defeasible Propositions’, *Australasian Journal of Philosophy*, 45 (1967), pp. 185–97.

the phenomenology of reasoning about dispositions in everyday or in science contexts. But of course the circularity makes defeasibly quantified analyses unavailable for reductionist purposes.

IV. THE PROBLEM OF THE MISSING REDUCTION BASE

There is only a loose connection between a metaphysics that is reductionist about dispositional properties and functionalist definitions of dispositions. Definitions like RCA are neither necessary nor sufficient for the ontological reduction of powers to categorical properties. They are not necessary, because the ontological reduction of dispositions does not require the translation of sentences containing dispositional expressions into sentences lacking such expressions. They are not sufficient, because functionalist definitions do not identify any reduction base. RCA says that for an object to have a disposition is for it to have two properties: a first-order property, the so-called ‘causal base’, and a (second-order) functional property that is realized by the causal base. This analysis is not reductionist *per se*, since it does not rule out the possibility that, for every disposition to which RCA applies, the causal base itself may be a disposition.

At best RCA can be thought of as one member of a set of conditions that are jointly sufficient for reductionism. Functionalism definitions that require dispositions to have causal bases must satisfy two ontological conditions in order to be applicable with reductionist intent. First, the world has to contain the properties that realize the functions specified in the definition. Second, if the functionalist definition has to be applied regressively to a hierarchy of dispositions that have as their causal base other dispositions, then the chain of regression must terminate in some dispositions that are grounded in non-dispositional properties. Not only must there be causal bases, they must include some properties that are themselves not dispositions. In the rest of the paper I am going to ask whether it is possible to satisfy the ontological conditions that need to be satisfied for a functionalist analysis to become a complete reductionist theory.

The traditional starting-point for reductionism is micro-reduction. The manifestation events of coarse macroscopic physical capacities of medium-sized objects can be explained in terms of the microstructural properties of the objects, and it has become commonplace to identify the causal bases of dispositions with microstructural properties. This does formally satisfy RCA, but, as has been frequently pointed out,⁸ the analysis of the having of

⁸ Martin p. 5; C.D. Broad, *The Mind and its Place in Nature* (London: Routledge & Kegan Paul, 1925), pp. 435–6; N. Goodman, *Fact, Fiction and Forecast* (Harvard UP, 1983), p. 45.

a power as the having of a causal function realized by a microstructural property that is itself a disposition cannot accomplish any ontological reduction. Not that this sort of analysis is pointless. By reducing the large number of types of disposition to a few general and pervasive ones, the analysis achieves simplification and unification and so greatly increases the explanatory power of theories. But because the appearance of dispositionality is only concentrated and not dispelled, scientific simplification does not improve ontological economy.

The simplification of the variety of macroscopic dispositions to microstructural ones reaches its limit when the functionalist analysis is applied to the powers of the subatomic particles. Subatomic particles are simple. They have properties but not parts. The strategy of selecting substructural properties as putative causal bases does not work here, nor are there any other non-structural intrinsic properties of these particles that could be selected instead.

We can provisionally conclude that a functionalist analysis which depends on the distinction between a dispositional property and its causal base is empirically inadequate. When the analysis is applied to the powers of macroscopic objects, one finds that the causal base consists of other dispositional properties of their structures. When the analysis is applied to the powers of structureless entities, no causal bases can be found at all.

V. RESPONSES TO THE PROBLEM

There are several lines of response to the charge of empirical inadequacy. One is to claim that the microstructural reduction base exists but is unknown. A second is to claim that the reduction base exists but is not microstructural. A third is to claim that the essential properties of the simplest physical objects are not powers and so do not need any reduction base. I mention examples of each strategy.

A real but unknown reduction base? There is no proof of the structurelessness of subatomic particles. It is an open question whether what we now take to be ultimately simple entities may in the future reveal a deeper structure. The claimed structurelessness may only be epistemic, which would allow one to say that electrons have a substructure, although it is unknown *pro tem*. Even the possibility of 'structures all the way down' cannot be ruled out *a priori*. Properties that form the causal bases of the fundamental dispositions really exist, but our ability to describe them is limited by the progress that science makes in revealing the hidden deep structure of matter beyond the point reached today.

This appeal to future science gives the defence two resources. First, there is the possibility that future science will discover a set of sub-substructural non-dispositional properties which can serve as the regress-stopping causal bases for the dispositional properties of the subatomic particles. Alternatively, future science may, somehow, confirm the hypothesis of ‘structures all the way down’. The world may be infinitely complex (or indefinitely complex), in which case there could be no arguments against reductionism from the existence of dispositions of simple objects.

Ultra-grounding. Rom Harré has suggested that physical dispositions are ‘finally to be grounded not in some ultimate level of micro-regress, ... but in the properties of the universe itself’.⁹ For a model for this, we are referred to Ernst Mach’s anti-absolutist analysis of matter in motion, which involves denying the intrinsicity of inertial mass, and explaining the resistance to acceleration and deceleration of a given body by the actual mutually induced accelerations of that body and every other body.¹⁰ On this model, or on some elaboration of it, we are to think of the properties of the simple objects as grounded in global properties of the entire universe, in some sense of ‘grounded’. This is how Harré proposes to reconcile the rule that powers must have a causal base with the fact that microstructural causal bases are not available for the fundamental physical powers.

Disempowering the fundamental particles. Some philosophers have said that the intrinsic properties of the subatomic particles do not represent counter-examples for reductionist analyses. They should be regarded as *not being dispositions at all*. The properties in question do (co-)determine the behaviour of their bearers, but this determination nexus is not part of the essential nature of the property, as is the case with dispositions. One can explain how the properties determine the behaviour in some way which does not require us to regard the properties as dispositions. If the behaviour-determining properties of the subatomic particles are not dispositions, then their lack of a causal base does not refute RCA.

VI. EVALUATING THE RESPONSES: THE UNKNOWN REDUCTION BASE

Ever since Rutherford found ‘bombardment’ as a method of probing for subatomic structure, every significant increase in the level of projectile

⁹ Rom Harré, *Varieties of Realism: a Rationale for the Natural Sciences* (Oxford: Blackwell, 1986), at p. 295.

¹⁰ Ernst Mach, *The Science of Mechanics: a Critical and Historical Account of its Development*, 6th edn (New York: Open Court, 1960), pp. 283–90.

energy has led to discoveries of new, deeper levels of structure.¹¹ But now there exists a strong body of evidence, from experiment and theory, to show that this history will not keep repeating itself. Collisions have been produced in accelerators with energies over a hundred thousand times above the level at which new structures could have been expected to reveal themselves if history was going to repeat. Yet electrons and quarks continue to come out as point-like structureless entities. Streams of protons directed at atoms cause behavioural changes that are only possible if the atoms have internal structure. In the case of quarks and electrons, similar structure-revealing results could be expected if the particles were energized by several thousand million eV, at a rough guess, but when the experiments are run, electrons and quarks continue to behave like entities without inner structure. The recent discovery of the monstrously massive top quark has not changed the position: the subatomic particles identified in the Standard Model are structureless. (The mass of the top quark is 175 GeV, about the same as an atom of gold, as compared with the next most massive fundamental particle, the bottom quark at 4.5 GeV.¹²) At present we have the technical ability to probe physical interactions to a distance of 10^{-16} cm, the electroweak unification level. When the Standard Model is extrapolated to even shorter distances, it predicts that all the forces are unified at approximately 10^{-30} cm. This simplifying result is taken by physicists to indicate the extreme improbability that in the range from 10^{-16} to 10^{-30} cm any new phenomenon, such as previously hidden structure, is to be found.

According to all indications the subatomic particles are absolutely simple. But even if there were structures all the way down, that would not be enough for the reduction of dispositions. For if throughout the indefinitely extended hierarchy of nested structures there are only dispositional structural properties at every level, there will still be no reduction base. The 'structures all the way down' defence is incomplete in principle, and has to be supplemented with a claim that the fundamental physical properties, at some level or other, are non-dispositional.

VII. EVALUATING THE RESPONSES: ULTRA-GROUNDING

The ultra-grounding properties of the universe are collective properties. A collective property is definable as a property of a whole not had by any of its

¹¹ Gordon Kane, in *The Particle Garden: Our Universe as Understood by Particle Physics* (New York: Addison Wesley, 1995), surveys the evidence for structurelessness.

¹² Tony M. Liss and Paul Tipton, 'The Discovery of the Top Quark', *Scientific American*, 277 (September 1997), pp. 36–41.

parts, and the having of which depends on (is inferable from) properties and relations of the parts. Collective properties contrast with other properties of wholes which are not dependent on properties of the parts but are emergent with respect to them.

Mach and Hertz have produced dynamics for a Newtonian world in which the concept of force plays no essential part. Force is treated instrumentally: ' F ' in the law $F = ma$ is simply *defined* as 'the product of the mass-value of a body into the acceleration induced in that body' (Mach pp. 303–4). There is thus no question of any property of a body's being a disposition to feel and exert a force. Force, on this view, is not the right sort of thing to be the manifestation of any disposition.

Mach also wanted to get rid of inertial mass as an intrinsic property of physical particulars. He gave an account of the mass-ratio of bodies as the ratio of the accelerations mutually induced between them. The essential elements of this analysis are bodies, their spatial and temporal relations and their induced accelerations. In Mach's system the existence of induced accelerations is a primitive empirical datum. This is how he puts it (p. 303):

Experimental Proposition. Bodies set opposite each other induce in each other, under certain circumstances to be specified by experimental physics, contrary *accelerations* in the direction of their line of junction. (The principle of inertia is included in this.)

On this account of inertia, bodies must have the active power of inducing accelerations in other bodies and the passive power of having accelerations induced in them. The Machian relativization of inertial mass, without re-introducing the already banished concept of force, nevertheless requires the attribution to individual bodies of the capacity to induce accelerations in one another. This is not surprising. As an even simpler example, before the seventeenth century, common sense and physics regarded *weight* as an intrinsic property of physical bodies. We have since discovered that the determinate weight of a body is a function of its mass and of the impressed forces acting on it. This too illustrates, even more tellingly than Mach's treatment of inertia, that in relativizing one seemingly intrinsic dispositional property, essential reference to some *other* intrinsic dispositional property is required. In the case of weight, the reference is to the quantified capacity to feel an impressed force. No model for the reduction of *all* fundamental dispositions can be found in any of this.

Harré's own threadbare account (p. 296) of ultra-grounding points to the same conclusion.

Ideally the dispositions which theoretical micro-regresses require physicists to ascribe to unobservable beings, like quarks and gluons, would be grounded, at least in principle, in observable properties of the universe. These properties would be occurrent

rather than dispositional, embracing such matters as the quantity and distribution of energy fields.

The possibility in principle of grounding the dispositions of subatomic entities in a set of properties of energy fields depends on the set's including, in addition to quantity and spatio-temporal distribution, properties that constitute physical capacities for those fields. Harré is not proposing a fully developed theory of ultra-grounding, but merely offering some pointers towards such a theory. He gives no reason for thinking it can be completed by invoking only geometric or numerical or other non-dispositional field properties.¹³

VIII. EVALUATING THE RESPONSES: DISEMPOWERED PARTICLES

According to RCA, the having of a disposition D is, as a matter of analytic necessity, the having of a property distinct from D which realizes a certain functional role. The intrinsic properties of subatomic particles are *prima facie* counter-examples for RCA, because (a) they are powers; and (b) there is, for them, no distinct property capable of realizing the relevant functional role. A defence against this move is to deny (a).

Some people have said that the properties of the simple entities are law-governed but not dispositional. To support such a view one needs more than a purely negative description of the fundamental physical magnitudes. If we are to get away with saying that electromagnetic charge or gravitational attraction are not dispositions, we have to give some positive account of their categorical nature. What could that be?

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. There is thus a strong presumption in favour of saying that the properties of the subatomic particles are dispositions. The onus is on anyone who wants to overturn that presumption to give some positive

¹³ For a similar point, see the brief but excellent Jim Franklin, 'Are Dispositions Reducible to Categorical Properties?', *The Philosophical Quarterly*, 36 (1986), pp. 62–4.

characterization of the non-dispositional nature of the fundamental physical magnitudes, without ascribing to these properties features that physics does not ascribe to them.

The reductionist could say in reply that the definitions in physics of the intrinsic properties of the fundamental particles are only nominal definitions, and that dispositionality is only a part of the nominal essence of the properties of the fundamental particles. These properties do not have a real essence, at least not one that is sufficiently rich to individuate them. There are only numerical differences among the monadic properties which determine (via the relevant laws) the behaviour of the simple particles. It is *not* that such properties have a noumenal character, or that they are ‘a something I know not what’ (Locke). Speaking literally, the properties just *have* no character or nature whatever.

Bare tropes or completely featureless universals are neither inherently plausible nor easy to inject into a reductionist theory of dispositions without threatening inconsistency. For purposes of functionalist reductionism, not only must each disposition have a causal base but the causal bases must include properties that are not themselves dispositions. Therefore at the ultimate stage of a regressive micro-reduction one has to say that nomological properties of the simple particles, such as electric charge and colour charge, are first-order monadic categorical properties. Only then is the regress stopped. But on the present proposal, electric charge and colour charge cannot be first-order or monadic or categorical, since supposedly they are totally featureless and differ from other properties of simples only numerically. The problem is that the reductionist on the one hand must attribute a monadic and categorical and first-order nature to the properties the having of which governs the behaviour of the basic particles, and on the other must deny that they have any nature at all.

These difficulties may tempt some to turn anti-realist about dispositions without a causal base. One defender of the functionalist analysis has this to say about the problem of the missing reduction base:

Something has a disposition if and only if it has a property which occupies a certain causal role. Some things may behave in a certain way but have nothing which occupies the causal role of causing such behaviour. In such a case we should say that the behaviour of this thing was instantiating a law of nature, that is, its behaviour is just a brute fact for which no further explanation can be given.¹⁴

This introduces a double standard. On the one hand we have macro-dispositions, which are perfectly real functional properties realized by other

¹⁴ Stephen Mumford, ‘Dispositions, Bases, Overdetermination and Identities’, *Ratio*, 8 (1995), p. 58.

perfectly real first-order properties. The behaviour of the bearers of these dispositions is lawfully regular precisely because it is the manifestation of the dispositions. Here we have a realist ontology of macroscopic physical objects and of their essential powers. When it comes to what are seemingly dispositional properties of subatomic particles, on the other hand, we are to say that the behaviour of the particles is not a manifestation of their powers but a brute fact. The laws describing such behaviour do not have properties of the particles as their truth-makers: the laws are just descriptions of an otherwise inexplicable regularity. If, as physics tells us, the essential properties of subatomic particles are all dispositional, then this instrumentalism about the properties will carry over into anti-realism about the particles themselves. We are landed with a picture of a curiously divided Nature. The objects and properties of the macroscopic part of the physical world are to be taken realistically, but the properties and hence also the objects of the microscopic part are not to be taken realistically.¹⁵

Is the ontological double standard compatible with what our current best science tells us about the basic nature of the material world? A long tradition in physics, stretching from Leukippus to Einstein, has familiarized us with a *compositional* picture of the universe. By this I mean that physics is based on the conjunction of two broad framework principles, the first of which I call object atomism (OA), and the other attribute atomism (AA). According to OA, complex physical systems are made up of simpler systems, and these in turn of still simpler systems. Ultimately *every* enduring material entity is composed of fundamental point-particles (leptons and quarks) that are themselves absolutely simple. According to AA, the physical magnitudes that characterize complex systems are factorizable into the magnitudes of the component systems. (The net electric charge of an object is the sum of the negative and positive charges carried by the particles, etc.) The properties of complex systems are collective properties in the sense I have previously defined.

What follows for the double standard if we suppose that both OA and AA are true? If one is going to be instrumentalist about some or all of the essential properties of the fundamental particles, then one has to be anti-realist about the particles themselves. If there is no electric charge (but only 'electric behaviour'), then there is no electron. Anti-realism about the particles and the compositional model jointly imply the incoherent view that complex physical systems are composed of non-existent parts, and that the physical properties of these systems ontologically depend on properties that

¹⁵ Michael Dummett also supports, cautiously and with qualifications, a double standard in physics, arriving at his position by a different route from that of the problem of the missing reduction base: see *The Seas of Language* (Oxford: Clarendon Press, 1993), pp. 376–410.

themselves do not exist. Therefore we should turn this *modus ponens* into a *modus tollens*. If current best science really dictates the compositional view of the physical world, then one is only left a choice between, on the one hand, anti-realism about the essential properties of subatomic entities and consequently about the entities themselves, leading to a comprehensive denial of any physical reality; and, on the other hand, a realist acceptance of both simple and complex physical entities and their properties. The former course is explicitly taken by candid idealists like John Foster and Howard Robinson, and the latter is the normal position of scientific realism. The double standard is ruled out.

It has been argued, quite plausibly, that quantum theory undermines the version of the compositional model that I have sketched, by showing that AA is not unrestrictedly applicable.¹⁶ Some metaphysicians take Bell's Theorem to show that there are complex (correlated) quantum systems whose dynamic states (position, momentum, spin direction) are not factorizable. These states of a correlated system are emergent in relation to the states of the system's components. Skipping the technical details of the argument, what is salient for us is, first, that non-dynamic properties (electroweak charge, colour charge, rest mass) retain their status as collective properties irrespective of how Bell's results are interpreted; and second, that there is no compelling argument from quantum theory for modifying OA. At most one needs to give up the unrestricted version of AA and replace it with some restricted version. It is difficult to estimate the full extent of the revisions this would force on a metaphysical theory based on compositional physics. But it is not too difficult to see that an appeal to Bell's Theorem will not rescue the double standard. For quantum theory still assigns to the particles essential, non-dynamic, intrinsic, dispositional properties, and that is all that my argument against the double standard requires. If one's theory leads one to be anti-realist about the ungrounded dispositions of the subatomic particles, then one had better be anti-realist about the particles themselves, and that in turn commits one to a comprehensive anti-realism about the physical world. The only *prima facie* coherent alternatives are realism about the essential dispositions of fundamental particles and fields, or idealism. The double standard looks no less incoherent *post bellum* than it looked in the context of straightforward special relativity physics uncluttered by quantum complications.

¹⁶ Don Howard, 'Holism, Separability, and the Metaphysical Implications of the Bell Experiments', in J.T. Cushing and E. McMullin (eds), *Philosophical Consequences of Quantum Theory* (Notre Dame UP, 1989), pp. 224–53; also Paul Teller, 'Relativity, Relational Holism, and the Bell Inequalities', in Cushing and McMullin, pp. 208–23; M.G. Redhead, *From Physics to Metaphysics* (Cambridge UP, 1995), ch. 3.

IX. IRREDUCIBILITY PRESERVED

The main argument of this paper is directed at functionalist reductionism, which Lewis' new analysis intends to reinforce. Functionalist analyses depend on the distinction between a disposition and its causal base, and I have argued that, the world being as it is, the only candidates for the role of causal base are themselves dispositions. When it comes to the fundamental micro-entities, no suitable properties exist that could serve as a causal base of their dispositions. For the reasons I have given, I reject the usual means of avoiding these conclusions.

RCA is an improvement on its predecessors because it preserves the important idea, sacrificed in some other analyses, that dispositions are intrinsic properties of their bearers. It also answers Martin's objection to the conditional analysis, at least for grounded dispositions. This represents progress. RCA does have serious residual defects which should stop one from accepting it as it stands, although further work might yield improvements. But what could be the point of a research programme aimed at improving RCA? If the problem of the missing reduction base has no solution, then it is futile to look for better versions of the causal conditional analysis. For no matter what analytic recipe for reduction one produces, it will not be possible to apply it if the world is so unkind as not to contain a reduction base.¹⁷

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