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Chapter 4

The Causal Efficacy of Macroscopic Dispositional Properties

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Introduction

A vase falls from high on hard ground. Small wonder it breaks. Is its fragility among the properties causally efficacious for its breaking? It is controversial whether a property can be both dispositional and causally efficacious. Fragility is a dispositional property because its identity depends essentially on a counterfactual conditional: an object is fragile to the extent that it *would*, in otherwise normal circumstances, break *if* it were to fall from high on hard ground. The antecedent of this conditional need never be actually satisfied: dispositional properties can be possessed while they do not manifest themselves, and even without *ever* manifesting themselves. The identity of categorical properties does not so depend on what would happen in certain counterfactual situations: whether an object is spherical is determined by a criterion that can be spelled out in terms of actuality: all points on the surface of the object are at the same distance from its centre. Among others, Armstrong[1] holds that dispositional properties can be causally efficacious, first of all by bringing about their own manifestation, in a situation where they are put to the test. In the case of the vase, a fall from high on hard ground is a test situation[2] for fragility, and breaking its manifestation. Prior,

[1] D.M. Armstrong, *A Materialist Theory of the Mind* (London, 1968), p. 88; D.M Armstrong, *A World of States of Affairs* (Cambridge, 1997), pp. 70-71.

[2] In a test situation, which is otherwise normal (more on this restriction later), the disposition manifests itself. Cf. R. Carnap, 'Testability and Meaning', *Philosophy of Science*, 3 (1936): 420-471; N. Goodman (1955), *Fact, Fiction, and Forecast*, 3rd edition (Indianapolis, 1973), and the introduction to this volume. Many dispositional properties give

Pargetter and Jackson[3] argue on the contrary that dispositional properties (or dispositions) are in principle incapable of causal efficacy, in other words that they are epiphenomenal. However, there is more agreement among the parties in this debate on the interpretation of the nature of dispositions than these opposite theses suggest. It is generally presupposed in the debate that the dispositional properties at issue are macroscopic, and in principle reducible to a microscopic reduction base. By 'macroscopic' I simply mean that they are properties of objects that have parts: the properties of the whole are macroscopic relative to the properties of its parts which are by definition, microscopic. In this sense, 'microscopic' and 'macroscopic' are relative terms. It is common ground shared by both positions that the only causally efficacious properties are the microphysical base properties. Because it is usually taken for granted that these properties are not themselves dispositional, the reduction base is often called the 'categorical base' of the disposition. The disagreement is only over whether the macroscopic disposition inherits this efficacy by being identical to its reduction base (which is Armstrong's position)[4] or whether it is epiphenomenal because it is not identical to its reduction

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rise to different characteristic manifestations in different types of test situation. D.H. Mellor, 'The Semantics and Ontology of Dispositions', *Mind*, 109 (2000): 760. Mellor mentions mass as an example of such 'multi-conditional' dispositional properties: the mass m gives its bearer both the disposition to accelerate with f/m, in a situation in which it is subjected to a force f, and the disposition to exercise the force m^2/r^2 on another mass m, in a situation in which they are at a distance r. Another case is fragility, which also gives its bearer many dispositions: the disposition to break in a certain type of situation, the disposition to fissure in another type of situation. In a similar way, the high temperature of an inflammable gas is a dispositional property that gives the gas the disposition to be at a certain pressure, but also the disposition to explode. Thus, in the case of such properties, the distinction between *dispositions* and *dispositional properties* is important. Nevertheless, I shall often speak indifferently of dispositions and dispositional properties, in contexts in which there is no danger of confusing the dispositional property with the different dispositions to manifest itself the property gives its bearer.

[3] E. Prior, R. Pargetter and F. Jackson, 'Three Theses about Dispositions', *American Philosophical Quarterly*, 19 (1982): 251-257.

[4] In the general context of the analysis of the logic of reducing one scientific theory to another, many authors follow Causey's thesis that reduced and reducing properties are *identical*. R.L. Causey, *Unity of Science* (Dordrecht, 1977). In Locke, one can find both the doctrine of the *identity* of dispositions (or, as he says, powers) with their microscopic categorical basis, and the idea that the former only *depends* on the latter, which is the thesis I shall defend. Locke seems to express the former doctrine when he says that 'whiteness or redness are not in it [i.e., in the Porphyre] at any time, but such a texture, that hath the power to produce such a sensation in us' (Locke 1689, II, 8, 19). The colours are identical with a texture, which is a microscopic categorical base property; and the latter can be causally efficacious in producing sensations in us when we look at a coloured object. But on the other hand, Locke's view may be interpreted as being compatible with the second doctrine when he says: 'Colours and Smells, … and other the like sensible Qualities … are in truth nothing in the Objects themselves, but Powers to produce various sensations in us, and

base (which is the 'functionalist' position defended by Prior, Pargetter, and Jackson).[5]

In this paper, I challenge the consensus about the monopoly of microproperties in matters of causal efficacy, by showing that it is coherent, and at least sometimes also plausible, to conceive of dispositional macroproperties as causally efficacious and nevertheless distinct from the microscopic properties in their reduction base. 'Is fragile' designates a macroscopic property of the vase, which is dispositional in the sense that its bearer has (by virtue of the meaning of the word 'fragile') the disposition to break when falling from considerable height on hard ground. However, the possibility of conceiving of this property in a dispositional way does not prevent it from causally contributing to the breaking. One can conceive of one property in both dispositional and in categorical ways. The second conception is in play when one attributes causal efficacy to the property.

Part of the importance of this issue lies in its bearing on the nature of mentality: If I am right about macroscopic dispositions in general, this gives legitimacy to the idea that our desires, beliefs and other psychological properties give us dispositions to think and act, and contribute thus causally to the actions by which these dispositions manifest themselves.

There are several arguments believed to show that dispositional properties in general are not causally efficacious as such. First, I shall briefly provide some considerations showing how to resist these arguments. Then I will turn to a group of arguments that Armstrong and the functionalists have offered specifically against the idea that dispositional *macroscopic* properties, which are micro-reducible, have their own causal efficacy.

General Arguments Against the Efficacy of Dispositions

Many philosophers deny the efficacy of dispositions in general, for one or several of the following reasons:

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depend on those primary Qualities, viz. Bulk, Figure, Texture, and Motion of parts' (Locke 1689, II, 8, 14); here, Locke says that sensible qualities *depend on* the texture and other 'primary qualities', i.e. microscopic categorical properties, rather than being identical with them. I will express essentially the same idea by saying that the microscopic categorical properties *determine* the macroscopic dispositional properties. To say, as Locke, that these secondary qualities are 'Powers to produce various sensations in us', seems compatible with saying, as I shall do, that they are macroscopic properties that can be conceived as dispositions which can cause (produce) certain effects (e.g. sensations).

[5] F. Jackson, R. Pargetter and E.W. Prior, 'Functionalism and Type-Type Identity Theories', *Philosophical Studies*, 42 (1982): 209-225.

1. According to one such argument, dispositional properties lack causal efficacy because they are unobservable. The issue of realism with respect to theoretical properties lies beyond the scope of this paper. According to scientific realism, theoretical predicates used in science refer to real objects and properties even if they are not directly observable. However, to disarm this argument against the efficacy of dispositions, it suffices to note that the impossibility of observing them directly does not distinguish the dispositional property of being brittle from theoretical properties, such as being magnetized or having spin ½. By parity of reasoning, the fact that the former are unobservable is not a reason to doubt their reality and causal efficacy any more than it is a reason to doubt the reality and causal efficacy of the latter. Now, from a realist point of view, explanations mentioning unobservable theoretical properties are accepted as causal explanations; therefore, to the extent that the fact that a piece of iron is magnetized is accepted as causally responsible for the movement of the iron filings it attracts, the fact that brittleness is not observable does not constitute a legitimate reason to deny that it can causally contribute to the vase's breaking.
2. A second argument consists in pointing out that non-occurrent properties cannot be efficacious and that no property can be both dispositional and occurrent. However, the idea that dispositions are non-occurrent seems to result from the following fallacious reasoning. Dispositional properties seem to be non-occurrent (and therefore incapable of causal efficacy) because they are conditional or hypothetical. The property (or disposition) that every French citizen over 25 possesses to be potentially, or conditionally, president of France is not sufficient for giving every French citizen the causal powers of the president. All one may legitimately conclude from this is that the disposition does not have the causal powers possessed by its manifestations. This does not preclude the possibility that the dispositional property itself lends *other* powers to its possessor, e.g., to become a candidate for presidency. It is the manifestations of the disposition, not the disposition itself, that exist only conditionally or hypothetically. It is fallacious to argue from the non-occurrence of the manifestation to the non-occurrence of the disposition. Therefore, nothing prevents us from allowing that dispositions are occurrent even while they are not being tested, and thus while they do not manifest themselves.[6]

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[6] This point has been made by C.B. Martin, 'Final Replies to Place and Armstrong', in D.M. Armstrong, C.B Martin and U.T. Place, *Dispositions: A Debate*, (ed.) T. Crane (London, 1996) and S. Mumford, *Dispositions* (Oxford, 1998). Martin observes that the disposition itself is 'something that is fully real and actual (unlike some of the manifestations) […]. Dispositions are actual continuants that predate, outlast, and may exist entirely without the existence of their manifestations.' (Martin, 'Final Replies to Place and Armstrong', p. 166; Cf. also S. Mumford, *Dispositions*, p. 74). Mumford makes the same point even more explicitly: ' "Categorical" means "unconditional" and this casts doubt on the putative distinction that is being drawn [between the dispositional and the categorical]

3. According to a third argument, dispositions are permanent states, or static properties, whereas only changes can be causes. The correct reply seems to me to follow Mill[7] in refusing the obligation of philosophical analysis to stick to common sense at any cost. True, in most ordinary circumstances, common sense prefers to pick out changes as 'the cause' among many causal factors. However, from a scientific and according to Mill a philosophical point of view, stable factors can play exactly the same causal role in producing an effect as changes. This gives us ground enough for holding that a stable factor can be a 'cause […] philosophically speaking'.[8] If I introduce tension into a copper wire, the change in tension is certainly a causally efficacious factor in producing electrical current flowing through the wire. But the resistance of the wire, although a stable disposition that does not undergo any change, is also a causally efficacious factor determining, together with the tension, the intensity of the current. The wire's resistance contributes causally to determining that intensity by microscopic interactions between the conduction electrons and the microscopic constituents of the wire. However, the fact these microscopic interactions bring about microscopic changes does not imply that the macroscopic resistance undergoes any change whatsoever. Thus, it is a stable factor that is nevertheless causally efficacious.

Two other arguments against the efficacy of dispositional properties have affinities with the argument that permanent states cannot be causes.

4. Dispositions are *facts* whereas only *events* can be causes. Helen Steward[9] has recently argued that by attributing a disposition to an object one can only refer to a fact, not to an event. Now, according to Steward, facts are entities that exist only by virtue of the linguistic expressions whose meaning they are; therefore, they lack causal efficacy although it can be *relevant* to mention them in an *explanation*. This argument has the same source as the preceding one because the reason why it is linguistically awkward to form expressions referring to events with dispositional predicates, stems from the permanent nature of dispositions and from the fact that it is more natural to conceive changes as events rather than permanent states. However, this argument presupposes the Davidsonian conception of the distinction between events and facts, according to which events are particulars whereas facts are linguistic entities whose identity is determined by virtue of the meaning of the words expressing them.[10] This is not the right place to go into the details of the complex debate on the nature of events and facts.[11] Let me just note that

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because dispositions are, in a very obvious way, categorical.' (Mumford, *Dispositions*, p. 64).

[7] J.S. Mill, *A System of Logic, Ratiocinative and Inductive* (Honolulu Hawaii, 2002).

[8] J.S. Mill, ibid., III, V, 3, p. 217.

[9] H. Steward, *The Ontology of Mind* (Oxford, 1997).

[10] Cf. D. Davidson, *Essays on Actions and Events* (Oxford, 1980).

[11] Some efforts for clarifying this distinction can be found in M. Kistler, 'Causes as Events and Facts', *Dialectica*, 53 (1999): 25-46 and M. Kistler, *Causalité et lois de la nature* (Paris, 1999).

Davidson's account has the implausible consequence of denying that there is any difference among the properties of a given cause event, with respect to their contribution to bringing about a given effect event, over and above a pragmatic difference between good and bad explanations. Consider a red billiard ball that hits a white billiard ball at rest by a central elastic shock, thereby transferring the red ball's momentum M to the white ball. Let us now compare two causal explanations of the fact that after the shock, the white ball carries momentum M. The first explains this fact by saying that the red ball's carrying M at the moment it hit the white ball with an elastic shock is causally responsible; the second explains it by saying that the red ball's being red at the moment it hit the white ball with an elastic shock is causally responsible. It is clear that the first explanation is not only good and relevant but also true and that the second is not only bad but false. There must surely be something about that causal relation that makes the former true and the latter false. According to one account, the truth-maker of the first explanation is the fact that there is a relation of causal responsibility between the fact that the red ball carries M before the shock and the fact that the white ball carries M after the shock. However, there is no analogous truth-maker for the second explanation: there is no relation of causal responsibility between the fact that the red ball is red before the shock and the fact that the white ball carries M after the shock.[12] If this account is correct, it is legitimate to attribute a causal role to facts: they are terms of relations of causal responsibility. Therefore, that attributions of dispositions normally have a factive rather than an eventive format is no reason for denying that dispositions can contribute causally to bringing about their manifestations.

5. Squires[13] argues that the hypothesis that dispositions can be causes leads to an infinite regress. According to Squires, in order to explain why a disposition manifests itself at some times but not always, it is necessary to postulate a further disposition: the disposition which the original disposition has to manifest itself. But then, this new disposition itself can also manifest itself or not. Therefore, we must suppose that it has yet another disposition to manifest itself, and so on to infinity. To this, Armstrong[14] has given a convincing reply. Armstrong compares Squires' infinite regress to the infinite series of facts existing superposed on any fact p: the fact that it is true that p, the fact that it is true that it is true that p, etc. One can account for this infinite series of facts in at least two ways: either one distinguishes a linguistic concept of fact, according to which this is really an infinite series of different facts – because their linguistic expressions differ – from a 'Russellian'[15]

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[12] I have developed this argument for the existence of facts, from the truth-makers of causal explanations elsewhere. Cf. M. Kistler, 'Erklärung und Kausalität', *Philosophia Naturalis*, 39, Heft 1 (2002): 89-109.

[13] R. Squires, 'Are Dispositions Causes?', *Analysis* 29 (1968): 45-47.

[14] D.M. Armstrong, 'Beliefs as States' (1973), in R. Tuomela (ed.), *Dispositions* (Dordrecht, 1978), p. 419.

[15] This terminology is due to J. Bennett, *Events and their Names* (Cambridge, 1988), p. 41. According to Bennett, the identity of a 'Fregean' fact is determined by the meaning of

conception according to which a unique fact underlies all these linguistic facts. Or one can, as Armstrong proposes to do, distinguish between the linguistic expression of a fact and what makes such an expression true, its truth-maker. According to the first way of putting it, there is only one real disposition, which belongs to the one Russellian fact; according to the second way, just as the infinite series of facts superposed on p all have the same truth-maker, i.e. p, the one truth maker of the infinite series of higher order dispositions is simply the first order disposition. Both analyses allow us to reject the objection of the infinite regress, by arguing that the apparent infinite series of dispositions described by Squires is only an artefact of language, whereas only one (Russellian) fact containing a unique (first-order) disposition makes them all true.

6. According to the traditional objection Molière has made famous by making fun of the alleged causal and explanatory power of the 'dormitive virtue' of opium, dispositions cannot be among the causes of their manifestations because they are related to them by an analytical and therefore necessary link, whereas causation is an essentially contingent relation. It often happens, at least in my kitchen, that a fragile object breaks after having fallen on hard ground. Now, it is part of the meaning of the predicate 'is fragile' that objects to which it applies break when, in otherwise normal circumstances, they fall from high on hard ground. Therefore, goes the argument, given that this fragile vase has fallen from high on hard ground, the judgment that is has broken after its fall is analytic. This implies that, in the sentence 'this vase has broken after having fallen because it is fragile', the word 'because' does not express a cause-effect relation but rather an analytic relation of implication, based on the meaning of the word 'fragile'. So it seems that the vase's fragility cannot be among the causes of its breaking.

However, this argument is fallacious because it overlooks, in the statement of the relation between the disposition, a test condition and its characteristic manifestation, the essential reference to *normal conditions*. It is part of the requirements of the correct attribution of a disposition that it does *not always* manifest itself in the characteristic way in a given type of test situation, but only most of the time, in a statistical sense. Even a fragile vase that falls from high on hard ground does not always, or necessarily, break, but only most of the time, or in ordinary circumstances. One can imagine extraordinary circumstances in which the hard surface rests on springs absorbing the shock and other extraordinary circumstances in which the vase and the ground contain strong magnets repelling each other. True, such situations are far fetched. However, to show that there is no

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the linguistic expression used to express it. The facts designated by two expressions are identical only if their linguistic expressions may a priori be derived from each other, by virtue of their meaning (Cf. Bennett, *Events and their Names*, pp. 35-37). However, 'we sometimes use definite descriptions as though they were Russellian, regarding them merely as pointers to their referents' (Bennett, *Events and their Names*, pp. 39-40). In this sense, two different statements can express one 'Russellian' fact even if their senses are not equivalent, i.e. if their expressions cannot a priori be derived from one another.

necessary (because analytic) link between the fact that a given object falls on hard ground and the fact that it breaks, it is sufficient to show that *there are* situations even if they are very rare, in which the first is a fact but not the second. In other words, what is analytically implied by the fact that the fragile vase falls on hard ground is only that it breaks *in otherwise normal circumstances*. However, that fact does not analytically entail that it breaks, *tout court*. Therefore, the fact that it breaks remains a contingent fact and nothing prevents the fragility of the vase from being among the factors causally contributing to its breaking.

It has often been observed that dispositions do not always give rise to their typical manifestations in characteristic test conditions. Martin[16] has shown it by carrying out the following simple thought experiment. He imagines a mechanism that is so conceived that, when connected to an object possessing a given disposition, prevents it from showing its characteristic manifestation in a given test situation. A copper wire under tension has the disposition to give an electric shock to anyone touching it (if the person's feet touch the ground and the person isn't wearing rubber soles). Now, Martin's imagined 'electro-fink' is a mechanism that takes the disposition away if and only if it is put to the test, i.e. when someone touches it. In this type of test situation, the disposition, although really there, never manifests itself in the characteristic way. Relatively to the pair <test situation, characteristic manifestation> consisting in: <touching the 'finkish' wire, receiving an electric shock>, the fink takes care that circumstances are never 'normal'. Martin's electro-fink is not as far fetched as it appears at first sight: in fact, it is just an extreme case of a quite ordinary phenomenon. The electric circuit in every modern house contains a 'circuit breaker', a mechanism working just like the electro-fink. More generally, as Bird (1998) has noted, for every disposition and every relevant test situation, there are 'exceptional' circumstances where an 'antidote', to use Bird's expression, prevents the manifestation although the disposition is present.[17] The springs under the hard surface, which absorb the shock received by the falling object, act as an antidote against the vase's fragility in this sense.
Before we return to the analysis of the 'ceteris paribus' clause that accompanies the expression of the link between the disposition, the test condition and its

[16] C.B. Martin, 'Dispositions and Conditionals', *Philosophical Quarterly*, 44 (1994): 1-8.

[17] M. Johnston, 'How to Speak of the Colors', *Philosophical Studies*, 68 (1992): 221-263 and G. Molnar, 'Are Dispositions Reducible?', *Philosophical Quarterly*, 49 (1999): 1-16 call them 'maskers': they mask the original disposition by preventing it from manifesting itself. D. Lewis, 'Finkish Dispositions', *Philosophical Quarterly*, 47 (1997): 143-158 and W. Malzkorn, 'Realism, Functionalism and the Conditional Analysis of Dispositions', *Philosophical Quarterly*, 50 (2000): 452-469. W. Malzkorn have tried to analyse the meaning of disposition attributions with counterfactual conditionals that do not contain any 'ceteris paribus' clauses, thereby avoiding refutation by cases such as Martin's.

manifestation, we must look at a group of arguments that question more particularly the efficacy of *macroscopic* dispositional properties.

The Epiphenomenalist Trilemma for Macroscopic Dispositions

All dispositions have manifestations. By the 'causal base' (or 'categorical basis') of a disposition possessed by an object, I mean the set of intrinsic (i.e. non-relational) properties of the object that contribute causally to bringing about the manifestations of the disposition. Insofar as the bearer of the disposition contributes causally to bringing about its manifestations, the properties of the bearer of the disposition contain the causal basis for that disposition. Within this conception of the causal base, the properties belonging to the causal base are categorical properties, because they are causally efficacious. However, in the case of macroscopic dispositional properties, there are different ways of conceiving of the relation between a disposition and its causal base, which lead to denial that the disposition has its own causal powers.

1. According to the 'functionalist' conception of dispositions, a disposition is a second order property. However, only a first order property can be causally efficacious. There are two reasons for thinking that dispositions are not identical to any first-order properties. First, one disposition may be grounded on different microscopic bases; second, it is contingent which base underlies a given disposition.
2. According to an important conception of intertheoretical reduction (Cf. Causey),[18] the reduction of a macroscopic property to underlying microscopic properties discloses an identity. To the extent that the disposition is identical with its categorical reduction base, it is causally efficacious because the latter is.
3. Kim's[19] conception of functional reduction combines elements of the other two conceptions. According to this third conception of the relation between a disposition and its base, attributing a disposition to an object means to attribute a second-order *predicate* to it: the object possesses a property that plays the role of causing the disposition's characteristic manifestation in a given test situation, when circumstances are otherwise normal. The predicate specifying the role is second order to the extent that the reference to *a* property playing the role is equivalent to an existential generalisation over first-order properties. Only the property playing the role is causally efficacious, but not the disposition corresponding to the role itself. However, Kim also considers that the property playing the role is necessarily microscopic, even when the disposition is attributed to a macroscopic object.

None of these conceptions allows macroscopic dispositions to have their own distinctive causal powers. This is a dilemma, in fact a 'trilemma', because 1) there

[18] R. L. Causey, *Unity of Science*.
[19] J. Kim, *Mind in a Physical World* (Cambridge, 1998).

does not seem to be any further possibility and 2) neither of these possibilities seems to be compatible with our common sense intuition that our own mental properties, at least, are macroscopic properties that are causally responsible for our own actions without necessarily being identical with any microscopic property of our brain.[20] I call the trilemma 'epiphenomenalist' because all alternatives end up denying that the macroscopic dispositional properties have any causal powers of their own. As far as they have their own identity, they appear therefore as epiphenomenal. According to the first horn of the trilemma, dispositions lack efficacy, whereas according to the second and third, they are efficacious but only by being identical to their microscopic base properties.
I shall show that the trilemma can be avoided, and that macroscopic dispositional properties can be conceived as causally efficacious though not identical to their microscopic bases, with the help of two premises:

1) the distinction between the dispositional and the categorical applies to predicates and not properties, and
2) the categorical base is not necessarily the reduction base.

Rejecting both of these theses leads to the first horn of the dilemma represented by functionalism, whereas accepting 1) but not 2) leads to the latter two horns of the epiphenomenalist trilemma, represented by Armstrong's and Kim's accounts. I shall argue for thesis 1) in the section 3, and for thesis 2) in section 4.

Dispositional and Theoretical Properties

Before arguing that the distinction between the dispositional and the categorical bears on predicates rather than on the properties those predicates designate, I shall sketch a general account of the role dispositions play in explanations, and in

[20] Whether this intuition is correct is of course controversial. It is the object of a now classical debate between Wittgenstein (1953) and his followers on one side, who deny conceptual coherence to entities (the so-called 'mental representations') whose content justifies an action and which are nevertheless also causally responsible for that action, and Davidson (1963) on the other side, who argues that it is necessary for our conception of ourselves as agents exercising causal power on our own actions to suppose that our reasons to act are at the same time causally responsible for our actions, by being mentally represented. The intuition mentioned above is compatible with Davidson's intuition but not with Wittgenstein's. L. Wittgenstein, *Philosophical Investigations*, trans. G.E.M. Anscombe (Oxford, 1978). D. Davidson, 'Actions, Reasons, and Causes', in D. Davidson, *Essays on Actions and Events* (Oxford, 1980).

particular scientific explanations. The logic underlying explanations referring to dispositions is best revealed in exceptional cases where a disposition does not manifest itself although it is subject to one of its characteristic tests. To explain the exceptional behaviour of an object that does not manifest one of its dispositions in a given test situation, one refers to other properties that may be those of the object itself, or may more generally belong to the situation. As we have already seen, in the clause expressing the dependence of the characteristic manifestation with respect to the object's being in a test situation, it is essential to mention the otherwise 'ordinary circumstances' relevant for the case under consideration, because each concrete test situation possesses innumerable other properties that can in principle interfere with the manifestation of the disposition.

However, the scientific conception of properties aims at doing away with that 'ceteris paribus' clause. Thus, one may turn to a scientific explanation to find out why a given disposition did *not* manifest itself in a particular test situation; in this case, the scientific explanation must not itself contain any ceteris paribus clause. Take the case of an object in free fall, close to the surface of the Earth. If I let go of an object that is not held up by anything else, it has a disposition to fall a distance of $s=1/2\ gt^2$ in t seconds. However, in the presence of such 'antidotes' as friction with the surrounding air, the disposition does not manifest itself in this way. The discovery of the different antidotes present in a given concrete situation, which allows us to explain an object's behaviour that deviates from the direct manifestation of the disposition, is a scientific task and requires in general the postulate of properties that are not directly observable. Ideally, if all factors contributing to determine the process have been identified, it is possible to explain the manifest behaviour without any need for a ceteris paribus clause expressing our partial ignorance of the circumstances.

Once a complete scientific description of the situation has been given, dispositional properties can be conceived as *powers* necessitating their effects. However, these effects are not necessarily manifest; they can themselves be powers. In the case of free fall, a scientific description of the situation allows us to substitute for the body's disposition to fall $1/2gt^2$ meters in t seconds, the force $g \cdot m$ that produces an acceleration g. Let us call the force and the acceleration 'constraints' or 'powers' that determine each other by virtue of laws of nature. The force $g \cdot m$ determines a power to accelerate by g by virtue of Newton's law, better known in the form $F = m \cdot a$. This tendency to accelerate, although it is a necessary consequence of force, does not necessarily manifest itself directly. What is manifest is the result of the superposition (or of the interaction) of all tendencies to move imposed on the body by the different powers that are present. Friction with air is another power present in the situation, which imposes another tendency to accelerate in a direction opposed to that of the acceleration produced by the force of attraction.

At this point we must pause to consider an important objection to my thesis that theoretical properties are powers related by laws to other properties that, being

themselves powers, do not necessarily manifest themselves directly.[21] Suppose Galileo's law of free fall, taken as a hypothesis, predicts that a body falls $1/2gt^2$ metres in t seconds but that observation tells us that the distance it really falls is less. My account suggests that this is reason enough to legitimate the postulation of a power to fall $1/2gt^2$ metres, which does not manifest itself directly, instead of being a case refuting Galileo's hypothesis. However, if the discrepancy between theoretical prediction and observed result was in itself sufficient to justify the postulation of that power, it would seem that we have legitimized a general strategy of immunization of theories, which would even allow justifying phlogiston theory. Given that empirical observation contradicts the prediction of phlogiston theory that the residue of combustion is lighter than the body before combustion, my account seems to legitimize the postulation of a tendency, or power, of combustible bodies to become lighter during combustion, a power which does not, however, directly manifest itself by any measurable loss of weight. This objection can be overcome by requiring that the postulate of a power is subject to the usual conditions of legitimacy for the postulate of theoretical entities: the postulate of a power that does not directly manifest itself is scientifically legitimate only to the extent that it is possible to provide, in each situation in which it is not manifest, an independent explanation of the fact that it is not manifest.[22] It is legitimate only if the difference between the postulated power and the manifestation can be accounted for by the interference of other factors whose presence can be independently detected. In other words, the hypothesis explaining the discrepancy between the regular manifestation of the power and what is observed must abide by the Popperian criteria for an empirically meaningful, non ad hoc, hypothesis, as much as any other scientific hypothesis. The hypothesis of a power of combustible objects to lose mass during burning is not scientifically legitimate because the only way to reconcile it with the empirical fact that burning makes objects *more* massive, is by making another postulate which cannot be independently justified, namely the ad hoc postulate that they gain mass by liberating a substance with negative mass, phlogiston. By contrast, attributing to free falling bodies the power to fall $1/2gt^2$ metres in t seconds is legitimate in so far as one can find, in each situation empirically investigated, independent grounds for postulating interfering factors (themselves powers) such as friction with air, whose effects add up to, with that of the initial power, the distance fallen, empirically observed.

The main conclusion that I propose to draw from this analysis is this. Substituting a force that itself produces a tendency to accelerate, for the disposition to fall $1/2gt^2$ meters in t seconds, corresponds to a change in the way of conceiving of one and

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[21] This objection is also discussed by P. Lipton, 'All Else Being Equal', *Philosophy*, 74 (1999): 155-168. Cf. Schrenk, this volume.

[22] Pietroski and Rey show that it is necessary and sufficient to impose such a constraint to save ceteris paribus laws (i.e. laws that allow for exceptional situations) from vacuity. P. Pietroski and G. Rey, 'When Other Things Aren't Equal: Saving Ceteris Paribus Laws from Vacuity', *British Journal Philosophy of Science*, 46 (1995): 81-110.

the same property. The first conception of the property is grounded on a dispositional predicate whose meaning contains a link to the manifestation of the disposition, which raises the suspicion of analyticity. However, the second conception of the same property on the basis of scientific predicates justifies attributing causal efficacy to it: the link between two properties established by a causal law is never a priori, because laws of nature are discovered a posteriori. The fact that the link is not analytic removes the suspicion that the thus conceived properties are 'dormitive virtues'. Such a scientific conception thus puts us in a position to conceive in a categorical way the same property that has first been conceived of dispositionally.

This analysis suggests that the distinction between the conception of a property as dispositional and its scientific conception as categorical can be grounded on the following criteria. The attribution to an object of a dispositional property exercising a constraint on its evolution is subject to three requirements:

First, the dispositional property is just one among many properties of the object and the overall situation. Some of these other properties are unknown. A fragile object has a property that imposes a constraint on it to break when it falls from high on a hard surface; however, among its unknown properties some may impose other constraints acting against this first constraint, thereby preventing its breaking after the fall. By contrast, to the extent that the attribution of the property is part of a complete specification of the situation by scientific predicates, which completely determines the evolution of the situation, the attribution (and the property thus conceived) is not dispositional. One wouldn't call a vase fragile in a situation in which one knows that its tendency to break is counterbalanced by an installation that is sure to absorb the shock.[23] The hypothesis according to which some of the other properties of the situation must be unknown in order for it to be appropriate to attribute a disposition allows us to explain why it is impossible to specify explicitly those 'ordinary circumstances' in which the disposition, subject to a test, manifests itself in the characteristic way. By contrast, no such restrictions are placed on the scientific conception of properties. The attribution of a property according to its scientific conception can in principle be part of a *complete* description of the situation.

Second, the attribution of a disposition implies the truth of a counterfactual conditional that necessarily contains a ceteris paribus clause. By contrast, the attribution of a scientifically conceived power implies a strict counterfactual conditional.[24]

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[23] Bird makes the same observation. 'The combination of [uranium] pile and boron rods, [...] does have a disposition to chain-react when the rods are outside the pile, but loses this disposition when the rods are in the pile. [...] The reactor as a whole, [...], i.e., including the fail-safe mechanism, as long as the mechanism is effective has no disposition to explode at all.' A. Bird, 'Dispositions and Antidotes', *Philosophical Quarterly*, 48 (1998): 229-230.

[24] According to most interpretations of quantum physics, there are fundamental probabilistic laws. However, these laws allow us to make predictions that do not depend on

Third, a property is conceived as dispositional insofar as it is conceived as establishing a (ceteris paribus) dependency of a manifestation on a test situation, where both are described *in observational* terms. Falling and breaking are observable conditions, as well as being dropped and falling s metres in t seconds.[25] However, the identity of scientifically conceived properties is determined by laws that do not necessarily bear on observable properties.[26]

The account sketched here implies an important modification of Quine's theory that a disposition is a 'partially discerned physical property that will be more fully identified, we hope, as science progresses' (Quine)[27] and of Armstrong's thesis that 'dispositions, in fact, are primitive *theoretical concepts*'[28] Our analysis shows that the dispositional conception of a property can *coexist* with its scientific conception. Each obeys its own logic and serves its own purposes. The distinction between the dispositional and the categorical is an epistemic distinction and does not introduce any difference between efficacious and non efficacious properties. To the extent that it is possible to conceive of a property in a scientific way, i.e. to conceive of it as a relatum of a law of nature, it is legitimate to consider it to be causally efficacious, even in case there also exists a dispositional conception of the same property. The fact that a disposition does not always give rise to its characteristic manifestations while it is subject to a relevant test, can be explained by the simple

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partially unknown aspects of the circumstances, as is the case with predictions grounded on ceteris paribus generalisations, in particular on the attribution of dispositions.

[25] The manifestations of some dispositions, which may be called 'spontaneous', do not depend on any particular test condition. Radioactive substances have the disposition to decay; however, this manifestation need not be triggered by any test condition, observable or not. Having a belief is having the disposition to act as if the belief were true. No external and observable factor is necessary to trigger an action manifesting the disposition: I can express it by producing an utterance, without being under the influence of any external stimulation. No doubt, Aristotle was the first to insist on the fact that the independence of human utterances of all external stimulation is an essential feature of human language that distinguishes humans from all animals producing sounds or other signs that can have all physical characters of human speech.

[26] Theoretical properties have second order, relational properties in virtue of the laws bearing on them. If a copper cable has conductivity σ, this conductivity constrains other properties of the same object in virtue of the laws governing it. It exercises, e.g., a constraint on the electric current and the electric field, to be related as J/E = σ, in virtue of the law J = σE. If an object O has mass m1, and another mass m2 is in its neighbourhood, O's property of having mass m1 constrains O's movement in imposing upon it a force $F = \gamma \cdot m_1 m_2 / r_2$, by virtue of the law of gravitation. The complete set of properties instantiated by the body determines, together with the properties of its surroundings with which it interacts, its evolution and causal interactions. For a defence of this thesis, see Kistler (2002a).

[27] W.V. Quine, *The Roots of Reference* (LaSalle, 1971), p. 13.

[28] D.M. Armstrong, 'Beliefs as States', p. 420.

fact that it is not the only property of the situation. Furthermore, the fact that such a property is not by itself sufficient to produce a certain effect does not constitute any reason to deny it causal efficacy. For the same is true of clearly efficacious factors, such as the momentum M of the billiard ball which is only causally responsible for the fact that the second ball has M after the shock, because the situation is such that the shock is elastic. The uncertainty about whether the disposition manifests itself in a given situation, which is expressed in the ceteris paribus clause of the conditional linking the test condition to the manifestation, has its root in the partial ignorance of the circumstances, which is a necessary condition for the attribution of a disposition. Neither the fact that a property is not in itself sufficient for producing the effect nor the fact that we do not know whether this effect will come about in a situation we partially ignore, provides any reason to deny it causal efficacy.

One way to express the thesis that one may conceive of a given property alternatively either in a dispositional or in a categorical way, is to say that the dispositional-categorical distinction applies to the *predicates* making reference to properties, *not to the properties themselves*.[29] An important argument for this thesis consists in reducing its negation ad absurdum. Suppose that the dispositional/categorical distinction applies to properties themselves, independently of the predicates we use to make reference to them. All natural

[29] Alston was one of the first to challenge the 'assumption that the dispositional and the "occurrent" ("episodic") interpretations are incompatible'. W.P. Alston (1971), 'Dispositions, Occurrences and Ontology', in R. Tuomela (ed.), *Dispositions* (Dordrecht, 1978), p. 359. The thesis that the dispositional/categorical distinction applies to predicates rather than properties has been defended by Shoemaker, Mellor and Mumford. S. Shoemaker, 'Causality and Properties', repr. in S. Shoemaker, *Identity, Cause and Mind* (Cambridge, 1984), pp. 206-233; D.H. Mellor, 'The Semantics and Ontology of Dispositions' *Mind*, 109 (2000): 757-780. S. Mumford, *Dispositions*. 'I think that the term "dispositional" is best employed as a predicate of predicates, not of properties.' (S. Shoemaker, 'Causality and Properties', p. 211). 'Dispositionality is a feature not of properties but of predicates, namely of those whose application conditions can be stated in reduction sentences. […] Properties in our sense […] need not in themselves be either dispositional or categorical; those that exist can just be.' (D.H. Mellor, 'The Semantics and Ontology of Dispositions', p. 767). Lowe also distinguishes between '"occurrent" predication' and '"dispositional" predication' E.J. Lowe, 'Dispositions and Laws', *Metaphysica*, 2 (2001): 11. However, his conception is incompatible with ours: according to Lowe, dispositional predication attributes a universal property to an object via a kind of object of which it is an instance, whereas occurrent predication attributes a property instance to it. This distinction does not allow us to account for the difference between a dispositional and a categorical attribution of a property, insofar as it does not bring into play the semantic link between a disposition and its manifestation. Lowe puts the distinction in purely ontological terms; however, at an ontological level both types of attribution attribute ultimately the same type of property, though in different ways: the property instance which is the object of 'occurrent predication' is an instance of the very universal property which is the object of 'dispositional predication'.

properties take part in laws of nature by virtue of which the objects possessing those properties have also other properties. This is also true of properties that we do not intuitively conceive of as dispositions, such as the property of a gas to have a certain temperature, or the property of a stone to have a certain mass, m. By virtue of the so-called ideal gas law, all gases (whose properties are sufficiently close to the properties of an 'ideal' gas) that are at temperature T also have, in a volume V, the pressure p=nRT/V (where R represents a constant factor, and n indicates the quantity, in moles, of gas molecules contained in the sample under consideration). Now, the existence of this law provides us with a means of conceiving of the property of being at temperature T in a dispositional way: it gives its bearer the disposition to have another property, to which it is linked by the law. Temperature is a dispositional property insofar as it gives a gas having it the disposition to be at a pressure p, when n moles of it occupy a volume V. Similarly, its property of having a mass m gives our stone, by virtue of the law of gravitational attraction, the disposition to move towards other massive bodies, and in particular to fall when it happens to be close to the surface of the Earth. Therefore, the hypothesis that dispositionality is a property of properties, and not of predicates or of our concepts of properties, leads to the result that *all* natural properties – i.e. all properties figuring in laws of nature – are dispositional. However, this is clearly incompatible with our intuitive understanding of the concept of disposition according to which some natural properties such as 'consisting of water' are not dispositional.[30]

This thesis that the dispositional/categorical distinction bears on our conceptions of properties and on the predicates expressing them rather than on the properties themselves allows us to offer a plausible interpretation of Popper's thesis that all properties are dispositional.[31] As we have just seen, for every natural property there are dispositional ways to conceive of it. If P is an arbitrary natural property P linked by a causal law to another property R, knowing this law puts us in a position to conceive of P as 'the disposition to (cause) R'. Interpreted this way, Popper's

[30] S. Shoemaker, 'Causality and Properties', S. Mumford, *Dispositions*, pp. 757-780 and D.H. Mellor, 'The Semantics and Ontology of Dispositions' show that one can avoid the paradoxical conclusion that all properties are dispositional by conceiving of the dispositional-categorical distinction as a semantic distinction between predicates rather than as an ontological distinction between properties.

[31] K. Popper, 'The Propensity Interpretation of the Calculus of Probability, and the Quantum Theory', in S. Körner (ed.), *Observation and Interpretation (*London, 1957), pp. 65-70. Cf. the introduction to this volume. Other defenders of this thesis are I.J. Thompson, 'Real Dispositions in the Physical World', *British Journal for the Philosophy of Science* 39 (1988): 67-79, pp. 76-77; S. Blackburn, 'Filling in Space', *Analysis*, 50 (1990): 62-65. R. Harré and H. Madden, *Causal Powers* (Oxford, 1975); R. Harré, 'Is There a Basic Ontology for the Physical Sciences?', *Dialectica*, 51 (1997): 17-34. N. Cartwright, *Nature's Capacities and their Measurement* (Cambridge, 1989). N. Goodman, *Fact, Fiction, and Forecast*, makes the more modest claim that there are many more dispositional predicates than it appears at first sight.

thesis loses much of the counter-intuitive character it is usually understood to have: that is, when it is interpreted to mean all properties are dispositional and therefore, no property is categorical.[32] As soon as the distinction is understood as bearing on concepts or predicates, nothing prevents a given property from being conceived as both dispositional and categorical.[33]

Frank Jackson has offered a way to avoid the conclusion that all properties are dispositional, which allows him to stick nevertheless to the traditional idea that the dispositional/categorical distinction bears on properties themselves. He introduces a distinction between properties that are *essentially* tied to characteristic manifestations in relevant test situations, and others that are *only contingently* tied to their manifestations. 'What makes a property a disposition is that it itself is *essentially* linked to the production of certain results in certain circumstances…'[34] However, insofar as the tie between a natural property and its manifestation in relevant circumstances is grounded on a law, it is difficult to justify Jackson's distinction. It presupposes that there is, among the laws a property figures in, a first set of laws that are essential to the property and a second set of laws that are only contingent relative to the property. It is possible that the property exists even if the laws in the second set do not exist, though it is impossible that it exists without the laws in the first set. I do not know of any independent justification of this

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[32] There is a powerful objection against this interpretation of the thesis, variants of which have been put forward by P.J. Holt, 'Causality and Our Conception of Matter', *Analysis*, 37 (1976): 20-29. H. Robinson, *Matter and Sense*, (Cambridge, 1982). S. Blackburn, 'Filling in Space', *Analysis*, 50 (1990): 62-65; D.M Armstrong, 'The Causal Theory of Properties', Properties according to Shoemaker, Ellis and others', *Metaphysica*, 1 (2000): 5-20; also published in *Philosophical Topics* 26 (1999): 25-37. However, this objection according to which the thesis that all properties are dispositional makes us 'lose the substance of the world'. P.J. Holt, 'Causality and Our Conception of Matter', *Analysis* 37 (1976): 23. P.J. Holt does not bear against the interpretation suggested here.

[33] A different way of reconciling the fact that all natural properties can be conceived of in a dispositional way, on the basis of the dispositions they give their bearers, with the paradoxical appearance of the thesis that all properties are dispositional is to say, with Martin and Heil, that all properties have a 'dual nature' (C.B. Martin, 'Final Replies to Place and Armstrong', J. Heil, *Philosophy of Mind* (London, 1998), p. 182), in other words that a property 'endows its possessor with both a particular disposition or 'causal power' and a particular quality' (J. Heil, *Philosophy of Mind*, p. 181). However, rather than offering a solution, this is just a way of stating the problem that these two apparently incompatible 'aspects' do nevertheless coexist. My thesis that the dispositional/categorical distinction is of a conceptual and semantic nature solves the problem by offering a hypothesis for analysing the distinction, in terms of the difference between the analytic or a posteriori nature of the entailment, by the attribution of the property to an object, of counterfactual conditionals linking the instantiation of the property to characteristic manifestations, this difference being in turn explained in terms of the meaning of the predicates with which we make reference to the property.

[34] F. Jackson, *From Metaphysics to Ethics: A Defence of Conceptual Analysis* (Oxford, 1998), p. 101.

distinction between two sets of laws in terms of the modal strength with which they determine the identity of the property.[35]

Mumford has suggested a promising way to understand the dispositional/categorical distinction at the level of predicates.[36] A predicate D is dispositional if and only if its attribution *analytically* (in virtue of the meaning of the predicate) entails a counterfactual linking a test condition to a characteristic manifestation. The statement 'The vase is fragile' analytically entails: if the vase were to fall from high onto hard ground, all other circumstances being normal, it would break. By contrast, 'the vase is made of thin terracotta' entails the same counterfactual conditional, but not analytically: in the case of the latter statement, the entailment of the counterfactual conditional is not grounded exclusively on the meaning of the predicate 'is made of thin terracotta', but on laws, which are known *a posteriori*.[37] The laws in which a natural property takes part guarantee the existence of such counterfactuals, but their knowledge is not always included in the meaning of the predicates with which we make reference to these properties. Hence this difference allows us to ground the distinction between dispositional and categorical predicates: the attribution of dispositional predicate entails a counterfactual linking a test situation to a manifestation in an analytical and therefore a priori manner, whereas that entailment is a posteriori in the case of categorical predicates.[38]

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[35] Elsewhere (M. Kistler, 'The Causal Criterion of Reality and the Necessity of Laws of Nature') I have argued at length for the opposite thesis that all laws in which a given property takes part are essential to it.

[36] I do not exactly follow Mumford's way of spelling out the distinction, insofar as I put it exclusively in terms of the a priori/a posteriori distinction, whereas Mumford (as Jackson 1998) sometimes expresses it by saying that categorical properties are *contingently* related to their nomological consequences.

[37] Shoemaker gives the example of the predicate 'being made of copper' which is 'not dispositional in this sense. There are causal powers associated with being made of copper – for example, being an electrical conductor. But presumably this association is not incorporated into the meaning of the term 'copper'. (Shoemaker, *Identity, Cause and Mind*, p. 210). I would like to prevent a misunderstanding. Someone who knows the relevant laws about copper can infer a priori from the fact that something is copper, the fact that it is a good conductor of electricity. The same is true for someone who knows the lawful properties of terracotta. But the knowledge of those laws is a posteriori. Knowledge of the behaviour of these substances in counterfactual circumstances is not analytically entailed by the mere meaning of the predicate attributing them the properties of being of copper and of being of terracotta.

[38] Another misunderstanding must be avoided here: it is of course not a priori whether a given object is fragile or not. But the attribution of fragility, itself made on empirical grounds, to a given object, brings analytically with it the commitment to the counterfactuals that are characteristic of fragility.

Two Ways of Conceiving of the 'Categorical Basis' of Dispositions

David Armstrong's view of dispositions is compatible with the thesis that dispositionality and categoricality are two ways of conceiving of properties which are, in themselves, neither dispositional nor categorical. Armstrong cites as an example, the occurrent state of a brittle glass. This state could be considered causally efficacious in that it contributes to the glass' breaking when it falls on the kitchen floor. The properties that are causally efficacious in such a case are intrinsic properties of the glass. However, we often ignore those intrinsic properties. Therefore, instead of making reference to that occurrent state by naming directly its intrinsic (and potentially causally efficacious) properties, we do it by means of a definite description in terms of the state's typical effects in certain circumstances. We call it 'brittleness', which is a word whose meaning is defined by its typical effects in certain circumstances. However, these are just two ways of referring to one state, one being direct (but inaccessible to us, because we ignore the intrinsic nature of the property), the other indirect in terms of its typical causes and effects. Two ways of referring to one state do not make it into two states or two properties. This difference is the result of 'a verbal distinction between the disposition and the state. (A verbal distinction that cuts no ontological ice).'[39] According to Armstrong, 'disposition' is a concept that corresponds to a certain functional way of referring to properties or states, rather than to a particular type of properties or states. 'Dispositions are marked off from (many) other states by the way they are *identified*'.[40] So far, Armstrong expresses a position equivalent to our thesis (1). The controversial step in his reasoning is the following. Armstrong thinks that the only way to make sense of the idea that one property can be conceived both as dispositional and as categorical, is by supposing that the property is really (identical with) its microscopic reduction base, which he calls the 'categorical basis'. However, Armstrong does not justify the implicit premise that only a microscopic property can be categorical and efficacious. 'What then is the disposition, the brittleness? It is the "categorical basis", the microstructure, but it is this property of the object picked out not via its intrinsic nature, but rather via its causal role in bringing about the manifestation'.[41] Armstrong starts from Quine's thesis that, by using a dispositional predicate, 'we can refer to a hypothetical state or mechanism that we do not yet understand'.[42] We can substitute a direct way to refer to it as soon as science has discovered the intrinsic nature of that state: for Quine, a disposition is 'a partially discerned physical property that will be more

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[39] D.M. Armstrong, 'Beliefs as States', p. 419.

[40] D.M. Armstrong, ibid.

[41] D.M. Armstrong, 'Place's and Armstrong's Views Compared and Contrasted', in D.M. Armstrong, C.B. Martin and U.T. Place, *Dispositions: A Debate* (London, 1996), p. 39.

[42] W.V. Quine, *The Roots of Reference*, p. 10.

fully identified, we hope, as science progresses'.[43] However, Armstrong does not justify a second thesis implicitly presupposed by his reasoning, according to which the scientific property, discovered as the 'intrinsic nature' of the state that was provisionally conceived of in a dispositional way, is necessarily *microscopic*. In the case of brittleness, it is a property of the chemical bonds between the glass molecules.[44] In the case of the disposition to transmit one's hereditary characteristics, it is microscopic properties of DNA molecules. 'A good model for the identity of brittleness with a certain microstructure of the brittle thing is the identity of genes with (sections of) DNA molecules. Genes are, by definition, those entities which play the primary causal role in the transmission and reproduction of hereditary characteristics. [...] in fact sections of DNA play that role. So genes are (identical with) sections of DNA.[45] In the case of dispositional mental properties, the underlying properties are microscopic properties of the brain.[46] Armstrong does not offer any reasons for thinking that the categorical basis of a disposition is necessarily microscopic.[47] However, the debate within which Armstrong develops his thesis suggests a hypothesis about its origin. In the text preceding the

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[43] Ibid., p.13.

[44] Cf. D.M. Armstrong, *A Materialist Theory of the Mind*, p. 86; *A World of States of Affairs*, p. 73.

[45] D.M. Armstrong, 'Place's and Armstrong's Views Compared and Contrasted', p. 39. Cf. also D.M. Armstrong, *A Materialist Theory of the Mind*, p. 90. A complication arises for Armstrong because he holds, on one hand, that the truthmaking relation (between a proposition and a state of affairs) is necessary, so that if having a certain molecular structure makes true the attribution of the disposition to be brittle, it is necessary that all things with this molecular structure are brittle. On the other hand, Armstrong holds that laws are contingent, and that the relation between having the molecular structure and breaking after falling depends on the laws. (This is one of the reasons why Prior, Pargetter, and Jackson (1982) deny the identity of disposition with their categorical basis. See above.) Therefore, Armstrong (1997) changes his position: now he says that the molecular structure *together with the laws* makes true the ascription of brittleness.

[46] In *A Materialist Theory of the Mind*, pp. 76-77, Armstrong develops the analogy between those two identifications, with respect to their contingency. However, in *A World of States of Affairs*, p. 73, he explains that this contingency stems only from the contingency of the laws of nature responsible for the fact that the DNA molecules play, by virtue of their properties, the role of genes, and for the fact that the brain, by virtue of its properties, plays the roles that characterize mental states. Given the laws, the identification is necessary.

[47] Armstrong is not alone in assuming this thesis without giving any reasons for it. Mackie (J.L. Mackie, 'Dispositions, Grounds, and Causes', *Synthese* 34 (1977): 361-370) characterizes his own 'realist view' of dispositions by saying that 'there will always be a categorical ground', and then immediately moving on to state that this categorical ground is necessarily different from the dispositional property itself: 'This ground will not in itself be specifically dispositional', his example being the categorical microproperties underlying the macroscopic disposition of solubility. 'In crystalline sugar the feature causally relevant to its solubility in water will be something about the bonds between the molecules in the crystal structure' (Mackie, 'Dispositions, Grounds, and Causes' p. 365).

introduction of his thesis about dispositions, Armstrong criticizes Ryle[48] and Price[49] for two mistakes: the first is rejecting for a priori philosophical reasons the scientific research for the microscopic grounding of a given dispositional macroscopic property, in particular in the case of mental properties, and therefore to reject the perspective of a discovery that provides the means for constructing a *microreduction* of that property. The second mistake is the verificationist refusal to accept the existence of theoretical properties whose identity conditions are independent of single verification conditions or procedures.

Armstrong's reasoning would be valid if these two errors were just one. In that case, it would be natural to assume only one move is necessary and sufficient to avoid it; for indeed, the only way to avoid both mistakes in just one move consists in postulating a theoretical property underlying the disposition, which is at the same time the microscopic property providing the basis for its microreduction. Identifying the disposition with a theoretical microscopic property avoids the verificationist mistake because it is a theoretical property whose identity is independent of particular verification procedures; and it avoids the mistake of a priori rejecting the perspective of microreduction.

However, there is in fact no reason to think that Ryle and Price commit only one error rather than two independent errors. To overcome the error of verificationism, it is necessary and sufficient to postulate a theoretical property which is occurrent and categorical and which is not identified with a single <C,M> (test condition, characteristic manifestation) – or <S,R> (stimulus/response) – pair, but can contribute in many and complex ways to different causal processes. Nothing prevents the property thus postulated from being a macroscopic property belonging to the same object as the disposition: the person - and not some of its neurons or neuron circuits – in the case of mental properties, the body – not the DNA molecules – in the case of the capacity to transmit hereditary characteristics. It is therefore conceivable to remedy the error of verificationism, without at the same time overcoming the other mistake of rejecting a priori the perspective of microreduction. That second mistake can be avoided in a second and independent step.

The microreduction of a macroproperty consists in the discovery of a nomological explanation of the possession of the macroproperty by an object, on the basis of the microproperties of its parts and their interactions by virtue of laws. Molecular biology can explain, on the basis of the numerous microscopic components of an animal's body and their numerous and complex interactions, why that organism has the macroscopic capacity to transmit part of its hereditary characteristics to its offspring. However, this reduction does not justify the *identification* of that macroscopic capacity with any particular microscopic property. In particular, a

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[48] G. Ryle, *The Concept of Mind* (London, 1949).

[49] H.H. Price, *Thinking and Experience* (London, 1953).

number of authors have shown[50] that this capacity of the organism cannot be identified with any microscopic property of the DNA molecules contained in its cells.[51]

Once we recognize that a microreduction requires two separate steps: first, the dispositional conception of a macroscopic property and second, the discovery of its microscopic reduction base, it becomes clear that the expressions 'causal basis' and

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[50] Cf. P. Kitcher, 'A Tale of Two Sciences', *Philosophical Review* 93 (1984): 335-373; A. Rosenberg, *The Structure of Biological Science* (Cambridge, 1985); M. Morange, *La part des gènes* (Paris, 1998), trans. M. Cobb, *The Misunderstood Gene* (Cambridge, 2001). Armstrong is well aware that the identification of the gene with a segment of a DNA molecule is an oversimplification; however, he thinks that it does not threaten the coherence of his position: 'The statement "The gene is the DNA molecule" is not a very exact one from the biological point of view. But it will prove to be a useful example in the development of the argument, and it is accurate enough for our purposes here.' (Armstrong, *A Materialist Theory of the Mind*, p. 77). However, this does not seem to be a matter of neglecting some details: it is a fundamental mistake to take a microscopic property of a part of an organism for the causal basis of its disposition to transmit part of its hereditary characteristics. The causal basis of hereditary transmission consists in a complex mechanism of which DNA is only a part. However, the property of possessing that mechanism can only be attributed to the whole organism, but not to any of its microscopic parts, be it as important as the DNA.

[51] P. Menzies, 'Against Causal Reductionism', *Mind* 97 (1988): 551-574. Menzies proposes another argument against the identification of a dispositional macroproperty with the underlying microproperty. Taking an example from David Lewis, he points out that the electrical and thermal conductivities of a metal are two different dispositions grounded in the same set of microproperties: the properties of the 'free' electrons of the metal, i.e. the electrons not chemically bound to individual atoms. Given the transitivity of identity, these dispositions cannot both be identical with their common reduction base, without being also identical to each other, which they are not. However, at a closer look, the reduction bases of these two dispositions are not exactly the same. In the model of their reduction proposed by Drude in 1900, the electrical conductivity σ and the thermal conductivity κ are determined by *different* properties of the free electrons: the electrical conductivity σ is determined by the microscopic properties n (the number of free electrons per cube centimetre), *e* (the unit electrical charge), τ (the relaxation time or mean free time of the free electrons, i.e. the mean time interval between two collisions) and *m* (the electron mass), according to the formula $\sigma = \frac{ne^2\tau}{m}$ (N.W. Ashcroft and N.D. Mermin, (1976), *Solid State Physics* (Philadelphia, 1988), p. 7, whereas the thermal conductivity κ is determined by *n*, τ, *m* and *T* (temperature), according to the formula $\kappa = \frac{3n\tau k_B^2 T}{2m}$ (N.W. Ashcroft and N.D. Mermin, *Solid State Physics*, p. 23). Block is therefore right to note (in correspondence with Jackson) 'that cases where different dispositions appear to have the same basis, and, more generally, cases where different functional roles appear to be occupied by the same state, turn out on examination, to involve subtly different bases and states.'. F. Jackson, *From Metaphysics to Ethics: A Defence of Conceptual Analysis* (Oxford, 1998), p. 92, note 3. However, the case is compatible with our thesis that it is different properties of the various microscopic parts of the metal that nomologically determine the different macroproperties of the metal, by virtue of the various interactions between these properties.

'categorical basis' are being used in this debate in two fundamentally different senses: according to the first, they designate the set of categorical properties underlying a disposition that are together causally responsible for its manifestations. Those properties may well be macroscopic in the sense of belonging to the same object as the disposition, rather than to one or some of its parts. The second sense is strongly suggested by the word 'basis': when a microreduction of the macrosopic property underlying a disposition has been found, one often calls 'reduction base' the set of microscopic properties of the parts of the object, which nomologically determine the macroscopic property. Armstrong's (and Kim's) mistake consists in confusing these two senses of 'basis', and to admit without justification that the categorical basis in the first sense of the term must necessarily also be the basis in the second sense, in which it means 'microreduction basis'.

A Solution to the 'Problem of the Missing Reduction Base'

A positive argument for the existence of at least some categorical bases that are not reduction bases is the following: suppose that the hierarchy of levels of constitution of objects is not infinite, but rather contains a level of properties and objects that are absolutely 'atomic' in the sense of not being themselves microreducible because its objects have no parts. In that case, the chain of microreductions also stops with the discovery of that fundamental level. A property M belonging to that absolutely fundamental level still gives, at least indirectly, causal powers to its bearers, else there would be no reason to postulate its existence. The powers, property M gives its bearer have a categorical basis: remember that I understand by the 'categorical basis' of the power, the property of its bearer that is causally responsible for the manifestations of the power. Now, given that M has no microreduction base, that categorical basis can only be the property M itself or some other property at the same level as M, in other words a property that is 'macroscopic' from the point of view of M.

Our hypothesis that properties that are conceived in a dispositional way can also be conceived in a categorical way, suggests a simple solution to Molnar's (1999) 'problem of the missing reduction base'. Molnar convincingly shows the implausibility of three solutions to the problem that arises if the following two theses are true.

1. Every disposition has a categorical basis, understood as a microscopic reduction base.
2. There are absolutely structureless fundamental particles.

The three implausible solutions are: a) to suppose that the causal basis of structureless absolutely atomic particles are global properties of the universe;[52] b) to deny the second thesis, and to speculate that there is an infinite hierarchy of structures grounding even properties and objects appearing at some point as structureless and absolutely atomic; c) to suppose that the fundamental properties of the absolutely atomic particles are not dispositional.

After having provided strong reasons for rejecting these three proposals, Molnar concludes that, 'when it comes to the fundamental micro-entities, no suitable properties exist that could serve as a causal base of their dispositions'.[53] Similarly, Mumford concludes that, in the case of absolutely fundamental properties for which no microreduction does exist, there is 'just the one mode of characterizing it available to us: the dispositional'.[54]
Our distinction between two senses of the word 'basis' provides a means for avoiding this conclusion, which is paradoxical insofar as it implies that the manifestations of the powers due to absolutely fundamental properties have no cause whatsoever. This result can be avoided, in the absence of any microreduction, by the hypothesis that the dispositional property of a fundamental particle is itself the categorical basis that is causally responsible for its manifestations.[55]

The Example of the Representation of Colours

The perception of colours by the human visual system may illustrate the argument developed above. In psychology and psychophysics, representations of colours are conceived as macroscopic dispositional properties of persons: they give them the disposition to make judgments of similarity and distinguishability.[56] These judgments constitute observation data whose theoretical explanation requires postulating the existence of a psychological space by means of which the subject represents colours. The logic of theory construction is essentially the same in

[52] Harré has proposed the idea of such a grounding from above, or 'ultra-grounding'. R. Harré, *Varieties of Realism: a Rationale for the Natural Sciences* (Oxford, 1986), p. 295.

[53] G. Molnar, 'Are Dispositions Reducible?', p. 17.

[54] S. Mumford, *Dispositions*, p. 169.

[55] It is common to call such hypothetical dispositions which cannot be micro-reduced, 'ungrounded dispositions' (e.g. Mumford, *Dispositions*, p. 167; Molnar, 'Are Dispositions Reducible?', p. 4). However, in the sense of the word 'basis', in which it designates the property of the bearer of the disposition that is causally responsible for its manifestations, it is clear that every disposition necessarily has a (categorical) basis. Therefore, to say that a disposition has no basis can only mean that it has not been (micro) reduced and hence does not have any basis in the sense of a reduction base.

[56] Two colours are said to be distinguishable if a normal subject can systematically distinguish them.

psychology and in physics: the theory describes non-observable entities whose postulation allows us to explain a certain number of empirical regularities, and ultimately observable facts. Shepard[57] has shown that such judgments of similarity[58] contain enough constraints to determine,[59] for any domain of perceived qualities,

1) the minimal number of dimensions that the psychological space must have, in order to give the subject the means to represent the domain of stimuli under consideration,
2) a representation of the location of each perceived stimulus within a space isomorphic to the psychological space; this representation contains the coordinates of the different stimuli within the representation space.

The algorithm developed by Shepard allows him to construct 'maps' of a certain number of psychological spaces corresponding to different domains of stimuli: the 'proximity structure' by means of which a subject represents, among others, the different facial expressions of its co-specifics,[60] colours,[61] the consonants of her native language, musical intervals, or familiar animals. [62]

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[57] R. Shepard, 'The Analysis of Proximities: Multidimensional Scaling with an Unknown Distance Function', *Psychometrika*, 27 (1962): 125-140 and 219-246.

[58] Shepard uses only the *order* of similarity between pairs of stimuli presented to subjects, such as it appears in the judgments of the tested persons, without making use of any quantitative estimates the subjects make about the apparent distances between the stimuli. Apart from direct judgements of similarity, Shepard also uses data obtained by more indirect means that allow us to judge the proximity of the representations of stimuli in psychological space, such as the frequency with which the subjects confuse different stimuli, the delay required for discriminating two stimuli, or (for young children and animals) the size of the orientation reflex, when the first stimulus is replaced by the second.

[59] Mathematically, Shepard's algorithm uses two a priori constraints: 1) The function relating the apparent similarity to the proximity in the representation space is supposed to be monotonous. The monotony of the function guarantees that if two colours A and B are judged to be more similar than the colours C and D, the distance in psychological space, between the representations R(A) and R(B) of the former is smaller than the distance between the representations R(C) and R(D) of the latter. In the same systematic way, apparent similarity depends on the distances between the representations. In particular, the representations of the stimuli judged to be most similar must be separated by the smallest distance. 2) The psychological space has the smallest dimension that allows us to construct a monotonous and unique function relating apparent similarities and distances between representations in the psychological space.

[60] R. Shepard, 'The Analysis of Proximities: Multidimensional Scaling with an Unknown Distance Function'.

[61] Ibid. and R. Shepard, 'Approximation to Uniform Gradients of Generalization by Monotone Transformations of Scale', in D.I. Mostofsky (ed.), *Stimulus Generalization* (Stanford, 1965), pp. 95-110.

[62] R. Shepard, 'Representation of Structure in Similarity Data: Problems and Prospects', *Psychometrika*, 39 (1974): 373-421.

In the case of colours, the first result that Shepard's algorithm provides is the fact that two is the minimal number of dimensions that the psychological space must have in order to be able to represent the colours visible by the human perceptual system (abstracting away from the dimension of saturation). Any simpler psychological structure would be incompatible with the experimental findings. It is in particular impossible to account for the judgments of similarity between (perceptions of) colours on the basis of a psychological space of colour representation that has only one dimension: taking into account the judgments of the similarity of red and yellow, yellow and green, green and blue, and blue and violet, one might try to situate the representations of these colours in only one dimension, following the order of the rainbow. However, such a one-dimensional representation would not allow to account for the perceptual similarity between red and violet. If the representations of the colours were structured in the order of the rainbow along one dimension, red and violet would have to be the most dissimilar colours of all, whereas in fact they resemble each other much more than each of them resembles, e.g., green or yellow. Shepard's second result is that there is only one topological structure or 'map' of represented colours that is related by a unique monotonic function to the judgments of similarity. On this map, the representations of the different visible colours are situated on a circle.

Insofar as representations of colours are conceived as intermediaries between stimuli and judgments of similarity, they are dispositional properties. However, once we have overcome the verificationist prohibition that prevented Ryle from conceiving representations as entities independent of any particular manifestation, we may consider representations of colours as theoretical entities that allow us to give causal explanations of similarity judgments. As theoretical entities that are not directly observable but are postulated in order to explain observable phenomena, they belong to the same category of entities as protons and neutrons whose postulation allows to construct causal explanations of, e.g., the phenomena observed when elementary particles interact in particle accelerators.

The hypothesis of the existence of colour representations and of the structure of these representations in a psychological space is independent of the discovery of a *reduction* of these representations and of this space, to neurophysiological objects and properties. In an analogous way, the legitimacy of the postulate of the existence of protons and neutrons does not depend in any way on their eventual microreduction (to 'quarks'), which is rather the object of independent research. The neurophysiological reduction of the representation of colours is a topic of intense research. According to a promising hypothesis, colour representations are determined by the simultaneous activation of neurons within a precise region of the visual cortex, an area called V1. Such reductions have already been accomplished in the case of a certain number of other psychological spaces, relative to the representation of certain perceptual domains in certain animals: the neural structure by means of which the barn owl (*Tyto alba*) represents the location of a sound source has been identified in the superior layer of the optic tectum of the brain of

that animal.[63] A neural structure situated in the auditory cortex of the moustache bat has been found to allow the animal to represent the position and velocity of objects in its surroundings by means of the mechanism of echolocation.[64] Each time, the subjective sensation, which causes action or judgment, results from, or is nomologically determined by, the simultaneous activation of a large number of neurons situated in the region corresponding to the cognitive map of the relevant perceptual domain. It is conjectured that the representation produces its effects by means of a mechanism equivalent to the vectorial calculation of the mean activation, taken over all neurons of the map.[65] The representation of a colour, say yellow, is determined by the neural activity distributed over the whole area. Certain directions on the cortical surface correspond to certain dimensions of the psychological space it determines. In spite of the distributed character of the activation underlying the representation of a given colour, it is possible to attribute a specific content to individual neurons: the neuron corresponding to a given shade of yellow is that whose isolated activation would produce the same sensation of yellow as the distributed activation grouped around it produces if the vector sum of the latter is equivalent to the vector corresponding to the activation of the first.[66]
The lesson I propose to draw from this sketch of results of psychological and neurophysiological research about colour representation is that it is coherent and conceptually possible to conceive of the categorical psychological property that produces the manifestations of a mental disposition (its 'categorical basis' in the first sense of the term) as a macroscopic theoretical property: as a property belonging to a person rather that to its microscopical parts, its neurons. The research for the microscopical, i.e. neurophysiological, basis of that macroscopic psychological property, which allows us to construct a reductive explanation of it, is a second and independent step.

Two Objections

Before concluding, we must consider two objections against our thesis that it is coherent and at least in the case of psychological properties also plausible, to suppose that the categorical basis that causes the manifestations of a dispositional property is a macroscopic property rather than its microscopic reduction base.
The first objection challenges us to justify the crucial thesis that the categorical macroproperty is not identical to any microproperty. Maybe it is too simple to

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[63] Cf. C.R. Gallistel, *The Organization of Learning* (Cambridge, 1990), p. 478ff.

[64] Ibid., p. 492ff.

[65] C.R. Gallistel, *The Organization of Learning*, p. 489, p. 515; P.S. Churchland and T.J. Sejnowski, *The Computational Brain* (Cambridge, 1992), pp. 233-237.

[66] It is well known that a large number of global distributions of neural activity can produce the same (type of) sensation: the stimuli producing such indistinguishable sensations are called 'metamers'.

point out that the manifestations of a disposition of object O must be caused by properties of O, not by properties of O's parts. Kim has proposed an interesting alternative to our conception according to which a given macroscopic property of a person, say of representing yellow (as seen at a certain point in the visual field), is determined by the interactions of the neural parts of that person's brain, by virtue of laws of nature. According to Kim, there is a neural property that is in a sense 'microscopic' and that does all the 'causal work' we attribute to the psychological property. This property belongs to the category of what he calls 'micro-based properties', which I shall call 'micro-based macroproperties' (in brief, MMP), defined as 'the property of being completely decomposable into nonoverlapping proper parts, a_1, a_2, …, an, such that $P_1(a_1)$, $P2(a_2)$,…, $P_n(a_n)$, and $R(a_1, a_2,\ldots,a_n)$'.[67] This concept allows us to attribute to the whole the property of having parts, each of which has its own properties and relations to the others. Thus it points towards the elaboration of the concept of a causally efficacious macroproperty. However, the conditions imposed by Kim on the concept of an MMP are too weak to guarantee that a given property is efficacious at all. It is easy to find MMP that obey Kim's constraints but have no causal efficacy whatsoever. Take an arbitrary mereological sum whose elements do not physically interact in any way. The mereological sum whose elements are the electrons of billiard ball A and the atomic nuclei of billiard ball B does not have the causal powers of a billiard ball. The existence of an MMP as defined by Kim is a logical consequence of the existence of the 'parts' (of the mereological whole to which the MMP is attributed), whereas the existence of a whole possessing its own causal powers depends on the existence of appropriate interactions between those parts. However, Kim's condition does not impose any constraint on the relations R between the parts; in particular, it does not require that they correspond to any physical interactions. Here is another way of showing that the conditions Kim imposes on MMP are not sufficient to guarantee that each so conceived MMP is causally efficacious. A given whole has a different MMP for each of its possible decompositions in parts. However, an indeterminate and perhaps infinite number of such decompositions does not give rise to an equivalent number of different causally efficacious properties. Inversely, an object that can only be decomposed in one natural way can have different causal powers, by virtue of different interactions between the various properties of its parts. A hydrogen molecule H_2 whose only natural decomposition consists in splitting it into two H atoms nevertheless possesses several different causal powers, such as its magnetic momentum and its base frequency of oscillation. A person who sees a yellow spot at a certain point in her visual field possesses an MMP by virtue of her neurons and their states of activation. However, even if these neurons with their respective activities are in their 'normal' spatial relations (i.e., in conditions appropriate for bringing about the mental state of perceiving a yellow spot at that point), if you prevent them from interacting, every mental property will disappear. This shows

[67] J. Kim, *Mind in a Physical World,* p. 84.

that it is necessary to enrich Kim's concept by taking into account the various nomological interactions between the parts: it is these interactions that determine the existence of a real whole and its various causal powers.

According to the second objection, the thesis of the causal efficacy of the categorical macroproperty is refuted by the 'principle of causal-explanatory exclusion' according to which 'two or more complete and independent explanations of the same event or phenomenon cannot coexist'.[68] This refutation is based on the hypothesis we have taken for granted all along, according to which it is always in principle possible to discover a microreduction of a given macroproperty. But then, the microproperties of which the reduction shows that they are underlying the macroproperties, seem to monopolize causal efficacy and to condemn the macroproperty itself to the shadowy existence of a mere epiphenomenon. Prior, Pargetter and Jackson who understand 'causal basis' as meaning 'reduction base', use the exclusion principle to show that the macroproperty itself (also conceived as dispositional) is epiphenomenal: 'Any disposition (and thus fragility) must have a causal basis. This causal basis is a sufficient causal explanation of the breaking *as far as the properties of the object are concerned*. But then there is nothing left for any other properties of the object to do. By the Distinctness thesis, the disposition is one of these *other* properties, ergo the disposition does nothing'.[69] The principle of causal-explanatory exclusion is plausible insofar as it is equivalent to the supposition that there is no general overdetermination of a given type of effect by two *independent* causes. However, in the form Kim gives it, the principle does not exclude the possibility that two sets of properties, which are instantiated at the same time and place but which are *not independent* because one set of properties nomologically determines the other, are both sufficient for the same effect. For this reason, there is no valid argument based on the principle of causal-explanatory exclusion that allows for the conclusion that a macroproperty P of an object O is epiphenomenal, simply because there is a microreduction explaining the presence of P from the properties P_1, P_2, … of the microscopic parts of O and their interactions. The result of a microreduction is precisely to establish that and to show how the microproperties nomologically determine the macroproperty.

Consider the power (or the disposition) of person A to transmit part of her hereditary characteristics to her children. Suppose the molecular mechanism underlying this transmission has been completely discovered and has led to the construction of a reductive explanation of this disposition in terms of microproperties. Does this mean that the only properties that are causally efficacious in the transmission of the hereditary characteristics of A are the properties of her microscopic parts, in particular of the DNA molecules contained in her germinal cells? No, for the simple reason that A's DNA molecules are not

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[68] J. Kim, *Supervenience and mind* (Cambridge, 1993), p. 250.

[69] Prior, Pargetter, and Jackson, 'Three Theses about Dispositions', p. 255, italics theirs.

directly causally responsible for the manifestation of the disposition: the apparition of some of A's phenotypic traits in her children. This effect is only brought about by the mediation of a complex set of interactions between the DNA molecules and a large number of other parts of the organism. No property of any part of A can be said to be in itself the basis of the transmission, insofar as the causal basis is an intrinsic property of the object possessing the disposition, which is, in favourable circumstances, sufficient to produce the manifestation. We have already seen that the logical conjunction of the set of microproperties (the MMP) that intervene in the determination of the power is not the causal basis either: it is only by virtue of their nomological interactions that the set of microproperties of its parts gives A's organism the disposition to transmit her hereditary characteristics. The micro- and macroproperties do not compete for being the property that is causally responsible for the manifestation of the disposition. Both participate in bringing it about, though in quite different ways: the microproperties of A's parts provide A, by virtue of a relation of nomological determination itself grounded on the nomological interactions among the parts, with a global property that is first conceived of as the disposition to transmit hereditary characteristics. That very global macroproperty can also be conceived of as categorical insofar as it is directly causally responsible for the transmission.

Conclusion

I have tried to show that macroscopic properties such as a vase's property of being fragile or my current property of having the intention to write the word 'disposition' can be causally efficacious in bringing about their manifestations although they can also be conceived of as dispositional properties. The defence of this thesis requires arguing that the dispositional/categorical distinction applies first to predicates and concepts expressed by these predicates and only indirectly to the properties to which the predicates refer and which are conceived by these concepts. If this is correct then a dispositional and a categorical predicate can designate one property. We have seen that this conception provides the means for refuting a number of traditional objections against the efficacy of dispositional properties and for escaping what we have called the epiphenomenalist trilemma with respect to macroscopic properties. According to the major theories defended at present, such properties are either epiphenomenal and thus causally inert or efficacious only by being identical with microscopic properties, which also constitute their reduction base. I have shown that it is coherent and plausible to consider the dispositional macroscopic property itself as causally responsible for its manifestation, thereby showing that this property is also capable of a categorical conceptualization. Its reduction is the object of an independent enterprise; however, the construction of such a reduction does not justify the identification of the reduced property with the reducing property. I have also shown that acknowledging the causal efficacy of macroproperties does not lead to an unacceptable overdetermination of their

effects: the microproperties in the reduction base cause these effects only indirectly, by lawfully determining the existence of the macroscopic property. This provides a justification for following the intuition that my present act of typing the word 'disposition' has been caused by my decision to do so, this decision being a macroscopic mental property that is not identical with any microproperty of my brain.[70]

[70] I thank my auditors in Lund and London, and Anouk Barberousse, Tim Crane, Joan Cullen, Mauro Dorato, Ludger Jansen, Michael Martin and Jürgen Schröder for helpful comments on earlier versions of this paper.