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THE DISPOSITIONALIST CONCEPTION OF LAWS

ABSTRACT. This paper sketches a dispositionalist conception of laws and shows how the dispositionalist should respond to certain objections. The view that properties are *essentially* dispositional is able to provide an account of laws that avoids the problems that face the two views of laws (the regularity and the contingent nomic necessitation views) that regard properties as categorical and laws as contingent. I discuss and reject the objections that (i) this view makes laws necessary whereas they are contingent; (ii) this view cannot account for certain kinds of laws of nature and their properties.

KEY WORDS: dispositions, dispositionalism, laws of nature, natural necessity, properties

1. INTRODUCTION

The prevailing debates surrounding the nature of laws of nature have focussed on the rivalry between the regularity conception of laws and recent nomic necessitation accounts. This paper aims to delineate a third view of laws which rejects two assumptions shared by both of the rivals in the existing debate. First, they both take laws to be contingent rather than metaphysically necessary. (Perhaps confusingly, nomic necessitation in the hands of Armstrong et al. is a *contingent* relation between properties.) Second, they both take properties to be categorical. That is, properties have no essential nomic or causal powers. Such powers are thrust upon properties by the contingent laws of nature in which they feature. In different worlds where those laws do not hold, those same properties will not have the powers they have in this world.

The dispositionalist regards properties as having their nomic and causal powers essentially.[1] As I shall go on to explain, this means that the relevant nomic and causal relations will have to hold necessarily and not contingently. Far from being a disadvantage of the dispositionalist conception it is in fact an advantage. For it allows us to avoid the problems that beset the other two

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conceptions on offer. The conflict with our intuition that laws are contingent is not damaging at all, since that intuition is manifestly misleading.

In Section 2 I sketch an idealised version of the dispositionalist account of laws, relating it to the conditional analysis of dispositions. The following section demonstrates the advantages this account has over the two leading contingentist views of laws – the regularity view (e.g., Lewis) and the contingent nomic necessitation view (Armstrong, Tooley, Dretske). In Section 4 I address the fact that the conditional analysis employed in Section 2 is false. But I argue that this is after all an advantage of a sophisticated dispositionalist view. To the extent that dispositions deviate from the conditional analysis, laws deviate from being strict, exceptionless laws and are instead ceteris paribus laws. In Section 6 I raise three objections, including the objection that our intuitions tell us that the laws of nature are contingent; these objections are answered in Sections 7.1 and 7.2.

2. THE DISPOSITIONALIST CONCEPTION SKETCHED

The dispositionalist takes the properties with which science is concerned, the properties that appear in laws of nature (Lewis' 'sparse properties') to be essentially dispositional. A disposition is characterised by its stimulus and its manifestation. For example, something that has the property of being elastic can be characterised as displaying the manifestation of stretching without deformation in response to the stimulus of being put under tension. At a more fundamental level inertial mass can be characterised as the disposition to respond to the stimulus of a force by accelerating in proportion to that mass. For the moment we shall imagine that the relationship between stimulus and manifestation is one of counterfactual/subjunctive implication. Thus, *if* an elastic object were put under tension, *then* it would stretch without deformation; *if* an inertial mass were subjected to a force, *then* it would accelerate in proportion to that force. If this is right, then the following holds:

(CA) $Dx \leftrightarrow Sx \mathrel{\Box\!\!\rightarrow} Mx$

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where D is the dispositional property, S is the stimulus property and M is the manifestation property. This biconditional is known as the conditional analysis of dispositions. From (CA) it follows that $(Dx \mathbin{\&} Sx) \rightarrow Mx$ always holds. Generalising over the unbound variable x, we have the universal truth, $\forall x((Dx \& Sx) \rightarrow Mx)$. Thus the truth a universal generalisation follows from (CA). Ideally the dispositional account of laws would say all laws can be accounted for in this way, or as supervening on laws explained in this way. Matters are, as we shall see, more subtle, because (CA) is not strictly true. I shall return to this in Section 4.

Since the dispositionalist holds that the dispositional nature of properties is essential, (CA) is not merely an analysis of the dispositional concept '*D*' but rather characterises the nature of the property D. Hence (CA) is metaphysically necessary. Consequently, the law statement $\forall x((Dx \& Sx) \rightarrow Mx)$ is necessary also.[2]

3. ADVANTAGES OF THE DISPOSITIONALIST CONCEPTION

The main challenge to regularity accounts of law is to distinguish between accidental regularities and genuine laws. The simple or naïve regularity theory holds generalisations to state laws, whereas many such generalisations are clearly merely generalisations without any nomic backing whatsoever. More sophisticated regularity theories seek to pare down the set of generalisations admissible as law statements. The best of these is the systematic regularity theory of Lewis (following on from Ramsey) (Lewis, 1973, p.73). According to this view, a generalisation states a law only if it is deducible from that axiomatic systematisation of the facts that optimally combines strength and simplicity. While this reduces the pressure of the objection from accidental regularities, it does not remove it altogether. For we could imagine a system of laws that was itself rather complicated and weak but which generated an accidental regularity, whose addition to the axiomatic system might in fact add considerably to its strength without detracting much from its overall simplicity.

The nomic necessitation approach of Armstrong (1983), Tooley (1977), and Dretske (1977) can avoid the problem of accidental regularities altogether. On this view the ontological component of a law is not a regularity. Rather it is a second order

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relation between first order universals. The relation is given the name of 'nomic necessitation'. When it holds between two universals it entails the corresponding generalisation but the reverse entailment does not hold. Thus the law that *Fs* are *Gs* can be represented by $N(F, G)$, where $N(F, G) \Rightarrow \forall x(Fx \rightarrow Gx)$, but not $\forall x(Fx \rightarrow Gx) \Rightarrow N(F, G)$ (where '$\Rightarrow$' symbolizes entailment). The problem facing this view is telling us more about what *N* is.[3] For all we have been told so far, *N* cannot be distinguished from that relation which holds between *F* and *G* when $\forall x(Fx \rightarrow Gx)$ is deducible from the strongest, simplest axiomatic systematisation of the facts. Tooley tries to avoid this problem by making *N* irreducibly second order and by taking '*N*' to be a theoretical concept. We hypothesize the existence of *N* (and related second order universals) in order to explain the existence of the regularities we see around us. This seems odd. Certainly we hypothesise the existence of particular laws to explain particular regularities and patterns. Doing so presupposes the existence of laws in general and the capacity of laws to explain. But Tooley's proposal is that we hypothesise the existence of lawhood in general to explain the existence of regularities in general. The oddity is explicated thus. An inference on the basis of explanatory power employs the concept of explanation. While there is no universally agreed account of explanation, all the leading accounts on offer either invoke the notion of law (e.g., Hempel, 1965) or the related notion of cause (e.g., Lipton, 1991; Ruben, 1992, and others). If Hempel's *D–N* model of explanation is right, we cannot invoke the notion of explanation in trying to explain the concept of lawhood in general and '*N*' in particular. One would similarly doubt that the notion of explanation can be invoked even if our account of explanation is causal. For one would expect the concept of cause to depend on the concept of law rather than vice versa.

The dispositional conception of law avoids both these problems. On the one hand the source of laws is to be found in the nature and relations of properties, and not in regularities. Hence the need to exclude accidental regularities does not arise with the force it does for regularity theorists. If asked to distinguish a nomic regularity from an accidental one, the answer is straightforward. A regularity is nomic if and only is if it is entailed by the essence of one or more dispositional properties as captured in

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(CA). Above I showed how one could deduce a nomic regularity in the form $\forall x((Dx \& Sx) \rightarrow Mx)$ from (CA). One will not be able to do this for an accidental regularity. For example, recalling Reichenbach's example, it is an accidental regularity that all gold spheres have a mass less than 10 tonnes.[4] But this regularity is not a consequence of gold's dispositions. On the other hand, all persisting spheres of uranium-235 are also less than 10 tonnes in mass. According to the dispositionalist this is a consequence of the fact that uranium-235 possesses certain dispositions essentially, and these dispositions entail (via (CA)) that a 10 tonne sphere uranium-235 would chain-react and explode.

By locating the source of lawhood beyond regularities, the dispositional conception shares the advantages of the nomic necessitation view over the regularity view. But it does better than both. For the nomic necessitation view does not explain how nomic necessitation entails the corresponding generalisations – it has to stipulate that it does. By contrast, the truth of nomic generalisations is deducible from (CA). Since the dispositional conception does not invoke '*N*' it does not need to explicate it and so avoids the problems sketched in the last paragraph. It is the essential dispositional nature of properties that does the work that *N* is intended to do. In effect the mysterious relation of contingent nomic necessitation is replaced by the more familiar notion of metaphysical necessitation. Necessitation really is necessary.[5]

4. THE FALSITY OF THE CONDITIONAL ANALYSIS

The most important obstacle to the account just sketched is that the conditional analysis of dispositions, (CA), which underpins the account, is false. In this section I shall argue that recognising the falsity of (CA) does not require us to abandon the dispositionalist conception. On the contrary, the required modifications turn out to be an advantage because they allow us to account in a natural way for the existence of ceteris paribus laws.

The conditional analysis of dispositions, (CA), states that where *D* is the disposition to manifest *M* in response to stimulus *S*:

(CA) $Dx \leftrightarrow Sx \,\square\!\!\rightarrow Mx$

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There exist numerous counterexamples to (CA). Charlie Martin (1994) has shown that dispositions may be *finkish*. Dispositions may come into existence and go out of existence – an object may be made brittle by sudden cooling, and may lose its brittleness by being heated. A finkish disposition is one which is caused to cease to exist by its own stimulus. One can imagine an arrangement where an item is brittle due to a low temperature but the act of striking or otherwise stressing it causes some mechanism to heat the object up sufficiently quickly that the object loses it brittleness. If it loses its brittleness sufficiently quickly, the striking will not cause it to break. So, at the time of striking the object was brittle (and so disposed to break when struck); however, although it was struck, it did not break. We have a counterexample to (CA). The object **a** has the disposition D, i.e., $D\mathbf{a}$ (**a** is disposed to break when struck). We also have $S\mathbf{a}$ (**a** was struck), but we also have $\neg M\mathbf{a}$ (**a** did not break); hence we have $\neg(S\mathbf{a} \rightarrow M\mathbf{a})$. Other circumstances may display the reverse of this finkishness. An object may not be brittle, but the act of striking cools it sufficiently fact to make it very brittle and responsive to that very act of striking; it therefore breaks. So at the time of striking the object is not brittle, i.e., $\neg D\mathbf{a}$. But the striking does bring about breaking, hence $(S\mathbf{a} \rightarrow M\mathbf{a})$.

Further counterexamples to (CA) exploit the fact that the environment plays a part in enabling dispositions to yield their manifestations and can also bring about effects similar to dispositions. For example a poison requires not only its own chemical or biological constitution to cause illness; it also requires the participation of the victim's body. On ingesting a poison that would normally cause illness, a person may take an antidote that interferes with the metabolic pathways the poison would otherwise have exploited, preventing the poison from doing harm. This case is not like the fink case, since the poison was not made non-poisonous; its internal constitution was not changed. So it remains the case that the poison is disposed to cause illness when ingested, even though on this occasion it did not cause illness when ingested. This is a case of an *antidote* to a disposition. We have an antidote in a philosophical as well as an everyday sense (Bird, 1998). While a finkish disposition is changed by its own stimulus, an antidote to a disposition leaves the

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disposition unchanged but alters the environmental conditions that are required to permit the disposition to yield its characteristic manifestation.[6]

5. CETERIS PARIBUS LAWS

The preceding section gave us reason to think that (CA) is false. But an even earlier section explicated the dispositionalist conception of laws by employing (CA). Does not the one refute the other? In this section I shall argue that it does not and that the reason why not indeed gives added strength to the dispositionalist view.

The counterexamples to (CA) would make serious trouble for the dispositionalist view of laws, if all laws were straightforward exceptionless universal generalisations. But we know that they are not. For many laws are *ceteris paribus* laws (cp-laws). There are two kinds (at least) of cp-laws.[7] In the first, *comparative* kind, the law states that two or more parameters are related in a certain way, so long as the values of other parameters are kept constant. So, for example, the pressure of a gas is inversely proportional to the volume it occupies, so long as its temperature and other variables are maintained constant. In the second, *exclusive* kind of cp-law, a certain relation is said to hold, provided that certain disturbing factors are absent. Thus planets travel in ellipses, but only if disturbing factors, such as the gravitational influence of other planets, is absent. In such cases, it is not so much that other things are equal as that they are absent.

It is the latter, exclusive cp-laws, that concern me here. My suggestion is twofold. First, we can see these cp-laws as reflections of dispositions. Second, the disturbing factors that are required to be absent are precisely the sorts of factor that provide counterexamples (finks and antidotes) to the conditional analysis. In the light of this we may conclude that the dispositional conception of laws still holds, despite the counterexamples to (CA). The account will now be more nuanced and inclusive. The account already given based on (CA) may be regarded as holding for those dispositions that do not experience finks and antidotes. These dispositions generate genuinely universal laws that are not exclusive cp-laws.

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Whether there are any such dispositions and laws is an interesting question, to be pursued elsewhere. But even if there are none, that account, linking fink- and antidote-free dispositions to perfectly universal laws can be seen as an ideal or limiting case of the relationship that holds more generally between dispositions and laws. Where a disposition is subject to finks and antidotes, we can say that where there is a disposition D then the conditional $S \rightarrow M$ holds, so long as finks and antidotes are absent. While this is not much use as a deep analysis of the concept of disposition, it nonetheless accurately represents the metaphysical relationship between the disposition and its associated conditional. This generates the following law: $<\forall x((Dx \,\&\, Sx) \rightarrow Mx)$, so long as D's finks and antidotes are absent$>$, which is clearly an exclusive cp-law.

The case for the view that dispositions subject to finks and antidotes support exclusive cp-laws is bolstered by looking at a few cases. Take that already presented, the law that planets travel in ellipses around the Sun. The disposition in question here is the simply the disposition of the planet to travel in an ellipse around the Sun. This is a slightly unusual disposition, since the relevant stimulus, being under the gravitational influence of the Sun, is strictly speaking satisfied by the planet (or any other object) wherever it may be. For this reason it need not be stated. And for the same reason we might expect the manifestation (travelling in an ellipse) to be manifested permanently. And indeed for the most part that manifestation is manifested. But the disposition is subject to antidotes, that is to say, interfering environmental factors. An antidote to the disposition to travel in an ellipse will be something that exerts an independent force on the planet, such as the gravitational attraction of another planet.

This case is straightforward, but may have the air of being somewhat contrived. For we do not find it particularly helpful to think of planets being disposed to travel in ellipses. It is more revealing to think of the ellipses as being consequences of more fundamental and general laws. That however does not mean that the dispositions do not exist; and indeed their existence is a consequence of the laws in question (which, if the dispositionalist is right, are themselves reflections of deeper dispositions). Not knowing the more general laws always may make it useful to

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think in terms of dispositions, and that is exactly how Aristotle, Ptolemy, and Copernicus (and arguably Kepler) did indeed think of planetary motion. The point of the case is to show just that in so far as we do identify a disposition here, the antidotes to the disposition will correspond to the factors excluded by the *ceteris paribus* clause in the corresponding cp-law. A more natural case concerns the disposition of arsenic to bring about serious and potentially fatal illnesses in human beings. (It is more natural to think here in terms of dispositions since it is pragmatically less helpful to think in terms of the underlying chemical and physiological laws.) As we have seen this disposition has antidotes, in both the natural and the philosophical senses. Someone can ingest arsenic in quantity yet not suffer any ill effect, so long as they have taken an antidote. One can also be protected from arsenic poisoning by a gradual process of habituation. This is not quite an antidote in the natural sense, but is an antidote in the philosophical sense. The existence of such antidotes means that arsenic has the disposition to make people ill who ingest it, even though not all those who ingest it get ill. Hence it is no surprise that the corresponding law, that arsenic causes illness in humans, is not a truly universal law but is an exclusive cp-law. And of course the factors excluded by the *ceteris paribus* clause are precisely such factors as taking antidotes, having acquired immunity, and so forth, factors which are all antidotes to the disposition. At this point it is worth mentioning that the antidotes to arsenic typically work by changing the physiology of the person in question. But some antidotes may work by reacting with the poison changing its chemical or biological constitution so that it becomes harmless. In which case the antidote is an antidote in the natural sense but not in the philosophical sense. In such cases the disposition of the poison to cause illness is a finkish disposition – the stimulus (ingestion) causes the poison to lose its disposition. This possibility too is a reason why (CA) does not hold for this disposition, and is correspondingly a factor that is excluded by the *ceteris paribus* clause in the associated laws.

In conclusion, the moral of this story is that the failure of (CA) due to finks and antidotes is no difficulty for the dispositionalist account of laws. On the contrary, the very existence of finks and antidotes explains why not all laws are perfectly general but some are exclusive cp-laws. Had (CA) been true, then the dispositional conception would have required all laws to be perfect generalisations – which would have permitted cp-laws to have refuted the dispositional conception. But rather than refuting the dispositional conception, the existence of cp-laws confirms it, since cp-laws are what we would expect once we appreciate that dispositions can be subject to finks and antidotes.

6. SOME OBJECTIONS

In this section I shall outline two objections. In the subsequent sections I shall sketch the appropriate responses to these objections.

First objection. The laws of nature are contingent. The dispositionalist conception entails that they necessary. That conception is thus false.

Second objection. Some laws appear not to be reflections of dispositional properties.

(i) Some laws involve fundamental constants. One could have a world in which the values of these constants are very slightly different. Presumably such small differences in the values of fundamental constants would not require that the properties related in the law in question are different from this world. So even if we think of the properties in question as dispositions, that dispositionality cannot account for the difference between the law we have and the law we might have had. Hence the dispositional account of laws is not a complete account of the nature of laws. Put simply, the values of fundamental constants are nomic features of the world not accounted for by the dispositional conception.

(ii) Conservation and symmetry laws tell us that interactions are constrained by the requirement of preserving, e.g., mass-energy or momentum. But that constraint does not appear to be the manifestation of a disposition.

(iii) Least action principles are treated as laws and again are not easily cast as relating the stimulus and manifestation of a disposition. Joel Katzav (2004) argues that the principle of least action (PLA) for a system assumes that given its

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initial state (i.e., given the essential, intrinsic properties of the system in its initial state) various different evolutions are possible. The PLA provides a rule that selects just one of these. The dispositional essentialist, however, believes that given the initial state of the system, only one evolution is possible, that fixed by the essential dispositional natures of the intrinsic features of the initial state.

(iv) Two properties might be involved in distinct laws in accordance with the dispositional conception. But if there is a third law relating these two properties, then that third law will not be the outcome of the dispositional natures of the properties. This might be exemplified by the relationship between gravitational mass and inertial mass. Prima facie, at least, it looks as if we have here two dispositional properties, one whose essence is mutual attraction and the other whose essence is to govern the relationship between force and acceleration. Neither essence entails the other. Gravitational mass is analogous to charge, except that for charge the force is repulsive. But charge is not related to inertial mass. Nonetheless it is a fact, a law of nature, that inertial mass and gravitational mass *are* related. Regarding these as distinct properties, we can say that every body possesses the one in perfect proportion to the other. This would be a law not entailed by the essence of any property.

7. RESPONSES

7.1. *Response to the First Objection – the Illusion of Contingency*

The key premise of the first objection is the claim that the laws of nature are contingent. The appropriate response is simply to deny this premise. What we do know is that most laws of nature are discovered *a posteriori*. That is only a very weak reason for thinking that those laws are contingent. Many necessary facts can be known to be true only by *a posteriori* means. As we know from Kripke (1980), certain identity statements, including identity statements concerning scientific and natural kinds, express propositions that are necessarily true but which can be known only *a posteriori*. Another case involves propositions of the form

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$p \vee q$ where p is some contingently true proposition that can be known only *a posteriori* and q is some necessarily true but undecidable proposition of mathematics. The whole disjunction $p \vee q$ will be necessary since the disjunct q is necessary; it will be knowable only *a posteriori* because the only disjunct that is knowable at all is p which is knowable only *a posteriori*.

So, in general, the thought that laws might be necessary but knowable only *a posteriori* is not objectionable and should be familiar from other cases. Furthermore, it can be shown, without begging the present question, that some laws of nature are necessary but have every appearance of contingency. Let us for sake of argument grant that the basic laws of nature are contingent. Let a non-fundamental law, say a law of chemistry, assert that the substance S has some property D. We shall call this law, $L(S, D)$. This law may supervene some underlying, more fundamental (contingent) law C. So $C \Rightarrow L(S, D)$ (i.e., necessarily, C implies $L(S, D)$). Substances themselves exist as a result of the laws of nature. And it might be that in order for the substance S to exist, some fundamental laws must be true. In particular the existence of S might require the truth of C. Hence S exists $\Rightarrow C$. So we have $L \Rightarrow C \Rightarrow L(S, D)$. Hence the very existence of S necessitates the truth of the law $L(S, D)$. Hence there is no world where S exists but the law $L(S, D)$ fails to hold. Precisely this relationship can be shown to hold between the existence of salt (sodium chloride) and the law that salt dissolves in water.[8] The underlying law in this case is Coulomb's law which governs both the electrostatic attraction required for salt to exist and also is sufficient to ensure that salt dissolves in water. Clearly the law that salt dissolves in water is *a posteriori* and at first sight it seems to be entirely contingent. But it can be shown to be necessary, even if we assume that the underlying laws are contingent.

7.2. *Response to the Second Objection*

(i) *The problem of fundamental constants*
Here the concern was that the values of fundamental constants are nomic facts that are not explicable on the dispositionalist conception. The force of gravitational attraction between to point-masses is proportional to the product of the masses and inversely proportional to the square of their displacement. Even if these

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facts concerning proportionality are reflections of the dispositional nature of gravitational mass, it seems not to be essential to gravitational mass that the gravitational constant, G, which governs this proportionality is equal to: $6.672 \times 10^{-11}\ \mathrm{Nm}^2\ \mathrm{kg}^{-2}$? If this constant is genuinely fundamental, there seems to be a possible world in which the same property entered into a very similar law, which differed from our law in that the constant of proportionality is $6.682 \times 10^{-11}\ \mathrm{Nm}^2\ \mathrm{kg}^{-2}$.

The key premise here is the assertion that G is indeed a fundamental constant. If the law of gravitation is not fundamental but is derived from deeper laws (as physicists indeed believe) then it could well turn out that the value of G is constrained in a way that we do not yet understand. In which case it might be, for all we know, that the value of G is necessary, despite appearances to the contrary, just as the fact that salt dissolves in water is necessary, despite initial appearances.

Furthermore, there is indeed reason to think that this might be the case. The intensity of light from a constant and uniform source falling on an unit area decreases in inverse proportion to the square of the distance from the light source. This law could have been discovered experimentally. One could imagine someone thinking the exponent of the displacement, -2, is a fundamental constant. there might be a very similar possible world in which the light intensity is proportional to $d^{-2.000001}$. However, the fact that the intensity is proportional to exactly d^{-2} is derivable from the law of the conservation of energy. So a world in which the intensity is proportional to $d^{-2.000001}$ is not at all similar to ours; it is one where energy (or mass-energy) is not conserved (and it is not clear to me that such a world is genuinely possible). Newton's law of gravitation is similarly an inverse square law, and its similarity to the law of luminosity encouraged many to think that it too must be explicable as reflecting some deeper law that would show why the force of gravity is proportional to d^{-2} rather than to $d^{-2.000001}$. Einstein eventually showed that they were right. It is thus a possibility (an epistemic possibility) that scientists will find that G is not a fundamental constant either. Indeed there might not be any fundamental constants. This is exactly what Nobel-prize-winning physicist Steven Weinberg speculates (1993, pp.189–191).

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It may at first sight seem strange that the acceptability of a philosophical position concerning the nature of properties and laws should depend on certain scientific discoveries. But on reflection this is not so perverse. We have already discussed how necessary truths may be discoverable only *a posteriori* and it is not unreasonable that some such necessary truths are ones we would classify as metaphysical. Furthermore, the naturalistic tendency of much contemporary philosophy should make it easier to think that the boundary between the physical and the metaphysical is not a sharp one, let alone a sharp one characterised by the difference between what is knowable *a posteriori* and what is knowable *a priori*.

(ii) *The problem of conservation and symmetry laws*

Several of our mot important laws state that certain quantities are conserved in all interactions – mass-energy, charge, momentum, lepton number, angular momentum, etc. Corresponding to these are laws asserting that the universe displays certain symmetries. It is difficult to see why, for example, when two charged objects interact, it is a manifestation of a dispositional essence that the total charge should remain constant.

This, I believe, is an important challenge to the dispositional essentialist. One approach is the following. Bigelow et al. (1992) regard such laws as reflections of the essence of the world. They takes the world to belong to a kind (and *a fortiori* to be the only actual member of that kind). They also take kind membership to depend on essences and laws to flow from essences. So in this case, the world has an essence, and that essence requires that mass-energy, charge, lepton number etc. are conserved in all interactions. While they do not state that all essences are dispositional in nature, one could argue that one should see this essence as the disposition to conserve energy, etc. in response to any event. In which case the conservation and symmetry laws are reflections of the fact that the world belongs to a certain kind, such that it is essential to this kind that entities (worlds) exemplifying it are disposed to conserve energy etc.

(iii) *The problem of least action principles.*

Here it looks as if the existence of a least action principle implies that a multiplicity of evolutions for a system are possible, given

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only the intrinsic features of its initial state (absent the PLA itself), whereas dispositional essentialism requires that just one be possible (in a deterministic system). The least action principle seems to govern the system and its evolution rather than flow from the essential character of its intrinsic properties. The response to this problem is to question the sense in which the PLA for a system implies that, were it not for the PLA, many evolutions are *possible*. It is natural to say that the PLA chooses one path from many possible paths. But the mathematics of the PLA do nothing to show that such paths are metaphysically possible. The sense of 'possible' is a mathematical/logical one. All that is required is that no contradiction is deducible from the claim that the system's evolution takes a path other than the actual one. The point can be put epistemically. It might be that the intrinsic properties of the initial state make only one evolution possible, thanks to the dispositional essences of those properties. However, in the absence of full knowledge of those essences we may not know which path that is. A PLA is an *a posteriori* tool for providing the answer. That is consistent with the PLA itself being necessary, with the actual path being necessary, and with those necessities flowing from the (in this case, unknown) essences of the intrinsic properties of the initial state of the system.

(iv) *The problem of mass.*

In classical physics mass is (i) a fundamental property, and (ii) associated with two dispositions, one inertial and one gravitational. The latter makes classical mass a *multi-track* disposition, i.e., a disposition that relates multiplicity of stimuli and manifestations. I will not argue for it here in detail, but my view is that multi-track dispositions cannot be fundamental. It seems odd that a *fundamental* property should both yield manifestation M_1 in response to stimulus S_1 and also manifestation M_2 in response to stimulus S_2. That does not seem fundamental at all. It would appear that such a property, if genuinely a single property, would be a non-fundamental property. There ought to be an explanation of why these stimulus/manifestation combinations occur together. It might be thought that we can split the property into two: one which is the disposition to yield M_1 in response to S_1 and another which is the disposition to yield M_2 in response

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to S_2. In effect this would be saying that there are two properties, inertial mass and gravitational mass. While there is nothing wrong with this per se, it does not do much to help solve our problem. For if we split mass into two properties, inertial mass and gravitational mass, then we must add a new (fundamental) law that these are always and everywhere proportional to one another. This law would be a non-dispositional, contingent law, undermining the claim of dispositionalist to give a full account of the laws of nature.

I do not yet have a clear view of how to answer this problem. A starting point is this. We abandon the conception of mass employed in classical physics. Dispositionalism is much better suited to the conception of mass presented by General Relativity. According to the latter mass and space-time form a reciprocal dispositional pair – each space-time point is characterized by its dynamic properties, i.e., its disposition to affect the kinetic properties of an object at that point, captured in the gravitational field tensor at that point. The mass of each object is its disposition to change the curvature of space-time, that is to change the dynamic properties of each space-time point. That said, Einstein's equivalence principle is only of limited assistance to the dispositionalist, for inertial and gravitational mass come apart, in effect, for charged masses in electric fields. Whether physics presents an irresolvable problem for dispositionalism or indeed a resolution of its problems must await further developments.

8. CONCLUSION

This paper sought to sketch the dispositionalist conception of laws and to show how the dispositionalist should respond to certain objections. The view that properties are *essentially* dispositional is able to provides an account of laws that avoids the problems that face the two categoricalist views of laws (the regularity and the contingent natural necessity views). Furthermore, advances in physics that we have some reason to believe might in fact be close to revealing the nature of the fundamental laws and properties, fit well with the dispositionalist conception.

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NOTES

1. Related dispositionalist views are to be found in, for example, Shoemaker (1980), Ellis and Lierse (1994), and Ellis (2001). The relationship between dispositional essentialism and the laws of nature is discussed by Mumford (1998, 2004).
2. Stephen Mumford (2004, p.121) argues that this position should be seen as *eliminating* rather than explaining laws.
3. c.f. van Frassen's concerns on this score (van Fraassen, 1989, p.96).
4. (c.f. van Fraassen, 1989; 27, 352).
5. It seems to me that Hume recognized this when he criticized the necessity view of cause. Because he took necessary relations to be what we call analytic, he believed that the necessity view entails that effects must be deducible from causes, which is patently not the case. But this objection fails if we deny that all necessary relations are analytic (or *a priori*).
6. The right-to-left implication of (CA) is refuted by *mimics,* which explicate the action of a disposition even no disposition is present. A sturdy cast-iron cooking pot might break if knocked. Not because it is fragile (it is not), but because it is attached to a powerful bomb with very sensitive detonator. The reverse case of finkishness also refutes the right-to-left implication.
7. See (Schurz, 2001) for a useful discussion.
8. For details see Bird (2001).

REFERENCES

Armstrong, D.: 1983, *What is a Law of Nature?* Cambridge: Cambridge University Press.

Bird, A.: 1998, Dispositions and Antidotes. *Philosophical Quarterly* 48: 227–234.

Bird, A.: 2001, Necessarily, Salt Dissolves in Water. *Analysis* 61: 267–274.

Bigelow, J., B. Ellis and C. Lierse: 1992, The World as One of a Kind: Natural Necessity and Laws of Nature. *British Journal for the Philosophy of Science* 43: 371–388.

Dretske, F.: 1977, Laws of Nature. *Philosophy of Science* 44: 248–268.

Ellis, B. and C. Lierse: 1994, Dispositional Essentialism. *Australasian Journal of Philosophy* 72: 27–45.

Ellis, B.: 2001, *Scientific Essentialism*. Cambridge: Cambridge University Press.

van Fraassen, B.: 1989, *Laws and Symmetry*. Oxford: Oxford University Press.

Hempel, C.: 1965, *Aspects of Scientific Explanation*. New York: The Free Press.

Katzav, J.: 2004, Dispositions and the Principle of Least Action. *Analysis* 64: 206–214.

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Kripke, S.: 1980, *Naming and Necessity*. Oxford: Blackwell.

Lewis, D.: 1973, *Counterfactuals*. Oxford: Blackwell.

Lipton, P.: 1991, *Inference to the Best Explanation*. London: Routledge.

Martin, C.: 1994, Dispositions and Conditionals. *Philosophical Quarterly* 44: 1–8.

Mumford, S.: 1998, *Dispositions*. Oxford: Oxford University Press.

Mumford, S.: 2004, *Laws in Nature*. London: Routledge.

Ruben, D.H.: 1992, *Explaining Explanation*. London: Routledge.

Schurz, G.: 2001, Pietroski and Rey on Ceteris Paribus Laws. *British Journal for the Philosophy of Science* 52: 359–370.

Shoemaker, S.: 1980, Causality and Properties in *Identity, Cause, and Mind* Cambridge: Cambridge University Press.

Tooley, M.: 1977, The Nature of Laws. *Canadian Journal of Philosophy* 7: 667–698.

Weinberg, S.: 1993, *Dreams of a Final Theory: The Search for the Fundamental Laws of Nature*. London: Vintage.

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