Dispositional Essentialism and the Laws of Nature

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Abstract

In this paper, I look at the argument for Dispositional Essentialism (DE) that has been put forward by A. Bird in his recent book *Nature's Metaphysics*. Bird's overall argument comes in two parts, one negative and one positive, which together are to establish DE as the best contender for a theory of properties and laws. I argue that, even if all their particular steps go through, both parts of the argument have significant gaps. The negative argument, if successful, shows that at least one property has an essence, but not that any property has a *dispositional* essence. The positive argument, which aims to demonstrate the explanatory power of DE, fails to take account of the *quantitative* nature of the fundamental natural properties and laws. I finish by suggesting a revision of DE's doctrine that might solve the latter problem, but yet remains to be spelled out.

1   Introduction

Dispositional Essentialism is the view that '[a]t least some sparse, fundamental properties have dispositional essences' (Bird 2007, 45). This minimal characterization can be expanded in various ways, and various dispositional essentialists disagree on just how it should be expanded. Thus Alexander Bird holds, but Brian Ellis denies, that not only *some* but in fact *all* sparse, fundamental properties have dispositional essences; while Brian Ellis holds, and Alexander Bird is neutral on the question whether, the essentially dispositional properties are in turn essential to their bearers. In this paper, I will be concerned only with the minimal version of dispositional essentialism, and the argument that is given for it in Bird's recent book *Nature's Metaphysics* (Bird 2007).

Dispositional essentialism is a form of scientific realism that has much to offer. The 'sparse, fundamental' properties are precisely those properties

that participate in the (fundamental) laws of nature; but on the dispositional essentialist view, they do not only participate in laws. They *ground* those laws. Negative charge, for instance – if it is a fundamental property – is the disposition to repel other negative charges and attract positive ones; hence it is a law that negative charges attract other negative charges and attract positive ones. The same will hold, on the dispositional essentialist view, for other laws – at least the causal laws. Thus the laws discovered by such sciences as physics will not only be real, existing features of the world; they will be deeply rooted in the very fabric of the world. Bird begins his book with the observation that on the main competing views of laws, those of David Lewis and David Armstrong, it would be very easy to imagine a world without laws. Ours could have been one of them. You can have all that it takes to build a world like ours – particulars possessing properties and undergoing processes in space and time – without laws; lawhood will be an additional, separate ingredient into the world. On the dispositional essentialist picture, if you take the laws away, there is nothing much left to make a world. For the dispositional essentialist, the tenets of scientific realism – that the laws discovered by science are a real, genuine part of our world – are not merely true, they are constitutive of what the world is made of.

Unsurprisingly, its ability to account for the laws of nature has been taken as the central advantage of dispostional essentialim. Ellis (2001) argues that dispositional essentialism can solve the three main problem with which rival views of the laws are confronted: the Necessity Problem (explaining the necessity involved in laws – the necessity expressed in the thought that negative charges *have to* repel each other); the Idealization Problem (explaining that many laws hold only *ceteris paribus*, i.e. can be interfered with); and the Ontological Problem (providing adequate ontological grounding for laws in reality). I have already indicated how a dispositional essentialist account of laws deals with the ontological problem; the idealization problem is addressed by the fact that a given law expresses the essence of some particular property, but in reality there will always be other properties operating, thus interfering through external forces. The Necessity Problem, finally, is solved very simply by the fact that laws are grounded in essences: like charges *have to* repel each other because that is their essence. The laws turn out to be metaphysically necessary. This is a controversial consequence of dispositional essentialism which I will not, however, be concerned with in this paper.

Intuitively, these are considerations in favour of dispositional essentialism. But they cannot fully come to bear until we have seen exactly how the dispositional essentialist view is spelled out, what exactly it is for a property to be essentially dispositional, and what the laws' being 'grounded' in those properties amounts to. Bird's book is notable for its careful attention to such questions, and for offering what is probably the most detailed formulation and the most extensive defense of dispositional essentialism to date. Where it goes wrong – and I will argue that it does go wrong – there is not, to my

knowledge, any alternative available in the literature that would avoid the shortcomings. This is not to say that they cannot be fixed; but any fix will have to take Bird's formulation as a starting point and proceed from there.

Before I look at the argument for it, let me analyse Dispositional Essentialism in a little more detail. It can be understood in three simple steps.

First step: some fundamental properties have *essences*.

Second step: (some of) these essences are *dispositional*.

Third step: for a property P to be dispositional is for P to be characterized by a stimulus condition S and a manifestation condition M, which behave very much like a counterfactual conditional $S x \mathbin{\square\!\!\rightarrow} M x$ (with a *ceteris paribus* clause).

Note that nothing in any one step forces us to take the next one: one might hold that some properties have essences, but that these essences aren't dispositional; or one might hold that they are dispositional, but give a non-standard account of dispositionality. We will see, however, that all three steps are required for Bird's argument, and I believe that they are shared by everyone who commits themselves to dispositional essentialism.

In what follows, I shall understand 'Dispositional Essentialism' (DE) as the conjunction of these three steps. *Nature's Metaphysics* offers an indirect argument for DE. The indirect argument comes in two parts, one negative and one positive. The negative part aims to expose the explanatory poverty of DE's competitors, a cluster of views that Bird calls 'categoricalism'; the positive part then seeks to establish the superior explanatory power of DE itself. There is no attempt at a direct proof; rather, the overall argument is to establish DE as the best contender.

In this paper, I will argue that Bird's overall argument fails. I will do so not by disputing any particular step in the argument; I will grant that each one of these steps goes through. What I will dispute, rather, is that these steps establish DE as the best contender. I will argue that there are significant gaps in both the negative and the positive argument and that, unless these gaps can be filled, we have not been given a good reason to favour DE.

2   The Case against Categoricalism

The cluster of views that Bird opposes to DE is *categoricalism*. Categoricalism about properties is characterized as the view that

> [p]roperties are categorical in the following sense: they have no essential or other non-trivial modal character. For example, and in particular, properties do not, essentially or necessarily, have or confer any dispositional character or power. Being made of rubber confers elasticity on an object, but it does not do so necessarily. Being negatively charged confers on objects the power to repel other negatively charged objects, but not necessarily. In other possible worlds rubber objects are not elastic, negatively

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charged objects attract rather than repel each other. (Bird 2007, 67)

Of the three steps towards DE that I set out in the preceding section, the categoricalist parts way at the very first step: for the categoricalist, properties do not have essences. It is a simple consequence of this, and not a further substantial categoricalist claim, that properties do not have *dispositional* essences. This is not to say that the categoricalist has to deny dispositional properties altogether: the characterization explicitly allows that properties may 'confer' powers on objects. Is this not a 'non-trivial modal character'? It is: powers, after all, are modal properties. But their modality is different from that of essence or necessity. It is akin to the counterfactual conditional, or so the third step towards DE contends, and the categoricalist has no quarrels with that step. The first sentence, then, somewhat overstates the tenet of categoricalism. The categoricalist does not deny, qua categoricalist, that properties have *any* non-trivial modal character. Rather, he denies that properties have an essential or other necessity-like modal character. This, again, is merely to say that the categoricalist denies only the first step towards DE.

Like DE, categoricalism is primarily a thesis about properties, but comes with a view about laws. Unlike DE, categoricalism does not ground the laws in the properties that participate in them: nothing about a property itself determines what these laws will be. The laws, therefore, have to be externally imposed on the properties involved. Being externally imposed, they will plausibly be contingent: whatever it is that relates, say, charge and attractive force in Coulomb's Law, having no special grounding in either the property of charge or that of attractive force, could plausibly have failed to relate them. Again, this is not so much a substantial further claim as it is a (plausible) consequence of the central categoricalist thesis about properties. It is not a logical consequence, however: in a footnote, Bird notes that the categoricalist about properties might in principle hold that the laws are necessary, but it is hard to see a motivation for this on the categoricalist picture. (Bird 2007, 68, fn. 67) The central tenet of categoricalism remains its denial that any property has an essence or other non-trivial necessary feature.

If the laws are externally imposed on properties, what exactly is it that is imposed? Bird considers the two main categoricalist answers to that question and poses a dilemma for the categoricalist: on one answer, the Lewisian regularity theory, the laws fail to perform the explanatory task that is central to lawhood; while the other, the Armstrongian view of 'nomic necessitation', is forced to give up the central tenet of categoricalism.

According to the regularity view of laws, 'there is nothing metaphysically deeper or more substantial from which laws flow. Rather laws are no more than regularities that also meet some further, metaphysically innocuous, condition ... [for instance the] condition that laws are regularities that can be suitably systematized.' (Bird 2007, 81f.) This, of course, is referring to the version of the regularity theory famously proposed by David Lewis

(for instance, in Lewis 1994).

To understand what is at issue, it is useful to note (as Bird does) that DE itself can be formulated as a regularity theory. According to DE, the laws are those regularities that supervene on the dispositional nature of the fundamental properties. According to the Lewisian regularity theory, the laws are those regularities that yield the best system. Both characterize the laws as a subset of the regularities, a subset that meets a further condition. The crucial point is the nature of that further condition: the Lewisian condition is to be 'metaphysically innocuous', while the dispositional essentialist condition is anything but metaphysically innocuous. On the Lewisian view, not every regularity is a law, to be sure; but there is nothing special about the law-qualifying regularities themselves that sets them apart from others. Metaphysically, the laws are just regularities and no more.

It is this feature of the Lewisian view, and not anything more specific about the best-system account, that Bird finds unsatisfactory. His argument applies to any equally 'thin' theory. Let me use the term 'regularity theory' (as is usual) to refer only to the thin versions, excluding metaphysically 'thicker' accounts such as the version of DE just formulated. Bird's argument against the regularity theory is an elaboration of an argument first formulated by Armstrong (1983). It goes, roughly, as follows.

A first premise of the argument concerns explanation: nothing can explain itself. This is understood in a thoroughly metaphysical way: for p to explain q, the fact that p must be metaphysically something over and above the fact that q. (Bird substantiates this idea by talking about the 'ontological content' of a proposition.) A second premise concerns the role of laws: a law must explain its instances; or, if the law itself does not, then whatever it is grounded in must explain the instances. Thus if it is a law that all Fs are Gs, whatever that law metaphysically consists in or is grounded in must explain why a particular F is also a G.

According to the regularity theory, if it is a law that all Fs are Gs, then we can capture all there is (metaphysically) to that law by the universally quantified material implication $\forall x(Fx \rightarrow Gx)$. But this universal statement is nothing 'over and above' the particular instances – it is only, as it were, the collection of all of them. As such, it does not provide the explanatory resources to explain any one instance. The fact that a, which is an F, is also a G, cannot be explained by the further fact that b, which is an F, is also a G (nor that b and c, which are both F, are also both G, etc.); that latter fact is simply of no consequence to the former. Nor, of course, can it be explained by the one instance contained in the regularity that is of relevance – the fact that a, which is F, is also G; for that is the very fact to be explained, and nothing can explain itself.

If laws are to explain their instances – *all* of their instances – and regularities are nothing 'over and above' these instances, then the regularity cannot play the explanatory role of a law; rather, it is itself an explanandum for the law. Whatever is or grounds a law must explain, and so must be metaphysi-

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cally something over and above, that regularity. [1]

If, as I am granting, the argument goes through, then it shows that laws need to be, or be grounded in, something metaphysically 'over and above' the fact that, say, all Fs are Gs. It is a further but overwhelmingly plausible assumption that this something, which distinguishes a law from a mere regularity, is somehow modal: if it is a law that all Fs are G, then not only will all Fs *actually* be G; they *have to* be G. This element of necessitation is what is missing from the regularity theory, and *it* is what is needed for a law to play its explanatory role: if Fs *have to* be Gs, then that modal fact is metaphysically 'thick' enough to explain why all Fs *are* Gs.

The second horn of Bird's dilemma considers the categoricalist view which accepts this and tries to balance the element of necessitation with the categoricalist commitment to non-modal properties. What is imposed on the properties that participate in laws, on this view, is a relation of 'nomic necessitation', or *N* for short, which holds between two properties F and G if, and only if, it is a law that all Fs are G. Nomic necessitation views have been defended by a number of authors, notably Armstrong (1983), but also Dretske and Tooley.

Bird agrees with the nomic necessitation theorist that an element of necessity is what is missing from the regularity theory, and that this is what laws need to explain their instances. He argues, however, that a categoricalist cannot have this element of necessity; that the combination of categoricalist contingentism and necessitation is not stable. To see why, we need to ask *how* it is that *N* necessitates, and thereby explains regularities.

Bird focusses on Armstrong (1983)'s version of the nomic necessitation view, and so will we. According to Armstrong, *N* is a second-order relation that holds between natural properties and has the notable feature of entailing regularity: $N(F, G)$ entails $\forall x(Fx \rightarrow Gx)$. That *N* holds between F and G is external to the latter two and is contingent; hence the nomic necessitation view is categoricalist. Yet *whenever N* holds, then so does the regularity; this is not a contingent fact, hence the element of necessitation is captured.

Has Armstrong succeeded in locating the element of necessity while upholding categoricalism? The properties F and G, to be sure, have been saved for categoricalism: they do not *have to* be related by *N*, nor do they have to be anything else of necessity or essence. But, Bird asks, what about *N* itself? Categoricalism is a claim about *all* properties. This should include relational and second-order properties, and in particular it should include the

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[1] The Lewisian may dispute either the metaphysically 'heavy' conception of explanation, as being partial towards the metaphysically 'heavy' conception of the laws themselves; or he may point out that the best-system condition does, after all, have some kind of objective grounding in the world: they are not up to us, or so Lewis claims, cf. Lewis 1994, 232f.. If this is not enough for 'over-and-above-ness', then again, the Lewisian may complain that the metaphysically heavy conception of over-and-above-ness is partial to the metaphysically heavy conception of laws. But I will press neither of these two responses; as I said, I am going to grant Bird all the steps in his arguments, to point out a lacuna that is left even if they all go through.

second-order relational property that is called nomic necessitation. But *N* is associated with an entailment; it could not hold between two universals without there also being a corresponding regularity. If *N* entails regularity, it thereby has what categoricalism denies to any property whatsoever: a non-trivial necessary or essential character.

This violation of the categoricalist doctrine is not a mere slip. If the relation between nomic necessitation and regularity were de-modalized and understood as mere material implication, then we would lose again any grasp on the modal element that it is supposed to possess 'over and above' the regularity. For *N* to relate universals with the right kind of modal force *N* itself has to be related to regularity with some modal force. Nor will it help to apply to that modal force the same strategy that has been applied to the modal force of the laws themselves, and relate *N* to regularity by a third-order relation of nomic necessitation. That strategy, Bird argues, would lead into a vicious regress: the modal force will be continuously pushed up to ever higher-order relations of nomic necessitation, and at no point will we have succeeded in locating the aspect of necessity involved in a law. If that aspect is to be captured by nomic necessitation, it is through Armstrong's appeal to entailment – and that is, through giving up categoricalism.

I will, again, grant that the argument goes through: Armstrong, or indeed any categoricalist who wants to provide an explanatory role for laws at all, must reject categoricalism at least for the relation of nomic necessitation itself. But Bird draws a stronger conclusion: Armstrong, he says,

> must allow for there to be relations of metaphysical necessitation between distinct entities [namely, *N* and regularity]. But to do that is to permit potencies or potency-like entities. In which case [categoricalism] is false. And furthermore, we may avail ourselves of these potencies or potency-like entities in explaining laws and repudiate the now-redundant N. (Bird 2007, 92)

Now, *potencies* have been defined as 'properties that have dispositional essences' (Bird 2007, 3). But nothing in the argument so far has forced Armstrong, or anyone else, to accept that properties have *dispositional* essences. The friends of nomic necessitation may accept Bird's argument and yet be a long way from accepting DE. Armstrong, in particular, may retain his view that *N* entails regularity, and accept that this is to reject categoricalism as understood by Bird. But categoricalism as understood by Bird, while opposed to DE, is not its contradictory (i.e. the falsity of categoricalism does not entail the truth of DE). As we have seen, categoricalism parts way with DE at the first step. Armstrong, then, may be forced to take that first step and say that some property has a non-trivial modal feature, or an essence. Some property – that is, precisely one: *N* itself. Nothing in the argument we have been offered forces him to take any further step towards dispositional essentialism, or in particular, to take the second step and accept potencies.

It may be argued that, once categoricalism is given up, there is no more reason to believe in nomic necessitation. For was N not a purely theoretical construct, introduced only to preserve categoricalism by reconciling it with the necessitating force of laws? But if it does not succeed in doing this, then, it may be said, why should we believe in such a construct in the first place?

But Armstrong will have various lines of response to that (rhetorical) question. Introducing N still preserves categoricalism for a wide variety of properties: the first-order properties that scientists study. If we have to have some modality in the world, would we not rather have it located in one source? Moreover, investing N with a necessary character preserves not only categoricalism for the first-order properties, it also preserves the contingency of laws. If an essential or otherwise necessary character for one higher-order property is what it takes to strike the right balance between necessitation and contingency, then that's a price worth paying, and true enough to the spirit (if not the letter) of categoricalism to be far more attractive to the categoricalistically inclined than the thoroughly modal world of DE.

Let me stress that I am not endorsing either side of this dialectic. My point is merely that there is much argumentative space left between the rejecting categoricalism and accepting DE. The negative argument has taken us a little way towards DE (to be precise, one out of three steps). But that is not nearly enough for it to give us a good reason to adopt DE, as Bird seems to think it does.

Bird's negative argument, then, shows less than it is intended to show. This is not a devastating diagnosis: there is, after all, the positive argument. My criticism of the negative argument only places greater weight on the positive argument. It should give us very good reason to take not only the first step towards DE, but to go all the way, without bothering with the half-hearted intermediate views. So let me now look at the positive argument: DE's explanation of the laws of nature.

3 The Explanatory Power of DE

Like Armstrong, the dispositional essentialist holds that the laws are something over and above the regularities. We have seen that DE can be phrased as a form of metaphysically 'thick' regularity theory: the laws, according to that version of DE, are those regularities that hold in virtue of, or supervene on, the essentially dispositional nature of the sparse properties (Bird 2007, 82). The more general, official characterization of laws on the dispositional essentialist picture comes later in the book:

(L) The laws of a domain are the fundamental, general explanatory relationships between kinds, quantities, and qualities of that domain, that supervene upon the essential natures of those things. (Bird 2007, 201)

This characterization provides an answer to the ontological question about laws: they are grounded in the dispositional essences of properties. As we have seen in the argument against the regularity theory, regularities are to be explained by the laws, or by whatever grounds the laws. The dispositional essences of properties, which ground the laws on this view, do explain regularities. Both the grounding of the laws, and the explanation of regularities, is achieved in a most simple and elegant manner: by entailment.

According to DE, the fundamental properties at issue have dispositional essences, characterized by a stimulus and a manifestation condition. Where P is any fundamental property, dispositional essentialism says that P is essentially, and hence necessarily, a disposition to yield a particular manifestation M in response to a particular stimulus S. Using as an approximation the conditional analysis of dispositions, this gives us

(I) $\Box(Px \rightarrow (Sx \:\Box\!\!\rightarrow Mx))$,

which in a few simple steps of first-order modal logic with modus ponens for the counterfactual – assume $Px \wedge Sx$, derive Mx, discharge the assumption – leads to the statement of a nomic generalization:

(V) $\forall x((Px \wedge Sx) \rightarrow Mx)$.

(V) is a statement of a regularity; DE explains this regularity in terms of its derivation from (I). (V) is also a statement of a law, and we have a simple way of distinguishing a regularity that is a law from a regularity that is not a law: the former, but not the latter, can be derived from a (true) characterization of a dispositional essence, of the form of (I). The 'grounding' of laws in essentially dispositional properties has now a rather precise meaning: it can be cashed out in terms of logical entailment. Thus the Ontological Problem is answered: we know what the laws are grounded in, and what grounding consists in. The Necessity Problem is answered too: being derived from a necessary truth, (V) itself will be metaphysically necessary. The Idealization Problem, finally, will be addressed by the fact that the conditional analysis employed in (I) is only an approximation and holds *ceteris paribus* (Bird, however, believes that this does not apply at the fundamental level.

Presented in this abstract manner, the account is highly attractive. But let us fill in the schema and look at an example. One good candidate for an essentially dispositional fundamental property is charge – one of the favourite examples of dispositional essentialists. The law that characterizes charge, or rather: that should be grounded in charge, is Coulomb's Law. Coulomb's Law states the relation between any given determinate charge Q and any other charge q_i, the distance r_i between Q and q_i, and the attractive or repulsive force F_i that is exerted:

(CL) $F_i = \epsilon \frac{Qq_i}{r_i^2}$

Clearly, (CL) does not look anything like (V). A first and minor point of dissimilarity is that (V) is, and (CL) is not, stated in the form of a conditional.

What is more important is that (CL) states a *function*, and the variables in it range over *quantities*. Charge, force, and distance are quantities: they are determinable properties that come with an ordered range of determinates. An object is not merely charged (positively or negatively), it has a particular determinate charge, say, charge e or charge 2e. The same holds of exerting a force and being at a distance from something. Coulomb's Law, accordingly, states not merely *that* an object with a (positive or negative) charge will manifest a certain kind of force (attractive or repulsive) in response to a certain kind of stimulus condition (say, another charge at some distance from it); it states exactly *how much* force the object will exert in response to exactly *how much* charge at *how great* a distance.

(I) and (V), on the other hand, appear rather to be designed for qualitative properties; they can tell us merely that *if* such-and-such properties are instantiated, *then* such-and-such other properties will be instantiated too. But as Bigelow/Pargetter (1988) note, with quantities 'the simple "on" or "off" of being instantiated or not being instantiated seems to leave something out' (Bigelow/Pargetter 1988, 287). Can the quantitative nature of charge and Coulomb's Law be integrated into the derivation of (V) from (I)?

To see how this might be done, we need to fix the minor dissimilarity and formulate Coulomb's Law in the form of a conditional. Now, (CL) is a function with several variables, and we do not want any free variables in a (V)-like statement of a law. There are two things we can do with the free variables: we can fill in determinate values for them, or we can quantify over them. For simplicity's sake, let us focus on a particular determinate charge, say, electric charge (charge e). Then the first strategy yields an infinity of rather specific statements, one of which is

(V-1) $\forall$x ((x has charge e $\wedge$ x is 5.3 $\times 10^{-11}m$ from a charge of 1.6 $\times 10^{-19}C$)
$\rightarrow$ x exerts a force of 8 $\times 10^{-8}N$).

The second strategy, on the other hand, yields only one, multiply quantified, statement:

(V-$\forall$) $\forall x \forall r_i \forall q_i$ ((x has charge e $\wedge$ x is at a distance of r_i from a charge q_i)
$\rightarrow$ x exerts a force of $F_i = \epsilon \frac{eq_i}{r_i^2}$).

Note that (V-$\forall$) is closer to Coulomb's Law, but (because of its multiple quantification) is not quite of the same form as (V). (V-1), on the other hand, is an instance of (V). Accordingly, (V-1) can be derived from an instance of (I):

(I-1) $\Box$ (x has charge e $\rightarrow$ (x is 5.3 $\times 10^{-11}m$ from a charge of 1.6 $\times 10^{-19}C$
$\Box\rightarrow$ x exerts a force of 8 $\times 10^{-8}N$)).

(V-$\forall$), on the other hand, can be derived from the following:

(I-$\forall$) $\Box$ (x has charge e $\rightarrow$ $\forall$ charges q_i $\forall$ distances r_i (x is at r_i from q_i $\Box\rightarrow$
x exerts force $F_i = \epsilon \frac{eq_i}{r_i^2}$)

Again, (I-1), while an instance of (I), is not a characterization of charge e; and (I-∀), while being a better candidate for characterizing the dispositional essence of electric charge, is not quite of the same form as (I). There is a tension here: we can either keep strictly to the form of Bird's derivation, or we can capture the law (Coulomb's Law) and the property (electric charge) that we intuitively want to capture; but we cannot do both. I will argue that this tension is no mere appearance: there is a real conflict here, and it cannot be resolved without giving up some part of DE.[2]

The question that I put to the dispositional essentialist, then, is this: which is the fundamental property, and which is the law to be derived: (I-1) and (V-1), or (I-∀) and (V-∀)?

Given his explicit preference for the property of electric charge (p. 44), and the known quantitative nature of the properties and laws of physics, it is surprising that Bird does not devote a substantial part of his exposition to this question. His answer to it is hidden in an early and somewhat peripheral section on multi-track dispositions (p. 21-24), and is curiously forgotten in the rest of the book. In the section on multi-track dispositions, Bird argues for the priority of (I-1) and (V-1) over (I-∀) and (V-∀). Here is what he says (slightly rephrased to fit my set-up).

(I-∀) is equivalent to a conjunction of (infinitely many) statements such as (I-1). Undoubtedly (I-1) characterizes *some* disposition; the question then is, which of them is more fundamental, (I-1) and its cognates, or (I-∀)?

Bird defines a 'pure disposition' as one 'which can, in principle, be characterized ... as a relation between a stimulus and a manifestation' (22). (I-1) gives the characterization of a pure disposition; (I-∀), as we have seen, is equivalent to a conjunction of pure dispositions. And Bird continues:

> It is my view that all impure dispositions are non-fundamental. Fundamental properties cannot be impure dispositions, since such dispositions are really conjunctions of pure dispositions, in which case it would be the conjuncts that are closer to being fundamental. (22)

The fundamental properties are those characterized by (I-1) and its many cognates, and not properties such as charge e, which is better characterized by (I-∀). It turns out not only that charge, or even charge e, is not, after all, one of the fundamental properties. It also turns out that Coulomb's Law, or even (V-∀), is not, after all, a law that can be derived from the dispositional essences of the fundamental properties. What can be derived are infinitely many law-like statements such as (V-1).

What, then, is the status of Coulomb's Law, or even the instance of it expressed in (V-∀)?

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[2]Alice Drewery has raised worries very similar to the ones I am going to discuss in a talk given at the Metaphysics of Science conference in Nottingham, September 2009.

(V-∀) certainly states a regularity; but does it, on the present account, state a law? We have seen that a regularity will qualify as a law just in case it is entailed by the dispositional essence of a fundamental property, as expressed in (I). But there is no such dispositional essence to entail (V-∀); (I-∀), which does entail it, does not state the dispositional essence of any property. So (V-∀) does not seem to state a law. Similarly, there is no dispositional essence to entail Coulomb's Law in its full generality; so Coulomb's Law is not a law.

The same point can be made the other way around: assuming that Coulomb's Law, or at least (V-∀), is a law, what is this law grounded in? By the explication of grounding, it would have to be electric charge, i.e. the disposition expressed in (I-∀); but that has a rather questionable ontological standing. If the property expressed by (I-∀) is 'really' just a conjunction, as Bird tells us, then it is 'really' nothing but its conjuncts. It is, metaphysically speaking, nothing over and above the conjuncts, in the same way in which a regularity has been argued to be nothing over and above its instances. But if it is nothing over and above the conjuncts, then it cannot provide the ontological grounding for anything over and above what its conjuncts provide the grounding for.

If regularities themselves are explananda, then dispositional essentialism has not delivered the explanation it has promised. Its laws, (V-1) and its cognates, can explain *some* regularities – the regularity, for instance, that a given object exerts a force of $8 \times 10^{-8} N$ whenever it is $5.3 \times 10^{-11} m$ from a charge of $1.6 \times 10^{-19} C$. But the crucial regularity is the similarity *between* these specific regularities: the fact that they all exhibit the same mathematical correlations between stimulus and manifestation.

How is that regularity to be explained? It is clear that the 'impure disposition' (I-∀) will have to play a role. And indeed Bird says that '[w]hile it is possible to gerrymander impure dispositions of all sorts, it is clear as regards the cases we are interested in, [such as] charge [...], that the conjunctions are natural or non-accidental.' (22) That is clear indeed; but it is far less clear how the dispositional essentialist is to account for the naturalness of these conjunctions. It will not do to say that (V-∀) is grounded in a non-fundamental disposition captured by (I-∀). For as we have seen, that non-fundamental disposition could not be, and hence could not ground, anything over and above the fundamental conjuncts of which it is made up.

If a single determinate charge such as charge e and the instance of Coulomb's Law that is expressed in (V-∀) cannot be captured by DE, then even less will the determinable property charge and Coulomb's Law be captured. So I conclude that, with Bird's preference for (I-1) over (I-∀), DE fails to accomplish its explanatory task when it comes to the property of charge and Coulomb's Law. To see just how damaging this conclusion is, we need to consider (1) how far the argument I have given generalizes beyond the one property and law that I have been considering; and (2) whether the competing views, the regularity theory and the nomic necessitation view, run into similar problems.

First: how far does the argument generalize? The answer is: very widely. It may be, in fact it is rather likely, that charge and Coulomb's Law are not fundamental. But my argument did not turn on any specific features of charge, or of Coulomb's Law. It turned only on charge being a quantity, and Coulomb's Law being a functional law that states mathematical correlations between quantities. Every candidate fundamental property that participates in a functional law will be subject to the same line of argument. Bird conjectures, I believe for the reason stated, that the really fundamental laws will not have any constants, such as ϵ in Coulomb's Law (Bird 2009). But not only is that an undesirably strong prediction; it will not be enough to avoid the kind of argument I have given. The argument applies to properties and laws that involve *any* mathematical operation – multiplication or division is enough. And Bird should certainly not predict that there will be no mathematical operations whatsoever in the fundamental laws. That would not only be a daringly strong prediction. It would make it utterly mysterious what *could* count as a fundamental law at all.

Second: how do the rival views fare? The answer is: better. The regularity theory can take regularities of the form expressed in (V-1), note the similarity between them, and recognize it as just another regularity. The nomic necessitation theorist can see regularities of the form expressed in (V-1) as grounded in a relation of (second-order) nomic necessitation holding between the determinate quantities, note the similarity between them, and see that further regularity as grounded in a (third-order) relation of nomic necessitation holding between the former (second-order) relations. (A strategy roughly along these lines seems in fact to be suggested in Armstrong 1983, 113.) In general, the categoricalist views connect the properties participating in a law by imposing the laws on them, as it were, from above. There is no problem in principle with going up one step further and applying the same operation again. DE, on the other hand, does not impose connections from above; it finds them all on the level of the properties themselves. Connections that are not provided for on that level cannot be found elsewhere, nor can they be imposed from above without giving up the central tenet of DE.

The answers to both of my questions, then, confirm that Bird's argument for the fundamentality of (I-1) rather than (I-∀) has very damaging consequences for DE. The natural solution is to give up the multi-track view and adopt (I-∀) as fundamental instead. That, of course, means that we must reject Bird's argument. Let us see how that can be done.

Bird said that dispositional properties such as the one expressed in (I-∀), or electric charge, are 'really conjunctions of pure dispositions' (p. 22). Now, what is the status of that 'really'? Earlier, I compared the situation to the argument against the regularity view: there too the universally quantified material implication $\forall x(Fx \rightarrow Gx)$ was 'really just' an infinite conjunction, it was 'nothing over and above' its instances. But DE's solution to this problem was precisely to stipulate a property which grounded the regularity. Why should we not apply the same strategy to the conjunction that is now at issue?

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The answer lies in what I have called the third step towards DE: the characterization of what it is for a property to be dispositional. Dispositionality, we have seen, is understood as connecting a stimulus property and a manifestation property, the connection amounting to something like a counterfactual conditional (with a *ceteris paribus* clause). The 'pure' dispositions are pure simply in that they perfectly conform to that characterization.

If we look at (I-∀), however, the characterization of dispositionality fails: we cannot take it apart in the way we can take apart (I-1), factoring it into two separate properties. With (I-1), the stimulus condition is: being $5.3 \times 10^{-11} m$ from a charge of $1.6 \times 10^{-19} C$; the manifestation condition is: exerting a force of $8 \times 10^{-8} N$. In (I-∀), we have quantifiers ranging over q_i and r_i in both the stimulus and the manifestation condition. If we try to separate them and specify one in separation from the other, we lose the very correlation which (I-∀) has been formulated to capture. But not only can the properties not be separated from each other; the counterfactual conditional is not doing any work. What (I-∀) says is that everything with charge e will always exert a force that stands in a certain mathematical correlation to whatever other charges are present and their distance from it.

We can see now why Bird went for his multi-track view. It is the third step towards DE, the characterization of dispositionality, that forced it on him. If we think that a disposition has to come with separable stimulus and manifestation conditions, related in a counterfactual-like way, then the best (I-∀) can hope for is to count as a conjunction of such dispositions. If (I-∀) is to stand on its own, an entirely different conception of dispositionality will be needed: to begin with, dispositionality will look more like a one-place operator, but one that takes complex functions as its complements.

It is, of course, not an idiosyncrasy of Bird's to rely on the conception of dispositionality that he does rely on. This is the one established conception of dispositionality throughout the literature. Much of the recent debate on dispositions is taken up by objections to, and variations on, the 'conditional analysis' of dispositions – assuming that, if dispositions are to be analysed in any way, it will have to be in terms of a counterfactual conditional. Taking (I-∀) and such-like properties to stand on their own will require a radical departure from these extant views of dispositionality, and a considerable amount of work on the alternative view.

For instance, an account will be needed of how electric charge, the dispositional property characterized by (I-∀), is related to such specific sub-dispositions as (I-1) if it is to be more than just a conjunction of them. Note that, while the apparatus of determinables and determinates may enter in some way or other, it cannot be used to characterize the relation between electric charge and the many sub-dispositions. For the determinates of one determinable exclude each other: while having charge entails having some determinate charge, having any one determinate charge entails not having any other determinate charge. In the case at hand, however, having electric charge entails not merely having *some*, but indeed having *all* the many

parallel sub-dispositions.

Another question that will need to be answered is just what kind of modality it is that is involved in dispositions, if it is not that of the counterfactual conditional. Is a one-place dispositionality operator to be understood in terms of plain necessity? And how does this characterization relate to the mathematical functions in its scope, and to the essentiality or necessity operator in whose scope the disposition is characterized in (I-∀)?

If, as I have argued, the third step towards DE has to be given up, the dispositional essentialist will have to provide a novel metaphysics of dispositions. I am optimistic that such a view can be developed. In the meantime, however, the superior explanatory power of dispositional essentialism is yet to be demonstrated.[3]

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