Dispositions and Laws of Nature

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Viewed through the Humean lens, laws of nature are understood to be laws only in a metaphoric sense; the world operates *as though there were* laws governing its operation. Recently, John Roberts presents an alternative to this view which seeks to entrench a greater degree of power to the laws of nature.[1] According to his thesis, the world is genuinely *governed* by such laws. However, I contend that neither the governing view nor the lawless view is apt to do the explanatory work we desire from laws of nature. I proffer a thesis which retains those promising attributes of the lawless and governing accounts, but avoids their pitfalls by cashing out laws of nature through the dispositional nature of properties.

Lawlessness: Life is like a box of chocolates…

According to Lewis's contemporary defence of the Humean picture of the world, "all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another."[2] The mosaic (or chocolate box, if you prefer) analogy is most instructive.[3] A mosaic consists of an array of individual tiles, as our world consists of an array of events. The tiles, like events, are entirely self-contained – they are discrete entities which have their nature quite independently of the tiles around them. Though it might be suggested that the tiles jointly form a 'bigger picture', the individual tile has a nature and existence distinct from that bigger picture. Importantly, the array of tiles exhibits no necessary connections between the tiles. Though there are relations between the tiles, none hold with any necessity. There is nothing about, say, one tile's being red (an intrinsic property) that accounts for why it appears always three inches from an orange tile. On the Humean view, the regular relations between two apparently connected events A and *B* cannot be explained by any intrinsic facts about *A* or *B*.

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[1] (Roberts 2008)
[2] (Lewis, Philosophical Papers II 1986, ix)
[3] For this explication of the analogy, I am indebted to (Mumford, Laws in Nature 2004, 23-25)

The regularity account originating with Hume neatly distinguishes the metaphysical from the epistemic questions of causation and laws of nature. It was Hume's view that our apparent epistemic acquaintance with these laws (framed as connections) was not a reliable guide to their metaphysical existence. The world *appears* to be filled with recurrent patterns, and our minds inexorably suppose that these patterns obtain *with necessity*. Hume famously notes that our empirical observations provide knowledge of a cause only as "*an object followed by another, and whose appearance always conveys the thought to that other*."[4] What we desire, but lack, is "that circumstance in the cause, which gives it a connexion with its effect."[5]

A naïve version of the regularity account would take it that laws of nature are nothing more than regularities, such as 'all rubies are red'; that is, statements involving natural terms taking the universally quantified form $(\forall x)(Fx \rightarrow Gx)$. This view, however, is subject to a host of difficulties which I will not rehash in detail here. Suffice it to say that if regularity were a sufficient condition for a law of nature, then we would countenance a preponderance of illegitimate candidates for laws. It is a true regularity that all flowers in my vase are white,[6] but it is not apt to be a *law*. Specifying that laws must be universal rather than local merely relocates the problem. It is a true universal regularity that there are no spheres of gold with a mass greater than 100,000kg, but neither is this apt to be a law.[7] We wish to include real laws in our ontology, and to exclude those which are merely "historical accidents on the cosmic scale."[8] However, it is argued that there are good reasons to suppose that regularity, while not sufficient, is at least a *necessary* condition for a law of nature.

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[4] (Hume 1748, 77), emphasis in the original

[5] (Hume 1748, 77)

[6] It masquerades as a law in virtue of having a universally quantified conditional form: For all *x*, if *x* is a flower in my vase then *x* is white.

[7] These sort of examples appear in (Hempel 1966), and also exhibit the universally quantified conditional form as above.

[8] (Kneale 1950, 123)

Mill-Ramsey-Lewis

The Mill-Ramsey-Lewis theory of laws of nature develops the Humean regularity theory in which laws of nature are laws only in a deflated or metaphoric sense. Mill characterizes laws of nature as the answers to the question, what are "the fewest general propositions from which all uniformities which exist in the universe might be deductively inferred?"[9] It is clear, however, that there are indefinitely many true propositions which are candidates for laws of nature, and Lewis proffers some ways in which we might evaluate them. Since they are scientific laws, Lewis advocates the scientific method of choosing those propositions which achieve the best combination of simplicity and strength.[10] It is clear that this formulation will rule out obvious imposters, such as the silver coins in Nelson Goodman's pocket.[11] However, the simplicity-strength analysis requires careful attention, since these two 'theoretical virtues' tend to conflict. Strength is measured in the amount of true information the theory provides. In order to provide greater amounts of true information, one typically requires more axioms in the system; however, adding axioms generally makes a system less simple.

Often Ockham's razor seems to provide the clean shave we desire for our metaphysical vestiges. If, say, we have a system in which we have to choose between explaining the attraction of objects to the earth through (a) gravity or through (b) gravity and invisible spirits tugging objects downwards, then we will prefer the former theory. We prefer it because it provides the same strength (truth and precision of information) in a simpler way. While this conception seems plausible, how ought we to choose between two theories, one of which is simple but lacks strength, and the other of which is strong but lacks simplicity? Should we accept as a law that there are no golden spheres with a mass greater than 100,000kg? To do so would provide some new information, and thus some strength. Corresponding to this increase in strength would presumably be a loss in simplicity. We imagine that the loss in simplicity ought to be comparatively unsatisfactory, that we ought not to admit the golden

[9] (Mill 1904)
[10] (Lewis, Counterfactuals 1973, 73)
[11] Cf. (Goodman 1984, 18-19). Inclusion of 'all coins in my pocket are silver' as an axiom adds true information to a system, but would lead the system to suffer an untenable loss of simplicity; thus it is rejected.

sphere postulate as a law, but rules for such a calculus are far from forthcoming.[12]

Bas van Fraassen sets up the following objection to Lewis' theory.[13] Suppose there were a possible world in which all the best true theories included the statement that all and only spheres are gold. We would imagine a world, say, which consisted of some gold spheres circling in orbit, and with some iron cubes resting upon them. Van Fraassen says that if asked he would deny that these gold objects *must* be spherical; that is, he denies that they are spherical with any *necessity*, since he imagines that they might have collided, say, and changed their shape. He thinks however, that Lewis' account is committed to affirming that the gold objects are spherical, and must be by physical necessity.

It seems to me that van Fraassen here underestimates the power of the counterfactual analysis in Lewis' account. It is not sufficient for a law under Lewis' theory that the generalisation 'all and only spheres are golden' is true. It must also support the counterfactual claims that 'had the object not been golden it would not have been a sphere', and 'had the object not been a sphere it would not have been golden'. Since these counterfactuals come out false in nearby worlds which share the same physics, the law is not a candidate to appear among the 'best true theories'. The law would feature among the best true theories only if it were a true generalisation and supported the relevant counterfactuals. And if it did so, it seems sufficient to conclude, contra van Fraassen that the gold objects *are* spherical with necessity. Counterfactuals are precisely the litmus test required to tell apart real laws from accidental regularities, and countless examples demonstrate this result. The law that a uranium sphere cannot be sustained beyond a particular mass is supported by the counterfactual 'x is a uranium sphere $\Box\!\!\rightarrow$ x is smaller than 1 mile in diameter.' However, 'x is a gold sphere $\Box\!\!\rightarrow$ x is smaller than 1 mile in diameter'

[12] There are additional worries about the very possibility of a simplicity-strength calculus. One such objection concerns the language in which the laws are framed. In natural language, we can have complex predicate constructions which appear simple though conceal their complex parts (say, that the 'simple' term bachelor conceals a complex combination of predicates, like humanhood, manhood, and being unmarried). Lewis has a rejoinder, which I take to be plausible, by way of a hypothetical perfect language system consisting only of perfectly simple predications as in the predicate logic. For further explication of this issue, see (Van Fraassen 1989, 42-43).

[13] (Van Fraassen 1989, 46-47)

is false, since there are near physically possible worlds in which *x* is a gold sphere with a diameter greater than 1 miles.

This response seems apt to defuse van Fraasen's objection, and to entrench the validity of counterfactual analyses in separating laws from regularities in a way consistent with Lewis' other claims. However, I contend that for Lewis, this move is illegitimate. The problem with invoking counterfactuals to define laws as Lewis does is that the counterfactual analysis *presupposes the existence of laws of nature for its procedure*. What are the satisfaction conditions for the counterfactual '*x* is a gold sphere $\Box\!\!\rightarrow$ *x* is smaller than 1 mile in diameter'? The counterfactual is false where the antecedent is true but the consequent false in a nearby physically possible world. However, the notion of 'a physically possible world' just is a world which shares our physical laws.[14] The counterfactual account here assumes what it is required to prove.

Most troubling for Lewis' account is that regularities just don't *explain*. We want laws to provide us with understanding of the phenomena which instantiate the laws. However, on the regularity account, laws *are nothing more than their regular instantiations* and thus convey no further information. Perhaps if laws existed in a more robust sense, they would gain the explanatory power Lewis' account could not.

The Law-Governed World

And now consider a rather different picture of the world (here I take John Roberts' recent account as a token systematization of realism about laws).[15] In this picture, events in the world appear regular and reliable. Night follows day, tsunamis follow earthquakes, and so on. And these regularities are manifestations of the metaphysical laws that *govern* nature. When an eagle remains aloft it is because it obeys certain laws about pressure and gravity. Science reveals these laws to us, and does so with increasing precision. When scientific theories are amended – say, from thinking that there is nothing smaller than an atom to positing even smaller fundamental entities – it is not that laws of nature have changed or been broken. Rather, it is our *articulation*

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[14] Cf. (Handfield 2009, 11): "What makes for closeness of worlds? …the laws of nature play a very large (though not exclusive) role in determining closeness. Worlds with the same or similar laws are *ipso facto* very close."

[15] (Roberts 2008)

of these laws that has changed.[16] When science converges on these laws, we see that they do hold with necessity. The laws of nature differ from the laws of a nation in several respects: (i) laws of nature need no policing because they cannot be broken, and (ii) laws of nature are not amenable to revision. Regarding (i) and (ii), the idea is that laws of nature are *inevitably* true – and have always been inevitably true. The governing view of laws holds that *L*'s being a law of nature is what makes for *L*'s being inevitably true.[17]

That *L's lawhood* is the truthmaker (indeed the inevitable-truthmaker, since it makes *L inevitably* true) for *L* is seen through the counterfactual account in the following way: '*L* is a law of nature $\Box\!\!\rightarrow L$ is inevitably true.' The inevitability of *L*'s truth *depends on L*'s lawhood. There are several ways of formulating the inevitable-trueness of law *L*, but one which seems plausible is $(\forall x)(x \rightarrow L)$.[18] The denial of this is $(\exists x)\neg(x \rightarrow L)$, which leads us swiftly to $\neg L$; that is, there is some proposition the truth of which renders *L* false. Thus the whole subjunctive conditional is rendered as 'if *L* were not a law of nature then there are circumstances p such that *L* is false.'

This seems at first blush like precisely the right sort of result. If *L's* being a law makes for its inevitability, then we should expect that had *L* not been a law, it would not be inevitable – there would be circumstances in which *L* is false. Consider, 'if it were not a law that all bodies with mass attract one another, then all bodies with mass would attract one another.' This is clearly not true, since if gravitation were not a law, we could conceive of (physically possible) circumstances in which, say, planets did not regularly stay in orbit. It is precisely because it is a law that it is inevitably true.

However, an explanatory worry again swiftly arises. On this view, can laws really *explain* their phenomena, specifically their inevitability? The

[16] Cf. (Bird, Philosophy of Science 1998, 17): "A statement of a law is a linguistic item and so need not exist, even though the corresponding law exists." Sometimes the distinction is evinced terms of laws of science and laws of nature, where laws of science are scientists' current approximations of laws of nature. Cf. (Weinert 1995)

[17] Cf. (Roberts 2008, 176)

[18] That is, for any x, *L* is true. This formulation appears in Roberts, though appears to me to be technically incorrect (though perhaps more revealing). In the predicate calculus, we do not permit unbounded atomic variables like 'x' in the antecedent – they must bind to a predicate letter, as in '*Fx*'. I suspect a more accurate translation would be, simply, (∀x)*L* .

counterfactual conditionals above appear to relate by way of logical entailment – that is, *L*'s being a law of nature confers inevitability onto *L* by *logical necessity*. In fact, analysis reveals that the entailment holds because of a logical equivalence between the two, and thus the formulation conveys no further information. Since nothing can explain itself, the link between laws and inevitability does no explanatory work, and the governing account is found wanting.

Dispositions: Stupid is as stupid does...

Three points are clear from the preceding discussion: (1) laws of nature appear to play an *explanatory role*, and we desire a thesis which captures that role, (2) *counterfactuals*, correctly applied, appear promising as means by which to discover laws, and (3) a satisfactory thesis of laws of nature must explain the sense in which laws have *modal force*. I wish now to present and defend a thesis which does justice to these three intuitions – dispositional essentialism.

If object *X* has disposition *D*, then *X* would manifest the response if exposed to the stimulus. For example, if a glass has a fragile disposition, then the glass would break if dropped. Immediately clear here is the role of the counterfactual and the tie to causation. Dispositions are cast in terms of their 'aptness' to cause certain effects in the right circumstances. A match is apt to ignite if struck, and this is the corresponding truthmaking fact for the counterfactual 'the match is struck $\Box\!\!\rightarrow$ the match ignites.'

However, my examples above allow significant room for debate within the theory. What is the truthmaker for the dispositional property? Or, more concretely, in virtue of what is the glass fragile or the match flammable? The distinction here lies between categorical and dispositional properties. Categorical properties are non-dispositional properties intrinsic to an object, and which don't depend on counterfactuals for their explication. The glass's having a mass of 350g is a categorical property, while fragility is clearly dispositional. Those who advance a categoricalist version of dispositionalism assert that an object has a disposition in virtue of possessing a categorical property which realises that disposition. So, for a glass to be fragile is for it to have a corresponding true counterfactual (as above), and for the dispositional property to depend on one or more of the glass's categorical properties (say, having a density of $2kg/m^3$).

The ontological parsimony of this view is clear. We need only posit the existence of categorical properties since they are sufficient for the existence of those dispositional properties which supervene upon them. Furthermore, I contend that binding dispositions to intrinsic categorical states provides the appropriate way to make sense of laws of nature. If dispositions supervene on categorical properties, then categorical properties are apt to be the truthmakers for corresponding counterfactual conditionals involving dispositions. Furthermore, following Kripke, once we have discovered the essential properties of an object, we find that the object has those properties with necessity.[19] Thus if gold has atomic number 79, then *necessarily* gold has atomic number 79. Since having atomic number 79 is sufficient to have some dispositional property (e.g. being soluble in potassium), and gold has this property necessarily, and, since potassium has similarly necessary properties, we have a model for the emergence of laws of nature.

Laws of nature, on my view, obtain in virtue of relations between essential properties and their corresponding supervenient dispositions. In this way, we see how it is that laws have modal force: they hold with necessity (though are known *a posteriori*) because they capture relations between modally powerful *essential* properties. In addition, this view makes sense of *why and how laws explain*. The orbiting of the earth around the sun is explained by the law of universal gravitation because the law is constructed out of necessary relations between essential properties (here, e.g., the masses of the earth and the sun).

It has occurred to some theorists to deny the categorical-dispositional distinction, since the glass's mass seems apt to be captured correctly by counterfactuals too – say, 'x has a mass of 350g $\square\!\!\rightarrow$ x deflects the meter on a fair scale to the 350g mark.'[20] I take this to be a highly unnatural evasion of the distinction. It might be true that categorical properties *can support* counterfactual analyses. However, categorical properties *do not depend* on

[19] (Kripke 1972, 123-124)

[20] Cf. (Goodman 1984, 41): "...more predicates than we sometimes suppose are dispositional. A tell-tale suffix like "ible" or "able" is not always present. To say that a thing is hard, quite as much as to say that it is flexible, is to make a statement about potentiality. If a flexible object is one capable of bending under appropriate pressure, a hard object is one capable of resisting abrasion by most other objects."

counterfactuals for their explication, while dispositions *must* be explained in terms of counterfactuals.

In closing, I wish briefly to consider a response from Mumford to the categorical thesis. Mumford presents a deductively valid argument of the following form:

(1). There are subatomic particles that are simple.
(2). That which is simple has no lower-level components or properties.
(3). The properties of subatomic particles are (all) dispositional.
(4). The grounds of a dispositional property can be found only among the lower-level components or properties of that of which it is a property.
(5). The dispositional properties of subatomic particles have no ground (there exist some ungrounded dispositions).[21]

It is my view that this argument is mistaken, and that the error lies in premise (3). That a subatomic particle is simple does not entail that all of its properties are dispositional. Why ought we to believe that such a particle is *merely* dispositional? It strikes me that in order to predicate a disposition of the particle, there must be some entity of which we make the predication; that is, there must be *some entity* which possesses the disposition, and that this entity is a candidate for grounding the disposition. Furthermore, the categorical option is available to someone who would wish to allow that there is nothing to the particle over and above its dispositions – he could opt for a reductive identification of the dispositional properties with the (categorically-defined) substratum that possesses them. If simple particle *x* has disposition *D*, then *x* has the categorical property *K* ('possesses disposition *D*'), and *D* and *K* are identical with each other.

There are two conclusions here. Firstly, it appears that the categorical view is compatible with the existence of simple particles, since in those instances the categorical property and the dispositional property are reductively identified. Secondly, Mumford's view, even if it succeeded, would not constitute a significant dent in the categoricalist armour.[22] It is unthreatening, since it

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[21] (Mumford, Filled In Space 2007, 68)

[22] Mumford's argument is similar to others opposed to the 'categorical realism' I argue for here, insofar as they argue that *some* dispositions are not reducible to their categorical bases. Even if such arguments were correct, they would succeed only in undermining a very small class of reductions, since most dispositions appear naturally to be determined

would not undermine the claim that any objects *other than simple particles* have their dispositions in virtue of other categorical properties. Dispositions must make reference to stimulus and response conditions, while categorical properties (like mass) accrue to the object quite intrinsically. There are legitimate concerns about theories which posit 'free-floating' dispositions. Tethering them to categorical properties as I propose ensures that the counterfactual component of dispositions are appropriately grounded in physical matters of fact.

I have not canvassed all the reasons why one might endorse (or deride) the dispositionalist account proposed here. However, it is clear that it is a promising account which goes a long way in meeting our requirements of laws of nature (counterfactuals, modal force and explanatory power). The categoricalism I advance appears successfully to avoid excessive ontological commitments, yet retains the talk of dispositions – grounded in modally forceful categorical properties – from which laws arise.

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(through supervenience) by their categorical realisers, and most categorical properties are construed as dispositional only in the most gerrymandered sense.

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