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Laws and Natural Properties

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According to David Lewis not all properties are equal. Lewis posits that there is an elite class of properties—the perfectly natural properties—that play crucial roles in metaphysics and science. They are the properties that are said to "cut nature at its joints." He also defends an account of scientific laws called "Best Systems Account" (BSA). Lewis's version of the BSA says that laws are certain regularities entailed by the best systematization of the totality of instantiations of perfectly natural properties and relations.[1] I am very much attracted to the BSA because of the way it incorporates the criteria physicists use for counting generalizations and equations as expressing laws and also because it, unlike many of its rivals, doesn't posit metaphysically primitive laws, primitive causal powers, propensities, governing relations, or other metaphysically heavy-duty and suspect entities. However, I will argue that Lewis's notion of *naturalness* and, more specifically, the way natural properties figure in Lewis's version of the BSA are problematic and undercut the appeal of the BSA. Further, Lewis calls on natural properties to perform work on all manner of problems in metaphysics that don't have obvious connections with the role he asks them to play in the BSA. After making a case against Lewis's version of the BSA I will propose an alternative that doesn't depend on Lewis's account of natural properties or on taking *naturalness* as primitive. The significant difference between my account and Lewis's is that where he invokes *naturalness* as a metaphysical primitive and analyzes "scientific law" partly in terms of it, my account involves a "package deal" that characterizes laws and scientifically significant properties together in

terms of their roles in fundamental physics. I let physics rather than metaphysics tell us what the scientifically significant properties are and what they are like. I call my account the "Package Deal Account": the PDA. The first two sections of this paper spell out Lewis's account of natural properties and the BSA. The third contains my criticisms and suggested alternative.

I. NATURAL PROPERTIES

Lewis is known for his view that reality includes not just the actual world but a very large infinitude of possible worlds that are like the actual world in being concrete totalities.[2] Each world is constituted by a space-time manifold and by concrete entities of various kinds with various properties and relations distributed throughout the space-time manifold. Lewis doesn't say much about possible space-times, but he seems to think of them as manifolds with topological and geometrical structure (e.g., Newtonian absolute space and time, Galilean space-time, Minkowski space-time, GR curved space-times). Perhaps some space-times have more or less than four dimensions, perhaps some have the structure of a configuration space, and perhaps some involve nothing that counts as a time dimension—perhaps not even spatial dimensions as we understand them. A space-time provides the stage on (i.e., the locations) which the events of a world play out. Lewis doesn't say much about the possible fundamental concrete entities that can occupy a space-time. Putative examples are the points and regions of space themselves, classical point particles, Bohmian point particles, one-dimensional strings, two-dimensional branes, electromagnetic fields, gunk, and wave function fields.

Lewis thinks that his account of possible worlds as concrete and the various doctrines that go along with it (the indexical account of actuality and counterpart theory) are to be preferred as the best explanation and systematization of truths concerning metaphysical necessity and possibility and matters connected with these notions. Like many other philosophers I don't buy the view that possible worlds are concrete totalities.[3] However, this difference of view about possible worlds and modality makes no difference to the ensuing discussion in this paper since neither his account of natural properties nor his account of laws nor the account of laws that I will defend depend on his particular account of possible worlds.

Lewis identifies monadic properties with classes of possible entities. Every class of possible entities is a property.[4] Properties are the semantic values of one-place predicates. So, for example, the semantic value of "is a tiger" is the property of being a tiger and that is a class that includes all the tigers that inhabit (did, do, and will inhabit) the actual world and all other possible worlds. Some classes will correspond to relatively simple predicates of fundamental physics (e.g., "has negative charge"), some to very complex gerrymandered predicates (e.g., "is green or made of plastic or beloved by the first president"), some to many distinct predicates of

our language and some will correspond to no predicate at all of our or any other human language. But so far all properties are, metaphysically speaking, on a par.

In "New Work for a Theory of Universals" Lewis announced that David Armstrong persuaded him that not all properties are equal. Reality also includes a distinction between perfectly natural properties/relations and the rest. He says,

> Formerly I had been persuaded by Goodman and others that all properties were equal: it was hopeless to try to distinguish "natural" properties from gruesomely gerrymandered, disjunctive properties. Eventually I was persuaded, largely by D. M. Armstrong, that the distinction I had rejected was so commonsensical and so serviceable—indeed, was so often indispensable—that it was foolish to try to get on without it.

While properties in general are abundant the perfectly natural properties are sparse and special. They constitute an *elite* minority. Lewis says that the distinction between the perfectly natural properties and the others is either itself primitive or that it may be explained in terms of primitive notions of *universals* or *similarity.*[5] His reasons for positing perfect naturalness are, as he says, that it is commonsensical, serviceable, and explanatorily indispensable. His reason for taking it or distinctions in terms of which it can be defined as primitive is that he cannot see how to analyze it in terms of the ontology of concrete possible worlds alone. Lewis writes:

> Many philosophers are skeptical about the distinction between natural and gruesome properties. They think it illegitimate, unless it can somehow be drawn in terms that do not presuppose it. It is impossible to do that, I think, because we presuppose it constantly. Shall we say that natural properties are the ones that figure in laws of nature?—Not if we are going to use naturalness of properties when we draw the line between laws of nature and accidental regularities. Shall we say that they are the ones that figure in the content of thought?—Not if we are going to say that avoidance of gratuitous gruesomeness is part of what constitutes the correctness of an ascription of content. Shall we say that they are the ones whose instances are united by resemblance?—Not if we are going to say that resemblance is the sharing of natural properties. Unless we are prepared to forgo some of the uses of the distinction between natural and unnatural properties, we shall have no easy way to define it without circularity. That is no reason to reject the distinction. Rather, that is a reason to accept it—as primitive, if need be. (Lewis 1983, 344)

Lewis says that it is the job of physics to find fundamental laws and because fundamental laws link perfectly natural properties physics is our best guide to the latter. On the assumption that physics has been doing its job well he gives as examples of good candidates for natural properties *charge, mass,* and *spin.*

Lewis employs *naturalness* in analyses and explanations of central notions in metaphysics, the philosophy of science, philosophy of mind, and philosophy of language. Among these are analyses of exact duplicate, the intrinsic/extrinsic distinction, the qualitative/nonqualitative distinction, the formulation of certain supervenience theses (in particular, in the formulation of physicalism), the BSA,

and accounts of counterfactuals, causation, projectible property, and reference. Perfectly natural properties also play a central role in his account of metaphysical modality via a recombination principle that says, roughly, that possible worlds can be cut up into regions whose entities exemplify perfectly natural properties and relations and that these regions can be duplicated and recombined to form other possible worlds.[6]

Although Lewis takes *naturalness* to be metaphysically primitive he says a lot about it and about the work he intends for perfectly natural properties that helps to identify it and them. Here is some of what he says:

1. Each world is associated with a class of fundamental natural properties/relations that are instantiated (or *can* be instantiated) at that world.[7]
2. *Naturalness* is a matter of metaphysical necessity; a property that is natural with respect to one world is natural with respect to all worlds although may be associated (instantiated or possibly instantiated) only at some.
3. The natural properties associated with a world are fundamental in that they form a supervenience base for all other properties instantiated at that world. It follows that if W and U are worlds that are associated with the same class of natural properties and agree on their space-time manifolds and on the distribution of natural properties in that manifold then they agree on all positive propositions.
4. Entities that satisfy the same natural properties/relation (and whose parts *are* similarly arranged and satisfy the same natural properties) are qualitatively perfectly similar (duplicates) to each other.
5. Natural properties are intrinsic to the individual or region of space at which they are instantiated.[8]
6. There are no necessary connections between natural properties instantiated in wholly distinct regions.
7. Natural properties are categorical. In other words, natural properties are individuated independently of laws, causal relations, chances and other nomic features.[9]
8. Although natural properties are not individuated nomologically they figure in laws.
9. It is the job of the sciences—especially fundamental physics—to find the laws and natural properties associated with the actual world.
10. The natural properties (depending on degree of naturalness) serve as a kind of "reference magnet" for our concepts and predicates. Given two assignments of references to a person's predicates that equally well meet constraints of charity, rationality, and so on the one that assigns the natural (or more natural) properties as semantic values is the correct one.[10]
11. The natural properties instantiated in the actual world meet a condition Lewis calls "Humean Supervenience."

Performing all the metaphysical jobs asked of natural properties is a very heavy load for one distinction to carry. I am skeptical that there is any single kind of property that can do all the work that Lewis assigns to natural properties, and I am also skeptical that all this work can or needs to be done at all.[11] Here I will focus mainly on the role of natural properties in Lewis's account of laws. The gist of my argument is that Lewis's metaphysical notion of natural property is not needed by the

BSA and, in fact, undermines what seems to me to be the most attractive feature of the BSA. Before getting to a discussion of laws I want to briefly discuss Lewis's views about the kinds of natural properties that are instantiated at the actual world (i.e., condition 11 above).

Lewis's account of natural properties is *Humean* in that it stipulates that there are no primitive necessary connections among perfectly natural properties instantiated in different regions of space-time. This yields a kind of "cut and paste" identification of possible worlds since different regions and their natural properties may be recombined (depending on the space-time structure) to produce possible worlds. Lewis has also advocated a more specific Humean doctrine about the natural properties associated with the actual world that he calls "Humean Supervenience" (HS). HS makes two claims (1) the perfectly natural properties associated with the actual world (and worlds similar to it) are instantiated by points of space-time or by point-size entities; e.g., point particles or field values at points. (2) The only perfectly natural relations are topological and geometrical.[12]

HS is a contingent claim. It may seem at first to be a correct account of the fundamental properties and quantities posited by classical mechanics and classical electrodynamics and insofar as these were thought to provide a complete theory of the world there may have been reason to believe it. But HS is almost certainly false. By 1986 Lewis was aware that there are tensions between HS and the ontologies of certain theories that physicists have been taking as serious candidates for fundamental theories since the early twentieth century.[13] The conflict is especially clear in the case of quantum mechanics. The heart of the conflict involves what Schrödinger called "quantum entanglement." It is this feature of QM that is responsible for QM violations of Bell's inequalities. The quantum state or wave function of a pair (or any number) or elementary particles located in distinct regions may fail to supervene on (be determined by) any physical state that quantum mechanics assigns to the individual particles referring to the region in which the particle is located. The simplest example is the singlet state of a pair of particles one in region R and the other in region L.

$$1/\sqrt{2}|x\text{–up}>_R|x\text{–down}>_L - 1/\sqrt{2}|x\text{–down}>_R|x\text{–up}>_L$$

The outcomes of measurements of the same component of spin for the two particles are anti-correlated but there is no determinate spin for either electron.[14] A measurement of any component of spin will result in a value for that component. In other words, the state of the pair of the electrons is not determined by the states of the electrons separately.[15] In 1986 Lewis said:

> I am not ready to take lessons in ontology from quantum physics as it now is. First I must see how it looks when it is purified of doublethinking deviant logic; and—most of all—when it is purified of supernatural tales about the power of the observant mind to make things jump. If, after all that, it still teaches nonlocality, I shall submit willingly to the best of authority. (1986b, xi)

Given the state of the philosophical interpretation of QM (both in physics and philosophy) in 1986 this attitude may not have been unreasonable. But the situation is now quite different. There are a number of realist interpretations of quantum mechanics purged of observer-induced collapses that are taken seriously in the foundations of quantum theory.[16] These accounts (and specific versions of them) involve different ways of understanding the quantum state. I won't go into details here except to say that all are incompatible with HS; at least as long as the space-time is three plus one.[17]

HS is dead; at least as far as the actual world is concerned. However, the failure of HS doesn't mean the failure of Lewis's account natural properties or the failure of the BSA since neither presupposes the truth of HS.

II. THE BEST SYSTEM ACCOUNT OF LAWS AND CHANCES

Lewis's versions of the Best System accounts of laws and chances are also Humean. He describes the BSA this way:

> Take all deductive systems whose theorems are true. Some are simpler, better systematized than others. Some are stronger, more informative than others. These virtues compete: An uninformative system can be very simple; an unsystematized compendium of miscellaneous information can be very informative. The best system is the one that strikes as good a balance as truth will allow between simplicity and strength. How good a balance that is will depend on how kind nature is. A regularity is a law iff it is a theorem of the best system. (1994, 478)

Chances enter the picture by letting deductive systems include sentences that specify the chances of events.

> Consider deductive systems that pertain not only to what happens in history, but also to what the chances are of various outcomes in various situations—for instance the decay probabilities for atoms of various isotopes. Require these systems to be true in what they say about history. . . . Require also that these systems aren't in the business of guessing the outcomes of what, by their own lights, are chance events; they never say that A without also saying that A never had any chance of not coming about. (1994, 480)

As Lewis says axiom systems are more or less strong (informative), more or less fit the facts, and are more or less simple. Fit is a kind of informativeness appropriate for probabilistic claims. A probabilistic theory informs about the facts by specifying probabilities so that, e.g., the claim that coin tosses are independent with constant chance of .8 for heads fits the sequence hhthhhhhthtthhhhhhthh better than the hypothesis that says that the chance of heads on each toss is .5.[18] Strength and/or fit can often be improved at the cost of simplicity and vice versa. By assigning probabilities to types of events a system sacrifices strength but may also make

great gains in simplicity. For example, only a very complicated deterministic proposition truly describes the previously exhibited sequence of hs and ts. But the sequence is simply and informatively described by a chance theory. The best system is the one that gets the best balance of the three while not both implying both q and that the chance that q is less than 1. Lewis identifies the laws with generalizations and equations entailed by the best system for that world.[19]

Each of the notions involved in the BSA, "simple," "informativeness," "fit," and "best," require more elucidation than Lewis (or anyone else) has given them. I won't say much more about them here except to suggest a way to think about the criteria for a Best Theory that makes me optimistic that they can be nailed down. At least since the seventeenth-century physicists have attempted to find a scientific system of the world that is true, fundamental, simple, informative, and comprehensive. Just what these features are—i.e., exactly what simplicity, informativeness, comprehensiveness, and so on are—is determined by the practice of this tradition of fundamental physics. This doesn't mean that these notions are not objective but rather that their contents are partly determined by the aims and practice of physics. No doubt the practice of physics leaves leeway concerning how to evaluate these criteria and how they apply. But it is not implausible that our world is so rich and complicated that all reasonable ways of precisifying these notions will result in Best Theories of our world that agree on the laws.[20] If they don't agree then an advocate of the BSA would have to accept that what the laws are is to an extent, indeterminate.

In order not to beg questions about the best account of laws and chances I will call the propositions that the BSA identifies as laws "L-laws" and the chances specified by L-laws "L-chances." Of course Lewis thinks that the L-laws and L-chances are the laws and chances.

How is Lewis's BSA related to his account of natural properties? Lewis says that if there are no constraints on the language in which potential best systems can be formulated then the BSA collapses into triviality. His argument is this. Consider the predicate "Fx" that is true of all and only the individuals that exist at the actual world (recall that for Lewis individuals exist at just one world). Lewis observes that the theory axiomatized by the single sentence "(x)Fx" is true, simple, and maximally informative. It is maximally informative since it excludes all possible worlds except the actual world and so necessitates every truth; i.e., in any world at which (x)Fx holds all and only the actual truths hold. This is a disaster for the BSA since it entails that every true generalization is an L-law. The distinction between accidental and lawful generalizations collapses. Lewis takes this to show that the BSA requires a preferred language or languages in which candidate systems are formulated and evaluated. He proposes that this language is one whose simple predicates/function terms refer only to perfectly natural properties. Since "Fx" does not refer to a natural property, the proposed counterexample to the BSA fails. Lewis concludes that the distinction between natural and other properties is essential to formulating the BSA.

How is the BSA related to HS? The claim that the BSA specifies the laws is, if true, a necessary truth. On the other hand, HS is contingent. The requirement on languages eligible to formulate systems competing for the title "Best System" doesn't require that the only relation terms are geometric or that the space is three dimensional. It doesn't require that natural properties are instantiated at points or that fundamental entities are point size. It allows that fundamental entities include strings and branes and that among the fundamental relations are quantum entanglement relations. So the death of HS doesn't undermine the BSA. Although the BSA doesn't presuppose HS it is still Humean since it identifies laws with propositions that express regularities and claims that nomological truths supervene on the history of the world's physical states.

Lewis's Humean account of laws is a vast improvement over previous Humean (so-called regularity accounts; e.g., Reichenbach's and Goodman's). Here is a list of its virtues:

1. It is a necessary truth that if it is an L-law that p then p.
2. There is a principled distinction between L-lawful and accidental regularities.
3. There may be vacuous L-laws.
4. "It is an L-law that" creates intensional contexts. So it may be an L-law that Fs are followed by Gs and F and F* are co-extensional while it is not an L-law that F*s are followed by Gs.
5. The account is not restricted to the simple and unrealistic philosophical illustrations of laws e.g. Fs are followed by Gs but can count Hamilton's equations, Maxwell's equations, Schrödinger's equation and so on as laws.
6. L-laws are laws of fundamental physics since they are formulated in the language of fundamental natural properties. But the worlds Best System may entail special science laws in virtue of the relations between fundamental physical and special science properties.
7. On the usual accounts of counterfactuals and explanation L-laws support counterfactuals and explain their instances.
8. There is an internal connection between L-laws and the criteria (e.g., simplicity) physicists employ in formulating fundamental theories.
9. Since laws supervene on the distribution of properties they are not ontologically mysterious and no mysterious notion of *governing* is involved.
10. Similarly L-chances also supervene on the distribution of natural property instantiations thus avoiding mysterious propensities or degrees of propensities.
11. The account extends smoothly to provide Humean accounts of objective probabilities when the dynamics is deterministic.[21]
12. The L-account of objective probabilities provides a *rationale* for connections between objective probabilities (and beliefs about objective probabilities) and subjective degrees of belief; e.g., Lewis's PP.[22]

Despite all of these attractive features there are philosophers who say that L-laws (and L-chances) are not genuine laws (chances). They think that Humean regularities, no matter how special, are too weak to perform the jobs that laws perform. Among the objections are that L-laws are too weak to ground explanations, support counterfactuals, ground inductive reasoning, be confirmed by their instances, and so on. At the core of many of these objections is that since L-laws supervene on the history of the states of the universe L-laws cannot *explain* the evolution of states. Here is an especially clear and forceful formulation of this point by Tim Maudlin:

> If one is a Humean, then the Humean Mosaic itself appears to admit of no further explanation. Since it is the ontological bedrock in terms of which all other existent things are to be explicated, none of these further things can really *account for* the structure of the Mosaic itself. This complaint has been long voiced, commonly as an objection to any Humean account of laws. If the laws are nothing but generic features of the Humean Mosaic, then there is a sense in which one cannot appeal to those very laws to *explain* the particular features of the Mosaic itself: the laws are what they are in virtue of the Mosaic rather than vice versa. (2007, 172)

In my view this objection rests on a confusion of metaphysical and scientific explanation. Maudlin is correct that on a Humean account the total history of states ("the Humean mosaic") *metaphysically* explains the L-laws; i.e., explains which propositions are L-laws. But this doesn't mean that L-laws together with the state at t fail to *scientifically* explain the evolution of states or that L-laws cannot ground counterfactual and causal relations that underlie scientific explanations. For example, assuming the truth of classical mechanics, the Newtonian gravitational and dynamical laws together with the state of the solar system at time t *scientifically explains* the positions of the planets at a subsequent time t'. The explanatory relation in this case is simply entailment of a proposition specifying the positions of the planets at t' by the Newtonian laws and a proposition specifying the state at t. Nothing in this explanation excludes the classical mechanical laws being understood as L-laws. Similarly, accounts of counterfactuals that characterize counterfactuals in terms of laws don't depend on any particular metaphysical account of laws.[23]

A proponent of Maudlin's objection might respond that the proposed explanation involving L-laws isn't a genuine explanation or that L-laws can't support genuine counterfactuals because the L-laws are not genuine laws. But it is clear that this response is an instance of ***petitio principii.*** My view is that the other objections to L-laws are equally question begging. However, since my main aim in this paper is to pose a problem with Lewis's account of laws and natural properties and propose an alternative account, this is not the place to adjudicate the issue of whether the laws of our world are best understood as L-laws or as some more metaphysically robust way.[24]

III. A PROBLEM WITH LEWIS'S VERSION OF THE BSA

Bas van Frassen raises a problem for Lewis's account concerning its dependence on the language of natural properties.[25] He points out that improving a theory by making it more simple and informative may actually take it further away from the Best theory if the improvement involves reformulating in a language whose basic predicates fail to correspond to perfectly natural properties. This suggests that a theory thought to be best by scientists might not be best according to Lewis's account since its simple predicates may fail to refer to perfectly natural properties. Here is my version of the problem. Suppose that FT is what Steven Weinberg calls "a final theory." FT maximally satisfies all the requirements that the tradition and practice of fundamental physics puts on a fundamental theory of the world. FT is true, simple, highly informative, comprehensive; FT reconciles relativity and quantum theory, explains statistical mechanical probabilities, and explains special science regularities, and so on. It does all this better than any alternative theory whether the alternative has ever been or ever will be thought up by anyone. There is no true theory that better than FT balances all these virtues. Even so it may turn out that some contingent generalizations/equations entailed by FT are not L-laws. Further, there may be L-laws that FT fails to entail. The reason that this can occur is that FT may not formulated in NL, the language whose simple predicates/functions symbols correspond to perfectly natural properties/quantities but in a different language FL. There is no guarantee, as far as I can see, that FT will be formulated in LT or that when it is translated into NL it will be the Lewisian best theory in that language. It seems possible that when FT is translated into NL it is beaten out in the contest for best theory by LT. But that when LT is translated in FL it is FT that wins the competition. Further when comparing FT in FL with LT in NL it is FT that is simpler, more informative, and so on. So the pair <FT, FL> better satisfies the conditions for a final theory than does <LT, NL>. Here are two versions of the BSA. Lewis's version on which the laws are specified by the (or "a"" if there is more than one) best theory when formulated in NL and a version on which the laws are specified by the (or "a"" if there is more than one) final theory. If these can differ, and I see no reason why they cannot, then which one is the "law giver"? If Lewis is correct then it is LT and not FT which identifies the law. But this raises an epistemological and a metaphysical problem. The epistemological problem is that on Lewis's account even knowing all the non-nomological contingent truths in every possible language isn't sufficient for knowing which truths are the laws. One would also have to know which predicates refer to Lewisian natural properties. The metaphysical problem is the problem of justifying why the aims of science should be coupled to the aims of Lewisian metaphysics, or why the properties that Lewis harnesses for metaphysical duty should play a role in identifying the scientific laws. Since these issues were suggested by van Frasen's intriguing discussion I will call them "Van Frassen's problems."

Three responses to Van Frassen's Problems:

First Response: Defend Lewis's version of the BSA:

Defend Lewis's account by granting that FT may misidentify the genuine laws even though it optimally satisfies all the scientific conditions on an FT just because it is optimal only when formulated in FL and not in NL. This leads to a kind of skepticism since if FT is not identical to LT then we will never know the L-laws even if physicists find the final theory. But realists (like Lewis) already accept that there may be logically incompatible theories that are empirically adequate and meet all the other criteria for a best theory except truth. To insist that FT is the law giver is just to give into verification and everyone knows verification is bad.

Second Response: Denial:

Deny that a mismatch between LT and FT is possible. In other words, argue that the simple predicates of theory that optimally satisfies all the criteria for a final theory (which includes truth) *must* refer to perfectly natural properties. Here is an argument that has occurred to me which points in this direction. Recall that according to Lewis the natural properties serve as "reference magnets." This means that given various "eligible" interpretations for a predicate the interpretation that assigns the most natural of these is the reference of the predicate.[26] Lewis characterizes "eligibility" in terms of interpretations of a person's beliefs and desires, etc.; in terms of the roles that the predicates (or their mental correlates) play in that person's psychology. The idea is that a specification of these roles will leave open many possible interpretations of the person's language and that correct ones maximize the naturalness of the properties assigned to predicates. It is not clear how this account of reference can be applied to a proposed final theory (which no one believes), but perhaps this idea can be massaged into an argument that FT (and every equally optimal final theory) will be optimal when formulated in NL. If this were correct then we would have a very neat solution to Van Frassen's problem since it would entail that LT and FT cannot differ from each other. But I don't find this response plausible. First, it depends on a very controversial account of reference. But more important there is a gap between the claim that the predicates of FT refer to the most natural eligible properties and that they refer to perfectly natural properties. Further, there is some reason to suspect that there will be a mismatch between FT and LT since it may turn out FT requires that its simple predicates refer to properties/quantities that fail to satisfy some of the conditions on natural properties; for example, they may refer to properties/quantities that are not intrinsic to the regions in which they are instantiated or which do not occur in laws in other possible worlds. It appears to be just an article of faith that FT and LT will coincide.

Third Response: Reformulation, the PDA:

Claim that FT is the law-giving theory and reformulate the BSA to say that the laws of our world are certain generalizations and equations entailed by an FT for our world. This response doesn't deny that there are perfectly natural properties in Lewis's sense. But it does claim that even if there are Lewisian natural properties in that sense they do not play the constitutive role that Lewis claims for them

in characterizing the BSA of laws. Here is a way of thinking about the BSA in which Lewisian natural properties play no role. Consider the world w all pairs <L,T> of possible languages L and candidates for best systems of w T such that

i) T is formulated in L
ii) T is true of w
iii) T is a final theory for w (i.e., T is true and best satisfies the criteria of simplicity, informativeness, comprehensiveness, *and whatever other conditions the scientific tradition places on a final theory for w.*

From all such pairs <L,T> select the one (ones) <FL,FT> that includes the best theory. <FL,FT> is the "best of the best" and determines the laws of w.

This is "the package deal account" (PDA) of laws since it identifies the laws and the nomological properties together. The PDA is not constrained by the requirement that its primitive predicates refer to Lewisian natural properties. FL may contain fundamental relational predicates other than geometrical ones, predicates referring to, nonintrinsic properties, terms referring to vector magnitudes, predicates instantiated only by larger than point-size entities, and so on. There are no restrictions on FL that come from outside of science as there are on Lewis's account. Let's call the primitive vocabulary of FL refers to properties that are "nomologically natural" relative to FL.

I propose that the PDA is the right response to Van Frassen's problems and as a better version of the BSA. On a Humean account propositions count as laws in virtue of their connection to the best scientific summary of the world. If the best scientific summary of the world is best when formulated in FL and is better than any system formulated in NL then it should be the law giver.

I will conclude by discussing three objections to the PDA.

1. The PDA claims to do without Lewisian perfectly natural properties, but aren't they needed to properly formulate the BSA? The first work that Lewis put natural properties to do was to pick out a language NL relative to which the Best Theory is evaluated with respect to simplicity. Recall that he motivated the introduction of natural properties into his characterization of laws because the system axiomatized by "(x)Fx" (where "Fx" is a predicate true of all and only individuals that exist at the actual world) apparently maximizes simplicity and informativeness and so counts as the best system of the world. The consequence is that all true generalizations are laws. Lewis's remedy is to add the requirement that the atomic predicates in the language of a Best Theory refer to perfectly natural properties—where these are properties that do all the metaphysical work Lewis assigns them.

Lewis's argument shows that simplicity, informativeness (and other virtues of a Best Theory) must be evaluated relative to some language, but it doesn't show that the language relative to which BSA is characterized must be NL. From the perspective of the aims of science the obvious trouble with "(x)Fx" is not that "Fx" doesn't refer to a perfectly natural property but that "(x)Fx" is not a credible scientific theory. It is completely lacking in explanatory value. While it might be maximally

informative given Lewis's characterization of information as excluding alternatives this merely shows that Lewis's proposal for evaluating informativeness is not relevant to the way scientists evaluate informativeness. The information in a theory needs to be extractable in a way that connects with the problems and matters that are of scientific interest. So we need not claim that "Fx" doesn't refer to a natural property in order to have reasons to dismiss "(x)Fx."

Lewis's argument does show that the PDA version of the BSA requires a preferred language. Here is a proposal. Let SL be a present language of science, say scientific English (English supplemented by the languages of mathematics, fundamental physics, and the various special sciences). A candidate for a final theory is evaluated with respect to, among the other virtues, the extent to which it is informative and explanatory about truths of scientific interest as formulated in SL or any language SL+ that may succeed SL in the rational development of the sciences. By "rational development" I mean developments that are considered within the scientific community to increase the simplicity, coherence, informativeness, explanatoriness, and other scientific virtues of a theory. An optimal final theory FT is a theory that best satisfies the virtues of a final theory relative to a successor of SL so that no development of that language and FT leads to an increase in the satisfaction of the scientific virtues. This proposal is admittedly vague and in need of development, but it is clear that excludes Lewis's "(x)Fx" and other trivializing proposals.

2. The PDA characterization of laws is too subjective and anthropomorphic. The same objection is often lodged against Lewis's version of the BSA and since my aim in this paper is to deal with a problem I find in Lewis's account and not adjudicate the dispute between the BSA and accounts like Maudlin's that posit primitive laws or law-making facts that don't supervene on the totality of states I won't address this objection at length. However, it should be recognized that both Lewis's version of the BSA and the PDA say that laws are truths that are mind-independent. On both accounts part of what makes a truth a law is to an extent anthropomorphic since it involves human criteria of simplicity and informativeness and, in the case of the PDA, explanatoriness and "scientific interest." But these may well be relatively objective notions.[27] The PDA goes farther in the direction of anthropomorphism—or one might say "physicist-morphism"—in that what counts as a final theory depends on the tradition of fundamental physics. I see this as an advantage of rather than an objection to the PDA. One of the problems with Maudlin's and other primitivist accounts of laws is the way they sever the connection between lawhood and the tradition of physics. The main point of this paper is that Lewis's account despite its appealing to simplicity and informativeness also severs this connection. The PDA reconnects the two.

3. Lewis's perfectly natural properties are required for there even to be possible worlds like ours and for it to be possible for us to refer to features of the world. One objection is that without them the world would be an amorphous lump. Another objection (or perhaps another way of lodging the first objection) is without them there are too many properties. In either case the world lacks objective

structure. Further, without natural properties to serve as reference magnets our thoughts and language could not succeed in referring to the world. I find these objections to be very obscure. But even if there is a transcendental argument to the effect that there must be an objective structure of natural properties for there to be a world or for their to be thoughts about the world it is not at all obvious that these arguments would show that it is the job of physics to locate these properties or that scientific laws in any way involve them. In this paper I have not argued against the existence of perfectly natural properties. Lewis can have them if they do the metaphysical work he claims for them and that work needs doing. I have argued that by linking the BSA to them raises a problem in that it threatens to sever the connection between the BSA and the goals of fundamental physics.

NOTES

1. Lewis develops his account of natural properties in articles in (1986a) and in (1986b).
2. Lewis says that the actual world is one of the possible worlds no different in kind from any of the others. It is actual—for us—because we inhabit it.
3. It is not that I have a better account to offer. As far as I understand, all existent accounts of possible worlds and metaphysical modality have problems.
4. Every class of n-tuples of possibilia is a relation. For the usual relations each n-tuple consists of entities from the same world. In the following, "property" includes monadic and n-ary relations.
5. Lewis also thinks that there are degrees of naturalness. It may be that the degree of naturalness of a property can be defined in terms of perfect naturalness and complexity, but I don't now of any account that works. In any case, only perfectly natural properties figure in my discussion.
6. Lewis also claims that there are degrees of naturalness with perfect naturalness at the highest degree. *Acidity* presumably is more natural than *Green*, which is more natural than *Grue*, which is more natural than the majority of randomly selected properties. Perhaps it is possible to characterize *degree of naturalness* in terms of perfect naturalness and logical complexity or perhaps it is also primitive. Whichever, it won't make much difference to my discussion since for the most part we will be considering only perfectly natural properties. In the following I will use "natural" as short for "perfectly natural" unless otherwise noted.
7. Natural properties not associated with w are said to be "alien to w." Exactly which natural properties are associated with w? Lewis's view seems to be those instantiated at w plus others that are related to these in certain ways. For example, the property of having a mass of exactly 10kg may not be instantiated at w but is still natural at w since other mass properties are instantiated at w. Perhaps any determinate of a property one of whose determinates is natural and is instantiated at w is *associated* with w.
8. I am not sure what fundamental entities Lewis thinks instantiates fundamental natural properties. He speaks of them being instantiated at space-time points and regions but perhaps he thinks that some worlds contain fundamental individuals of various kinds (e.g., particles, strings, fields) that instantiate them.
9. More generally, there are no necessary connections between properties instantiated in disjoint regions. It follows from a property being intrinsic to a region that it is individuated independently of laws that connect it to properties instantiated in distinct regions.
10. On Lewis's account of reference degree of naturalness plays a role in reference fixing since degree of naturalness is balanced against other criteria for reference determination.
11. Maya Eddon and Chris Meacham also argue that Lewis's notion of natural property cannot do all

the work that Lewis asks of it in their paper "No Work for a Theory of Universals" (Eddon and Meacham forthcoming).

12. "Humean supervenience is named in honor of the great denier of necessary connections. It is the doctrine that all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another . . . . We have geometry: a system of external relations of spatio-temporal distances between points . . . . And at those points we have local qualities: perfectly natural intrinsic properties which need nothing bigger than a point at which to be instantiated. For short, we have an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that" (Lewis 1986a, ix).
13. HS even seems to be in trouble in classical mechanics (Butterfield 2006).
14. If the claim that there are not determinate values for the spins of the electrons and yet the outcomes of the spin measurements are correlated sounds strange it ought to. But that is what the textbooks influenced by the so-called Copenhagen interpretation say. For more discussion, see Loewer (1998).
15. The electrons don't have quantum states at all individually, but they are in what are called "reduced" states determined by the singlet state. In this case the reduced states determine the probabilities of the outcomes of measurements of the components of spin but don't determine whether these outcomes will be anti-correlated. Quantum nonlocality follows from the existence of entangled states.
16. Among these accounts are Bohmian mechanics, GRW collapse theories, and Everett's many worlds theory. These all contain objective accounts of fundamental ontology and laws and none involve consciousness as a primitive feature of physics. See Albert (1992) for a discussion of these.
17. In Loewer (1996) I suggested that the letter of HS could be saved if the space-time is many dimensional configuration space and the ontology included a field corresponding to the universal wave function that undulates in this space. True this saves the letter but I doubt that Lewis would think it saves the spirit of HS.
18. Lewis proposes measuring fit by P(e/T) where "e" is the totality of fundamental facts and T is the proposed best theory. This measure obviously has difficulty when P(e/T) is 0 or infinitesmal as it will be for a world like ours. Exactly how to define "fit" is an important question but it doesn't seem to be insuperable since statisticians have a pretty good idea how to measure the fit of hypothesis to facts even when P(e/T) is infinitesmal.
19. Not every generalization or equation implied by the Best Theory counts as a law (e.g., certain disjunctions of laws may not be count as laws), but I won't discuss what further conditions an equation needs to satisfy to count as expressing a law.
20. Lewis makes this point and also suggests that if there are more than one Best Theory (either because the criteria are vague or the world doesn't determine a single best theory) then the consequences they have in common count as the laws.
21. Lewis thought that the only objective probabilities are connected to dynamical laws but a strong case can be made for the objectivity of probabilities occurring in statistical mechanics and Bohmian mechanics which are both deterministic theories. By adding a probability distribution over initial conditions of the universe a system of dynamical laws (as in classical mechanics) can be made much stronger with just a little added complication. See Loewer 2001, 2006.
22. I discuss accounts of objective probabilities based on the BSA in Loewer (2004) and Loewer (2006).
23. For example, Lewis (1986a), Bennett (2003), Loewer (2006).
24. More metaphysically committed accounts of laws like Armstrong's and Maudlin's are subject to a criticism much like the one that I make of Lewis's account.
25. In Van Frassen (1989).
26. See Lewis's discussions of reference in "Putnam's Paradox" and "Radical Intepretation" in Lewis (1983).
27. It may turn out that the FT entails that any intelligent creature that has concept that plays a role like the concept of law plays for us will evaluate simplicity and informativeness in ways very similar to us.

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