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BOOK SYMPOSIUM

Counterfactuals all the way down?

Marc Lange: Laws and Lawmakers: Science, metaphysics, and the laws of nature. Oxford University Press, 2009, 280 pp, US$99 HB

Jim Woodward · Barry Loewer · John W. Carroll · Marc Lange

Jim Woodward

It is a pleasure to comment on Marc Lange's rich and provocative book, *Laws and Lawmakers* (*LL*). I will focus on just one of the guiding ideas in *LL*—the connection between lawfulness and *stability*. I agree with Lange about the centrality of this notion to the understanding of laws but favor a somewhat different interpretation of stability. Section "The Motivation for NP′" describes my own view, making use of the framework developed in my (2003). Section "Genuine Modality?" considers Lange's treatment.[1]

1.

Begin with the idea (which I hope seems uncontroversial) that many successful physical theories make use of a distinction between claims that are

[1] Thanks to Marc Lange for very helpful correspondence and corrections to an earlier draft.

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laws[2] and, claims that have a different status and which, at the risk of enormous oversimplification, can be described as *initial* or *boundary* or *background conditions.* (See below for distinctions among these). In my view, the law vs. initial/background condition distinction is part of a circle of concepts and distinctions that also include notions like physical dependence/independence, and physical necessity/contingency. I am skeptical about the possibility of providing a "reductive" account that explains these notions in terms of concepts that lie outside this circle but believe it possible to say something about how the concepts in this circle, and in particular the notions of law and initial/background conditions, are *connected.* Very roughly, "laws" describe relationships that continue to hold (are stable or invariant) over some substantial range of different initial and background conditions or, as one might also put it, under *changes* in those conditions. The range of conditions over which laws are stable includes both specifications of the values taken by the variables explicitly figuring in the laws when applied to particular systems (e.g., a specification of the distribution of electric charge when Coulomb's law is applied—what might be described as initial conditions, properly speaking), as well as values taken by variables that do not explicitly figure in those laws (e.g., colors of the conductors—background conditions, as I will call them).

This stability feature of laws seems naturally expressible by means of counterfactuals: Coulomb's law correctly describes, say, the actually existing field due to a spherical conductor with a certain charge, but in addition if, contrary to actual fact, that charge were doubled or the color or geometry of the conductor were altered, Coulomb's law would still continue to correctly describe the relationship between the charge distribution and the field, and similarly for other contrary to fact assumptions about initial and background conditions.

Assuming that this idea about stability is correct, we face a further issue. Many of the generalizations regarded as laws in contemporary science break down—are not stable—under *some* nomically possible initial and background conditions. For example, the Newtonian gravitational law breaks down in sufficiently strong gravitational fields; Maxwell's equations break down at length scales at which quantum mechanical effects become important; General Relativity (GR) is widely believed to require correction at very small length scales (the Planck length) and so on.

As I favor thinking about stability and its relation to lawfulness, it makes sense to describe as a "law" a generalization like $F = Gm_1m_2/r^2$, that is stable to a high level of approximation under a range of classical conditions (e.g., weak gravitational fields) including conditions produced as a result of intervention-like processes (see below), even if because of General Relativistic corrections, this generalization is not exactly true under those conditions and even if it does not hold even approximately under other conditions. One reason for allowing generalizations that are relatively stable but not exceptionless to count as laws is that many of the generalizations currently treated

[2] Some terminological regimentation: Many philosophers use "law" to refer to relationships or patterns within nature. By contrast, as I will use the expression, "laws" are representations or descriptions of those relationships or patterns. This fits aspects of ordinary scientific usage, according to which, e.g., Maxwell's equations are described as laws of nature and also avoids ruling out certain possibilities by terminological fiat—e.g., that laws might have exceptions. (It is unclear what might be meant by the claim that patterns in nature have exceptions.).

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as laws in science have this character. This point of view contrasts with the idea—widely accepted among philosophers, including Lange—that genuine laws ("laws *simpliciter*"—p. 193) must be exceptionless (and indeed such that they hold not just under all actually realized conditions but also under all nomically possible conditions). Of course, this is a possible stipulation regarding the notion of law, but it has the disadvantage that many and conceivably all generalizations currently regarded as paradigmatic laws turn out not to be laws. Moreover, even if we adopt this stipulation, it remains the case that—call them what you wish—generalizations like Maxwell's equations, the field equations of GR and so on, play a central role in current science: we appeal to them to explain and predict; their discovery is regarded as an important scientific achievement and so on. It thus remains an important project to try to elucidate the characteristics of such generalizations and to better understand how they can play the roles just described—roles which, after all, are just the roles traditionally ascribed to laws. A relativized notion of stability can contribute to this goal:

> IN: A necessary condition for a claim m to be a law is that m hold under some substantial range of initial and background conditions p.[3]

2.

Like me, Lange holds that laws are stable under various counterfactual suppositions. He notes, however, that for any law there will be some suppositions under which it does not continue to hold, although the undermining conditions on which he focuses are often different from those considered above. To use one of Lange's examples, even if it is a law that all copper conducts electricity, this law would not continue to hold under the supposition that all copper does not conduct electricity. As Lange notes, one possible strategy for preserving the connection between lawfulness and stability in the light of this difficulty is to restrict the relevant range of suppositions to those that are consistent with all of the laws taken together. Doing this, Lange (p. 20) arrives at the following principle, which he endorses

> NP: m is a law if and only if in any context $p \; \Box\!\!\rightarrow m$ holds for any p that is logically consistent with all of the *n's* (taken together) where it is a law that n.

($p \; \Box\!\!\rightarrow \; m$ means that if p were the case, m would be the case). However, while Lange regards NP as correct, he does not think it is completely satisfactory because, among other defects, it is "circular" in two respects. First, to apply NP we need to have already identified those counterfactual suppositions that are consistent with the laws; hence, we can't use NP to pick out which claims are laws. Second, NP fails to explain why the persistence of the laws under this particular set of counterfactual suppositions makes the laws "special" or "important" (p. 26).

[3] This is only a necessary condition. In distinguishing between laws and accidental generalizations, an additional requirement is that laws must be stable/invariant under some initial and background conditions that are produced by "testing interventions" (cf. 2003, 239ff).

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As an alternative to NP, Lange instead suggests characterizing the laws in terms of *sub-nomic stability*. A *sub-nomic claim* does not require for its expression phrases like "is a law" or the like. Lange (p. 29) then defines sub-nomic stability as follows:

> Consider a non-empty set of sub-nomic truths Γ containing every sub-nomic logical consequence of its members. Γ possesses sub-nomic stability if and only if for each member m of Γ (and in every conversational context),
> $\sim (p \diamond\!\!\rightarrow \sim m)$
> $\sim (q \diamond\!\!\rightarrow (p \diamond\!\!\rightarrow \sim m))$
> $\sim (r \diamond\!\!\rightarrow (q \diamond\!\!\rightarrow (p \diamond\!\!\rightarrow \sim m)), \ldots$
> for any sub-nomic claims $p, q, r\ldots$ where $\Gamma \cup \{p\}$ is logically consistent, $\Gamma \cup \{q\}$ is logically consistent, $\Gamma \cup \{r\}$ is logically consistent,…

(Here, $p \diamond\!\!\rightarrow m$ means: if p, then m might have been the case).

According to Lange, the set Λ of all sub-nomic truths which are laws is sub-nomically stable. Indeed, Λ is the largest non-maximal set that is sub-nomically stable. Moreover, various proper subsets of Λ are also sub-nomically stable (or may well be). For example, according to Lange, classical mechanics conceives of $F = ma$ as belonging to a proper subset of Λ that is sub-nomically stable, roughly because $F = ma$ would continue to hold under the supposition that various specific force laws such as the gravitational inverse square law do not hold. By contrast, either no set of accidental truths is stable or the only set of accidental truths that is stable is the set of all truths. This feature—that laws form a non-maximal set that is nomically stable (in fact, a nested hierarchy of such sets) while the only nomically stable set of accidents is the maximal set of all truths or else there is no such set—distinguishes the laws from accidents. In this way, one may use the notion of sub-nomic stability to characterize what is distinctive about laws in comparison with accidents in terms of the truth of various counterfactuals, without presupposing a notion of accident that is simply defined in terms of consistency with the laws. The upshot is thus that one may characterize the notion of law (and the difference between laws and accidents) in terms of a more fundamental set of counterfactual claims or "subjunctive facts" as Lange calls them. These facts are the "law makers"—"*subjunctive facts are ontologically primitive and responsible for laws*" (p. xiii).

How does this compare with IN? One obvious difference is this: While IN requires that we be able to evaluate counterfactuals concerning whether various generalizations would continue to be true (or approximately so) under different initial/boundary conditions, Lange's framework requires that we be able to evaluate a much wider range of counterfactuals, including counterfactuals whose antecedents involve violations of known laws and "nested" counterfactuals in which one evaluates whether various counterfactuals would themselves hold under additional counterfactual antecedents, including counter-nomic ones. In addition, for Lange, lawfulness requires stability under *all* allowable counterfactual suppositions that are consistent with the laws. This means that, for reasons outlined above, many generalizations currently regarded as laws such as the field equations of GR likely do not qualify as laws under Lange's criteria.

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Call the full range of counterfactuals employed in Lange's account *Langean* counterfactuals. Two crucial issues are whether: (i) it is possible to provide a clear account of what such Langean counterfactuals mean (or what their physical interpretation is); and (relatedly) (ii) it is possible to provide a plausible epistemological story concerning how one might assess which such counterfactuals are true. To sharpen these issues, consider that the counterfactuals associated with IN have a relatively straightforward physical interpretation: we are to think of nature or an experimenter as actually generating or physically realizing a range of different initial and background conditions, and stability in the sense of IN requires that the candidate generalization continue to hold in the sense of correctly describing how nature would behave under some range of these alternative conditions. Moreover, at least in some cases, it is unmysterious how to empirically assess whether such claims are true. To take one obvious possibility, insofar as different initial conditions in some range occur naturally (or can be made to occur experimentally) and we can observe whether some generalization G continues to hold under these, we can obtain evidence relevant to G's stability in the sense of IN. To take another possibility, one may also construct arguments for the stability or instability of a generalization in the sense of IN by combining empirical evidence with generally accepted theoretical claims (themselves grounded in part in empirical evidence). For example, theoretical considerations make it plausible that various generalizations describing large-scale cosmological uniformities (such as the generalization that the large-scale uniform mass distribution of the universe is uniform) are not stable under relevant changes in initial conditions and hence are non-lawful.

Consider, by way of contrast, counterfactuals like (2) "if the mass of the proton had been twice its actual value, then if the charge of the electron had been half its current value, it would have been a law that $F = ma$", (3) "If the fundamental force laws had been different, the Lorentz transformations would still have held", (p. 40), and (4) "If Coulomb's law had been violated before today, then Coulomb's law might not hold today" (pp. 38–39). Here, it is less clear either how to interpret such counterfactuals or how to assess them in an empirically disciplined way. To put the point in a more positive way: an important item on Lange's future research agenda should be an epistemological story that goes along with the metaphysical story he has already provided and that tells us how we can come to know which Langean counterfactuals are true.

This point is closely related to another. As noted earlier, Lange hopes to explain what laws and accidents are in terms of a more general notion of "subjunctive facts". However, there is an important complication that must be addressed before this project can succeed. This is that the category of "subjunctive facts" seems heterogeneous; only certain kinds of subjunctive facts seem relevant to the assessment of lawfulness. Thus, some prior demarcation of the right kinds of subjunctives seems required if we are to use them to provide a non-circular elucidation of laws and accidents.

Suppose we are interested in whether the field equations F of GR are stable in the way laws are supposed to be. Consider (5) which (we assume) is contrary to actual fact:

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(5) The majority of informed physicists in 2100 believe that (the field equations) *F* are false.

(5) is logically consistent with the truth of *F*, as well as with other laws, so, on Lange's account, it is a legitimate counterfactual supposition for the purpose of assessing the lawfulness of *F*. Consider

(6) If (5) were true, *F* would hold.

There is a way interpreting (6) according to which it is false or at least dubious. This interpretation construes (6) as (roughly) a claim about what it would be reasonable to believe under the assumption of (5): Assuming (5), then, since physicists generally form their beliefs about physics responsibly, they likely have strong evidence against *F*, in which case *F* may well be false.

There is also an obvious interpretation of (6) according to which it is true—this is the interpretation we have in mind when we judge that *F* is likely true and that its truth-value does not depend on anyone's beliefs; hence even if physicists think *F* is false, *F* would (still) be true. Intuitively, this "dependency" interpretation is the right interpretation of (6) to use in assessing whether *F* is stable. Recall, however, that Lange's test for stability requires that counterfactuals like (6) hold in *all* normal conversational contexts if *F* is to be a law, so that the falsity of (6) in some contexts, such as the context in the previous paragraph, is sufficient for *F* not to be a law.

In a footnote (pp. 197–205) which discusses several examples having this structure, Lange agrees that the interpretation of (6) according to which it is false should be disallowed for purposes of assessing the stability of *F*. He holds that under the appropriate way of interpreting (6), it is true, and hence poses no threat to the stability of *F*. His argument is that to the extent we are inclined to judge (6) as false, this is because it is being tacitly understood as an indicative conditional, rather than as a genuine counterfactual or subjunctive. When (6) is interpreted as a counterfactual/subjunctive conditional, which is what Lange's stability requirement demands, (6) is true.

I agree there are two distinct readings of (6), only one of which is relevant to the assessment of stability, but I'm not sure that the indicative/subjunctive contrast is the most perspicuous way of capturing this distinction. Taken literally, the indicative/subjunctive contrast (if defensible at all) has to do with grammatical "mood", while the contrast between the two different readings of (6) distinguished above seems semantic. It is often, perhaps even usually, true that subjunctive conditionals are used to express dependency relations conceived of as holding in the world, and indicative conditionals are often used to express claims about what it is reasonable to believe, but as (6) itself illustrates, conditionals that are literally subjunctive in the sense of being framed in terms of words like "were" and "would" can be used for the latter purpose.

If this is correct, the category of "subjunctive facts" begins to look rather heterogeneous, since subjunctives can be used to express either facts about dependency relations or facts (or recommendations) about reasonable belief revision. This in itself may seem not particularly problematic. Why not just think of Lange's project as one of elucidating the notion of law in terms of one particular sort of subjunctive fact, the sort that reflects claims about worldly relations of dependence?

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The difficulty with this suggestion is that not all of the subjunctives to which Lange appeals have an obvious interpretation in terms of worldly dependency relations—some of them seem to be more naturally interpretable as claims about what it is reasonable to believe (or perhaps have some third interpretation not yet considered). This is true for the claims (2)–(5) above. Assuming, for the sake of argument, that these subjunctives are true, it seems most plausible to interpret them along "it would be reasonable to believe" lines, e.g., if Coulomb's law had been violated in the past it would be reasonable to believe that it might not hold in the future, and so on. However, as noted, Lange needs an understanding of "subjunctive" fact which excludes (6) as true when interpreted along "reason to believe" lines. This raises the following question: what is the interpretation of "subjunctive fact" which allows claims like (2)–(5) to be true subjunctives and yet rules out (6) as a true subjunctive?[4]

I turn now to Lange's worry that NP is "circular". (It is worth noting that it might seem that to the extent that this worry is cogent, it equally applies to IN.) I agree that NP (and IN) do not provide a reductive analysis of the notion of law. However, it does not follow that these principles are circular in the sense of being empty or unilluminating—they do tell us something about one sort of evidence that is relevant to discovering whether a generalization is a law and they impose constraints on how the notions of law and initial condition are related. This is possible because, although NP and IN require that laws be stable under some set of assumptions consistent with all the laws, in identifying these assumptions one does not have to know or explicitly enumerate all of these laws. In particular, as emphasized earlier, we have some (partial) independent access to whether some particular condition is consistent with the laws on the basis of the consideration that whatever is actual must be consistent with the laws. For example, when an experimenter drops a non-copper wire onto Lange's desk and discovers that it does not become copper, this consideration is relevant to establishing that "All the wires on Lange's desk are copper" is not stable, and not a law. To conduct this experiment, the experimenter does not have to already know whether placing the non-copper wire onto the table is consistent with the laws of nature. I suggest that part of the reason why principles like NP and IN strike us as illuminating and non-trivial is that they are epistemically useful in this way despite their non-reductive character.

I'm afraid that I have followed the usual philosophical convention of focusing on points of disagreement with *LL*. So let me say by way of conclusion that this is a very worthwhile and stimulating book.

[4] This also bears on the general argument Lange gives in support of his claim that there is no non-maximal sub-nomically stable set containing accidents (pp. 32ff.). This has some plausibility if the counterfactuals in the argument are interpreted as "reasons to believe" claims. However, the claim seems less plausible if the relevant counterfactuals are interpreted as having to do with physical dependence. Consider a proposition *r* that characterizes the magnitude of some physical quantity at some particular space–time point *s*, where *r* is accidental. Let T be the set of propositions characterizing the values of all physically relevant variables in the entire backward light cone of *s*, all the way back to whatever happened at the beginning of the universe. T will not consist of all the accidental truths since, for example, it will not include truths about events at space like separation from *s*. Is T sub-nomically stable despite being non-maximal? Certainly, the truth of the propositions in T does not *physically depend* on truths about what happens at spacelike separation from *r*.

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Barry Loewer

The central metaphysical question concerning scientific laws is: What fundamental things or facts or *whatevers*, if any, make it the case that a true generalization or equation is lawful? The views most discussed in recent years divide into Humean and non-Humean accounts.

Humeanism is committed to two claims. (i) There are no *metaphysically necessary* or *fundamental nomic* connections between the instances of fundamental properties/relations instantiated in wholly distinct space–time regions; i.e., fundamental properties are categorical.[5] (ii) Claims about lawfulness supervene on the totality of instantiations of fundamental properties and relations. David Lewis' Best System Account (BSA) is the best Humean account currently on the table. According to the BSA, laws are certain propositions entailed by the true theory that best systematizes the totality of all truths about fundamental property/relation instantiations.[6]

Non-Humeans deny (i) or (ii) or both. Dispositionalist accounts of laws reject (i).[7] For example, on Alexander Bird's "powers" account the instantiations of certain fundamental properties in one space–time region metaphysically necessitate the instantiation of fundamental properties in completely distinct space–time regions. On this account, lawful propositions are metaphysically necessary truths made so by the natures of the properties they are about. David Armstrong agrees with Humeanism that fundamental properties are categorical. But he rejects (ii) and holds that a law is a higher order contingent fact with the structure N(*F, Q*) where N is a relation of "contingent necessitation" between properties, (or universals) *F* and *Q*. N(*F, Q*) somehow makes true the corresponding generalization "all *F*s are *Q*s" and also makes it lawful. Tim Maudlin (2007) develops a different non-Humean account. He claims that fundamental dynamical laws are entities belonging to their own unique ontological category. On Maudlin's view, a dynamical law takes the initial state of a system (or the universe) and "generates" subsequent states. It thus *makes* a generalization or equation lawful.[8]

The account of laws that Marc Lange develops in his *Laws and Lawmakers* is the new kid on the block. It occupies the non-Humean side of the street but differs from its non-Humean neighbors in a number of interesting ways. Here is a capsule summary.

5FL01 [5] This version is weaker than Lewis' doctrine of Humean Supervenience (HS) since HS requires that
5FL02 fundamental properties are instantiated by point size entities and that the only fundamental relations are
5FL03 geometrical.

6FL01 [6] Candidate systems are evaluated in terms of their simplicity, informativeness and perhaps other
6FL02 theoretical virtues prized in science. The Best System of a world is the system that best combines these
6FL03 virtues. The laws of a world are certain propositions entailed by the world's best system. For defenses and
6FL04 developments of Lewis idea see Loewer (1996).

7FL01 [7] Dispositionalists can hold (ii) since they think that fundamental properties essentially possess
7FL02 dispositions and so their instantiations do determine which generalizations are lawful.

8FL01 [8] On Maudlin's (2007) view, there is a close connection between laws and the direction of time: a law
8FL02 takes the state at one moment and produces subsequent states in accord with the direction of time. See
8FL03 Loewer (2011).

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It has long been noted that there are special connections between laws and counterfactuals; for example, a sign of the generalization "all *F*s are *Q*s" being lawful is that it "supports" the counterfactual "if b were an *F* it would be a *Q*".[9] Lange's key idea is that laws are distinguished from accidents in that lawful truths possess a kind of counterfactual stability. If a generalization G is lawful, then it would remain true under logically independent counterfactual circumstances that are accidental. But if G is accidental, then there is some logically independent accidental counterfactual circumstance under which G might not remain true. This suggests the following principle

(1) For all A, if A is logically consistent with the set of laws, then G is lawful if and only if A had been true G would still have been true.

In (1), A and G are restricted to "sub-nomic sentences" i.e., sentences that do not contain "it is a law that" or any other modal operators. Although counterfactual sentences are notoriously context dependent, Lange holds that (1) is true relative to all contexts.

Lange also claims:

(2) For all A, if A is logically consistent with the set of laws, then G is lawful if and only if had A been true then G would still have been lawful.

Lange points out that (2) implies that if G is lawful, then each of the infinity of these nested conditionals is true hold

(3) $A1\Box \rightarrow G$, $A2\Box \rightarrow (A1\Box \rightarrow G)$, $A3\ \Box \rightarrow (A2\Box \rightarrow (A1\Box \rightarrow G)))$, …

While (1) is compatible with Humean accounts of laws like Lewis' (2) and (3) are not. This is easily seen for the BSA as follows: Suppose that classical mechanics is the best system of world W. There is a world consisting of a single particle moving uniformly that is compatible with classical mechanics, but whose "best system" is just the proposition that there is a particle moving uniformly.[10]

(1) and (2) identify laws in terms of counterfactuals but do so circularly since the antecedents are restricted to those consistent with laws. Lange very cleverly shows how to remove the circularity. He defines a set of sub-nomic propositions as "stable" if the set's members would still have held under every sub-nomic supposition that is consistent with the set. He then proposes

(4) G is lawful if and only if G belongs to the largest non-maximal stable set of true propositions.

Call this set Γ. There may be stable sets that are smaller than the largest non-maximal set of true propositions ("Non-maximal" since it may be that the set of all non-nomic truths is stable). The set of metaphysical necessities and their consequences is plausibly such a set. Lange proves that the stable sets form a hierarchy

[9] For example, if "whenever ice is placed in warm water it melts" is lawful, then the corresponding counterfactual "if this ice cube were placed in warm water it would melt" is true.

[10] Given some plausible assumptions (2) is incompatible with any Humean account.

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(i.e., stable sets stand in the subset relation). The first-degree laws are the generalizations that belong to Γ–Z where Z is the next largest stable set.[11]

(4) entails (1) and (2) and thus endorses a very tight connection between laws and counterfactuals.

(4) specifies a connection between laws and counterfactuals but doesn't say that either is more basic than the other. It is generally (but not universally) held that laws are ontologically and conceptually more fundamental than counterfactuals.[12] Lange inverts this. He maintains that what makes G lawful is its belonging to a stable set and what makes the set stable is the truth of certain subjunctives (*aka* counterfactuals) and what makes subjunctives true are "subjunctive facts." Further, he proposes that "with these subjunctive facts, we have reached ontological bedrock. They (along with various sub-nomic facts) are primitive, lying at the bottom of the world. They are the lawmakers" (p. 136).

This is a very cool idea. Unlike all its neighbors, it takes counterfactuals to be conceptually and ontologically more basic than laws. But one may worry that counterfactuals are too context dependent, too many, and too obscure to pick out facts that lie "at the bottom of the world". Below I spell out some worries mostly from the Humean side of the street.

The truth of (1) is crucial to Lange's account.[13] But there is a well-known problem that has led some philosophers to reject it. Suppose the dynamical laws are two-way deterministic. Then, it appears that if A is false and consistent with the laws the following counterfactual is true

(5) If A had been true, then either the past would have been different or the actual laws would have been violated at some time(s) in the past or both.

If (1) and (5) are true, it appears to follow that

(6) If A had been true, then the past would have been different all the way back to the origin of the universe.

Letting A in (6) be "Nixon decided to press the button at t" the result is not obviously true. In fact, the following seems true at least relative to some contexts of evaluation:

(7) If Nixon decided to press the button at t, then it might have been that the state of the universe at the time of Christ was exactly as it actually was while there was a small violation of the laws shortly before t.

[11] Lange thinks that there are stable sets between the largest non-maximal set and the set of metaphysically necessary truths. For example, there is a set of "meta-laws" that would still hold were first-degree laws false. Whether there are such stable sets of course depends on what counterfactuals are true.

[12] On Lewis' account both laws and counterfactuals supervene on the totality of categorical propositions, so in a sense neither is ontologically more basic than the other. However, Lewis analyses counterfactuals in terms of world similarity and his account of similarity involves laws; so laws are conceptually more fundamental than counterfactuals.

[13] The truth of (1) is compatible with each of the accounts of laws mentioned above but only Lange's account requires that it is true. Lewis' account of counterfactuals violates (1) but that is not a consequence of his Humeanism but a feature of his particular account of counterfactuals.

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And if (7) is true, then (1) is false.

Lange is aware of this problem and discusses it in a long footnote (pp. 203–5). He ends up denying (7) and (6). He claims that tokens of (6) and (7) lack truth-value. Lange's idea is that when entertaining (6) or (7) we are not thinking about how it came about that Nixon pressed the button (whether that involved a difference in the past or a violation of law or a chancy outcome or whatever). How it came about happens, he says, "offstage." He says: "The function mapping the counterfactual sentences to different propositions, depending on the context fails to map the sentence to any proposition at all in a context where the counterfactual concerns offstage matters." Lange suggests that Lewis-Stalnaker possible world semantics seduces us into thinking that (6) and (7) must have truth-values since when evaluating $A\Box \rightarrow B$ it considers whole possible worlds at which A is true.

This saves (1) from refutation but raises a couple of questions. First, since he seems to be rejecting the Stalnaker-Lewis logic of counterfactuals, what logic does he propose?[14] This aside, one can imagine uttering these subjunctives while explicitly wondering how the antecedent might have come to be true; i.e., bringing this consideration "on stage." If one thinks that in this context had Nixon pressed the button at t might have involved a violation of the actual laws (as e.g., Lewis does), then there is a context in which one thinks an instance of (1) is false. If so, there goes (1) and with it Lange's account. Perhaps, he should simply bite the bullet and say that these contexts are excluded from (1). The questions now are how do we know that the rock bottom subjunctive facts yield this result? And, more importantly: what is a rock bottom subjunctive fact?

Michael Dummett (1996, 53) famously remarked: "a counterfactual cannot be true unless there is some statement, not involving the subjunctive conditional, whose truth renders the counterfactual true." Let's call this "Dummett's Dictum." I am not sure whether Lange's "subjunctive facts" satisfy Dummett's Dictum, since he doesn't provide a positive account of what subjunctive facts are, what structures they have, or how they are related to subjunctive sentences. Lange is aware of these lacunae: Admittedly a great deal more than I manage here needs to be said about "subjunctive facts: How do they differ from other kinds of facts? Is there anything especially "subjunctive" about them (or only about what they make true)? Why do they relate to one another so as to obey the logic of subjunctive conditionals? Is there distinct primitive subjunctive fact for every subjunctive conditional and context where that conditional is true? Questions analogous to some of these can also be raised regarding sub-nomic facts—without throwing any suspicion on their ontological bona fides. Fortunately no feature of my account of laws turns on giving certain answers than others to these questions" (p. 230).

I think that Lange is wrong to say that no feature of his account turns on answering the questions he raises about ontology and semantics. We just saw that his defense of (1) involves claiming that certain subjunctive conditionals e.g. (6) and (7), fail to have truth-values. And a number of his arguments (for example, the argument that stable

[14] Lange seems to blame possible world semantics for this result. But it holds in any counterfactual logic that endorses the validity of $A\Box \rightarrow L \rightarrow A\Box \rightarrow A\&L$, and $A\Box \rightarrow A\&L$ and B is entailed by A&L, then $A\Box \rightarrow B$.

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sets form a hierarchy) make use of logical principles and assumptions about the logic of counterfactuals and how they are mapped onto subjunctive facts. Most importantly, the plausibility of Lange's account ultimately depends on the plausibility of positing subjunctive facts as the fundamental ("at the bottom of the world") truthmakers of subjunctives and laws. I *am* suspicious of their ontological *bona fide* as fundamental truthmakers. I will explain why by attempting to spell out a bit of what is involved in their ontology so as to try to satisfy Dummett's Dictum. My proposal may not be how Lange would develop his account so it can be taken as an invitation for him to say a bit more about subjunctive facts.

What are fundamental subjunctive facts? Whatever they are if they are the truthmakers of counterfactuals there must be many of them, since logically independent true counterfactuals must be made true by different ones. Further they must have structure to differentiate them and account for why different true subjunctive sentences get mapped onto different subjunctive facts. Let's suppose that some counterfactuals are basic. These are ones that have fundamental subjunctive facts as their truthmakers. Non-basic counterfactuals obtain their truth conditions via paraphrase in terms of basic counterfactuals and other propositions. Consider a true basic counterfactual expressed by

(8) Fa $\Box\!\!\rightarrow$ Gb.

It seems reasonable to suppose that the primitive fact that is alleged to be the truthmaker of (8) has the structure

(8*) Fa *R* Gb

where Fa and Fb are states of affairs and *R* is a fundamental relation.

Given this account of subjunctive facts (and states of affairs), here is how the semantics for subjunctives might go. A basic subjunctive "A$\Box\!\!\rightarrow$ B" is true iff A *R* B. Non-basic subjunctives are paraphrased in terms of fundamental subjunctives and other fundamental expressions and thus obtain their truth-value via the truth-value of the paraphrase. Is "If Nixon had pressed the button there would have been a nuclear war" a basic subjunctive? I have no idea what Lange would say. If it is, the ontology of fundamental subjunctive states of affairs will be enormous. If not, it has a paraphrase in terms of basic counterfactuals and propositions concerning particular states of affairs. I have no idea how its paraphrase would go.[15]

Counterfactuals conform to various logical principles. For example,

(A$\Box\!\!\rightarrow$ B & A$\Box\!\!\rightarrow$ C) $\rightarrow$ A$\Box\!\!\rightarrow$ (B&C), A$\Box\!\!\rightarrow$ B $\rightarrow$ (A $\rightarrow$ B), are theorems of standard counterfactual logics. Possible world semantics of the sort developed by Stalnaker and Lewis validate these and other principles. But given the semantics I have so far sketched for Lange's account almost nothing of the usual logic of counterfactuals follows. The way to recover counterfactual logic within the ontology and semantics I proposed for Lange's account is to put conditions on *R* and on the mapping from counterfactuals to states of affairs. For example, if A *R* B obtains and A obtains, then so does B. Given appropriate conditions on *R* and on the

15FL01 [15] The story will have to be even more complicated since the proposition expressed by a token
15FL02 counterfactual is context dependent.

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semantics of conditionals one can obtain the same logic for conditionals as given by possible world semantics with a similarity ordering on worlds.

Does the ontology and semantics I have just sketched to fill out Lange's account satisfy Dummett's Dictum? It may appear that it does since there seems to be nothing "iffy" about *R* itself; it is just a relation between states of affairs. But Dummett's Dictum also says that that there should be some non-iffy way of specifying *R*. How can *R* be specified? There are many relations between states of affairs; and many that satisfy whatever other conditions we place on *R* to construct logic for counterfactuals. Which of all the possible contingent relations among states of affairs is the one (or ones) that grounds basic subjunctives? It doesn't seem a satisfactory answer to say that *R* is *the* relation that makes true subjunctives true. Suppose that when Kit Fine asked Lewis what the similarity relation is that grounds counterfactuals Lewis replied that it is the relation that makes true counterfactuals true. This wouldn't do. Lewis (1979), at least at first blush, does better by specifying similarity in terms of match of fact and laws. I think one can go further and explain why the propositions picked out by Lewis's account (or rather the propositions he is intending for it to pick out) are of special interest to us.[16] And further still we can understand why the Best System Account of a world and its consequences are of interest to us. But what is it about *R* and about the generalizations that are "counterfactually stable" as specified by *R* that is of special interest? Lange's account would be more persuasive if he provided answers to these questions that are at least as good as the ones that could be given on behalf of Lewis's account.

John W. Carroll

Necessity and laws of nature are just two of the many metaphysical topics discussed with brilliance and grace by Marc Lange in *Laws and Lawmakers*. With the expectation of prompting further insight on laws and necessity in particular, I here raise three issues for Lange's consideration. Each one involves his use of contexts.

The Motivation for NP′

The makers of laws for Lange are subjunctive facts. For him (p. 13), the guiding principle linking lawhood with the subjunctive conditional is:

NP *m* is a law if and only if *m* would still have held under any counterfactual (or subjunctive) supposition *p* that is logically consistent with all of the laws (taken together)

More briefly:

NP *m* is a law if and only if, for any *p* consistent with the laws, $p \mathrel{\square\!\!\rightarrow} m$ is true

16FL01 [16] The idea is that the lawful consequences of very small (and perhaps even counter-legal) departures
16FL02 from actuality are of interest to us in contemplating the consequences of alternative decisions (cf. Loewer
16FL03 2006).

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Not long after introducing NP, Lange (p. 15) reports that it needs refinement. Here is the refinement, what I call NP′:

NP′ *m* is a law if and only if for any conversational context, and for any *p* that is relevant as a counterfactual antecedent in that context and logically consistent with all of the laws (taken together), the proposition expressed in that context by '$p \mathrel{\square\!\!\rightarrow} m$' is true.[17]

On the face of it, NP′ is troubling. What regularities are laws is tied to whether certain sentences are true in all contexts. This is startling; I find myself imagining Kip Thorne phoning Robert Stalnaker for a consult on the laws of quantum gravity!

Lange's reason for the refinement is advanced at a point in the text where he believes that he has already motivated NP′'s restriction to relevant antecedents. He (pp. 14–15) describes a context in which a non-law is preserved under all relevant antecedents consistent with the laws:

> For example, suppose that I have just driven from Chapel Hill to Myrtle Beach in order to meet you, but I have arrived 30 min late. We discuss whether I would (or at least might) have arrived on time had I departed Chapel Hill an hour earlier, or had I taken U.S. Highway 15 instead of Interstate 95, or had there been no accident to slow traffic on I-95, and so forth… In this familiar sort of conversation, a counterfactual antecedent such as "Had Myrtle Beach been 100 miles nearer to Chapel Hill" is irrelevant. In this context, under every *relevant* counterfactual antecedent, the locations of Chapel Hill and Myrtle Beach are preserved… Nevertheless, the locations of Chapel Hill and Myrtle Beach… are accidents, not laws.
>
> Their accidental character is reflected in the fact that there are *other* contexts where these facts are *not* preserved under counterfactual antecedents that are relevant there and logically consistent with the laws.

This passage is puzzling. NP proposes a necessary and sufficient condition for lawhood in terms of the subjunctive conditional. It says nothing about contexts, sentences or anything linguistic. So, for there to be a direct threat to NP, that Chapel Hill and Myrtle Beach are 100 miles nearer to each other has to *really* not be relevant—roughly, it has to not be relevant in Lange's context of utterance or the context of this conversation between Lange and myself (or something like that). That is not the case. That proposition is quite relevant, and it is certainly true that, if Chapel Hill were 100 miles closer to Myrtle Beach, then Chapel Hill and Myrtle Beach would not have the locations they do. Their locations are not preserved under all relevant *p* consistent with the laws. Thus, NP does not have the absurd consequence that it is a law that Chapel Hill and Myrtle Beach have the locations that they do. Something must be going on in the passage just quoted other than a direct challenge to NP.

17FL01 [17] Lange assumes that sentences necessarily exist complete with their Kaplanian character; add a context,
17FL02 and sentences have everything they need to express a proposition (see p. 192, note 15).

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Here's a more charitable interpretation. Let's suppose that Lange takes as an adequacy condition on having successfully stated a conceptual truth that the sentence expressing that truth be true in all contexts. Then, in offering NP as a conceptual truth, he would commit himself to the NP sentence's being true in every context. Assuming the phrase 'if and only if' is not context dependent, this would entail

'*m* is a law' is true in *C* if and only if 'For all *p*, consistent with the laws, $p \,\Box\!\!\rightarrow m$' is true in *C*'.

Then, assuming 'for all' and 'is a law' are also not context dependent, Lange would be left with:

NP_{TC} '*m* is a law' is true in *C* if and only if, for all *p* consistent with the laws, '$p \,\Box\!\!\rightarrow m$' is true in *C*.

One way to challenge NP_{TC} would be to describe a context *C* such that for all *p* consistent with the laws, '$p \,\Box\!\!\rightarrow m$' is true in *C*, but where it is false that '*m* is a law' is true in *C*. This interpretation provides a role for the context described by Lange in the quoted passage. Indeed, NP_{TC} restricted to antecedents relevant in *C* evidently has the consequence that

(a) It is a law that Chapel Hill and Myrtle Beach have the locations they do

is true in the described context, and this is a consequence that Lange might well find absurd. So, by challenging NP_{TC} in this way, he would have indirectly challenged NP, establishing the need for an alternative, the proposed NP′.

If this interpretation does reflect Lange's reasoning, my issue is primarily with just one of the assumptions needed to connect NP to NP_{TC}. The assumed adequacy condition for having stated a conceptual truth stands in need of support, though I admit to finding it plausible. The assumptions that 'if and only if' and 'for all' are not context dependent are surely false; quantifier terms and conditional sentences are notoriously context dependent. Still, there might be something for Lange to say about why their context dependence is not important here. The clearly significant and questionable assumption is that 'is a law' is not context dependent. This is crucial to Lange's challenge to NP, because otherwise it is not clear that (a) is false in the described context. The participants in the conversation seem to be taking the locations as fixed, as true no matter what, and might even say, 'They couldn't have had different locations'. If so, why is (a) false? That they have the locations they do arguably should "by courtesy" (p. 15) get counted as a law relative to that context.

Are lawhood sentences context dependent? Here is one simple illustration of how their truth-value may vary with context. Suppose our universe is Newtonian and that, in fact, on Earth, free-falling bodies accelerate at 9.8 m/s^2. I have argued (1994, 36–38), based on considerations similar to those embodied in NP, that this regularity is *not* a law. Even though the free-fall principle is true, its truth is too accidental for it to be a law; if Earth were to have a much smaller mass, then the principle would be false. I also suggested that 'It is a law that, on Earth, free-falling bodies accelerate at 9.8 m/s^2' is true in contexts where different masses of the Earth, the total destruction of the Earth, the Earth being closer to the Sun, and similar

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considerations are all irrelevant. Such a context might be in play for participants in a conversation who are only concerned about approximately how fast a marble dropped from a ladder is moving just before it hits the ground.

While the free-fall example is a plausible and simple illustration of one way 'is a law' may be context dependent, and hence raises strong doubts about the supposed challenge to NP, I don't see an easy way to turn it into a challenge to NP′. NP′ places a strong necessary condition on lawhood. As a result, NP′ correctly judges the free-fall principle to not be a law. In Sect. "The Truth of NP′", however, I provide two more illustrations of how 'is a law' may be context dependent. Both of these examples do challenge NP′.

Genuine modality?

The trouble with contexts continues. Lange tries to explain the necessity associated with laws, in part by arguing that natural necessity is metaphysically prior to lawhood. Lange wants to show that not all modalities are conversational modalities. He (pp. 62–63) says:

> I will identify a feature of some modals in natural language–a feature we pretheoretically recognize as characterizing genuine modality and that distinguishes the philosophically venerable modalities from the merely conversational ones. Thus we will see why the philosophically venerable necessities (such as natural necessity) are varieties of genuine necessity. With natural necessity as *something* independent of lawhood, *p*'s natural necessity is available to make *p* a law…

The best case for thinking that all modalities are conversational modalities comes from a semantic theory in the work the Lewis (1973, 1976), Kratzer (1991) and von Fintel (2006). This theory treats conversational modalities as relative modalities.

> On this picture, any modality is relative to some contextually determined, typically tacit 'conversational background' *B*. The simplest version of this idea is that *B* picks out some of the facts and *p* possesses *B*-necessity exactly when *p* follows logically from those facts (pp. 59–60).

I have no objection to Lange's putting this approach front and center; that he does is a distinctive characteristic of the book. Nevertheless, ultimately, he fails to identify a feature that distinguishes the so-called genuine modalities.[18]

The following is the principle that Lange puts forward as revealing a requirement of genuine modality:

If $\Diamond p$ and $\Box q$, then $\sim[p \Diamond \rightarrow \sim q]$.

Put forward as a conceptual truth, this principle can be reasonably thought to implicate (cf., p. 65):

[18] I have condensed Lange's proof by moving quickly to its strongest version. My presentation is drawn from pp.71–74.

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M In any context C, if '$\Diamond p$' and '$\Box q$' are true in C, then '$\sim[p \Diamond\!\!\rightarrow \sim q]$' is true in C

Lange's goal is to show that M doesn't hold for the relative modalities. The strategy is to prove that, if M holds of the relative modalities, then the following absurdity follows: if p is relevant to a context C, then '$\Box p$' is also true in C. This is a consequence no friend of relative modality should accept.

Assume for a *reductio* that p is relevant in a context C and is not necessary relative to the salient modality. So, '$\sim\Box p$' is true in C. Also assume that, for some relevant q,'$\Box q$' is true in C though p neither logically entails nor is entailed by q. Then, from the fact that '$\sim\Box p$' is true in C, and standard conceptual connections between possibility and necessity, '$\Diamond\sim p$' and so also '$\Diamond(\sim p$ or $\sim q)$' are true in C. Via M, '$\Diamond(\sim p$ or $\sim q)$' and '$\Box q$' being true in C entails that '$\sim[(\sim p$ or $\sim q) \Diamond\!\!\rightarrow \sim q]$' is true in C. This holds for any pertinent context C—any C satisfying the initial assumptions—even ones that might vary in other regards, like the criterion of closeness of possible worlds; all that matters is that the salient modality and so also the selected background facts remain the same. We are now ready to complete the *reductio*. Consider the sentence '$(\sim p$ or $\sim q) \Diamond\!\!\rightarrow \sim q$'. With p and q both relevant (and neither logically stronger than the other), there must be at least one pertinent context with a criterion of closeness that does not make a definite choice between them; since we are dealing with a mere relative modality, neither p nor q takes priority over the other for all the criteria. So, in some pertinent context, some of the closest $\sim p$ or $\sim q$ worlds will be $\sim p$ worlds and some will be $\sim q$ worlds. As a result, in such a context, '$(\sim p$ or $\sim q) \Diamond\!\!\rightarrow \sim q$' is true and that contradicts the entailment derived via M.

Lange asserts that there must be a pertinent context with a criterion of closeness that will not make a choice between p and q. What may make this claim enticing for Lange is the thought that if we are dealing only with a mere conversational modality, then there is nothing in reality and so nothing that holds across all the pertinent contexts that would favor q except maybe the logical relationships between p and q, and in the proof q is stipulated to be logically independent of p. As he sees it, if the modality is a mere conversational modality, it can't be that q is genuinely, say, naturally necessary though p is not. Lange seems to think that this would be the only sort of consideration that would uphold M.

It is here that the proof stumbles. It would be an implausible semantics that treated conditional sentences and modal sentences independently of each other. Just as we require that any plausible semantic theory of modals respect connections between possibility and necessity, we should require that any such semantics also preserve their connections to conditionals. One such connection is given in the precursor of M:

If $\Diamond p$ and $\Box q$, then $\sim[p \Diamond\!\!\rightarrow \sim q]$.

There are more or less standard ways for a semantics to do so (cf., von Fintel 2001 and Warmbrod 1981). One would be to define '$p \Box\!\!\rightarrow q$' as '$\Box(p \supset q)$', thereby treating the conditional as equivalent to strict implication, but where the strictness is a relative modality. Another way would be to treat the selected background facts as

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restricting the domain of possible worlds. The salient modality and so also the selected background facts are held fixed. So, with this approach, if '$\Box q$' true in C, then there are no $\sim q$ worlds in the domain of worlds for C.

The truth of NP′

With little said about how contexts work, I fear that Lange has trusted too much in a hidden assumption that lawhood sentences are not context dependent, and more generally that the true theory of context (whatever it may be) will suit NP′. In this third section, I offer two different potential counterexamples to NP′.

Consider a conversation in which all the participants suppose that the universe is Newtonian. What effect will this supposition have on the truth-values of sentences in that context? One simple idea (cf., Stalnaker 1998, 16–17) is that the supposition posts itself as an antecedent in the expressed propositions. So, this context would assign the inverse-square sentence ('$F = Gmm'/r^2$') the proposition that, if the universe were Newtonian, then it would be the case that $F = Gmm'/r^2$. As a result, '$F = Gmm'/r^2$' is true in the context because the expressed proposition is true. That is a plausible result; were someone to utter this sentence in the conversation, the assertion made would be treated as obvious. Notice, however, that, if this is all correct, then there would be trouble for NP′. Consider the sentence

(b) If I were to wear an orange shirt, then no signals would travel faster than light

in the context with the supposition that the universe is Newtonian. The context would assign it the proposition that, if the universe were Newtonian, then, if I were to wear an orange shirt, then no signals would travel faster than light, which is false; if the universe were Newtonian, a signal might travel faster than light no matter my shirt color. So (b) is false in the context. Thus, NP′ has the mistaken consequence that it is not a law that no signals travel faster than light.

Here is a second illustration. Consider the seemingly abominable conjunction, 'It is a law that no signals travel faster than light, but it is possible that there is a signal that travels faster that light'. On the basis of this seeming abominable, one might argue that in contexts where the sentence

(c) It is possible that there is a signal that travels faster than light

is true, the sentence

(d) It is a law that no signals travel faster than light.

is false. Adopting the semantics of modals discussed in Sect. "Genuine Modality?", it is easy to see what a context in which (c) is true might be like. It could be one with a sparse set of selected background facts, one in which pretty much only the logically true sentences are counted as necessary. In such a context, one in which sentence (c) is true and sentence (d) is false, it is plausible that the following sentence is also true:

(e) If I were to wear an orange shirt, then it might be that some signal travels faster than light.

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If so, then even though really it is a law that no signals travel faster than light, there is a context in which (b) is false. More trouble for NP′.

Concluding thought

Whether these counterexamples work depends on matters of language, on questions like what exactly a context is, how conversational suppositions affect context, what features of contexts determine the truth of 'possible' sentences, etc. This itself is worrisome. It is surprising that in what is essentially a metaphysical investigation so much turns on these issues in linguistics and the philosophy of language. The importance of these issues is a sign that something extraneous is among Lange's lawmakers. Though he plausibly identifies *subjunctive facts* as lawmakers, he also—unwittingly if he took 'is a law' to be context independent—identifies *linguistic facts* as lawmakers too. Though Thorne should have to consider how events would be changed were surrounding conditions different, he shouldn't have to be up on the semantic role of contexts.[19]

Author's Response: Marc Lange

That laws are intimately tied to counterfactuals and necessity has long been recognized explicitly:

> [T]he laws of the physical world … unfold … the rules according to which the phenomena of nature take place, and must take place (Whewell 1837, 97).
>
> The very idea of a law includes that of contingency. … if such a case arise, such a course shall be followed,—if the match be applied to the gunpowder, it will explode. Every law is a provision for cases which *may* occur, and has relation to an infinite number of cases that never have occurred, and never will. Now it is this provision … for contingencies, this contemplation of possible occurrences, and predisposal of what shall happen, that impresses us with the notion of a *law*… (Herschel 1830, 36).

Subjunctive conditionals (to which Herschel alludes) express facts about what would happen: "subjunctive facts". I argue that subjunctive facts are the lawmakers.

I know no way to pick out a subjunctive fact except by the conditional that (in some context) expresses it. Thus, it is inevitable that NP and stability, though concerned with lawhood's relation to subjunctive facts, invoke sentences in contexts (as Carroll notes).

However, a conditional may mislead regarding the subjunctive fact it expresses, so we must proceed carefully in using conditionals to pick out lawmakers. For example, I argue (pp. 197–8) that in a certain context, the conditional

> Had the syringe been filled with arsenic, then such a dose of arsenic would not always have been lethal

19FL01 [19] As always, thanks to John Roberts and Marc Lange for our on-going conversations about lawhood.

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expresses a subjunctive fact better expressed when the antecedent is supplemented with "and the patient lived." This subjunctive fact is no threat to the laws' stability or NP since this conditional is a counterlegal. The original conditional was implicitly so.

Similar considerations apply when context equips a conditional not with a tacit clause in its antecedent but with a new antecedent altogether—making a nested conditional. If Carroll is correct, then in a certain context where the universe is supposed Newtonian, the subjunctive fact expressed by

> Were I wearing an orange shirt, no signals would be superluminal

is better captured by

> Were the universe Newtonian, then were I wearing an orange shirt, no signals would be superluminal.

This conditional's falsehood is no threat to NP or the laws' stability since its first antecedent is not sub-nomic (and is also counterlegal). (Analogously, in Carroll's "second illustration", the nested conditional's first antecedent is roughly "Had there been no laws beyond the broadly logical truths".) Again, my aim is to relate laws to subjunctive facts, and insofar as conditionals are imperfect (but indispensable) means of identifying subjunctive facts, such cases are inevitable.

Similarly, Woodward thinks

> Were the majority of informed physicists in 2100 to believe that GTR's equations are false, then they would be false

sometimes expresses "facts (or recommendations) about reasonable belief revision", and its truth then violates NP and the laws' stability. I say that if this conditional is ever so used, then on those occasions it expresses either the fact better expressed by the indicative conditional

> If informed physicists in 2100 believe GTR's equations to be false, then the equations really are false

or the fact better expressed by the subjunctive conditional

> Were I to learn that informed physicists in 2100 believe that GTR's equations are false, then I would stop believing those equations true.

The subjunctive fact that this last conditional expresses is no threat to NP or the laws' stability (since the laws are preserved under its antecedent). Nor is there any threat from the indicative conditional's truth, which is not a subjunctive fact at all.

Woodward asks how "subjunctive fact" should be understood so that the original conditional—taken as expressing facts about proper belief revision—does not qualify as expressing a subjunctive fact, whereas a subjunctive fact is expressed by

> Had Coulomb's law been violated in the past, it might have been violated in the future.

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I say that a subjunctive fact is not a fact about how we ought to revise our beliefs. Rather, it concerns the world—e.g., the way charged bodies would behave ("Had Coulomb's law been violated…") or the way I would behave ("Were I to learn…").[20] (More on this below.)

Loewer nicely summarizes my treatment of ordinary subjunctive conditionals where Lewis says the antecedent would be realized by a "miracle" violating actual laws. I say (p. 201) that in such contexts, how the antecedent would come about lies "offstage": no conditionals in such contexts express propositions about that. Stories also typically work in this fashion:

> In all narratives, there is a beauty to the merely given, as the narrator does us the honor of trusting that we will take it for granted. Conversely, there is something offensive in the implication that we might resent that pact, and, like plaintive children, demand to have everything explained (Lane 2009, 80).

But (Loewer asks) what if we entertain "Had Nixon pressed the button…" while properly considering how the antecedent would have arisen? There are two possibilities. First, suppose some but not all earlier times are onstage. In such a context, no counterfactual is true that posits a "miracle" bringing about some event because the causes of the earliest onstage events lie offstage. The second possibility is that every earlier time is onstage. Then, once again, no counterfactual is true that posits a "miracle" bringing about some event. Rather, in such a context (e.g., when we are illustrating how remarkable a deterministic universe would be),

> Had Nixon pressed the button, every prior moment would have been different somehow from how it actually was

is true (p. 201). In neither context is NP or the laws' stability violated.

Carroll correctly understands the Myrtle Beach example as intended to challenge NP_{TC} and similar principles. In the familiar sort of post-trip conversation, "Had Myrtle Beach been 100 miles nearer Chapel Hill" is an irrelevant counterfactual antecedent,[21] so facts about the towns' locations behave like laws in being preserved under all antecedents relevant in that context. Their behavior in other contexts manifests their accidental character.

I was not considering whether NP_{TC} *follows* from NP plus other premises. Rather, I took NP as a rough approximation requiring refinement to accommodate several factors, notably counterfactuals' context dependence. NP_{TC}, one possible refinement, fails. I agree with Carroll that "It is a law…" is context dependent: in a given context, it may refer to lawhood in some particular scientific field, with different fields implicit in different contexts.

20FL01 [20] Re Woodward's note 4: T is unstable since Coulomb's law might have been violated in *s*'s backward
20FL02 light cone, had it been violated at spacelike separation from *s*.

21FL01 [21] That it is an irrelevant *antecedent* is compatible with *propositions* about the towns' locations being
21FL02 relevant (just not as counterfactual antecedents).

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For simplicity's sake, I took natural law *simpliciter* as my principal target. But I mentioned how further refinement extends the account to lawhood in a particular science. Roughly:

> *m* is a law *of a given scientific field* exactly when for any conversational context *that is relevant in that field* and for any *p* that is a relevant counterfactual antecedent in that context and logically consistent with all of the laws *of that field* (taken together), $p \rightarrow m$ is true in that context. (p. 193)

The contexts relevant in a given discipline are those where certain sorts of considerations are relevant and certain other sorts irrelevant. For example, island biogeography ("IB"—see Lange 2002) deals with the abundance, distribution, and evolution of species living on separated habitat patches. Because IB is not concerned with geophysical considerations, an IB law need not be preserved under "Had Earth lacked a magnetic field", though this antecedent is logically consistent with all IB laws. This is an irrelevant antecedent in an IB context.

But under any IB-relevant antecedent that is logically consistent with IB laws, an IB law must be preserved *in any context that is relevant in the field*. In many different contexts, species' distributions (etc.) are relevant and geophysical considerations are not. IB laws must be preserved in all of them. In one such context (to take a Goodmanesque example), "Had Montserrat and Jamaica been the same size" posits Montserrat enlarged to Jamaica's actual size, whereas in another such context, the same antecedent posits Jamaica reduced to Montserrat's actual size.

In the Myrtle Beach example, I presumed that facts about the towns' locations are not matters of law (at least for the scientific field at issue). Perhaps, there is a field (twentieth first century auto navigation?) where the locations of Chapel Hill and Myrtle Beach are matters of law. However, the point illustrated by the example still stands: an accident in a given field may exhibit the same invariance as the field's laws do *in one context that is relevant in that field*, but not in all such contexts.

That various generalizations currently important in science qualify on my account as laws of certain "special sciences" is one response to Woodward's charge that few (if any) such generalizations are laws by my lights. But even if my account entailed that no genuine laws have been discovered yet, I would not mind—as long as my account captures a kind of fact that science appropriately *seeks* to discover for use in certain important roles. Though Maxwell's equations are not laws of fundamental physics if they fail at certain scales, their discovery nevertheless revealed much about those laws (and meta-laws).

Woodward's proposal (emphasizing invariance under "some substantial range" of initial and boundary conditions including some produced by "testing interventions" manipulating the generalization's independent variables) lowers the bar too far to capture the laws' characteristic necessity and explanatory role. Consider a generalization agreeing with Coulomb's law except as regards one arbitrary uninstantiated combination of charges and separation—concerning which it predicts a force departing wildly from the prediction made by Coulomb's law. (For argument's sake, consider Coulomb's law exceptionless.) Its range of invariance under "testing interventions" is nearly as broad as Coulomb's law's (being smaller by just one combination of the independent variables). It exhibits invariance under a "substantial

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range" of counterfactual antecedents. Yet it is not a law (and, though true, belongs to no non-maximal stable set). An actual case conforms to it not because all cases have got to, but because per happenstance, its demands in all actual cases agree with those of Coulomb's law and all cases must conform to Coulomb's law.

Conversely, a generalization constituting a special case of Coulomb's law for a single combination of charges and separation is not invariant under any "testing interventions" since the generalization contains no independent variables to manipulate. Therefore, the generalization answers no questions about what would have happened, had the charges or separation in some case been different. Whereas Woodward deems it non-explanatory (Woodward and Hitchcock 2003, 194), it is a law on my account—and would seem to have a law's characteristic explanatory power regarding the narrow range of cases in its scope. (Why do they all involve the same electrostatic force? Because given their charges and separation, they must.) Significantly, Woodward (unlike me) does not regard "It is a law that m" as explaining why m obtains. Concerning this "must": I agree with Carroll that a semantics for a merely conversational modality could enshrine principle M. But actual merely conversational modalities do not—or, if they do, then pressure to comply with M makes all relevant facts into necessities. To argue for this, at least, was my aim with the prune-sale conversation (pp. 67–71).

Ontologically basic subjunctive facts violate what Loewer calls "Dummett's Dictum." But what argument for this "Dictum" does Dummett deliver? Regarding the conditional

Were Jones to attempt to learn a foreign language, he would quickly succeed,

Dummett (1993, 54) seems sympathetic to the view that it is made true by "some feature of brain structure". Yet to render the conditional true, facts about that feature would have to be supplemented (Goodman argued) by the fact that the feature would persist, were Jones to attempt to learn a foreign language, and by the laws governing the feature's behavior. Analogous considerations apply if the conditional is made true by the fact that Jones is good at learning languages (another option Dummett finds congenial); this fact must be understood as a "permanent" (i.e., counterfactually invariant) condition (1993, 55). Dummett's Dictum dims.

I treat basic subjunctive facts much like basic sub-nomic facts. Unsurprisingly, then, they are plentiful. Moreover, just as the fact that m *or* n may be made true by the fact that m, so perhaps the fact that $p \mathrel{\square\!\!\rightarrow} (m \text{ or } n)$ may be made true by the fact that $p \mathrel{\square\!\!\rightarrow} m$. My arguments presuppose nothing about this—or about whether

Had Nixon pressed the button, there would have been a nuclear war

expresses a basic subjunctive fact. The principles of counterfactual logic underlying my arguments regarding stability are largely just the familiar ones. Where I depart from orthodoxy—for example, in denying $(p \mathrel{\square\!\!\rightarrow} m) \rightarrow \sim(p \Diamond\!\!\rightarrow \sim m)$—I give independent arguments (pp. 195–6). Likewise, I insist that from $(p \mathrel{\square\!\!\rightarrow} q)$ and q logically entailing r, it does not follow that $(p \mathrel{\square\!\!\rightarrow} r)$ unless r lies "onstage" (p. 206). But this seems a minor caveat, having independent motivation. (*Why* do subjunctive facts uphold certain principles of counterfactual logic? A possible worlds semantics nicely explains why; I offer no rival account, Loewer says. That's

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true. A "lacuna" indeed! It is noteworthy, though, that modest constraints on the "stability" at issue highly constrain the logic of the conditionals figuring in the definition of "stability". For example, the condition in the definition that a stable set be closed under logical consequence should serve merely to consolidate various sets displaying the requisite counterfactual invariance: if $m,\ldots,n$ span set Γ and have the invariance required for stability, then Γ's stability should follow. This entails that for whatever conditional ($\Box\rightarrow$) figures in stability, if $p\Box\rightarrow m$, …, $p\Box\rightarrow n$ all hold and $m\&\ldots\&n$ logically entails r (where r is "onstage"), then $p\Box\rightarrow r$. How far do such constraints on the sort of "stability" that should be associated with lawhood, necessity, etc. go in constraining the sort of conditional figuring in "stability"? Furthermore, a refined notion of stability (p. 153) places subjunctive conditionals not only in the definition of "stability" but also in the stable set. I wonder what constraints on the logic of these conditionals are imposed by the fact that the logical truths (including those involving these conditionals) must form a "stable" set.)

Woodward joins me (I think) in countenancing violations of "Dummett's Dictum" since the counterfactuals associated with IN "have a relatively straightforward physical interpretation", he says—but this interpretation involves counterfactuals:

> We are to think of nature or an experimenter as … realizing a range of different initial or background conditions, and … IN requires that the candidate generalization continue to hold in the sense of describing how nature would behave under some range of these alternative conditions.

Having resisted "reductive" accounts of IN's counterfactuals, Woodward fails to warmly welcome

> Had Coulomb's law been violated in the past, it might have been violated in the future.

Why should he be so unwelcoming? This counterfactual seems amenable to the same "physical interpretation" Woodward gives the counterfactuals he favors: in terms of how nature would (or might) have behaved had different initial or boundary conditions been realized—in this case, any of various counterlegal combinations of charge, separation, and electrostatic force. (Woodward has not deemed all counterlegals problematic.[22])

Science confirms the truth of such counterfactuals in exactly the way that science confirms predictions about actual unexamined cases. Indeed, they are confirmed together. Having discovered that the laws governing certain processes exhibit various symmetries and conserve various quantities, physicists justly regard this evidence as confirming that if there are (or had there been) further processes, the laws governing them are (or would have been) likewise symmetric and conservative. Subjunctive facts that Woodward finds problematic are crucial to Einstein's insight that the Lorentz transformations do not rest on electrodynamics (Lange forthcoming) and were commonly invoked by physicists arguing that parallelogram

[22] Woodward's "substantial range" of invariance could extend to counterlegal antecedents. Moreover, interventions on C break C's causal connections and so can violate laws (2003, §3.5).

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of forces is explained neither by Newton's second law nor by the principle of the transmissibility of force (Lange 2009).

My account of law is distinctive in recognizing that laws may come in strata. Central scientific roles are played by counterfactuals like

> Had the force laws been different so that photons, gravitons, and other particles that actually possess zero mass instead possessed non-zero mass, the Lorentz transformations would still have held (Lévy-Leblond 1976, 271).

If Woodward holds that such counterfactuals are unjustifiable empirically and alien to science, then I demur. If he says that a general account of their empirical confirmation would be nice to have, then I agree! The same goes for the confirmation of sub-nomic facts and of IN's conditionals. If Woodward insists that we cannot assess my proposal until we have such an account, then I don't see why. Woodward's view of such counterfactuals reminds me of Gwendolen's in *The Importance of Being Earnest*:

> GWENDOLEN: My own Ernest!
> JACK: But you don't really mean to say that you couldn't love me if my name wasn't Ernest?
> GWENDOLEN: But your name is Ernest.
> JACK: Yes, I know it is. But supposing it was something else? You don't mean to say you couldn't love me then?
> GWENDOLEN [glibly]: Ah! that is clearly a metaphysical speculation, and like most metaphysical speculations has very little reference at all to the actual facts of real life, as we know them.

I am with Jack—and (I believe) science.

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