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MARC LANGE

A COUNTERFACTUAL ANALYSIS OF THE CONCEPTS OF LOGICAL TRUTH AND NECESSITY

ABSTRACT. This paper analyzes the logical truths as (very roughly) those truths that would still have been true under a certain range of counterfactual perturbations. What's nice is that the relevant range is characterized without relying (overtly, at least) upon the notion of logical truth. This approach suggests a conception of necessity that explains what the different varieties of necessity (logical, physical, etc.) have in common, in virtue of which they are all varieties of necessity. However, this approach places the counterfactual conditionals in an unfamiliar foundational role.

I.

In this paper, I shall offer a new account of the concept of logical truth – an alternative to the standard, model-theoretic explications associated with Tarski. How successful we judge my proposal to be may depend to some extent on what we would like to see in an account of logical truth. So let's start by briefly considering some possible criteria of adequacy.

Carnap (1950, p. 5) famously tells us that a successful explicans strikes an appropriate balance among the following desiderata: (i) being coextensive with the explicandum; (ii) being capable of an explicit, clear, precise formulation; (iii) being fruitful; and, less importantly, (iv) being simple. While these criteria of adequacy are obviously reasonable, how we should apply them to a proposed account of logical truth depends in crucial respects on our other philosophical commitments and projects.

Take, for instance, the desideratum that the analysis pick out a range of truths coextensive with what we would pre-theoretically identify as the "logical truths." One goal here is to distinguish the logical truths from the ordinary, garden-variety truths. But another goal may be to distinguish the logical truths from other truths that are far from ordinary – namely, from mathematical truths, conceptual truths, metaphysical truths, such truths as "All red objects are colored" and "If Abe is taller than George, then George is not taller than Abe," and other truths that possess some sort of necessity (such as the "physical necessity" characteristic of the laws of nature). How important we deem this latter goal to be, and what we believe necessary to achieve it, will depend heavily on our philosophical views regarding these other necessary truths. Whether we deem set-theoretic truths to be mathematical or logical, whether we take a more expansive or more austere view of the range of metaphysical truths, and other controversial views will influence our judgement of the degree to which Carnap's first desideratum is satisfied by some proposed explication of logical truth.

The same goes for Carnap's other desiderata. Whether we take a given proposal as offering a clear explication will depend on whether or not we interpret "clarity" as demanding that the explication "reduce" the fact that L is a logical truth to something metaphysically more fundamental (and, if so, on what sorts of facts we take to be metaphysically more fundamental). Even if an account does not purport to identify the "truth-maker" of the fact that L is a logical truth, the account may nevertheless be philosophically very fruitful, in the sense of Carnap's third desideratum. But again, our other philosophical commitments and projects will quite properly influence how valuable we judge a proposal's various potential dividends to be. Quine, for instance, does not regard it as a weakness of Tarski-style model-theoretic accounts that they fail to relate logical truth to necessity, whereas Putnam (forthcoming, lecture 3) does see this as a defect. Insofar as we are prepared to countenance various other kinds of necessity (mathematical, metaphysical, conceptual, physical ...), we surely ought to seek an account of logical truth that not only explains what it is about the logical truths that makes them "necessary" in a distinctive sense, but also offers the prospect of a unified treatment of all varieties of necessity. And, of course, many philosophers would like an explication of logical truth to be fruitful epistemologically – by supporting some account or other of how we know some logical truth L to be true and, moreover, to be *logically* true.

A Tarski-style analysis might say that "a logical truth is a statement which is true and remains true under all reinterpretations of its components other than the logical particles" (Quine, 1961, pp. 22–23), or it might say that a logical truth is "a sentence for which we get only truths when we substitute sentences for its simple sentences [i.e., for its sentences containing no logical vocabulary]" (Quine, 1970, p. 50). Both versions presuppose a distinction between logical and nonlogical vocabulary, for which Tarski (1956, pp. 418–420) offers no ground. Perhaps this degree of freedom offers an opportunity to give different flavors of necessity a unified treatment, in terms of different vocabularies being held fixed. (But then would *every* selection of some vocabulary to privilege correspond to a variety of *necessity*?) On the other hand, perhaps this account, unless supplemented by a principle demarcating the logical vocabulary, is marred by a built-in *ad hoc* privileging of certain vocabulary, or even by a kind of circularity in analyzing "logical truth" in terms of "logical vocabulary" (Sher, 1996, p. 663).

Accounts exhibiting circularity of a more blatant kind presumably fall even further from Carnap's ideal of clarity. For instance, according to the non-Tarski-style approach that Etchemendy (1990, p. 20) calls "representational semantics," L is a logical truth if and only if L is true in all models, where "the class of models should contain representatives of *all* and *only* intuitively possible configurations of the world" (Etchemendy, 1990, p. 23). Of course, insofar as we have an intuitive grasp of which configurations of the world are possible, we can use this approach to distinguish the logical truths. Yet without some independent account of what is possible, representational semantics apparently amounts to little more than the thesis that the logical truths are exactly the truths that are true in every configuration of the world in which the logical truths are true. As it stands, this analysis can do little to clarify the notion of logical truth. Nor can this analysis by itself suggest that there is anything special or important about the logical truths; we would have to know already that there is something special or important about the set of configurations in which the actual logical truths all remain true. After all, one could just as well speak of the "Washington truths": exactly the truths that are true in every configuration of the world in which George Washington remains the first President of the United States.

My purpose here is not to evaluate, or even to survey, various alleged defects in standard Tarski-style analyses of logical truth. (For discussion, see Etchemendy (1990), Sher (1996), and references therein.) For even if those analyses were uncontroversial, an alternate analysis might retain considerable interest. As I shall explain, the following account would (I think) still be valuable even if it turned out ultimately to fall short of being a genuinely non-circular analysis of logical truth.

II.

Let's sneak up on the *logical* necessities by first examining one strategy for picking out the *physical* necessities (i.e., the laws of nature and their logical consequences). Implicit in the notion of a law of nature is that the laws *govern* the universe.[1] Some laws are meta-laws; they govern other laws. For example, it is a law that all laws are Lorentz-invariant. This fact can be expressed in the form "It is a law that L" where L (that all laws are Lorentz-invariant) itself expresses a fact that is nomic, and hence modal. Other laws are not meta-laws but rather lie further down in the hierarchy of governance. These laws govern non-modal facts – that is to say, facts at the very base of this hierarchy, facts that are governed but neither govern anything themselves nor concern what does the governing.[2] For example, it is a law that all electrons are negatively charged. This fact can be expressed in the form "It is a law that L" where L is a non-modal fact. Let's consider the non-modal facts, i.e., the facts residing the bottom of the hierarchy of governance. Let capital letters A, B, C, ... be variables standing for sentences that, if true, state such facts.[3] Among these facts, what sets apart those that possess physical necessity? (By a "physical necessity," I mean a non-modal fact that is a logical consequence of various facts A, B, C, ... all taken together, where it is a law that A, a law that B, etc.)

A counterfactual conditional, such as "Had I gone shopping, then I would have spent a great deal of money," is a subjunctive conditional with a false antecedent. Let "A > C" stand for the subjunctive conditional "Were it the case that A, then it would be the case that C." (Or, in the past tense: "Had it been the case that A, then it would have been the case that C.") Since the work of Goodman (1983) and Chisholm (1946, p. 302), it has been widely accepted that physical necessities stand in an especially intimate relation to counterfactual conditionals. In particular, many philosophers (such as Bennett, 1984; Carroll, 1994; Chisholm, 1946; Goodman, 1983; Horwich, 1987; Jackson, 1977; Mackie, 1962; Pollock, 1976; Strawson, 1952) have endorsed principles along roughly these lines:

(1) P is a logical consequence of the laws of nature (i.e., is physically necessary) if and only if $Q > P$ for every Q that is physically possible (i.e., logically consistent with every logical consequence of natural laws).

According to (1), every law of nature would still have held under any subjunctive antecedent that does not itself violate the natural laws. For example, had I arrived at my bus stop this morning just after my bus for work had left, and in frustration clicked my heels three times and made a wish to arrive instantly at my office some miles away, then my wish would not have come true, since the actual laws of nature would have remained in force. Principle (1) also says that for any P that does not follow from the laws of nature alone, there is a subjunctive antecedent that does not violate the natural laws and under which it is not the case that P would have held. (This is trivial. If P is an accidental truth, i.e., a physically unnecessary truth, then $\sim$P is such an antecedent, whereas if P is false, then any truth will serve as such an antecedent.[4]) Principle (1) accords with the routine scientific practice of using what we believe to be the natural laws to tell us something about what the world would have been like, had various initial or boundary conditions been different in various respects.

It has been widely appreciated that counterfactual conditionals are extremely context-sensitive. As Lewis puts it:

> The truth conditions for counterfactuals [,] ... like the relative importances of respects of comparison that underlie the comparative similarity of worlds, ... are a highly volatile matter, varying with every shift of context and interest. (1973, p. 92)

Principles like (1) are intended by their advocates to hold regardless of the context. Principle (1) demands that if P is physically necessary, then no matter what the context, $Q > P$ is true for any

Q that is physically possible.[5] For example, suppose we consider what would have happened had Jones jumped from the window ledge. The assertion that Jones would probably have suffered serious injury is true in certain conversational contexts. In other contexts, however, this assertion is false; instead the truth is that Jones would probably have arranged in advance for a net to be stationed below, and so Jones would probably not have suffered serious injury.[6] Different contexts may require that somewhat different features of the actual world be held fixed under a given counterfactual supposition. But according to principle (1), there is no context in which it is true that had you jumped from the window ledge, the actual laws of nature would have been suspended so that you would have floated safely back inside. (If you believe that there is a context in which this counterfactual is true, then I cannot trust you near open windows.)

My reason for mentioning principle (1) is that an analogous principle appears to hold for the *logical* necessities, namely,

(2) P is a logical truth if and only if Q > P is true (whatever the context) for every Q that is logically possible (i.e., logically consistent with every logical truth).

According to principle (2), the logical truths would still have held under any subjunctive antecedent that does not itself violate some logical law. For example, had I arrived at my bus stop this morning just after my bus for work had left, and in frustration clicked my heels three times and made a wish to arrive instantly at my office some miles away, then either my wish would have come true or it would not have come true. Principle (2) also says that for any P that is not a logical truth, there is a subjunctive antecedent that does not violate the logical laws and under which it is not the case that P would have held. (If P is a logically contingent truth, then ∼P is such an antecedent, whereas if P is false, then any truth will serve as such an antecedent.)

Principle (2) guarantees that a given logical truth P would still have held under some counterfactual supposition Q, where Q is logically possible. But principle (2) leaves it open for ∼P, a logical falsehood, to join P in holding under that supposition. Surely, we should rule this out through a principle like the following:

(3) P [∼P] is logically false if and only if ∼P [P] is logically true. If P is logically false, then ∼(Q > P) is true (whatever the context) for every Q that is logically possible (i.e., logically consistent with every logical truth).

So according to principles (2) and (3), if P is logically false, then under any counterfactual supposition Q where Q is logically possible, ∼P holds and P does not.

Of course, these three principles do not suffice to explicate "natural law" and "logical truth," since in each principle, the target appears on both sides of the (bi)conditional. However, the analogy between principles (1) and (2) is very suggestive. By generalizing these principles, I shall eventually arrive at a novel characterization of logical truth.

Consider a set Γ of sentences A, B, C, etc. – that is, of sentences that purport to state non-modal facts. How can we pick out which of these facts are physically necessary, which are logically necessary, and which are neither? As a first approximation to the account that I am gradually working towards, let's say that Γ is "stable" exactly when

(i) Every member of Γ is true (i.e., if P ∈ Γ, then P),
(ii) Γ is logically closed as far as non-modal facts are concerned (i.e., if P is a logical consequence of some members A, B, C . . . of Γ, then P is a member of Γ),[7] and
(iii) If P is a member of Γ and Q is logically consistent with every member of Γ (i.e., Γ ∪ {Q} is logically consistent), then Q > P is true (whatever the context).

Condition (iii) is going to be the generalization of principles (1) and (2). This definition says that a logically closed set of truths is "stable" exactly when every member of the set would still have been true under any counterfactual antecedent under which it is logically possible for *all* of the set's members still to be true. (For Γ to be stable, the counterfactual conditionals demanded by (iii) above must be true regardless of the context – just as principles (1)–(3) demand that certain counterfactuals hold no matter what the context.) According to principle (1), the laws of nature and their logical consequences form a stable set. According to principle (2), the logical truths form a stable set.

It is easily shown that if Γ and Σ are distinct stable sets, then one must be a proper subset of the other. Let's demonstrate this by *reductio*: suppose that sets Γ and Σ are stable, claim T is a member of Γ but not of Σ, and claim S is a member of Σ but not of Γ. Then (∼S or ∼T) is logically consistent with every member of Γ, since otherwise, some members of Γ would have to logically entail ∼(∼S or ∼T), i.e., (S and T), and hence some members of Γ would have to logically entail S. But Γ is stable, so (by condition (ii) in the definition of "stability") Γ is logically closed (as far as non-modal facts are concerned), and so since some members of Γ entail S, S must be a member of Γ, contrary to our initial supposition. Now since (by hypothesis) Γ is stable and, as we have just shown, (∼S or ∼T) is logically consistent with every member of Γ, it follows (by condition (iii) in the definition of "stability") that every member of Γ would still have been true, had it been the case that (∼S or ∼T). In particular, then, (∼S or ∼T) > T is true (whatever the context). Therefore, (∼S or ∼T) > ∼S. But by applying to Σ the same reasoning we just applied to Γ, we find that (∼S or ∼T) is logically consistent with every member of Σ, and so (∼S or ∼T) > S. But surely, it cannot be that (∼S or ∼T) > (S and ∼S)! (After all, (∼S or ∼T) is logically possible, albeit false, since as we have seen, (∼S or ∼T) is logically consistent with every member of Γ. So (∼S or ∼T) > (S and ∼S) would violate principle (3).)

Thus, given any two stable sets, one must be a proper subset of the other. The stable sets form a hierarchy. At one extreme of the hierarchy is the null set. Since it has no members, it is trivially the case that every member of this set would still have been true under various counterfactual antecedents. At the other extreme of the hierarchy is the set of all (non-modal) truths. Any counterfactual antecedent Q is false, and hence logically inconsistent with some member of this set, so there is no counterfactual antecedent Q under which every member of this set would have to still have been true in order for this set to qualify as "stable." This set trivially satisfies condition (iii) in the definition of "stability," since Q > P holds automatically if P and Q are true.

The hierarchy of stable sets, then, consists at least of the empty set, the set of logical necessities, the set of physical necessities, and the set of all truths. Since any proper subset of the set of logical truths fails to be logically closed, the set of logical truths is *the smallest nonempty stable set*. That is a first approximation to my proposed analysis of the concept of logical truth.[8]

III.

The explicans that I have just floated appears to be coextensive with the explicandum. On the other hand, my proposal obviously uses counterfactual conditionals in order to get a grip on logical truth. This might seem to be metaphysically back-to-front: if our goal was to reveal the truth-makers of the logical truths, then we are now stuck with first having to understand what makes various counterfactual conditionals true. That is fraught with peril. If counterfactual conditionals are ontologically more basic than logical truths, we are really up against it!

Of course, as noted earlier, an analysis of logical truth may be philosophically very fruitful even if it does not purport to reduce logical truth to something metaphysically more fundamental. But to concede even this much to the objection is unnecessary. Of course, it would be bizarre to suppose that some logical truth L, such as "Either Abe is Marc's son or it is not the case that Abe is Marc's son," is true in virtue of the truth of various counterfactual conditionals. But the proposed explication, even interpreted "reductively," demands no such thing. Rather, it demands (under a "reductive" interpretation) that the fact that L is a *logical* truth (or is *logically necessary*) reduce to some fact about which counterfactual conditionals obtain.

Those who crave a reductive analysis naturally want the reductive base to be pure: uncontaminated by the same mysterious elements as whatever they are trying to reduce to it. Now although a counterfactual $Q > P$ is plenty mysterious, it does not refer to *logical* truth or to any sort of *necessity* or *possibility* (since its antecedent Q and consequent P are themselves non-modal). So it might indeed amount to some progress, even for a reductive project, to analyze "L is a logical truth" in terms of the truth of such counterfactuals.

On the other hand, rather than various counterfactuals being responsible for some truth's logical necessity, it might be that various facts of the form "L is a logical truth" make certain counterfactuals true. Regarding this question of metaphysical priority, I offer no hypotheses.

The analysis floated in the previous section is not blatantly circular in the manner of representational semantics. Admittedly, some logical vocabulary appears in my definition of a "stable" set, since that definition refers to a set's being "logically closed" and to a counterfactual antecedent's being "logically consistent" with every member of the set. But not every use of logical vocabulary in an account of logical truth automatically renders that account uninteresting. (Otherwise it is difficult to imagine what sort of analysis would be interesting.) Unlike representational semantics, the proposed analysis does not build in some special role for the logically possible worlds, as against some other range of possible worlds, which then immediately becomes the basis for distinguishing the logical truths from other truths. Rather, the range of counterfactual antecedents under which the members of a set Γ must remain invariant, in order for Γ to qualify as "stable," is determined by Γ itself. Not, of course, by Γ *all by itself*, since Q's *logical consistency* with every member of Γ is what determines whether Q falls within the relevant range. Nevertheless, in so employing the concept of logical consistency, the account does not arbitrarily privilege the range of logically possible worlds over other ranges, as representational semantics does, or arbitrarily privilege the logical connectives over other vocabularies, as Tarski-style substitutional accounts have been accused of doing.[9]

There is, perhaps, a more effective response to the charge of vicious circularity. Let's redefine "stability" as follows:

Γ is stable if and only if

(i) Every member of Γ is true (i.e., if $P \in \Gamma$, then P)

(ii) If P is a member of Γ, then (Q > P) is true (regardless of the context) for every Q such that ∼Q is not a member of Γ.

This definition avoids any reference to "logical consistency" or "logical closure."

Now I shall argue that Γ is stable, according to this new definition, if and only if Γ is stable according to my original definition (in the previous section).

First, I argue that every set that qualifies as stable, according to the new definition, is logically closed as far as non-modal facts are concerned.

For suppose that Γ contains only truths (satisfying requirement (i) above), P is an element of Γ, but Γ is not logically closed as far as non-modal facts are concerned. Without loss of generality, suppose that (P ⊃ ∼Q) is a logical truth but ∼Q is not a member of Γ. For Γ to be stable (by the above definition), requirement (ii) demands that Q > P be true (whatever the context). There are two cases.

In case 1, ∼Q (a truth, since it is a logical truth that P ⊃ ∼Q, and P is true since P is a member of Γ, which by hypothesis contains only truths) is not a logical truth, and so Q is not logically false. Then principles (2) and (3) (from section II) apply to Q as a counterfactual antecedent. Since it is a logical truth that (P ⊃ ∼Q), it is a logical truth that (Q ⊃ ∼P), and so it follows by principle (2) that Q > (Q ⊃ ∼P), and thus that Q > ∼P. So Q > P (which is demanded by Γ's stability) would require Q > (P & ∼P), which is false (by principle (3)). So in case 1, Γ is not stable.

In case 2, ∼Q is a logical truth, and so Q is logically false. Then principles (2) and (3) fail to apply to Q as a counterfactual antecedent. Some philosophers contend that if Q is logically false, then for any P, ∼(Q > P) is true.[10] In that event, once again Γ is unstable. But I am not convinced that all counterlogicals are (trivially) false. Perhaps there is a context in which it is true that had Q been the case, then I would have received five additional points on my logic homework (since in the course of answering the homework questions, I mistakenly took Q to be true). However, as I have mentioned, counterfactuals are notoriously context sensitive. I find it difficult to imagine that there are any counterfactuals (Q > P), where ∼Q is a logical truth, that hold regardless of the context, as Γ's stability demands.[11]

I conclude that Γ is stable, by the above definition, only if Γ is logically closed as far as non-modal facts are concerned. Therefore, it is harmless to add such logical closure to the above definition as a further requirement for stability. In other words, the sets that qualify as stable, by the above definition, are exactly the sets Γ such that

(i) Every member of Γ is true
(ii) Γ is logically closed as far as non-modal facts are concerned
(iii) If P is a member of Γ, then (Q > P) is true (whatever the context) for every Q such that ∼Q is not a member of Γ.

But if Γ is logically closed as far as non-modal facts are concerned, then ∼Q is not a member of Γ if and only if Q is logically consistent with every member of Γ. Therefore, in the above (iii), it is harmless to replace "for every Q such that ∼Q is not a member of Γ" with "for every Q that is logically consistent with every member of Γ." This leaves us with exactly the definition of "stability" that we arrived at in the previous section. So the sets that qualify as stable by the definition I just introduced, which makes no reference to "logical closure" or "logical consistency," are exactly the sets that qualify as stable according to the original definition of "stability."

This revised notion of "stability" apparently allows us to avoid any threat of vicious circularity in defining the logical truths as the members of the smallest nonempty stable set. The revised notion of "stability" also addresses a second objection that might have been raised against the account floated in the previous section. It might have been objected that in stipulating that a "stable" set must be logically closed, I simply equipped my definition of "stability" with an *ad hoc* device for prohibiting any non-empty proper subset of the logical truths from qualifying as stable. This makes it too easy for the set of logical truths to count as the smallest non-empty stable set. In reply, it might have sufficed to point out that the fact that the set of logical truths is the smallest nonempty set that satisfies conditions (i) and (ii) in the original definition of "stability" in no way guarantees that it is going to be the smallest nonempty set that satisfies condition (iii). That the set of logical truths is the smallest nonempty set that, in light of conditions (i) and (ii), is eligible to qualify as stable does not automatically mean that it will succeed in qualifying. So it has not been made especially "easy" for the set of logical truths. Be that as it may, our revised definition of "stability" permits us to avoid the objection more decisively. It contains no *ad* *hoc* device for excluding proper subsets of the logical truths from qualifying as stable.

IV.

If we wanted to know what is especially notable about the logical truths, representational semantics could tell us only if we already recognized that there is something especially noteworthy about the logically possible worlds – which does not represent much progress. Admittedly, my proposal could tell us what is especially important about the logical truths only if we already recognized that there is something especially important about a set's being stable. But appreciating the importance of stability does not presuppose appreciating the importance of the logical truths. Stability, unlike the range of logically possible worlds, has the potential for independent significance. (Here we return to Carnap's desideratum of fruitfulness.) Let's examine this more closely.

Consider a set that is the logical closure of the laws of nature and some accidental generalization, such as Goodman's favorite: "All of the coins in my pocket are silver." Though satisfying conditions (i) and (ii) in the original definition of "stability," this set is not stable.[12] There are counterfactual suppositions that are consistent with every member of this set but under which Goodman's favorite accidental generalization is not invariant – such as "Had I put a penny in my pocket." This argument applies even to an accidental generalization that is invariant under a broad range of counterfactual suppositions. For instance, let the accident be "Whenever my office telephone is not ringing and I pick up my telephone receiver and put it to my ear, I hear a dial tone." This generalization would still have held had I kept different office hours, had I picked up my receiver one hundred times a day, not to mention had the weather been different, had I worn a different shirt this morning, and so forth. Nevertheless, the logical closure of this accident and the laws of nature is unstable. (Had I sometime unplugged the telephone cord . . .)

Although there is a rather wide range of counterfactual suppositions under which this accident would still have held, intuitively we do not regard this accident as possessing any sort of necessity, akin to (although "weaker" than) logical necessity, physical necessity, and so forth. Apparently, no set containing physically accidental truths has a corresponding sense of necessity. In this connection, it is highly suggestive that no set containing physically accidental truths is nontrivially stable. For if we are considering the logical closure of some accidental generalization G (such as Goodman's favorite: "All of the coins in my pocket are silver") and this set does not contain every accidental truth, then we can consider an accidental truth H outside the set (such as Hempel's favorite: "All gold cubes are smaller than one cubic mile") and then form the counterfactual supposition (∼G or ∼H). The set's stability would require that (∼G or ∼H) > (G and ∼H). But when G and H are utterly unrelated, it is hard to imagine that this counterfactual conditional is true (whatever the context). Indeed, with regard to "Had my pocket contained a non-silver coin or some gold cube exceeded one cubic mile," I daresay that in many conversational contexts, neither "... then my pocket would have contained a non-silver coin" nor "... then some gold cube would have exceeded one cubic mile" is true. (All that is true there is "then maybe my pocket would have contained a non-silver coin, but maybe not.")

Let's pursue this apparent correspondence between stable sets and varieties of necessity. Consider the set containing just one law of nature together with its logical consequences. Is this set stable? Apparently not. Suppose the law generating the set is the Lorentz-force law, $\boldsymbol{F} = (q/c)\boldsymbol{v} \times \boldsymbol{B}$, which gives the force $\boldsymbol{F}$ felt by a material point particle with electric charge q moving at velocity $\boldsymbol{v}$ in magnetic field $\boldsymbol{B}$, where c is the speed of light. Now take a natural law that was omitted from the set, such as the consequence of relativity theory that every material body accelerated from rest fails to exceed c. Now had this law been violated, would the Lorentz-force law still have held? (Would the Lorentz-force law have held of bodies moving with speed $v > c$?) The answer is almost certainly "No," though perhaps future discoveries in physics will reveal it to be "Maybe, maybe not." But the set's stability requires that the answer be "Yes." Again, the set is not stable, and there is no special sense of necessity pertaining to all and only its members. The Lorentz-force law and the consequence of relativity theory seem to possess necessity of the very same sort.

However, we can imagine a possible world where the laws of nature come in strata, with each stratum generating a stable set. One stable set might be the logical closure of Newton's laws of motion. Another stable set might be the logical closure of Newton's laws of motion and the laws governing the various forces (e.g., gravity, magnetism, or whatever) operating in this universe. Another stable set might be the logical closure of Newton's laws of motion, the force laws, and the laws specifying the physical properties (e.g., mass, charge, etc.) of the various species of elementary particle (e.g., electrons, muons, or whatever) in this universe. For the first of these sets to be stable, it must be the case that had the various force laws been different (e.g., had gravity been twice as strong), the relation expressed by Newton's second law of motion between a body's mass, the force it feels, and the acceleration it undergoes would have been no different. Likewise, for the second set to be stable, it must be the case that had muons been twice as massive, the force laws would have been no different. My point is that it is intuitively plausible to characterize such a universe as having *three grades of physical necessity*, each corresponding to a stable set.[13] (Science may eventually reveal that the laws of the actual universe form similar strata.)

As we saw in section II, a logically closed set of truths is stable if and only if every member of the set would still have been true under any counterfactual antecedent under which it is logically possible for *all* of the set's members still to be true. In other words, a logically closed set of truths is stable if and only if the range of counterfactual perturbations under which all of those claims are invariant is as broad as it could possibly be. *A stable set has as much invariance under counterfactuals suppositions as it could possibly have*. I suggest that this is what it means for the set of claims to be associated with a sense of *necessity* – since "necessity" is intuitively an especially strong sort of persistence under counterfactual perturbations, but (as we saw) not every fact for which there is a wide range of counterfactual perturbations under which it would still have held qualifies as "necessary" in any sense. Being "necessary" is supposed to be *qualitatively* different from being invariant under a wide range of counterfactual suppositions.

Here is another argument in support of this counterfactual analysis of necessity. Intuitively, if Q is possible and Q > P, then P must be possible; whatever would have happened, had something possible happened, must also qualify as possible. Suppose that what makes something count as "possible," in a particular sense of the word (logically, physically, etc.), is that it is logically consistent with every member of a particular logically closed set of truths, where each sense of "possibility" corresponds to its own particular logically closed set of truths. (Intuitively, of course, the logically closed set of truths associated with a given sense of possibility contains exactly the claims that are "necessary" in the corresponding sense.) What would that set have to be like in order for this view of possibility to respect the principle that if Q is possible and Q > P, then P is possible? On this view of possibility, the principle says that if Q is logically consistent with every member of the relevant set and Q > P, then P is logically consistent with every member of that set. This is guaranteed if the set is stable. (For if Q is logically consistent with every member of a given stable set, then under the counterfactual supposition that Q, every member of that set would still have held, and so – by principle (3) – anything else that would have been the case must be logically consistent with every member of the set.)

Now look what happens if the logically closed set of truths that corresponds to some sense of possibility is unstable: there is some Q, logically consistent with every member of the set, such that ∼(Q > P) for some P belonging to the set. The fact that it is not the case that P would have held, had Q held, means that ∼P might have held, had Q held. But since P belongs to the set, ∼P fails to be logically consistent with every member of the set, and so ∼P is deemed "impossible," on this scheme. Thus, if an unstable set corresponds to some sense of possibility, then had possibility Q obtained, the impossibility ∼P might have obtained. This conflicts with a principle slightly broader than the one introduced in the previous paragraph, namely, that whatever *might* have happened, had something possible happened, must also qualify as possible.

Thus, if the claims expressing possibilities in some sense are exactly the claims that are logically consistent with every member of some logically closed set of truths that is associated with that sense of "possibility," then all and only the *stable* sets are associated with senses of possibility. A set that contains exactly the necessities in some sense must be a stable set.

Here is another route to the same conclusion. Look what happens if the claims that express "possibilities" in a certain sense are exactly the claims that are logically consistent with a certain logically closed but *unstable* set of truths. Since the set is unstable, there is a claim Q, logically consistent with every member of the set, such that for some member P of the set, ∼(Q > P). Perhaps Q > ∼P. At the very least, had Q held, then ∼P might have held, But ∼P is (according to our initial supposition) impossible. To indulge in some "possible worlds" talk: some Q-world is possible (since Q is logically consistent with every member of the set), and yet at least one of the optimally close Q-worlds is impossible, since something impossible (∼P) might have happened had Q held. This result conflicts with the intuition that *any possible* Q-world is closer to the actual world than is *every impossible* Q-world.[14]

On the other hand, suppose that the claims expressing "possibilities" in a certain sense are exactly the claims that are logically consistent with a certain *stable* set. Then if there is a possible Q-world (i.e., if Q is logically consistent with the relevant stable set), then (given principle (3) and the set's stability) whatever might have happened, had Q been the case, must be possible (i.e., logically consistent with the relevant stable set). Hence, one or more *possible* Q-worlds are the optimally close Q-worlds and so, in particular, are closer to the actual world than is every *impossible* Q-world.

All of these arguments display the significance of a set's stability and the fruitfulness of explicating logical truth in terms of stability. It is difficult to resist the conclusion that a logically closed set of truths includes exactly the truths possessing a certain kind of *necessity* if and only if the set is stable. On this view, what makes the set of logical truths and the logical closure of the natural laws *alike* is that they are both nontrivially stable; this common feature is what is captured by characterizing each set's members as *necessary*, though in different senses. Unlike the Tarski-style model-theoretic analyses, the counterfactual analysis of logical truth allows the concept of logical truth to be connected directly to necessity. Moreover, different grades of necessity can be given a unified treatment, but without suggesting that *every* selection of some vocabulary to privilege or *every* logically closed set of truths corresponds to a variety of necessity. For the stable sets are not plentiful. (The "Washington truths," for example, fail to generate one.)

V.

I shall now entertain an objection that cuts right to the heart of this approach: principle (2), i.e., the stability of the set of logical truths. Consider the counterfactual: Had Gödel denied the "law" of double negation, then the "law" of double negation would (probably) have been false and its negation true. We can imagine perfectly legitimate conversational contexts where the reliability of Gödel's capacity for logical insight is especially salient, and hence where this counterfactual is correctly asserted. (In other contexts, it would instead be correct to say "Had Gödel rejected the 'law' of double negation, then he would have made a lousy logician.") But this counterfactual's antecedent expresses a logical possibility. So we have here an apparent violation of principle (2), i.e., a prima-facie counterexample to my claim that the set of logical truths is stable.[15]

In my 2000 (pp. 77–79), I discussed analogous challenges to principle (1), i.e., to the stability of the set of natural laws and their logical consequences. For example, consider: Had Smith [a distinguished physicist] proposed some alternative to special relativity that came to be accepted by the physics community, then special relativity would (probably) have been false. Counterfactuals are, as I have said, notoriously context sensitive. Had I jumped from the window ledge, I would have suffered serious injury. Yet in another context, where my circumspection is front-and-center, it is instead correct to assert that had I jumped, I would have first arranged for a net to be deployed below, and so would not have suffered serious injury. In still another context, it is instead correct to assert that I would have first made sure that it was a ground-floor ledge. Having become intoxicated by such cases, one might well think that there must surely be contexts in which, for some logically (physically) possible Q, it is correct to assert $Q > P$ for some logically (physically) impossible P. The Gödel and Smith examples would then seem made-to-order.

However, I do not believe that the Gödel and Smith examples constitute genuine counterexamples to the stability of the logical and physical necessities, respectively. In order to respect the stability of the logical (physical) necessities, one must accept Q > P for any Q that one takes to be logically (physically) possible and any P that one takes to be logically (physically) necessary. However, although (presumably) which truths really are logically (physically) necessary does not depend on which truths one takes so to be, nevertheless which truths it is appropriate for one to take so to be may vary somewhat in different contexts, where different evidence and different lines of argument are properly taken into account, or different thresholds for full belief are properly employed. In a context where we (fortified by the considerable empirical evidence for Einstein's theory of relativity) confidently take the theory of relativity as capturing various laws of nature, we should say (considering the objectivity of the laws of nature) that relativity theory would have been correct even if Smith and the entire physics community had rejected it. In other, more "philosophical" contexts, however, we may (despite having exactly the same evidence for relativity theory) keep a more open mind about the future of physics – about whether relativity theory will survive further scientific revolutions, whether it can be unified with quantum field theory, and so forth. (We might, for example, have been discussing the "disastrous pessimistic meta-induction" from the history of science.) In this sort of context, we should say that had the physics community sometime forcefully rejected the theory of relativity, then relativity theory would (probably) have been false. But this assertion does not violate the stability of the physical necessities, since in this context, we do not assert this counterfactual *while believing that relativity theory indeed captures the genuine laws of nature*.

To better appreciate this, notice that in such a context, we do not say, "Although relativity theory consists of genuine laws of nature, nevertheless had Smith led the physics community to reject relativity theory, then it would (probably) not have consisted of natural laws." There is an inconsistency between asserting relativity theory and asserting the Smith counterfactual. (In contrast, there is nothing inconsistent in saying "The Yankees won the game, but had Jeter failed to catch that vicious line drive in the eighth inning, the Yankees would probably have lost.") Similarly, in the Gödel example, we do not assert "Although the 'law' of double negation is truly a law of logic, it would (probably) not have been had Gödel said it isn't." We assert these Gödel and Smith counterfactuals only in contexts where we put aside some of what in other contexts we might profess as our beliefs.

In the case of natural laws, this putting aside can happen when we are discussing the evidence for believing that a certain claim expresses a natural law. For in discussing the force of that evidence, we cannot beg the question by presuming the theory that we are in the course of confirming. For example, imagine a vendor of weather glasses who knows that the accuracy of her products is secured by natural law. Suppose that she is speaking to a potential customer:

Customer (pointing to a glass): Is this weather glass reliable?
Vendor: Yes. For instance, it read "Fair" yesterday, and you can plainly see that it is fair weather today.
Customer: Yes it is. But maybe it read "Fair" yesterday because it was broken in such a way that it always reads "Fair." Then its "accuracy" yesterday would not constitute good evidence of its accuracy when it is in working order. Even a broken clock is right twice a day.
Vendor: It was in proper order yesterday.
Customer: Good. But does the fact that it read "Fair" yesterday and was in working order, and that today's weather is fair, confirm (to some degree) that whenever it is in working order, its prediction is accurate? In order for the test to supply us with good evidence, it must be that the hypothesis could have failed the test – that the test could have revealed the weather glass to have been inaccurate yesterday. For instance, you cannot confirm "All ravens are black" by asking your robot to bring only black objects to you and then noticing that one of them is a raven. By this procedure, you could not have discovered a counterexample, a raven that is not black.
Vendor: Yes, I too have studied a little philosophy of science. But had the weather glass read "Foul" yesterday and been in working order, it would have been inaccurate, since today's weather is fair. So yesterday's "Fair" reading, made while the weather glass was in working order, confirms (to some degree) that the instrument is accurate whenever it is in working order.

The vendor's assertion that "Had the weather glass read 'Foul' yesterday and been in working order, it would have been inaccurate" apparently conflicts with the stability of the natural laws since (in this story) it is a law of nature that these weather glasses are accurate, when in working order, and it is physically possible for the glass to have read "Foul" yesterday and been in working order.

However, the vendor makes the assertion in the context of trying to convince the customer of the very law that apparently fails to be invariant under this counterfactual's antecedent. Therefore, although the vendor herself believes in this law, she obviously cannot presume it when entertaining the counterfactual: from the customer's viewpoint, the vendor would then be begging the question.

The counterfactual asserted by the vendor is false, in view of the law guaranteeing the weather glass's reliability (when it is in working order). But because the customer does not know this law, she does not know that this counterfactual is false, and accordingly, the vendor asserts it when she adopts the customer's epistemic vantage point. To reinforce this point, we could adopt the procedure we followed earlier and see what happens if we try to assert the law and the above counterfactual in the same context. We end up with "Although it is a law of nature that weather glasses (in working order) are reliable, nevertheless had the weather glass read 'Foul' yesterday and been in working order, it would have been inaccurate." This is at war with itself.[16]

In short, the Gödel, Smith, and weather-glass counterfactuals that run contrary to the laws' stability are false. But they can be appropriately asserted out of ignorance of the actual laws, where this ignorance may be genuine or adopted sympathetically. These counterfactuals appear correct only when they are understood under the pretense that the logical (or natural) laws that govern the actual universe are (or may be) other than they really are.

VI.

What shall we conclude regarding my suggestion that the logical truths form the smallest non-empty stable set? One desideratum I mentioned for an analysis of logical truth is that the account distinguish the logical truths from the mathematical truths, conceptual truths, and such truths as "All red objects are colored" and "If Abe is taller than George, then George is not taller than Abe." I am not sure about whether these other necessary truths join the logical truths in belonging to the smallest non-empty stable set. Is it the case that had a red object not been colored, then $\sim(P\&\sim P)$ would still have held? A referee suggested that "If there were something red but not colored, then there would be something that had a color and did not have a color" does not sound too bad. If this counterfactual holds (in some context), then the smallest non-empty stable set must contain more than just the logical truths.

If these other necessities turn out to join the logical truths in the smallest non-empty stable set, then my account fails to describe what sets the logical truths apart – or deems all of these other necessities actually to be logical truths, despite the fact that they appear to have nothing specifically to do with logic. On the other hand, perhaps these other necessities do not all join the logical truths in the smallest non-empty stable set. For example, perhaps the mathematical truths are not members of the smallest non-empty stable set, but join the logical truths in forming a larger stable set. In discussing counterfactuals such as "If the axiom of choice were false, the cardinals wouldn't be linearly ordered," Field (1989, pp. 236–238) seems to suggest that the hierarchy goes as follows: logical truths, mathematical truths, laws of nature.

Perhaps I have at least characterized the most basic grade of necessity instead of characterizing logical truth. I leave it as an open question whether any truths besides the strictly logical ones possess this grade of necessity. It may be that the logical truths must be supplemented by some other necessary truths in order to form the smallest non-empty stable set. But I do not believe that any set formed of some of these other necessities, but omitting some logical truths, is stable.

Furthermore, my proposal allows us to characterize precisely at least one point that is at issue in whether the mathematical truths, conceptual truths, and so forth possess the same necessity as the logical truths. My proposal explains what it would take – that is, which counterfactual conditionals would have to hold – in order for these other truths to be as necessary as the logical truths. It might even be suggested that the uncertainty in our intuitions about whether these other truths possess the same kind of necessity as the logical truths is exactly matched by our uncertainty about the truth of certain counterfactual conditionals ("If there were something red but not colored ...") that would have to be true in order for the logical truths to form a stable set all by themselves.

As a referee noted, mine is not the first proposal for characterizing necessity in terms of counterfactuals. For example, Lewis defines "It is necessary that P" as $\sim P > \sim T$, where T is a sentential constant that is true in every possible world. Of course, Lewis's proposal differs from mine in failing to generalize to cover physical necessity and hence failing to explain what makes both of them flavors of necessity.[17] Moreover, Lewis's proposal must begin by defining T, and hence by referring to the worlds that are possible. We saw that "L is a natural law" cannot happily be explicated in terms of L remaining invariant under all counterfactual suppositions P where P is physically possible, since the laws play an important role in the explicans. Likewise, it would be more illuminating to characterize necessity without building in a special role for the *possible* worlds and thereby privileging that particular range of hypothetical worlds over any other range. We would like to explain what is special or important about the necessities without taking it for granted from the outset that there is something special or important about the range of hypothetical configurations in which the necessities all hold. (Of course, this is not a problem for Lewis, since he believes in a plurality of real worlds, and so he can pick out the possible worlds as simply all and only the real worlds.)

We could try to avoid this problem by replacing T (and its unfortunate reference to the possible worlds) with an arbitrary logical truth L. (Lewis offers us this option.) But even apart from this proposal's again failing to provide us with a unified account of logical and physical necessity, I do not find it obvious that P is a logical truth if and only if $\sim P > \sim L$. Admittedly, this biconditional is suggested by the thought that if P is a logical truth, then $\sim P$ is a contradiction, and anything (even $\sim L$) follows from a contradiction. However, the above biconditional is plausible only given the view (held by Lewis) that all counterlogicals are (trivially) true. The biconditional is implausible if there is a context in which it is correct (considering that I took $\sim P$ to be true in the course of completing my logic homework) that had $\sim P$ been the case (where P is a logical truth), then I would have received five additional points on my homework. It is not the case that I would then have received ten additional points; the point-values of the homework problems would have remained the same. In this context, then, not every counterlegal holds.

That the logical truths form the smallest non-empty stable set may be illuminating even if this proposal turns out not to reveal what *makes* L a logical truth or what gives L its variety of necessity. The account I have offered displays a kinship between the logical and the physical necessities and leaves room for there to be other members of the same family. It identifies a heretofore unrecognized relation between necessities and counterfactuals, a relation that proceeds through the notion of a stable set. Very few sets manage to be stable, and the stability of the logical truths and the natural laws may help to account for some of the important roles that these truths play in our reasoning.[18] This relation between the necessity of certain truths and the truth of certain counterfactuals may prove significant regardless of whether one of the relata ultimately supplies a reductive analysis of the other.[19]

NOTES

[1] This conception of natural law suggests that the laws fail to supervene on the facts that they govern, just as the rules of chess fail to supervene on the actual moves in a particular game of chess. For example, the rule governing castling is still in force in an actual game in which no one happens to castle, but a rule that forbids castling might instead have been in effect, making no difference to any moves. Analogous remarks apply to the natural laws in a universe in which nothing ever happens except for a single electron moving uniformly forever. For more discussion, see my 2000.

[2] A David-Lewis type might say that such facts form the Humean base on which all other sorts of facts supervene. I do not so regard them; see note 1. For example, the fact that some particular atom has a 50% likelihood of decaying in the next 102 minutes (as governed by quantum mechanics) is not going to pass Humean muster, yet this fact is governed by laws without governing anything itself. The same goes for facts ascribing dispositional properties to particular objects.

[3] For simplicity, I will use variables like "A" to stand not only for sentences expressing various actual and hypothetical states of affairs, but also for those states of affairs themselves, as in "It is physically possible that A."

[4] If the triviality of principle (1) in this direction strikes you as suspicious – in that you suspect that there should be a less trivial principle around here somewhere – then I am with you. Stick around.

[5] Indeed, this invites the search for peculiar contexts in which the counterfactual conditionals demanded by principle (1) are not true. To defend principle (1)

properly, I would have to investigate various possible counterexamples to it, as well as Lewis's (1986) philosophical motives for rejecting it (by positing that a "small miracle" occurs in the closest possible world in which, say, I wore a different shirt this morning). I investigate these matters at length in my 2000 and shall not attempt to summarize that discussion here. However, in section V, I will need to examine one sort of apparent counterexample to principle (1).

[6] I borrow this example from Bennett (1984, p. 71).

[7] Of course, B logically entails that it is not a law that ∼B, since (it is widely believed) laws must be truths. However, "It is not a law that ∼B" expresses a modal fact and so is ineligible for membership in the stable set Γ. So even if B is a member of Γ, not *all* of B's logical consequences are members of Γ.

[8] In my 2000, I elaborate the notion of a set that is stable *for the purposes of* a given "special science," such as human medicine, ecology, marketing, or aerodynamics. Roughly speaking, Γ's stability for a given special science requires that each of Γ's members P concern matters of interest to the science and be invariant under every counterfactual supposition Q that not only is logically consistent with each member of Γ, but also falls within the special science's range of interests. Furthermore, the requisite counterfactual conditionals Q > P must hold at least in whatever contexts arise in connection with that special science. (For further discussion and application, see my (2002) and (forthcoming).) A set that is stable for the purposes of a given special science may omit some of the laws of fundamental physics and, in turn, may include some truths that are accidents as far as fundamental physics is concerned. (That is why, I argue, a scientific explanation supplied by some special science may be irreducible to an explanation of the same phenomenon given at the level of fundamental physics.) Indeed, the laws of fundamental physics are not stable for the purposes of (say) island biogeography, and the laws of island biogeography are not stable for the purposes of fundamental physics. Every science is a "special science", in my view. The sets that are stable for the purposes of a given special science form a hierarchy, but the sets that are stable for ballistics need not join those that are stable for island biogeography in forming a single hierarchy. I ignore all of these details here and, for the sake of simplicity, proceed as if there were laws of nature *simpliciter*.

[9] It might be objected that if we help ourselves to the notion of logical consistency, then we have given ourselves all we need in order to define logical truth: P is logically false if and only if P is not logically consistent with any Q, and P is logically true if and only if ∼P is logically false. However, I take this to be an uninteresting analysis.

[10] That all counterlogicals are trivially false follows from Stalnaker's account of counterfactuals, as presented in his 1968 and elsewhere. On the other hand, all counterlogicals are trivially true according to Lewis's account, as presented in his 1973, 1986, and elsewhere.

[11] Unless, that is, P is a logical truth and there are various strata of logical necessity in the sense that I lay out in the next section, where I discuss the sense in which there may be various grades of physical necessity. To my claim in the main text, it might be objected that Q > Q, where ∼Q is a logical truth, is a counter-

logical that holds whatever the context. However, even if such a counterlogical holds regardless of the context, this fact would not undermine my claim in the main text, which concerned the possibility of a counterlegal Q > P *where P is true*.

[12] This set's instability does *not* follow simply from principle (1), which says that some members of the set are not invariant under every counterfactual antecedent consistent with the natural laws. The set's instability follows from its lacking invariance even under a somewhat narrower range of suppositions: those consistent with every member of the set. (This range is narrower because the set contains more than just the laws of nature and their logical consequences.)

[13] I first gave this example in my 1999a.

[14] Nolan (1997, p. 550) calls something like this the "strangeness of impossibility" condition. While he thinks it has "a fair bit of intuitive support," he suspects that on some occasions, it fails. In the next section, I shall explore why.

[15] This is the sort of case that gives Nolan (1997, p. 551) qualms; see the previous note.

[16] I first gave this example in my 2000 (p. 78).

[17] This is not surprising, since Lewis does not accept principle (1) – see note 5.

[18] For a start along these lines with regard to the natural laws, see my 1999b and 2000.

[19] Thanks to Larry BonJour, S. Marc Cohen, Mike Resnik, David Keyt, Gila Sher, and a referee for valuable feedback.

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Department of Philosophy
The University of North Carolina at Chapel Hill
CB#3125
Chapel Hill, NC 27599-3125
USA
E-mail: mlange@email.unc.edu