Humean laws and (nested) counterfactuals

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Abstract:
Humean reductionism about laws of nature is the view that the laws reduce to the total distribution of non-modal or categorical properties in spacetime. A worry about Humean reductionism is that it cannot motivate the characteristic modal resilience of laws under counterfactual suppositions and that it thus generates wrong verdicts about certain nested counterfactuals. In this paper, we defend Humean reductionism by motivating an account of the modal resilience of Humean laws that gets nested counterfactuals right.

1. Introduction

Humean reductionism about laws of nature is the view that the laws reduce to facts about the Humean Mosaic, i.e., the total distribution of non-modal or categorical properties in spacetime. David Lewis's influential best systems account (BSA) aims to achieve this reduction by analyzing laws of nature as efficient summaries of what actually happens.[1] The so-analyzed laws then provide a foundation for reducing all other natural modalities, including nomological possibility and necessity, counterfactuals, causation, and dispositions.

An important worry about the Humean BSA is that it cannot fully account for the resilience of the laws of nature under counterfactual suppositions. It is plausible that the laws (typically) still would be true under counterfactual suppositions that are logically consistent with them. For instance, lots of things would be different if the Sun were further away from the Earth. But we think that the laws of nature would be true,

[1] Other proponents of a best systems account include Beebee (2000), Hall (2015), and Loewer (1996). Anti-Humeans about laws, by contrast, hold that the laws of nature are identified with or 'grounded in' genuinely modal entities, such as instantiations of an irreducible higher-order necessitation relation (Armstrong 1983), primitive laws (Maudlin 2007), fundamental potencies (Bird 2007), or primitive subjunctive facts (Lange 2009a).

regardless of the Sun's position. This resilience allows the laws to underwrite counterfactuals. Since the laws would still be true if the Sun were further away from the Earth, we can use them to infer what else would be the case given this counterfactual supposition.[2] Humeans, however, arguably cannot motivate why the laws are resilient under nested counterfactual suppositions such as "had there been nothing but a lone electron, then had there been more electrons than one, the force between any two electrons would have accorded with Coulomb's law" (Lange 2009a: 54 and Hall manuscript; cf. Carroll 1994: ch. 3). The worry is that Humeanism generates the wrong verdicts about this and similar counterfactuals and so cannot fully explain the laws' modal resilience.

In this paper, we defend Humean reductionism by providing a Humean motivation of the modal resilience of laws that also applies to nested counterfactuals. We argue that holding fixed the actual laws under (nested) counterfactual suppositions serves the Humean goal of inferring truths about the actual world. Our argument in the paper is part of a larger defense of Humeanism. A general challenge for Humeans is to explain why we use modal notions, such as dispositions, causation, and counterfactuals, in the way we do. After all, Humeans deny that there are any fundamental modal facts, and so the point of employing these notions cannot be to describe any distinctive metaphysical structure. Our paper partly answers this challenge by providing a Humean-friendly motivation for why we use counterfactuals.

Our plan for the rest of the paper is as follows: In §2, we outline Humean reductionism about laws of nature. In §3, we explain the worry that Humean theories cannot fully account for the laws' modal resilience since they yield the wrong verdicts about certain nested counterfactuals. In §4, we argue that Humeans cannot simply set aside the relevant nested counterfactuals. In §5, we meet Lange's challenge by providing an independent Humean motivation for adopting a semantics of counterfactuals that holds the laws fixed under counterfactual suppositions. We then show that this motivation extends naturally to nested counterfactuals.

[2] Most philosophers, Humeans and anti-Humeans alike, hold that laws of nature are more fundamental than counterfactuals such that the nomic facts help fix the world's counterfactual structure. But see Lange (2009a) for an argument that the world's counterfactual structure fixes the laws. Some dispositionalists about laws of nature also hold that counterfactuals are more fundamental or at least ontologically on a par with the laws (see, e.g., Bird 2007: 64).

2. Humean reductionism about laws of nature

Setting the stage for our account of the modal resilience of Humean laws requires reviewing the central ingredients of Humean reductionism. We will focus on David Lewis's version since he is the most influential advocate of Humean reductionism. Lewis's central thesis is "Humean Supervenience," i.e.,

> […] the neo-Humean thesis that every contingent truth about a world—law, dependency hypothesis, or what you will—holds somehow in virtue of that world's total history of manifest matters of particular fact. Same history, same everything. (Lewis 1981: 20)

The "world's total history of manifest matters of particular fact" is usually referred to as the 'Humean Mosaic'. All there fundamentally is, according to Lewis, is this global distribution of perfectly natural intrinsic properties at spacetime points (or their point-sized occupants), such as determinate masses, charges, and spins. The Humean aspect of this view is that these property instantiations are freely recombinable: A property instantiation has no modal implications for its neighborhood. Lewis aims to show that this sparse amodal fundamental structure suffices to determine (or ground) all truths about the world, including all modal truths.[3]

Lewis's best systems account (BSA) of laws of nature plays a central role in this reductive program (see Lewis 1973, 1983, 1994). According to this account, what makes a fact *p* a law is that it is a contingent universal generalization belonging to the best systems about the Humean mosaic. Here is Lewis's classical formulation of the view:

> [A] contingent generalization is a *law of nature* if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength. (Lewis 1973: 73)

The idea roughly is that a systematization is best when it provides as much information as possible about the actual Humean mosaic in as simple a way as possible. If such systematizations are formulated as axiomatized (deductively-closed) theories in a

[3] Humean Supervenience as stated above arguably requires some amendments. See, for example, Dorr & Hawthorne (2013) for refinements of the recombination claim and Weatherson (2015) for discussion of (vectorial) magnitudes.

language whose predicates refer to perfectly natural properties, then the contingent universal generalizations therein are identified with the laws.[4]

Lewis's account of laws provides the foundation for a Humean reduction of all other natural modalities. Best systems laws determine nomological necessity and possibility and help fix the world's counterfactual structure (Lewis 1973, 1986c). Lewis then gives a counterfactual account of causation (Lewis 1986a) which, in turn, figures prominently in his causal account of explanation (Lewis 1986b). Dispositions, finally, are accounted for via a counterfactual *cum* causal analysis (Lewis 1997). But can Humean reductionism provide an adequate account of laws?

3. The problem of nested counterfactuals

A plausible principle about laws is that they (at least typically) are resilient under counterfactual suppositions that are logically consistent with them. Let us call this proposition '*counterfactual resilience*' (CR).

> (CR) The laws of nature (at least typically) would still have been true under counterfactual suppositions that are logically consistent with them.[5]

CR captures the idea that the laws 'support' counterfactuals. If it is a law that 'all *F*s are *G*s,' then if some *x* that actually is a non-*F* had been an *F*, it also would have been a *G*. This fact follows from the resilience of the laws under the counterfactual supposition that the distribution of *F*s is different. If we counterfactually suppose that *x* is an *F and* the law that 'all *F*s are *G*s' remains true under this supposition, then it follows that *x* is also a *G*.

CR needs to be distinguished from a stronger principle that may be dubbed 'counterfactual hyper-resilience', i.e., the claim that not only the laws' truth is held fixed under counterfactual suppositions but also their lawhood (see Carroll 1994 and Lange 2009a). A prima facie attractive feature of counterfactual hyper-resilience is that it would entail (and so perhaps explain) CR. However, as we will demonstrate below, we

[4] Lewis (1994) gives an analogous account of chances. Chances are fixed by their fit with the frequencies in the mosaic. Roughly put, a system that assigns the actual history of events a higher chance of happening has a better fit than one that assigns it a lower chance.
[5] See Lange (2009a: sec. 1) for discussion of various subtleties concerning CR, including how it relates to nested counterfactual suppositions.

can account for CR without adopting this principle. In the following, unless we explicitly say otherwise, if we talk about the counterfactual resilience of laws or holding the laws fixed, we mean 'holding the truth of the laws fixed', not 'holding the lawfulness of the laws fixed'.

Counterfactuals are notoriously context sensitive, and there might be contexts in which we do not hold the laws fixed. In such contexts, we could truthfully assert that the laws would have been false if certain facts that are logically consistent with them had been the case.[6] But it nonetheless is highly plausible that the laws are resilient in standard contexts. Moreover, this resilience is a characteristic feature of the laws that distinguishes them from non-laws. Thus, capturing the laws' characteristic modal resilience is a desideratum of a theory of laws.

Can a Humean theory of laws explain why the laws of nature have this characteristic modal resilience? Humeans can build the resilience of laws into their preferred semantics of counterfactuals. Take a standard, possible worlds semantics of counterfactuals. Roughly put, a non-vacuous counterfactual $A \mathrel{\square\!\!\rightarrow} C$ is true iff all A-worlds that are closest to the actual world are C-worlds (see Lewis 1973). Humeans can then make it a requirement on closeness that the laws of the actual world are still true.[7] For example, to evaluate the counterfactual 'if there had only been a lone electron, then Coulomb's law still would have been true', we go to worlds in which there is only one electron and the actual laws hold true. CR would then be directly built into the Humean semantics of counterfactuals.[8]

But there is a worry that a Humean account of laws cannot motivate why we hold the laws fixed under counterfactual suppositions. According to Lewis's BSA, the laws of nature are mere patterns in the distribution of non-modal properties and so are metaphysically no different from other facts about the Humean mosaic. Hence, the

[6] Lange (2009a) argues that the laws are held fixed under counterfactual suppositions that are logically consistent with them in all contexts. But see Demarest (2012) and Hall (2011) for criticism of Lange's account based on the context sensitivity of counterfactuals.
[7] CR is usually also built into the 'altered states' semantics of counterfactuals, an alternative to possible worlds semantics (see Maudlin 2007: 21–34 and Paul and Hall 2013: 47–53).
[8] Lewis's (1986c) own preferred semantics for counterfactuals allows small violations of the laws of nature (so-called "small miracles") to account for the time asymmetry of counterfactual dependence. Lewis, however, argues that these violations are extremely small and localized such that the laws can, for the most part, be treated as if they are resilient under counterfactual suppositions. Dorr (2016) argues that we should hold the laws completely fixed and accept that if determinism is true, the past depends, at least to some small degree, on the future (see also Albert 2015: ch. 2 and Loewer 2012).

resilience of laws under counterfactual suppositions cannot be grounded in any special metaphysical status of the laws. Why then is it built into our semantics of counterfactuals that the laws are typically held fixed but not other facts (cf. Armstrong 1983: 69 and Lange 2009a: 55)? Why do we not hold fixed, e.g., that the actual world contains wombats?[9]

Humeans have provided some reasons for why best system laws are (typically) held fixed under counterfactual suppositions that are logically consistent with them. The laws, according to the BSA, are especially important facts about a world since (unlike facts about wombats) they are part of the best systematizations of the total distribution of categorical properties. Moreover, when evaluating counterfactuals, it makes sense to hold fixed especially important facts about a world. Hence, we have reason for holding fixed the laws when we evaluate counterfactuals. As Lewis (1973: 75) points out: "It makes a big difference to the character of a world which generalizations enjoy the status of lawhood there. Therefore, similarity and difference of worlds in respect of their laws is an important respect of similarity and difference, contributing weightily to overall similarity and difference."[10] Let us call this account, according to which the laws are held fixed under counterfactual suppositions simply *qua* being part of the best systems, the '*received Humean view*'.

Unfortunately, the received Humean view cannot explain why we hold the actual laws fixed under nested counterfactual suppositions. Lange (2009a: 54) offers the following example: "Had there been nothing but a lone electron, then had there been more electrons than one, the force between any two would have accorded with Coulomb's law." This counterfactual appears to be true. And its truth is evidence that the counterfactual resilience of laws also extends to nested counterfactual suppositions. It is natural to think that if the laws remain true under simple counterfactual suppositions, then they also remain true if we add yet further counterfactual suppositions. So, the same reasons we have for thinking that CR is true for simple

[9] See Wilson (2013: 657). Some anti-Humean accounts also lack a worked-out story of why the laws are counterfactually resilient. Whatever metaphysical features the laws are supposed to be or be grounded in, we can always ask why we hold these features fixed under counterfactual suppositions and not others. For example, Tweedale (1984: 185–186) complains that it is not clear how Armstrong's (1983) theory of laws of nature can account for the laws' modal resilience.

[10] See also Roberts (2009: S504). Wilson (2013) also suggests this account on behalf of the Humean.

counterfactuals also seem to suggest that it is true for counterfactuals with nested suppositions. But now Humeans seem to be in trouble.

Lange argues that Humean accounts cannot accommodate the laws' resilience under nested counterfactual suppositions. According to the received Humean view, a nested counterfactual of the form $A \mathrel{\square\!\!\rightarrow} (B \mathrel{\square\!\!\rightarrow} C)$ is true at the actual world iff $(B \mathrel{\square\!\!\rightarrow} C)$ is true at all A-worlds that are closest to the actual world. Consider Lange's counterfactual about the lone electron from the previous paragraph. The closest possible world to the actual world in which the first antecedent is true is a lone-electron world, w_l. (Let us assume, for simplicity, that there is a unique such a world.) However, even if the actual laws are still true in w_l, its best systematizations arguably do not include most actual laws. These systematizations may include that there is a single (inertially moving) particle, but they surely will not contain Coulomb's law. According to the above rationale, Coulomb's law is then not among the important features of w_l. Hence, there is no reason why in the closest world, w_m, to w_l in which there is more than one electron, these electrons should exert forces according to Coulomb's law. Therefore, the above nested counterfactual appears to come out as false on the received Humean view. And, conversely, analogous reasoning shows that certain nested counterfactuals that are intuitively false threaten to come out true (see Hall manuscript for an example).

The lone-electron world, w_l, also illustrates that Humean theories of laws entail that there are nomologically possible worlds in which the actual laws are true but are not laws. Maudlin (2007) uses cases like these to object to the BSA on the grounds that it violates the condition that a law is a law in all of its models. However, it is doubtful that this condition is an independently motivated desideratum for a theory of laws. So, without additional arguments for this principle, Maudlin's worry seems to beg the question against the Humean (see Lange 2009b, Healey 2008, and Schwarz 2012). Lange's considerations regarding nested counterfactuals can be seen as providing such an argument.

Nested counterfactuals are problematic for Humeans because according to best systems accounts what facts deserve law-status is sensitive to the overall distribution of non-nomic properties. Which facts are included in a world's best systematizations changes given drastic enough changes in its non-nomic properties. The worry about nested counterfactuals then arises as follows: Take a counterfactual supposition that is consistent with the actual laws but where the closest possible world in which it is true

differs from the actual world enough such that the actual laws are not part of its best systematizations. According to the BSA, the actual laws are then not laws in this counterfactual world. If we then consider a second, nested counterfactual supposition, the received Humean view tells us to hold the laws of this counterfactual world fixed rather than the laws of the actual world. Hence, we arrive at the wrong verdicts for nested counterfactuals, such as Lange's example.[11] (You may think that nested counterfactuals are too baroque to play a role in ordinary and scientific reasoning. However, as we will show in the next section, such counterfactuals are quite pervasive and, in fact, central to the Humean project of reducing natural modality.)

Anti-Humeans avoid this problem. They deny that the laws are in this way sensitive to the overall distribution of non-nomic properties, and so their laws do not exhibit this kind of modal fragility. For example, Armstrong (1983) identifies the laws with higher-order facts about the instantiation of the nomic necessitation relation that are insensitive to alterations in the non-nomic facts (at least if we set Armstrong's Aristotelianism aside). Maudlin (2007) regards laws as *sui generis* entities over and above the pattern of their instances. Dispositional essentialists, such as Bird (2007), also seem to avoid the problem since they regard the laws as metaphysically necessary and thus *a fortiori* modally resilient. Finally, Lange (2009a) elevates the resiliency of laws under nested counterfactual suppositions to the defining feature of lawhood. So, the problem is distinctive to Humean reductionism.

Nested counterfactuals of the kind Lange points to confront Humeans with an uncomfortable choice between, on the one hand, not being able to capture our intuitive judgments about the relevant counterfactuals and, on the other hand, adopting an account of counterfactuals that is, by Humean lights, ill-motivated. Here is why: Suppose Humeans adopt a semantics of counterfactuals that builds the laws' resilience under nested counterfactual suppositions in *by fiat.* Lange anticipates this maneuver:

> [Y]ou might consider extending the requirement that the actual laws still be true in the closest *p*-world (if *p* is logically consistent with the actual laws) to require additionally that the actual laws still be true in the closest *q*-world to the closest *p*-world to the actual

[11] Several Humeans have proposed modifications of Lewis's BSA (see Cohen & Callender 2009, Dorst 2018, Hall 2015, Hicks 2018, Jaag and Loew 2018, Loewer 2007). These accounts, however, maintain that the laws are sensitive to the distribution of non-modal property instantiations, and so are equally susceptible to Lange's objection.

> world (as long as *p* is logically consistent with the actual laws and *q* is, too). (Lange 2009a: 55; see also Hall manuscript)

Let us call this additional requirement the 'resilience rule' since building it into the semantics of counterfactuals guarantees the modal resilience of the laws of nature. The resilience rule adjusts the similarity metric that is used to judge the closeness of worlds such that the laws are not only true in the closest *p*-world to the actual world, but also in the closest *q*-world to the closest *p*-world to the actual world. Adopting this semantic rule would, thus, secure the intuitively correct truth values for nested counterfactuals. For instance, Lange's counterfactual about the lone electron is guaranteed to come out true because Coulomb's law is now held fixed even under the nested counterfactual supposition of further electrons.

The resilience rule, however, is at odds with the received Humean view of why we hold the laws fixed under counterfactual suppositions. Lange continues the above quote as follows:

> But this is an unattractive option. If the closest *p*-world's laws differ from the actual laws, as the Best System Account entails for the closest lone-electron world, then surely the closest *p*-world's laws (rather than the actual laws) should influence which *q*-worlds count as closest to the closest *p*-world. (ibid.: 55)

The original Humean reason for holding the actual laws fixed when evaluating simple counterfactuals was that the laws are particularly important features of the actual world due to figuring in its best systematizations. But then in a counterfactual world where the actual laws are not part of its best systematization, the actual laws are no longer important features. So, it then seems, by Humean lights, unmotivated to hold the laws fixed under any further counterfactual suppositions. Hence, a semantics that contains the resilience rule (or a similar device for ensuring the correct verdicts for nested counterfactuals) is at odds with the received Humean motivation for CR.[12]

[12] In her discussion of Carroll's (1994) mirror argument, Beebee (2000: 591–592) seems to concede that when we entertain counterfactual suppositions within a counterfactual world, w_s, the Humean is bound to hold the laws of w_s fixed rather than the laws of the actual world. However, in §5 below we argue that there are principled Humean reasons to hold the actual laws fixed under such suppositions. Our account thereby provides new resources against Carroll's anti-Humean argument, though we will leave exploring them for another occasion.

It is important to keep separate two distinct challenges that nested counterfactuals raise for Humean accounts of laws. The first challenge is to provide a semantics of counterfactuals that yields the correct truth values for nested counterfactuals, including Lange's lone-electron example. Lange shows that Humeans cannot rely on the received way of evaluating counterfactuals because it yields incorrect verdicts given a Humean BSA of laws. So, the challenge for Humeans is to provide an alternative. However, Humeans additionally face a second, deeper challenge.

The second challenge is to show that a semantics of counterfactuals that yields the correct results for nested counterfactuals is motivated in light of a Humean metaphysics. Lange concedes that Humeans can meet the first challenge by adopting the resilience rule. However, he maintains that such a fix would be merely cosmetic. It allows Humeans to correctly model our counterfactual judgments, but it leaves completely unmotivated why we use counterfactuals in this way. Lange argues that this second challenge is truly devastating for a Humean theory of laws because it means that it cannot explain the role laws play in counterfactual reasoning.

Our goal in this paper is to respond to the second challenge. We will show that an account of counterfactuals that holds the actual laws fixed both under simple and nested counterfactual suppositions has, *pace* Lange, a Humean motivation. In fact, we will argue that such a semantics goes particularly well with Humeanism about laws. For simplicity, we will accept Lange's suggestion that the right way of amending the Humean semantics of counterfactuals is to add the resilience rule. However, nothing about our account hinges on this assumption. In whatever way Humeans ensure that laws are held fixed under nested counterfactuals suppositions, they need to motivate why it makes sense, given a Humean metaphysics of laws, to evaluate counterfactuals in this way. We will provide such a motivation in §5.

You may worry that our reply to Lange's worry is incomplete as long as we have not provided a semantics of counterfactuals that meets the first challenge. Defending such a semantics would go beyond the scope of the current paper. Our account, however, is highly interesting even without a worked-out formal semantics to accompany it: First, it would be pointless for Humeans to develop such a semantics as long as it has not been shown that it can be motivated on Humean grounds. In fact, Lange's challenge is precisely that merely providing a new semantics does not address

the deeper underlying problem. Our goal is to address this deeper problem, and so pave the way for a full Humean account of counterfactuals.

Second, there is reason to be optimistic that Humeans can provide a suitable semantics that captures our judgments about nested counterfactuals. Lange's proposal to adopt a resilience rule naturally extends the received Humean view by adjusting the standards for similarity between possible worlds. However, Humeans who would like to maintain the original similarity metric can adopt an even more conservative strategy. Hall (manuscript) proposes to simply restrict the sphere of possible worlds that are considered when evaluating counterfactual suppositions that are logically consistent with the actual laws to worlds that are nomologically possible relative to the actual world. Hence, only worlds in which the actual laws are true are candidates for the closest possible world in which the supposition is true. Like Lange's resilience rule, this amendment ensures that the laws are held fixed across both nested and simple counterfactuals. For example, Lange's lone-electron counterfactual comes out true according to this proposal. If we consider only worlds compatible with the laws of the actual world, then if we go to the most similar world to the actual world in which there is only one electron, the closest world to that world in which there are more electrons is still one in which Coulomb's law is true. At the same time, this proposal leaves the machinery of the received semantics untouched and merely restricts the sphere of possible worlds.[13]

Third, Humeans who want to maintain all aspects of the received semantics have an even more conservative strategy available. They can argue that counterfactuals such as Lange's lone-electron example are strictly false, but that there are pragmatic reasons for asserting them. According to this proposal, our intuitive judgments mistake the pragmatic assertability of these counterfactuals for their literal truth. This proposal then still needs to show how the relevant pragmatic aspects of our counterfactual reasoning are motivated in light of a Humean metaphysics. Humeans who are attracted

[13] This list of Humean moves is not exhaustive. Humeans who think that Humean Supervenience is only contingently true might hold that Lange's nested counterfactual is true by arguing that the closest possible lone-electron world is an anti-Humean world in which Coulomb's law still is a law. A different proposal, due to Bhogal (forthcoming), invokes metaphysically impossible worlds. Bhogal argues that nested counterfactuals such as Lange's come out true because the closest possible lone-electron world is a (by Humean lights) metaphysically impossible world in which Coulomb's law remains a law despite not being part of the best systems. Thanks to [omitted] for discussion.

to his pragmatic approach can understand our proposal in §5 as an account of why the relevant nested counterfactuals are assertable despite being literally false. Before we turn to our positive account, however, we want to address why it is important for Humeans to capture our judgments about nested counterfactuals in the first place.

4. The importance of nested counterfactuals

Humeans have argued, in other contexts, that some of our intuitions about laws issue from an incorrect picture of laws and so are unreliable (see Beebee (2000) against governing-conceptions of laws). Could Humeans employ a similar strategy to argue that our judgments about nested counterfactuals, or at least those that are problematic for Humeans, can be set aside when developing a theory of laws? In this section, we will show that Humeans cannot ignore nested counterfactual when constructing a theory of laws.

Nested counterfactuals are important for at least two reasons. First, nested counterfactuals reveal features of counterfactual relations that arguably play an important role in science. For example, Woodward's (2003) influential theory takes causal explanations in the sciences to exhibit patterns of counterfactual dependence. A characteristic feature of the relevant counterfactuals is *stability*, that is, the relevant counterfactuals still need to be true given (at least some) changes in the background conditions (Woodward 2007: 77). Consider the following counterfactual about a spring: 'If the spring's extension were different, then the restoring force would be different in accordance with Hooke's law.' For this counterfactual to be stable, it still needs to hold given a range of changes in the background conditions, such as certain changes in the spring's temperature or location.

Nested counterfactuals are the most natural tools for capturing this stability. For the counterfactual about the spring to be stable under changes in temperature, the following counterfactual needs to be true: 'If the spring's temperature were somewhat different, then if its extension were different, the restoring force still would accord with Hooke's law.' So, if something along the lines of Woodward's account of explanation is correct, nested counterfactuals are relevant for scientific explanations.

Second, nested counterfactuals are essential for the Humean project of reducing all modalities to fundamentally non-modal facts. Counterfactuals play an important role in this reduction: Humeans analyze counterfactuals in terms of best system laws; use

the so-analyzed counterfactuals to analyze causation (Lewis 1986a); and then, in turn, appeal to causation in their analyses of explanation (Lewis 1986b) and dispositions (Lewis 1997). So, causation, explanation, and dispositions for Humeans ultimately presuppose counterfactuals. Nested counterfactuals then are important for the Humean project because if causation, explanation, and dispositions presuppose counterfactuals, then any counterfactual claim *about* these phenomena involves a nested counterfactual.

Let us exemplarily work through the case of causation. Assume, for simplicity, that a simple counterfactual analysis of causation is correct: an event *c* causes a distinct event *e* iff had *c* not occurred, then *e* would not have occurred. Now, we do not just make claims about which events actually cause which other events. We also often make claims about which events would have caused which other events if certain things had been different. For example, we might want to say: 'If I had thrown a stone at the window, my stone throw would have caused the window to shatter.' Or, we might be interested in whether some causal relation still would have held if certain things had been different (see Lewis 1986: 186), say whether it is true that: 'If there had been more wind, then my stone throw still would have caused the window to shatter.' If a counterfactual analysis of causation is true, then unpacking these claims involves nested counterfactuals. For example, plugging the simple counterfactual analysis into the consequent of the first counterfactual yields: 'If I had thrown a stone at the window, then if I had not thrown the stone, the window would not have shattered.' So, counterfactuals about causal relations, given the counterfactual analysis of causation, are implicit claims about nested counterfactuals.

In fact, nested counterfactuals are relevant even if causation is not analyzed counterfactually. Counterfactuals, at the very minimum, are often evidence for causal relations. So, nested counterfactuals are important for getting a grip on what causal relations would have held in counterfactual circumstances. And, for analogous reasons, nested counterfactuals are relevant whenever we entertain counterfactuals about explanation and dispositions because these latter phenomena, like causation, are closely

related to counterfactuals.[14] So, Humeans cannot simply dismiss all nested counterfactuals as irrelevant.[15]

Could Humeans concede that some nested counterfactuals are important but deny the importance of those nested counterfactuals for which the received Humean view arguably returns the wrong verdicts? Recall Lange's example: "Had there been nothing but a lone electron, then had there been more electrons than one, the force between any two would have accorded with Coulomb's law" (Lange 2009a: 54). Humeans might argue that counterfactuals of this kind will rarely play a role in scientific practice (cf. Hall manuscript; but see our discussion in §5 below).

Many counterfactuals that are just as problematic for Humeans as Lange's example, however, seem clearly relevant for science. Consider the following claims about causation, dispositions, and explanation:

> 'Had there been nothing but a lone electron, the absence of external forces would have caused it to move inertially.'
> 'Had there been nothing but a lone electron, the absence of external forces would have explained its inertial motion.'
> 'Had there been nothing but a lone electron, then it would have been disposed to attract other electrons in accordance with Coulomb's law.'

Investigating the causal, explanatory, and dispositional features of electrons is of clear interest to science. So, it is hard to see how these claims could be dismissed as

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[14] Cf. Lange (2009a: fn. 23 and fn. 25, 194–196). Lewis's counterfactual *cum* causal analysis ties dispositions even more directly to nested counterfactuals. Here is Lewis's "unlovely mouthful" (Lewis 1997: 157): "Something *x* is disposed at time t to give response *r* to stimulus *s* iff, for some intrinsic property *B* that *x* has at *t*, for some time *t*' after *t*, if *x* were to undergo stimulus *s* at time *t* and retain property *B* until *t*', *s* and *x*'s having of *B* would jointly be an *x*-complete cause of *x*'s giving response *r*" (ibid.). Lewis's counterfactual analysis of causation entails that the consequent of the above counterfactual already presupposes a counterfactual claim. So, we get the following nested counterfactual: 'If *x* were to undergo stimulus *s* at time *t* and retain property *B* until *t*', then if *s* and *x*'s having of *B* had not occurred jointly, *x*'s giving response *r* would not have occurred.'

[15] Could Humeans try to rephrase all nested counterfactuals as non-nested counterfactuals with complex antecedents? This strategy will not work, or at least not always. For example, the nested counterfactual 'If I had thrown a stone at the window, then if I had not thrown the stone, the window would not have shattered' clearly is not equivalent to the counterfactual 'If had thrown a stone and I had not thrown a stone, then the window would not have shattered'. See Lange (2009a: 22–23) for a similar example.

unimportant. Moreover, each claim carries a commitment to some nested counterfactual. For example, the first claim is closely related to the nested counterfactual: 'If there had been nothing but a lone electron, then if there had been external forces acting on it, it would not have moved inertially.'

These counterfactuals are as problematic for a Humean account of laws as Lange's original example. For example, the nested counterfactual in the previous paragraph is plausibly true. However, in a world whose history consists only of a single electron, there is no guarantee that the actual force laws will be part of its best systematization. In this case, the counterfactual will likely come out as false according to the received Humean view. But if Humeans cannot account for these types of nested counterfactuals, then Lange's challenge has not been met.

In sum, Humeans cannot just ignore the nested counterfactuals that the received Humean view gets wrong. They either need to motivate an alternative semantics of counterfactuals that incorporates the resilience of laws under nested counterfactual suppositions, or they need to offer an error-theory that 'explains away' our judgments about the problematic nested counterfactuals. In the rest of the paper, we will spell out a Humean motivation for an alternative semantics that gets nested counterfactuals right (though we will also briefly discuss the possibility of an error-theory).

5. Motivating why Humean laws are counterfactually resilient

In this section, we present a motivation for holding the laws fixed in counterfactual reasoning that goes naturally with a Humean account of laws. Moreover, we will show that this motivation extends to nested counterfactuals and so provides Humeans with the resources to capture the kinds of counterfactuals that Lange has identified as problematic.

The following type of counterfactual reasoning plays an important role in science: Suppose you want to predict the future evolution of some system, such as a rock. How the rock will behave depends not only on its intrinsic properties and immediate environment. It also depends, for example, on gravitational and electromagnetic forces from distant bodies. If you knew the complete state of the world and had unlimited computational resources, you could use the laws of nature to infer the rock's behavior with complete certainty. But in practice you never have such complete knowledge, nor would you have the computational resources to utilize it. So,

making predictions about systems by applying the laws of nature to the world's complete state is beyond your capabilities.

But there are other predictions that you can use the laws to make. You can predict, for example, how the rock would behave if it were the only object in the universe; or, how it would behave if the only outside force acting on it were the Earth's gravitation; or, perhaps how it would behave if it were acted on by both the Earth's gravitation and the gravitational force from homogeneously distributed distant galaxies but nothing else. In other words, we can use the laws to infer how the rock would behave in certain non-actual circumstances. These types of inferences involve counterfactuals, rather than indicative conditionals, since we apply the laws to circumstances that are known not to obtain. Entertaining these counterfactual suppositions presents us with simplified scenarios that leave out physical details that prevent us from applying the laws to the actual circumstances.

Our best candidates for the fundamental physical laws are such that applying the laws to counterfactual circumstances in this way often yields (approximately) true predictions about actual systems (see Hicks 2018 and [author]). For example, you can make approximately true predictions about the evolution of your rock by supposing, contrary to fact, that it is isolated from most distant going ons. Adam Elga makes this point in the following passage:

> [W]hen it comes to the rough behavior of your rock, you can often treat it as if it were isolated from distant influences. Note the qualifications, though. Your rock isn't *really* isolated from distant influences. For example, the exact microscopic trajectories of the rock's molecules are sensitive to goings-on in the next room, due to gravitational effects. But who cares about the exact trajectories of rock molecules? When it comes to getting around in the world, the rough macroscopic behavior of rocks is much more important. (Elga 2007: 109; italics in the original)

Note Elga's emphasis on the counterfactual nature of this inference. In reality, there *are* numerous distant forces acting on the rock. These forces, however, typically do not make a difference to the macroscopic behavior of systems such as rocks. So, we often can make (approximately) true predictions about a rock's macroscopic behavior by

counterfactually supposing that it is not acted on by such forces.[16] In doing so, we consider a simplified, counterfactual model of the rock that is tailored to our epistemic limitations and computational resources. So, counterfactuals help creatures like us, who have only limited knowledge at their disposal, to infer (approximate) actual truths.

As Frisch (2014: 62–66) points out, physicists almost never apply the laws to complete models that include every physical detail of a system since such models would be much too complex. The type of counterfactual reasoning just sketched thus is pervasive in science. We are not saying that all counterfactual reasoning is aimed at inferring actual truths. When we ask, e.g., what would be the case if Denmark were ruled by beavers or if kangaroos had no tails, it is not clear that we aim to make predictions about the actual world. However, we contend that getting at actual truths is at least one important goal of counterfactual reasoning.

This role of counterfactual reasoning motivates a Humean account of the modal resilience of laws that is different from the received Humean view. We can explain the laws' modal resilience by the utility of applying the actual laws to counterfactual circumstances for the purpose of getting at actual truths. Our goal is to predict how an actual physical system will evolve in the actual circumstances. The best tool for making such predictions are the actual laws. But our limited capabilities prevent us from applying the laws to the exact actual circumstances. So, we instead apply the actual laws to counterfactual circumstances that figure as epistemically more tractable proxies. Our best candidates for the physical laws allow us to often still arrive at (approximately) true predictions in this way because these laws are such that for many physical systems the exact physical details do not matter for their rough, macroscopic behavior.[17]

At the heart of Humeanism is the claim that the world fundamentally is exhausted by the distribution of perfectly natural, categorical properties throughout spacetime. Laws of nature, hence, do not and cannot describe any genuine modal

[16] For some physical systems, including chaotic systems, their behavior is sensitive to the exact physical details. But for many systems this is not the case and for these systems we can make (approximately) true inferences from counterfactual circumstances.

[17] Bhogal (forthcoming) provides a Humean reason for applying the actual laws to counterfactual circumstances that, though less pragmatic, is similar in spirit to our own. He argues that considering alternative situations that are consistent with the actual laws can help us better understand the laws by drawing out their implications. Bhogal shows how his account helps with the problem of nested counterfactuals as well as other important problems for Humean reductionism about laws. We address how our own account bears on these other problems elsewhere (see [omitted]).

aspects of reality. Humeans, instead, maintain that laws provide efficient summaries of actual goings on that "will serve you well, or reasonably well, or as well as possible, in making your way about in the world" (Albert 2015: 23; see also Beebee 2000: 547). In other words, the ultimate purpose of laws of nature for Humeans is to facilitate the efficient derivation of actual truths. Our motivation of the modal resilience of laws derives from this overarching Humean goal. Holding the laws fixed in counterfactual reasoning helps creatures like us to infer (approximate) actual truths. So, the counterfactual resilience of laws of nature is motivated by the arch-Humean goal of inferring (approximate) truths about the Humean mosaic.[18] Our proposed Humean motivation for the laws' modal resilience extends naturally to nested counterfactuals and so answers Lange's objection. Nested counterfactual suppositions, just like simple counterfactual suppositions, facilitate inferring actual truths. Simple counterfactuals allow us to use the laws to infer (approximate) truths about actual systems from incomplete information about these systems. The role of nested counterfactuals is more indirect. Suppose you want to predict how an electron will behave. As pointed out above, it would be vastly too complex to apply the laws to the complete current state of the world. Instead, you apply the laws to a simplified model that contains only the electron and (perhaps) the gravitational force of the Earth, leaving out many other forces that also act on the electron. How can you be confident that the predictions you derive from this simplified, counterfactual model hold true for the actual electron?

Nested counterfactuals help justify the relevant predictions. First, since our knowledge not only of the electron's surroundings but also of the state of the electron itself is imprecise, we cannot reliably infer anything from the simplified model if the resulting predictions are extremely sensitive to the electron's initial state. So, within the counterfactual supposition that the electron is isolated, we need to test what impact its exact initial state has on the predicted behavior. We test for this insensitivity by

[18] This motivation also provides new resources for answering another challenge against Humean accounts of laws. Hall (2015) worries that if laws of nature are merely efficient summaries of the total distribution of non-modal properties (as Humeans think), then it is puzzling why science posits laws that cover a wide range of non-actual circumstances. This worry is about 'modal latitude'. It concerns the information content of the laws, viz., why they also cover non-actual circumstances. So, it is different from the question in this paper, which is why the laws are resilient under counterfactual suppositions. However, in [omitted] we argue that 'modal latitude' also is a by-product of the laws' allowing us to infer (approximate) truths given our epistemic situation as limited creatures.

considering nested counterfactuals of the form: 'If there had been only a single electron, then if its exact position had been *x,* it would (still) behave this way.' Only if its behavior is relatively insensitive to its initial position, can we trust our simplified model to make approximately correct predictions. In the ideal case, the behavior of the electron in the simplified model will depend continuously on its initial conditions such that small errors about its initial position only lead to small errors in predictions about its behavior. Nested counterfactuals allow us to test whether this is the case for our simplified model.

Second, nested counterfactuals justify that omitting certain factors from our models is legitimate. How do we know that our simplified, counterfactual model makes approximately true predictions about the behavior of the electron despite leaving out various distant objects? An obvious way is to suppose the presence of some distant objects and use the laws to infer what difference they would make to the electron's behavior. If such distant objects make little or no difference, then we have reason to trust the predictions of the original, simplified model. We will thus consider nested counterfactuals of the form: 'If there were only a single electron *e* and the gravitational influence from the Earth, then if some distant object *x* were present, *e* would (still) behave like this.' So, nested counterfactuals play a crucial role in justifying the application of simplified models to actual systems.

In fact, Lange's counterfactual "[h]ad there been nothing but a lone electron, then had there been more electrons than one, the force between any two would have accorded with Coulomb's law" (Lange 2009a: 54) can be understood as serving this purpose. Suppose we use a counterfactual model that represents a certain actual electron as the only particle there is. Lange's nested counterfactual then becomes relevant for justifying inferences about the electron that we draw from this counterfactual model. We might, for example, suppose the presence of other electrons in our counterfactual model and use the actual laws, including Coulomb's law, to determine how the resulting forces would alter the electron's behavior. In doing so, we hold the actual laws fixed in order to determine how sensitive the model's predictions are to changes in the background conditions, such as the presence of further electrons. Adding further charged particle to the model will, in accordance with Coulomb's law, make some difference to the electron's behavior. However, depending on the distance and charge of the additional particles, this difference may be negligible for predicting

the electron's approximate behavior. Considering nested counterfactuals like Lange's then teaches us to what extent we can ignore the presence of other particles and so trust the predictions of our simplified model.

We then have a principled Humean motivation for holding the actual laws fixed under both simple and nested counterfactual suppositions. With regard to Lange's example, it then follows that when we suppose the presence of further electrons in the second counterfactual supposition, we still hold fixed Coulomb's law. So, *pace* Lange, building the fixity of the actual laws into our semantics of counterfactuals has a perfectly good Humean motivation. Holding the actual laws fixed allows us to make and justify inferences about actual systems. Moreover, this Humean motivation for holding the actual laws of nature fixed is completely neutral with regard to how this constraint is formally implemented in the semantics (or pragmatics) of counterfactuals (see our discussion at the end of §3).

This motivation for the modal resilience of laws and the resulting account of (nested) counterfactuals fits well with the general Humean outlook on modality. Humeans hold that reality has no fundamental modal structure. So, the import of counterfactual reasoning cannot be to map out any genuine modal structure of reality. Instead, on our Humean view, the primary purpose of investigating counterfactual situations and counterfactually altering them is inferring truths about the actual world. And this purpose is best served by holding the actual laws fixed under both simple and nested counterfactual suppositions. So, the utility of applying the actual laws to counterfactual circumstances for inferring actual truths explains why the laws are held fixed under counterfactual suppositions.[19]

Before closing, we want to briefly discuss an alternative Humean reaction toward the above described role of nested counterfactuals in scientific reasoning. Defenders of the received Humean view might put forward an error-theory about nested

[19] Our account also addresses Lange's (2009a: 55) worry about counterfactuals such as "Had there been nothing in the universe's history except for two electrons, then Coulomb's law would still have been true." Lange (ibid.) worries that Humeans cannot supply a "scientific explanation of the truth of Coulomb's law" in such a world because Coulomb's law, though true, is not a law according to Humeans (due to being not part of its best systematizations). On our Humean account of counterfactuals, this explanatory request does not even arise. Counterfactual suppositions are not windows into distant worlds whose features we then seek to explain. They are mere tools that we us to infer truths about the actual world, and so we do not have to scientifically explain any of their aspects.

counterfactuals that come out wrong according to their view. We have argued that scientists use counterfactual suppositions about worlds that contain, for example, only a lonely electron to facilitate inferences about actual electrons that are isolated from certain aspects of their environment. But Humeans might argue instead that what scientists are actually stipulating in these counterfactuals is not that only a single electron exists but that some electron is, contrary to fact, completely isolated from its environment. Thus, the nested counterfactual scientists are really interested in is not Lange's but instead: "If an electron had been completely isolated from its environment, then if there had been another electron in its vicinity, they would have behaved in accordance with Coulomb's law."

This difference in the content of the relevant counterfactuals matters. While Lange's counterfactual about the lone electron comes out false according to the received Humean view, the alternative counterfactual about an isolated electron arguably comes out true. After all, the closest possible world to the actual world in which some electron is fully isolated from its environment plausibly still includes Coulomb's law in its best systematization. At the same time, counterfactuals about fully isolated electrons plausibly could play the same role in facilitating inferences about actual systems as counterfactuals about lone electrons. These counterfactuals could be used to justify predictions derived from models that leave out certain aspects of the environment. Humeans could then maintain the received view of counterfactuals and argue that we mistakenly regard counterfactuals such as Lange's as true because we confuse them with similar counterfactuals about isolated systems.

We are not in principle averse to this more conservative Humean approach to the challenge posed by nested counterfactuals. Nonetheless, we prefer revising the received Humean view of counterfactuals to guarantee the resilience of laws under nested counterfactual suppositions. First, the above error-theory is not very plausible. It is extremely natural that when scientists construct simplified models that ignore all external influences on, for example, an electron they do indeed stipulate that this electron is all there is. Such a lonely electron model, after all, is much simpler to construct than a model in which the electron is still embedded in an environment like ours but where this environment has no influence on its behavior. In many cases, it is far from obvious what a model that satisfies these latter constraints and in which, in addition, the actual laws are true would even look like.

And, second, not all scientifically-relevant nested counterfactual can be easily reinterpreted as concerning isolated systems. For example, consider the following two counterfactuals about the universe as a whole:

> 'If the initial mass-energy of the universe had been twice as high, its increased mass-energy would have caused the universe to expand at a different rate (or not to expand at all).'
> 'If the initial mass-energy of the universe had been twice as high, its increased mass-energy would have explained why the universe had expanded at a different rate (or not expanded at all).'

These counterfactuals appear to be true. Moreover, both claims are closely related to nested counterfactuals. For example, the first claim is closely related to the nested counterfactual: 'If the initial mass-energy of the universe had been twice as high, then had there been only half of this mass-energy, the universe would have expanded at its actual rate.'

It is doubtful whether the received Humean view can account for our judgments about these counterfactuals. The closest possible world in which the mass-energy of the universe is twice as high may well be one in which the Big Bang never happened. The pattern of non-nomic facts in such a world would then be drastically different. As a consequence, many actual laws may not be part of this world's best systematization. But then the actual laws of nature, according to the received Humean view, may not be true under the nested counterfactual supposition, and so there is no guarantee that the counterfactual will be assigned the correct truth value.[20] At the same time, it is hard to see what alternative nested counterfactuals scientists might have in mind when entertaining the above considerations. By contrast, a revised Humean account of

[20] Some Humeans hold that the universe's initial macrostate is a law of nature (see Albert 2015 and Loewer 2012; but see Earman 2006). The above counterfactuals would then not be counterexamples to CR because the supposition that the initial mass-energy of the universe is twice as high would be logically inconsistent with the actual laws. However, there may be similar counterexamples where the universe, while having the same initial macrostate, has a highly atypical initial microstate that leads to a vastly different distribution of matter. Moreover, Humeans would still have to explain the (at least apparent) truth of the counterfactuals even if they turn out to be counter-nomic.

counterfactuals that holds the actual laws fixed under all counterfactual suppositions delivers the correct truth values for these kinds of counterfactuals.

6. Conclusion

We have shown that Humeans can account for the modal resilience of laws of nature. According to Humeans, the primary purpose of (nested) counterfactual suppositions is to help us infer actual truths. Holding the actual laws of nature fixed under both simple and nested counterfactual suppositions allows us to use them for this very purpose. This Humean take on counterfactuals and natural modality contrasts sharply with that of most anti-Humeans. For anti-Humeans like Lange, counterfactual latch on to some fundamental aspect of reality. Humeans, by contrast, hold that counterfactuals are merely effective means for getting at non-modal truths. We have argued that this role of counterfactual reasoning accounts for why we hold fixed the actual laws under (nested) counterfactual suppositions.[21]

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