

## Grounding, scientific explanation, and Humean laws

Marc Lange

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**Abstract** It has often been argued that Humean accounts of natural law cannot account for the role played by laws in scientific explanations. Loewer (Philosophical Studies 2012) has offered a new reply to this argument on behalf of Humean accounts—a reply that distinguishes between grounding (which Loewer portrays as underwriting a kind of metaphysical explanation) and scientific explanation. I will argue that Loewer’s reply fails because it cannot accommodate the relation between metaphysical and scientific explanation. This relation also resolves a puzzle about scientific explanation that Hempel and Oppenheim (Philosophy of Science 15:135–75, 1948) encountered.

**Keywords** Scientific explanation · Laws of nature · Hume · Lewis · Grounding · Hempel

It has often been argued (notably by Armstrong 1983, p. 40) that Humean accounts of natural law, such as Lewis’s (1986), cannot account for the role played by laws in scientific explanations. Loewer (2012) has offered a new reply to this argument on behalf of Humean accounts—a reply that distinguishes between grounding (which Loewer portrays as underwriting a kind of metaphysical explanation) and scientific explanation. I will argue that Loewer’s reply fails because it cannot accommodate the relation between metaphysical and scientific explanation. This relation is worth making explicit for several reasons. It lies behind the original objection to Humean accounts of natural law, helping us to understand how this objection is supposed to work. Furthermore, many philosophers [such as Rosen (2010) and Schaffer (2010)]

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M. Lange (✉)  
Department of Philosophy, University of North Carolina at Chapel Hill, CB#3125—Caldwell Hall,  
Chapel Hill, NC 27599-3125, USA  
e-mail: mlange@email.unc.edu

have recently investigated grounding as a kind of metaphysical explanation and so their accounts of grounding need to accommodate its relation to scientific explanation. Moreover, this relation resolves a puzzle about scientific explanation that Hempel and Oppenheim (1948) encountered.

Maudlin has given a pithy statement of the familiar objection that Humean accounts of law cannot recognize the laws' explanatory power:

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

In short, if the Humean mosaic is responsible for making certain facts qualify as laws, then the facts about what the laws are cannot be responsible for features of the mosaic.

Loewer replies by contending that these two uses of “responsible” conflate two distinct notions:

I claim that this objection rests on failing to distinguish metaphysical explanation from scientific explanation. On Lewis' account the Humean mosaic *metaphysically* determines the ... laws. It metaphysically explains (or is part of the explanation together with the characterization of a Best Theory) why specific propositions are laws. This metaphysical explanation doesn't preclude ... laws playing the usual role of laws in scientific explanations. (Loewer 2012)

Loewer's point is that metaphysical explanation shows how a given event or fact “is grounded in a more fundamental event or fact”, whereas a scientific explanation “typically, shows why the event occurred in terms of prior events and laws.” It is only by “confusing the two kinds of explanation” that we would be led to think that there is any incompatibility between the mosaic metaphysically explaining Humean laws and those laws, in turn, figuring in scientific explanations of facts that belong to the mosaic.

For the sake of argument, let's accept Loewer's distinction between grounding and scientific explanation. I propose that these two kinds of explanation stand in a relation given by the following “transitivity principle”:

If E scientifically explains [or helps to scientifically explain] F and D grounds [or helps to ground] E, then D scientifically explains [or helps to scientifically explain] F.

That is, when E helps to scientifically explain F, then that explaining is being done by whatever D makes E the case. If D is what it is in virtue of which E holds, then D must play whatever roles in scientific explanations E is playing. If D does not help

to scientifically explain F, then D cannot constitute E if E helps to scientifically explain F.

This principle is suggested by scientific practice. For instance, consider the fact (E) that a given object's center of mass is not located directly over the object's base of support. This fact E (together with facts about the gravitational field and the relevant laws) scientifically explains why the object tips over. Now E is grounded in the location of the object's center of mass (together with the location of the object's base of support). So it follows from the transitivity principle that the location of the object's center of mass helps to scientifically explain why the object tips over. That is surely correct. Furthermore, the location of the object's center of mass is nothing over and above a weighted average of its parts' locations (the average being weighted by the parts' masses), so the location of the object's center of mass is grounded in the locations and masses of the object's various constituents. Therefore, by the transitivity principle, the location and mass of one of the object's constituents helps to scientifically explain why the object tips over (and similarly for each of the object's other constituents). This is also correct. Similarly, suppose that a given balloon expands because of various laws and the fact that the pressure of the gas inside the balloon is greater than the atmospheric pressure outside of the balloon. Then since the fact that the internal pressure is greater than the external pressure is grounded in the value of the internal pressure and the value of the external pressure, it follows from the transitivity principle that the internal and external pressures help to scientifically explain why the balloon expands. That is also correct. The internal pressure, in turn, is grounded in the forces exerted by various gas molecules as they collide with the balloon's interior walls. By the transitivity principle, then, those forces help to scientifically explain why the balloon expands.

The transitivity principle is also presupposed by various philosophical arguments aiming to show that some D cannot ground some E, because otherwise (since E scientifically explains F) D would have to scientifically explain F, which it fails to do. For instance, population biologists commonly use random genetic drift to explain why the frequency of some trait in a given population has departed from its expectation value. However, as is commonly noted (Beatty 1992, p. 36; Plutynski 2007), drift in a given case cannot *consist in* such a departure, since that departure would then have to scientifically explain itself. Similarly, a coin's chance of landing heads explains its actual relative frequency of landing heads, so if the chance were grounded in the actual relative frequency, then [as Hajek (1997, p. 79) argues] the actual relative frequency would have to explain itself, which it cannot do.<sup>1</sup>

This returns us to the original objection to Humean accounts of law: if the law that all sodium salts burn with yellow flames helps to scientifically explain why a

<sup>1</sup> I do not purport to have shown conclusively that the transitivity principle holds. But it seems plausible to conclude at least that the transitivity principle holds in a certain wide range of cases, even if there remain some pathological cases in which it fails. The wide range of cases in which it holds seems plausibly to include cases that figure (as I am about to contend) in the original objection to Humean accounts of law.

I have argued elsewhere (Lange 2005) that the transitivity principle undermines the Russellian analysis of instantaneous rates of change. However, an advocate of the Russellian account might offer this case as a counterexample to the transitivity principle.

given flame is yellow, but this law is grounded in the Humean mosaic, then (by the transitivity principle) the Humean mosaic would have to help scientifically explain why the given flame is yellow. The Humean mosaic, in turn, consists of the fact that the given flame is yellow (setting aside, for the sake of simplicity, any qualms we may have about the thoroughly Humean character of this fact) together with a host of other such facts; a giant fact capturing the complete Humean mosaic holds in virtue of various local Humean facts, one of which is the fact that the given flame is yellow. Hence, by another application of the transitivity principle, it follows that the flame's being yellow helps to scientifically explain itself. That cannot be. The distinction between scientific and metaphysical explanation does not alleviate this problem since the transitivity principle ties the two kinds of explanation together. They cannot run in opposite directions, as Loewer wants them to do, on pain of yielding scientific self-explanation (through the transitivity principle).<sup>2</sup>

By making the transitivity principle explicit, we see that the original objection to Humean accounts of natural law (that they cannot account for the laws' explanatory power) was that these accounts ultimately involve scientific self-explanation. The two directions of explanation (the laws explaining the mosaic's elements, while those elements explain the laws) are incompatible because even if they were to involve distinct varieties of explanation, they would (by the transitivity principle) result in scientific self-explanation.<sup>3</sup>

A defender of a Humean account might argue that even if the Humean mosaic helps to scientifically explain why the given flame is yellow, and the Humean mosaic consists of the conjunction of a host of facts including the fact that the given

<sup>2</sup> A referee suggests that a Humean account of law could accept that the transitivity principle holds in the various cases that I mentioned earlier (involving the center of mass, the balloon, and so forth), but deny that it holds in the argument against Humean accounts of law. The basis of this difference (the referee suggests) would be that the transitivity principle does not apply when the scientific explanation of F by E involves fundamental laws of nature, whereas in the various cases that I gave, the laws in the scientific explanation are not fundamental. However, it seems to me that the idea behind the transitivity principle (that if E explains F, then that same explanatory work must be done by any D that helps to constitute E) is no less plausible when fundamental laws are involved in the explanation than when derivative laws are involved. Furthermore, I do not see how a Humean account could afford to accept that the transitivity principle applies even to derivative laws without compromising the derivative laws' explanatory power. (After all, fundamental laws do not constitute derivative laws; they scientifically explain derivative laws.) For that matter, the laws in the center-of-mass example could be fundamental laws (in classical physics: Newton's second law of motion and gravitational-force law).

<sup>3</sup> A Humean might reply that just as a rule of inference does not figure in an inference that it mediates as a premise, but instead enables the premises to entail the conclusion, so a natural law does not help to explain an accidental fact, but rather enables the initial conditions to explain it. A natural law, on this view, specifies what can explain what and so (since it does not help to scientifically explain) falls outside the transitivity principle's scope. (Thanks to John Roberts for suggesting that a Humean might take this view.) I respond that even if a law underwrites an explanation in this way, there is a version of the transitivity principle that applies: if D helps to constitute E, and E helps to enable certain facts to scientifically explain F, then D helps to enable those facts to scientifically explain F. Roughly speaking, D must help to do whatever E does in enabling F to be explained. If the fact that the given flame is yellow helps to constitute a law's lawhood, and that law's lawhood helps to enable certain initial conditions to scientifically explain the fact that the given flame is yellow, then by transitivity, the fact that the given flame is yellow helps to enable those initial conditions to scientifically explain the fact that the given flame is yellow. That is not self-explanation, strictly speaking, but it seems uncomfortably close.

flame is yellow, it does not follow that the fact that the given flame is yellow helps to explain itself. After all, this step seems to use the “equivalence principle”:

If E scientifically explains F and E is logically equivalent to (A&B), where A and B are both contingent, then A helps to scientifically explain F.

However (the defender of a Humean account continues), this principle is clearly false. Suppose that E not only scientifically explains but also entails F. Then E is logically equivalent to (F&E). But obviously it does not follow that F helps to scientifically explain F. For that matter, E can even be expressed as a conjunction *neither* conjunct of which helps to explain F. If E entails F, then E is logically equivalent to  $(F \rightarrow E) \& F$ . But even if E explains F, it can be that neither  $(F \rightarrow E)$  helps to explain F nor F helps to explain F.

So the equivalence principle is false. But a defender of a Humean account cannot in this way avoid the specter of self-explanation. That is because the earlier step from “the Humean mosaic helps to scientifically explain why the given flame is yellow” to “the fact that the given flame is yellow helps to scientifically explain why the given flame is yellow” does not depend on the equivalence principle. Rather, it appeals once again to the transitivity principle. The key difference between the two principles is that the equivalence principle requires that E be *logically equivalent* to (A&B), whereas the transitivity principle requires that E be *grounded in* D. In the two examples we have just seen where the equivalence principle fails, E is logically equivalent to but not grounded in (A&B). For instance, where E scientifically explains and entails F, it is not the case that E is grounded in (F&E). Likewise, where E scientifically explains and entails F, it is not the case that E is grounded in  $(F \rightarrow E) \& F$ . So the transitivity principle does not apply to these cases. Hence the transitivity principle does not allow us to conclude that E cannot explain one of its consequences F merely from E’s logical equivalence to (F&E) and F’s obvious failure to help explain itself.

In contrast, a complete description of a Humean mosaic not only is logically equivalent to a long conjunction of Humean facts (including the fact that a given flame is yellow), but also holds in virtue of the various facts in that long conjunction. It is grounded in them. Hence the transitivity principle applies to that case. The original objection to the Humean account thus remains unaffected by the demise of the equivalence principle.

The distinction between the transitivity and equivalence principles resolves a puzzle about scientific explanation that (Hempel and Oppenheim 1948, pp. 161–162; Hempel 1965, pp. 274–276) encounter. Take an apparently straightforward scientific explanation where the law  $(x)[Px \rightarrow Qx]$  and the initial condition Pa entail and explain the explanandum Qa. Hempel and Oppenheim point out that the law is logically equivalent to  $(x)[\sim Px \vee Qx]$ , the initial condition is logically equivalent to  $[Pa \vee Qa] \& [Pa \vee \sim Qa]$ , and the explanandum is logically equivalent to  $[Pa \vee Qa] \& [\sim Pa \vee Qa]$ . The second conjunct of the explanandum is then explained by the law alone, whereas the first conjunct is explained solely by the first conjunct of the initial condition—and so is explained by itself! (Moreover, the initial condition’s second conjunct is explanatorily idle.) Thus Hempel and Oppenheim have apparently found that buried within the most innocuous scientific explanation is self-explanation. As they put it, “part of the content

of the explanandum is contained in the content of the singular component of the explanans and is, in this sense, explained by itself” (Hempel and Oppenheim 1948, p. 161; Hempel 1965, p. 275). They are not prepared to prohibit such “partial self-explanation of the explanandum” (Hempel and Oppenheim 1948, p. 161; Hempel 1965, p. 274), since the price of doing so would be too great of a departure from scientific practice; it would require ruling out any explanations of the above form. But we can easily appreciate the discomfort they feel in countenancing explanations that involve this sort of self-explanation.

We are now well-positioned to see that Hempel and Oppenheim find themselves having to countenance “partial self-explanation” only because they make use of some principle along the lines of the equivalence principle. The explanandum  $Qa$  is logically equivalent to  $[Pa \vee Qa] \& [\sim Pa \vee Qa]$ , where both conjuncts are contingent, so Hempel and Oppenheim conclude that  $Qa$ 's explanation must explain both of these conjuncts. Take the conjunct  $[Pa \vee Qa]$ . Here is an instance of the equivalence principle:

If  $(x)[Px \rightarrow Qx] \& Pa$  scientifically explains  $[Pa \vee Qa]$  and  $(x)[Px \rightarrow Qx] \& Pa$  is logically equivalent to  $[Pa \vee Qa] \& \{(x)[\sim Px \vee Qx] \& [Pa \vee \sim Qa]\}$ , where both conjuncts are contingent, then  $[Pa \vee Qa]$  helps to scientifically explain  $[Pa \vee Qa]$ .

Thus self-explanation.

But we have already seen that the equivalence principle fails. If we try to recreate Hempel and Oppenheim's argument by using the transitivity principle instead, then we do not arrive at any self-explanation. Although  $Pa$  is logically equivalent to  $[Pa \vee Qa] \& [Pa \vee \sim Qa]$ , it is not the case that  $Pa$  is grounded in this conjunction. On the contrary, each of these conjuncts holds by virtue of  $Pa$ . (The former conjunct also holds by virtue of  $Qa$ .) Therefore, the transitivity principle and the fact that  $Pa$  helps to explain  $Qa$  does not yield  $[Pa \vee Qa]$  helping to explain  $Qa$ , much less  $[Pa \vee Qa]$  helping to explain itself.

Thus, the relation between grounding and scientific explanation that is expressed by the transitivity principle allows Hempelian covering-law explanations to avoid involving any self-explanation. But the transitivity principle also finds self-explanation to be involved in Humean laws playing the laws' characteristic explanatory role in science, thereby supporting a familiar argument against Humean accounts of law.

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