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A pragmatist challenge to constraint laws

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Meta-laws, including conservation laws, are laws about the form of other, more specific or phenomenological, laws. Lange distinguishes between meta-laws as coincidences, where the meta-law happens to hold because the more specific laws hold, and meta-laws as constraints to which subsumed laws must conform. He defends this distinction as a genuine metaphysical possibility, such that metaphysics alone ought not to rule one way or another, leaving it an open question for physics.

Lange's distinction marks a genuine difference in how a given meta-law can be used in explanations, if it were a constraint rather than a coincidence. Yet, I will argue, it is not simply an *empirical* matter as to whether a given conservation law, for instance, is a constraint or a coincidence. There is no set matter of fact about the world that determines this, and physics alone will not be able to return a determinate verdict on a law-by-law basis, even while there is a genuine difference between that given law as constraint and as coincidence. Rather, the difference marks different ways of treating the same law in a theoretical setting: by shifting the explanatory context, treating the same law as part of a different mathematical structure, it can be a genuine constraint and a genuine coincidence.

The difference between constraint and coincidence relates to the way in which we use a law in specific theoretical and explanatory settings. Because the same law can appear in multiple contexts, it can be used in these genuinely different ways, without itself "really" being either one or the other as some atomistic empirical fact. In the visual illusion of a flat cube, the cube can come out of the page, or go into it; the lines themselves do not change location, and it is not merely perceptual—those are both genuine physical situations that would project onto the flat surface in the same way. There is no further answer about whether the box "really" goes into or out of the page. Similarly, conservation laws as constraints and conservation laws as

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coincidences are both genuine theoretical roles that the same law can play, even while there is no further fact about the world that makes one construal more “right” than the other considered on a law-by-law basis.

I conclude by considering how this pragmatist construal of constraints versus coincidences reveals how two parts of Lange’s work in this section of the book are unexpectedly independent of one another. The detailed examples he considers, and the conclusions he establishes in those examples regarding constraints versus coincidence, can be accepted without therefore also having to commit to the other conceptual infrastructure related to laws. His remarks about subnomically stable sets can be assessed, and accepted or rejected, separately from the examples of constraint laws.

Sweeping general principles

Lange has elsewhere (Lange 2012) argued for a distinctively strong form of necessity associated with some mathematical explanations in the sciences, a form of necessity that outstrips even the strongest causal claim. Causal explanation has received a great deal of quite fruitful attention in recent decades, but non-causal explanation is much less theorized in terms of its internal structure. It is also a heterogeneous category, defined primarily by not being causal explanation (e.g. Andersen 2016). In his new book (2017), Lange vastly extends the range of explanations that count as non-causal. His case studies are novel and incredibly rich in detail, and in the first main section of the book, he focuses on what he calls explanation by constraint.

Lange introduces it this way. “The distinction between ‘causal’ and ‘non-causal’ explanations (as I will use these terms) lies in how they work—that is, in what gives them explanatory power. A ‘non-causal’ explanation may incidentally identify (or, at least, supply information about) causes of what is being explained. But it does not derive its explanatory power by virtue of doing so” (3). This includes the category of distinctively mathematical explanations as exhibiting a stronger degree of necessity than causal explanations. But distinctively mathematical explanations are not the only such modally enhanced explanations. Lange now adds the idea of a meta-law that constrains other laws as a category that includes but is not limited to distinctively mathematical explanation.

> In this way [being modally stronger than ordinary laws of nature], distinctively mathematical explanations are examples of what I will dub ‘explanations by constraint’… Explanations by constraint work not by describing the world’s causal relations, but rather by describing how the explanandum arises from certain facts (‘constraints’) possessing some variety of necessity stronger than ordinary laws of nature possess. (10)

To motivate this distinction, Lange quotes Feynman:

> When learning about the laws of physics you find that there are a large number of complicated and detailed laws… but across the variety of these detailed

> laws there sweep great general principles which all the laws seem to follow. Examples of these are the principles of conservation. (Feynmann 1967, p. 59, quoted in Lange 2017, p. 46)

Lange continues: "I will argue that science recognizes an important distinction: between conservation laws (for instance) as *constraints* on the fundamental forces there could be, on the one hand, and conservation laws as *coincidences* of the fundamental laws there happen to be, on the other hand" (46).

He illustrates by comparing the law of energy conservation to laws regarding gravitation and electromagnetism. Why do gravitational and electric interactions alike conserve energy? There are three laws here: two are about gravitational and electric force interactions; and one is a conservation law, about conservation of energy in any interaction, including but not limited to both of gravitational and electric interactions. There are two possible answers as to why energy is conserved in both kinds of force interactions. The first possibility is that it is conserved in one, and also conserved in the other, but that this happens to be so. There is no further deep fact about why both conserve energy. The conservation of energy would then be a *coincidence*, a result of the fact that a series of interactions happen to conserve energy. There is in this case no guarantee, no requirement, that future interactions all be found to conserve energy. If energy conservation is a coincidence, its status as a law depends on the status of the specific force laws.

The second possible answer to the question about these three laws, though, has it that conservation of energy is itself a constraint, not a coincidence. As such, it is not merely that both forces *happen* to conserve energy and thus allow us to use the descriptively accurate but unprojectible law that energy is conserved. Rather, energy *must* be conserved, and so there is a further reason why both of these two specific force laws obey the constraint that energy must be conserved. Those interactions could not have been otherwise. Lange contends "that if energy conservation is a constraint, then it is like a mathematical truth in possessing greater necessity than ordinary laws of nature do and thereby limiting the *possible* kinds of forces to those that would conserve energy" (51).

Treating conservation laws as coincidences puts the nomic priority on individual force laws, such that the conservation laws are as they are because the force laws are as they are. Treating conservation laws as constraints reverses this nomic priority, such that conservation laws must be obeyed, and this constraint is both why the actual force laws obey it, and why any possible additional force we might find would also have to obey it. Shifting from coincidence to constraint shifts the locus of necessity from force law to conservation law. This also shifts the explanatory priority. For the coincidence case, features of the set of force laws determine which conservation laws hold, so that the explanation of conservation laws falls to the individual laws that they cover. For the constraint case, the force laws being as they are and not otherwise can be at least partially explained with recourse to the conservation laws that constrain them: there are kinds of forces that are ruled out as impossible, constrained to a smaller space of possibility because of the requirement that they conform to the conservation laws.

In the case of conservation laws as constraints, though, even though they explain force laws, they are not therefore rendered unexplained or unexplainable.

> A conservation law does not need to be a brute fact in order for it to be a constraint. It may have an explanation. In fact, one way for a conservation law to be a constraint is for it to arise from a symmetry principle, since it is then no coincidence that each of the actual forces conserves the relevant quantity. Each does so for the same reason: because of the symmetry principle. (64)

Lange offers a characterization of hierarchically nesting nomic and subnomic sets of laws, in which laws such as symmetry principles are regularities among other laws, which may themselves describe regularities among more concrete laws (82).

Two final claims that Lange makes about constraint versus coincidence are relevant here. The first is the emphasis on the openness of current science with respect to this distinction, and the second, a corollary of sorts, on the possibility of future empirical work to bear on whether a given law is a constraint or a coincidence. It may be that a law for which we are currently unsure about its status will, in the future, be determined to be a constraint and not a coincidence. Because we do not yet know, we must allow for both possibilities. Thus, "metaphysics should permit Feynman's 'great general principles which all the laws seem to follow' to be constraints. It should not oblige them to be coincidences" (95).

Issuing the pragmatist challenge

I want to offer a perhaps counterintuitive reconfiguring of the significance of this distinction. This is not a criticism per se. I agree that this is an important distinction to make, that it marks genuine differences in how physicists use laws, that it must be accommodated by metaphysics, and that these great general principles are especially revealing in physics. The point I want to add is that this is a legitimate distinction, on which empirical evidence certainly bears, but it is not itself a directly empirical question in the way Lange suggests. A given law is not "really" one or the other in some fixed, determinate way. Rather, this distinction tracks differences in usage of laws, how they are connected to other laws and to other theoretical apparatus such as models, derived predictions and use in various calculations. They have their status as part of a larger theoretical package that is empirically confirmed or disconfirmed, but not in isolated pieces such that individual laws can be evaluated as constraints or coincidences one at a time outside of this theoretical setting.

My point can be set up in analogy with the Necker cube. There is a genuine distinction between a cube that comes out of a page and one that goes into the page. Three-dimensionally, these are genuinely different and distinguishable. If one has such a three-dimensional cube, there is a fact about which way it goes relative to the two-dimensional page. However, both the cube that goes into the page and the cube that comes out of the page project onto the page the same way, with the appropriate caveats about orientation, etc. They are distinguishable, in that one can talk about the cube as one or the other, as a preferred orientation of the Necker cube for some given example. But for the Necker cube itself, there is no further "real" fact of the matter about whether it goes into or out of the page. It can do either, and while we may add *further* specifications that clearly pick out one orientation, such as adding illustrations around it that fix it as coming into or going out of the page, these are external to the cube itself. Considered on its own, there simply is no determinate empirical fact of the matter that decides whether it goes into or out of the page, and no further empirical evidence on which we could possibly wait. Even posing that dichotomy is somewhat false. It is a thing that could go into or come out of the page, and that very feature of it is worth noting. No further empirical evidence about just the cube itself will ever fully determine that.

This means that the modal necessity Lange highlights for constraints is like the extra dimension that is added when we treat a two-dimensional object such as a collection of lines *as* a projection of a three-dimensional object. A law is treated as one or the other, depending on the theoretical setting in which it is considered. Evidence, taken as a larger collection, may eventually settle on one construal rather than the other, but it does so because of how that law fits into a larger framework, not because it independently confirms just that law as a constraint or coincidence on its own.

Consider Lange's remarks about conservation laws as laws of concrete laws and symmetry principles as laws about constraint laws. It is the Hamiltonian dynamical framework in which the relevant laws are expressed that is the theoretical setting I mean when I say that they cannot be evaluated purely on their own. "Finally, this view explains why any conservation law that follows from a symmetry principle within a Hamiltonian dynamical framework constitutes a constraint rather than a coincidence… [and] thereby identifies the way that symmetry principles non-causally explain conservation laws" (82).

In Lange' example of fluid non-circulation in closed systems, the key to why these fluids do not circulate is that moving from a non-circulatory state to one with circulation requires energy and the system is stipulated to be closed. This can be explained in terms of coincidence, such that lots of the fluids that do not circulate can be individually explained using causal facts about that system, but without adding that there is something each such system has in common with others such that none of them will involve circulation. The constraint explanation goes further and is stronger: no such system could start circulating, because energy is conserved, so regardless of the particular fluid, we can know in advance that the system will not violate energy conservation and that it is not merely the case that this fluid *does not* start circulating, but that it *cannot* start circulating. These are clearly different explanations. How can they be assimilated to a choice in how we use laws?

To respond, consider Lange's analogy to drug sentencing laws. Two different judges each sentence a drug offender to 5 years. We can ask: Why did the two offenders receive the same sentences? One possibility is that each receiving the same sentence is a coincidence. Each committed a similar crime, each judge weighed the evidence and facts of the case separately, and then each independently reached a conclusion about the length of sentence. There is a reason judge one passed that sentence, and a reason judge two passed that sentence, but no further reason as to why both passed the same sentence. They just happened to do so. The other possibility is that there are mandatory minimum sentencing laws on the books for the crime in question, such that each judge evaluated each case, yet was constrained by a further law to pass a sentence no shorter than 5 years. In that possibility, there is a reason why the sentences are similar—both were results of the same mandatory minimum sentencing law.

It is exactly here that I want to argue that the analogy breaks down. For the legal example, there either is or is not a law on the books as to minimum sentencing. The existence of such a mandatory sentencing law is independent of other laws, such as the illegality of possession of drugs that resulted in the original criminal charge. We could verify the potential existence of such a mandatory sentencing law: we could look into it ourselves, we could ask a lawyer to check, and we could ask some other expert as to whether the judges were both bound by such a law. Even before we know the answer as to whether the state in question has mandatory minimum sentencing laws, we know that there is a well-defined answer to the question and clear results that will determinately resolve it. It is the existence of that law on the books that determines whether there is a further explanation of why the sentences were the same or merely separate explanations of each sentence.

The pragmatist challenge is thus a rejection of the idea that there exists any such independent method for checking the answer for whether a meta-law is a constraint or coincidence. It is a rejection of the idea that one law could have this status all by itself, such that we could check for just that law and not have to invoke the law's explanatory or theoretical setting to have an empirically meaningful unit to check in the first place. There is no such equivalent to checking state sentencing laws for a mandatory minimum law in the case of constraints. When we are considering the outer reaches of our understanding of the structure of the world, there is no extra, external, method that we have to get at the real answer. There just is what we were already doing to get that answer in the first place, namely, the very physics under question. We do not have the option of checking the law, using some extra set of tools we were keeping on the side.

In particular, there is no way of checking the law separate from its place in a Hamiltonian framework, where the features of the framework itself result in there being a distinction between constraints and coincidence in the first place. We do not get to "lift the veil" and just make sure our answer matches the one on the answer key. The pragmatist challenge is that, unless the laws of physics are, first, inscribed one by one in a great Book of Nature, each with their own line, and second, that it is a book we can check just like we can check legal statutes, we have no empirical outcomes, even in future science, that would bear on just one law by itself. Rather, all such empirical evidence would bear on laws in a network of theoretical and mathematical relationships to one another. A constraint is a law in a setting where it plays the role of constraining other laws. That the same law can figure in different settings as either a constraint of some laws or a coincidental consequence of those laws is itself useful for understanding that law, just as it is useful to know how to shift perspectives with a Necker cube.

Conclusion

The analogy between explanation by constraint and mandatory minimum sentencing laws is helpful for introducing the concept of constraint and coincidence. But the analogy breaks down in exactly the regard needed to sustain the distinction as a feature of specific laws and as potentially empirically verifiable for those laws taken individually.

There are several aspects to the pragmatist point here. One is the non-atomism about evidence bearing on the modal status of particular laws. Evidence bearing on where to locate various degrees of modal necessity in physics has to be part of a larger theoretical package, how these laws figure in some framework, even if there is no universal answer as to how big that framework has to be to have direct empirical import. A second is the focus on use. The degree of modality associated with a given law comes down to what we are doing with it. We can use it as a coincidence, or we can use it as a constraint, but it is not that one use is somehow "righter" by the lights of the universe if both return empirically well-validated results. They just are not quite in direct conflict, like switching between perspectives with the Necker cube. The third aspect is a challenge to the kinds of realism that require there to be One Right Answer hidden behind a veil that we could, in the end of time, lift, or which even if we cannot lift it, is there to do the work of making one answer correct and the other incorrect.

Ultimately, this pragmatist construal of the constraint–coincidence distinction manages to retain most if not all of Lange's interesting points about the particular examples: the varying gradations of modality, the different degrees of strength associated with explanation by constraint versus explanation by coincidence, the relationships between laws that constrain causal facts and laws that constrain other laws, and the distinction between constraint found in meta-laws such as energy conservation and constraint found in distinctively mathematical explanations. These are all recast in a new perspective but still have an import that is so similar as to be striking given Lange's decidedly non-pragmatist approach. The fact that the pragmatist can make so much of these examples and this distinction undermines the support that these examples give to the other parts of the book. In particular, one need not accept any of Lange's conceptual terminology regarding subnomically stable sets in order to draw on the detailed case studies and this distinction.

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