Context Changes Everything

How Constraints Create Coherence

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Multiple Realization and Supervenience

A Philosophical Case Study about Constraints

This chapter analyzes two contemporary arguments about multiple realizability and the relation between supervening and subvening entities and processes. Lawrence Shapiro and Thomas Polger's views (Shapiro 2000; Polger and Shapiro 2016) on functional multiple realizability are discussed first. I then examine Marc Lange's (2017) logic of explanation as it pertains to natural phenomena that are alike.

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The Principle of Supervenience turned on the relation between subvening processes (also called realizers) and supervening (realized) properties generally, not only in the mind–body realm. Its claims presupposed that the following questions had been answered in the affirmative: (1) Does multiple realization actually happen? (2) If so, do multiply realized (supervening) types identify real kinds? What qualifies as different tokens of the same kind? For example, Are camera eyes, like those of humans and octopi, and compound eyes, like those of insects, different realizations of the same kind of thing, eyes? Or are they two different kinds of things?

As we saw with the two versions of the identity theory, the classical question of type identity—are types real or not?—has reappeared. Or does reality, and, especially, causal power inhere only in ground-level primary properties, making types mere epistemic classifications?

Shapiro and Gillett on Multiple Realizability

American philosopher Lawrence Shapiro reaffirms Davidson's premise that only causally relevant properties, those that cause a thing or process to carry out a function, qualify as realizing properties. Kinds are defined in terms of type-level properties. In the case of mousetraps and corkscrews, those properties are functional: this device is a mousetrap if it performs the function of catching mice; that levered gizmo is a corkscrew because it carries out the function of uncorking bottles. It is only in virtue of those causal powers that they are the type of thing they are, corkscrews or mousetraps.

Shapiro maintains that two entities are distinct token realizations of the same kind only if their causal mechanisms are different. Even intuitively, differently colored corkscrews do not count as different types of corkscrews. Tokens must realize the same functional type through different causal mechanisms. Silicon and biological brains, for example, differ in material composition (one is made of organic neurons, the other of silicon wafers). But since electricity is what causes information processing in each, "There seems to be no more reason to count [silicon and biological brains] as distinct realizations" of mental events (Shapiro 2000, 645) than if some neurons were stained gray and others purple.[1]

Shapiro justifies this conclusion by referring to Fodor's principle that "what justifies a taxonomy, what makes a kind 'natural,' is the power and generality of the theories that are enabled when we taxonomize in that way" (Fodor 1981). Scientific theories discover similarities that enact lawful regularities; it is the scope and stringency of the natural laws they subtend, not mere correlation, that underwrite the power and generality of truly scientific predictions. So, to qualify as multiple realizability, causal mechanisms of allegedly distinct realizations must "require different manipulations, *[and be] described by different laws*" (Shapiro 2000; emphasis added).

From this premise, Shapiro concludes that functional properties are either not ("all that") multiply realizable, or there is nothing particularly interesting about higher-level functional phenomena as such.

He reasons as follows: mammalian and octopus eyes share the same causal mechanism: light impinges on a single lens, projecting an inverted image onto a retina, which converts the image into an electrical signal. Because the single lens, retina, and electrical signaling mechanism is the same in both mammals and octopi, there are no causal differences in virtue of which octopus eyes and mammal eyes realize vision. There is a fortiori no difference in the natural laws that bring about vision in the two cases. Since a "virtually identical structure" (Putnam 1967, 1975) governed by the same natural law causes vision in each[2] (Shapiro 2000; Polger and Shapiro 2016, chap. 3), mammal and octopus eyes are not multiple realizations of the same kind of thing, eyes.

If a predicate does not feature in a natural law, it does not pick out a real kind and so no multiple realization occurs. In philosophical jargon, only *projectible properties* appear in natural laws. By identifying traits governed by natural laws, projectible properties underwrite prediction; as such they support counterfactuals and can "be taken as guides to valid inductions."[3] That is what makes them real properties.

Shapiro argues that functional properties such as uncorking wine bottles and catching mice are not projectible because there are no natural laws that determine uncorking or mouse-catching. He goes further. The "sciences" of economics, ecology, and so on are also bogus, and for the same reason: they deal in bogus kinds because no predicates in those sciences are projectible. There are no natural laws of economics or ecology. Consequently, there are no proper natural laws in the special sciences. Indeed, there are no natural laws that hold for higher-level or purportedly functional properties as such.

The unavoidable implication for philosophy of mind is that thinking, intending, sensing, perceiving, and other higher-order (mental) events are projectible traits only if those characteristics feature in natural laws. But no psychobehavioral laws exist that universally and deterministically link mental properties as such with particular actions. So mental properties do not pick out real ontic kinds. They are not real properties. "If two realizations contribute to a capacity in causally distinct ways then this must mean that there are no *[lower-level]* laws common to both of them" (Shapiro 2000, 648; emphasis added); so each realization enacts a distinct natural law. Different corkscrews, mousetraps—or mental and social processes —might be functional isomorphs of one another, but they are not multiple realizations of real kinds.

American philosopher Carl Gillett (2003) describes this impasse as the clash of two opposing views on causal relations between realizer and realized. Under Shapiro's *flat realization view*, as Gillett terms it, the fact that the lenses of mammals and octopi eyes are composed of different proteins and rely on different pigments is irrelevant. These features have no direct causal role in bringing about vision. The real causal mechanisms are the single lens, inverted image, retina, and electrical impulses, which mammals and octopi share. Shapiro (2000): "Sameness in the processes that result in the formation and analysis of an image screen" provides truth conditions for determining causal relevance. Differences in proteins and pigments must be screened off as causally irrelevant to the actual and virtually identical causal mechanism in both.

The flat view, that is, requires that properties and causal mechanisms of subvening realizers directly cause the realized and supervening properties. The combination of realizing components and processes (here a single lens projecting an inverted image on a retina, which converts it to electrical signals) is what causes vision. The flat view, in short, implies a bottom-up and strictly determinist one-to-one correlation between realizer and realized (which, as efficient causes, must also be separately identifiable). Because natural laws project microlevel properties, only one macrostate realization results from a given set of microstates.

In contrast, the *dimensioned realization view* has a more expansive interpretation of cause: on that view, the powers of the realized (functional) property result from the "powers of the realizers" (Gillett 2003, 595) even if the realizers "may and often do contribute no common powers including those individuative of the realized property" (Gillett 2003, 602). As an example, individual neurons do not think or feel, yet thinking and feeling result from systemwide emergent properties of collective neuronal processes. The dimensioned realization view, in short, recognizes that, together, realizers can induce emergent qualitatively novel properties. Gillett (2016) notes that whereas physicists have long accepted that collective properties of nesting entities manifest emergent properties beyond those of their nested components, physicists still fail to recognize the active causal power of collective properties to change the go of events.

Unlike Shapiro, therefore, proponents of the dimensioned realization view take octopus and mammal eyes to qualify as different realizations of the same kind of thing. American philosophers Jerry Fodor and Ned Block argue that differences in pigments and proteins of lenses in mammals and octopi make those two instances multiple realizations of a distinct type of entity, eyes. "What is important is that the properties/relations of different realizations, such as lenses composed of different pigments and proteins, nevertheless contribute powers that result in the powers individuative of having an eye" (Gillett 2003, 596). Unlike corkscrew color, which contributes nothing to the device's uncorking powers, differences in proteins and pigments in the eyes of mammals and octopi do contribute to realizing vision in the two cases.

Significantly for our purposes, Gillett also points out that under the dimensioned view, although realizers are not technically causes because they are not spatiotemporally distinct from the realized properties, components can contribute powers that result in but do not literally (efficiently) cause the emergent properties of the whole. On the dimensioned realization view, constituent parts and processes are labeled potential realizers, not causes, of the higher-level property (Gillett 2003, 596, 601). The common set of powers of the realized property (Figdor 2010), goes beyond the powers of the realizers separately.

This contemporary disagreement about mereological causation revisits the entire history of the subject matter; the dimensioned view also makes room for the idea that enabling constraints generate multiply realizable supervening types with emergent properties (vision, in this example). Realizers of the same higher-level property can differ at the microlevel, depending on context. Nevertheless, they remain variant tokens of the same, type-defined, emergent constraint regime. The deep dyslexia example presented a dimensioned realization view of meaningful causation.

Throughout the debate, Fodor, Block, Shapiro, and other contemporary philosophers who study multiple realizability do not seriously consider the possibility that a form of cause other than efficient cause might, mereologically, bring about emergent, higher-level (realized or supervenient) properties. Shapiro explicitly maintains that only lower-level properties ground natural laws and guarantee their truth. He adheres to the received view that the explanatory arrow always points downward. From his perspective, only bottom-up causal relations underpin scientific explanations; only microlevel properties and causal mechanisms are projectible and support universal and determinate natural laws that hold across instances. It is only because identical causal mechanisms bring about vision in mammals and cephalopods (lenses, retinas, etc.) that the science of vision can study "optical principles that apply to light and lenses"[4] generally, he maintains. These correlations hold true "in virtue of some deeper set of laws" (Shapiro 2000, 653).

Having concluded that no higher-level functional properties are projectible or ground universal natural laws, Shapiro concedes, "There may be general statements about the higher levels that refer only to their capacities" (Shapiro 2000, 648), such as statements like "Lever corkscrews and rack-and-pinion corkscrews are both corkscrews," and "Natural selection selects organisms that can maintain their body temperature over those that cannot." Such propositions, however, are analytic and tautological, not proper natural laws. Their impoverished content is why most scientists aim to causally connect common lower-level internal mechanisms, processes, and properties with supervening properties and functionality, he maintains. Proper sciences thus aim to discover laws that correlate internal mechanisms with supervening properties (Shapiro 2000; Polger and Shapiro 2016). Only fundamental properties cause supervening functions, and functions are the direct effect only of relevant lower-level causal processes. Degeneracy or multiple realizability are therefore bogus ideas (See Figdor 2010 critique). All the heavy causal lifting is done by the subvening processes.

Gillett's 2016 book, in contrast, is a plea for *mutualism,* the view that emergent properties even physicists if not philosophers recognize to be real are also not epiphenomenal (which most physicists still espouse). But Gillett himself does not address the manner of causality in virtue of which the emergent powers of what he calls collectives and system-wide interdependencies might exercise that power on components and in behavior.

Lange—Because without Cause

Can Shapiro and Gillett's positions be reconciled? Contemporary American philosopher Marc Lange (2007, 2017) argues that not all scientific explanations appeal to causal force laws. Questions of the form, "Why are gravitational and electrical interactions alike in conserving energy?"—or more generally, why are X and Y alike with respect to Z?—cannot be explained solely by deriving gravitational interactions from gravitational laws, and electrical interactions from laws governing electrical interactions. Individually or jointly, such force explanations make no mention of why the two cases would be alike with respect to energy conservation.

The point is a general one: "Causal explanations do not unify two cases" from different fields (Lange 2017, 57). Neither do compound explanations such as combining appeals to gravitational and electric laws explain why two actual instances of gravity and electricity are alike with respect to energy conservation.[5] In particular, separate and joint explanations that make reference to forces cannot rule out the possibility that the two instances conserve energy just as a mere coincidence.

Whereas Polger and Shapiro dismiss appeals to noncausal relations, Lange argues that some scientific explanations do explain *alikeness* by reference to shared higher-level constraints and more inclusive dimensions (Lange 2017), not common efficient causes. Not only can shared constraints in a more encompassing dimension explain why X and Y hold independently (Lange 2017, 65), appeals to constraints in common can also explain why the individual force laws hold in the two cases (Lange 2017, 61). Let us see why.

Principles and Laws

As noted, in the natural sciences the term *law* is commonly used to designate only those correlations that support counterfactuals; natural laws commonly identify force laws underwritten by projectible predicates. Natural laws so understood ground the "covering-law model of explanation" that contends that events are successfully explained if and only if they can be inferred from a natural law together with initial condition statements. It is for that reason that philosophers like Shapiro refuse to apply the labels *lawful* and *scientific* to the special sciences; they are dismissed because their purported laws lack the necessity and universal scope to support inferential predictions.

Lange contends that even in those cases where entailment holds, proofs deriving the explanandum from force laws would still not show why two cases are alike with respect to a certain property despite being the outcome of different forces. Satisfactory explanations of the relation between the two cases must show not only why gravitational and electrical interactions are alike in conserving energy, they must also show why their joint occurrence is not coincidental. Coincidences, to put it crudely, do not have a "common reason" (Lange 2017, 66) for happening. (Note use of *reason* in lieu of *cause*.) In contrast, specifying a real and "distinct class" of which the two cases in question are instances would identify a common reason for why the two cases are alike. By identifying that they are similar "in virtue of some context where the results exhibit this noteworthy similarity" (Lange 2017, 280), explanations of this form would succeed in showing why distinct cases must be alike.

Lange emphasizes this is not merely an epistemic move. Epistemic and psychological considerations alone are insufficient to reveal what makes certain combinations of facts explanatory and not merely coincidental (Lange 2017, 287). Purported explanations are satisfactory depending on their ontic implications. In this example, reference to "energy conservation" moves the explanation to a shared ontic context in virtue of which the similarity is necessary. In mathematics, finding a shared "class of cases" might require moving to a third dimension and showing that the lower-dimensional outputs are alike by virtue of being instances of a class defined in that higher dimension—by being realizers of a common constraint, that is. "Metaphysics must not foreclose [on why-type] explanations . . . on pain of failing to do justice to the fact that science has rightly taken such proposal seriously" (Lange 2017, 67).

This requires taking relations and context seriously. This book has claimed that enabling and governing constraint regimes whose interdependencies weave together a common context within which individual instances are distinct realizations provide that why-type explanation. Constraints, in short, provide the reason why distinctly realized entities are tokens of the same kind or type of thing.

* * *

Lange notes a second difference between shared constraints operating in a third dimension, on the one hand, and force explanations, on the other: constraining principles that apply to both domains explain the (force) laws in question by describing a common context that excludes some alternatives while including others in its common possibility space. The coordinates and boundaries of that shared context limn what is empirically possible and what is not.

Possible force laws are force laws that satisfy constraints laid down in that third dimension. *Logically possible force laws* that cannot empirically satisfy those constraints are *factually impossible* (Lange 2017, 51). By underwriting “a certain distinctive kind of invariance under perturbations” (Lange 2017, 48), conservation principles—the shared dimension—serve as context-independent constraints on a shared space of *empirically possible force laws*, be they gravitational or electric.

That is, shared constraints from a common dimension define a more expansive possibility space where distinct but logically possible force laws can operate simultaneously. Conservation and symmetry principles—common dimensions of constraint in physics—do just that; they set the boundaries or coordinates of what is simultaneously realizable empirically and what is not. They determine context-independent constraints. The International Monetary Fund does the same; it does not lend much money directly, nor does it negotiate with a country and its creditors. The IMF “draws the boundaries of possibility and policy” (Lustgarten 2022) within which other banks, investors, and rating agencies must operate. It does so by setting the common boundary constraints that would govern any natural realization.[6] Lange’s third dimension thus corresponds to a shared background of context-independent constraints. This shared possibility space outlines the context in which invariances can hold and persist.

Lange prioritizes natural over logical possibility and impossibility. He cashes out natural necessity and impossibility in terms of invariance: conservation and symmetry principles establish “a certain distinctive kind of invariance under counterfactual perturbations” (Lange 2017, 48). Conservation and symmetry “would still have been conserved even if the forces at work were different” (Lange 2017, 48), “even if there had been additional *kinds* of forces threatening to undermine its conservation” (Lange 2017, 72; emphasis added). Because conservation and symmetry principles are multiply realizable, they can account for laws that could logically be in effect (but factually are not).

In such cases, the arrow of explanation of necessity points upward to a common dimension of constraint.

* * *

How stringent must the invariance preserved by shared constraints be to qualify as scientific? Lange’s case study is about reconciling instances of electrical and gravitational interactions by reference to energy conservation. In his example, the common dimension refers to “great general principles which all [force laws] follow” (Lange 2017, 51). Principles of energy conservation and symmetry are indeed universal; they “sweep across”[7] all other laws. By grounding “alikeness” in a universal and an unchanging dimension, they account for “why the [two cases] are alike in possessing certain features" (Lange 2017, 51). Despite being realized by different force laws (gravity and electromagnetism), *energy conserving* is a projectible predicate; it features in a universal principle, a shared and universal constraint regime.

In contrast, our own examples of constraints such as feedback and catalysts do not universally "sweep across" conditions universally. Their context dependence prevents them from grounding counterfactuals universally.[8] Is this a fatal objection to this book's project? Association and correlation are not causation; something stronger is required to justify a "causal" claim. We have suggested that, within a specified context, constraint regimes of mutual dependencies effect covariance and thereby ensure an interactional type's persistence. But must the counterfactuals in question hold universally?

I reject this assumption and the requirement of universally projectible predicates. Among the central claims of this book has been that context dependence is a feature (not a bug) that science (Science 2.0?) must incorporate into its conceptual framework. I reject the unstated premise that ontic kinds (which we have called interactional types) are solely underwritten by laws and principles that apply in all instances, anywhere and always. Requiring that all real events and processes refer to universal laws that support prediction under all conditions rules out, from the outset, any effective role for context dependence. That is the framework of modern science and philosophy. This approach was already tried with Platonic Forms, Aristotelian and Cartesian substances, and Laplacian laws that are allegedly unchanging and eternal regardless of context. It is a framework that works spectacularly well in many cases, such as with predicting the motion of two planetary bodies, for example. But there are cases, such as whirlpools and coupled pendulums, not to mention ecology, psychology, and other special sciences such as economics where it does not. In those fields, context changes everything.

In this connection, and in opposition to a Laplacian notion of natural law (equations that describe events at the most microscopic and fundamental level, from which all macrophenomena are held to follow and from which they can be deduced), Herbert Simon notes that a so-to-speak Mendelian notion of natural law

> takes as its ideal the formulation of laws that express the *invariant relations between successive levels of hierarchic structure*. It aims at discovering as many *bodies of scientific law* as there are *pairs of successive levels*. . . . . The fact that nature is [contextual, path dependent, nested, or] hierarchic doesn't mean that phenomena at several levels—even in the Mendelian view—cannot have common mechanisms. (Simon, in Pattee 1971, 24–25; emphasis added)

Or, on a generous understanding of "mechanisms," common constraints and shared contexts.

In the spirit of Simon's comments, this book calls for expanding the framework of the natural sciences to include what might be called *effective science*, where alikeness, lawfulness, and counterfactuals identify invariances conditioned on multiple shared constraints in specified possibility spaces. Complex dynamical systems theory calls for a science that includes indexicals and their contextually situated properties.

Effective science would seek counterfactuals that hold conditional on a specified range of contexts: this focal heterarchical level, in this embedding heterarchy, and realizable by a specified range of tokens. Figdor's excellent paper on degeneracy in cognitive neuroscience (Figdor 2010) presents empirical research that points in that direction. Considering the uncountable dimensions along which neuroanatomy as well as neurophysiology can be mapped onto cognitive and other supervenient and emergent properties, a heterarchy-inspired approach informed by Simon's comments becomes a reasonable methodological alternative.

The thesis presented in this book is that overlapping constraint regimes exist for a range of organizational levels. The interdependencies that characterize each level are as much the outcomes of context-independent and context-dependent, enabling and governing constraints as they are the effects of forces. Constraints generate indexical phenomena whose invariances must be explained in terms of the contextual constraints shared by the explananda in question. Theories about inflammation, for example, would need to directly address three different but interrelated bodies of law about invariant relations formed by constraints that enable, stabilize, and regulate homeostasis as a whole: one set of homeostatic constraints would be concerned with structure, one with function, and one with functional regulation (Medzhitov 2021). In each pair of levels, the latter supervenes on but exerts governing constraints on the former. Malfunctions of regulatory (governing) constraints can be expected to cascade down and decompensate functional constraints at the next level down. Malfunctions in functional constraints in turn can be expected to make structural constraints go out of kilter, with contextual constraints playing a significant role within and across all levels of organization.

On a positive note, previously unknown constraints shared by vastly different domains might be discovered through such a dimensioned and rich view of multiple realizability. Network theory, for example, has built on those insights to discover constraint architectures shared by widely diverse domains, from terrorist networks to disease transmission patterns.

The interpretive frame of coherence-making by contextual constraints partitions the world along an entirely different set of joints. Discovering shared constraints might reveal a whole new world of interdependencies. It would reveal new dimensions that could explain why two instances from entirely different domains are alike. The following is an illustrative case study.

* * *

The remarkable errors produced by a neural network trained to read words were described earlier. Neural networks and human cases of dyslexia that commit the same type of errors refute Shapiro's claim that the multiple realizability thesis is an a priori argument. These experiments provide empirical evidence of the operation of constraints at the heart of multiple realizability (Juarrero 1999; Moreno and Mossio 2015).

Facial recognition errors committed by both humans and software trained on similar databases offer a related empirical test case for this claim. People commonly misidentify faces of members of the other racial group when it is not represented in the training data set (Bothwell et al. 1989; Castelvecchi 2020; Heyer et al. 2018). If both human cross-racial identification and those of a neural network's middle layers are enabled and governed by shared context-dependent constraints, such errors can be explained as being alike with reference to the type-identified attractors in which both are embedded. Attractors generated by comparable enabling constraints constitute a shared dimension with emergent properties in common that renders two cases ontically alike and not merely coincidental. With respect to that context, each instance is a distinct token of the same Kind of entity. In the facial identification use case, the attractor embodies a multiply realizable type with the emergent property of facial recognition. Realized tokens of this type would be embody those shared constraints that generated the attractor, whether silicon or human.

Constraint regimes define and embody emergent properties of type-level constitutive and governing constraints. On our account, then, constitutive constraint regimes that govern interdependencies of a coherent dynamic describe a shared third dimension with respect to which token outputs are alike; they are tokens of that dynamic type. Attractors formed under the control of a shared constraint regime induced by analogous enabling constraints also illustrate that properties of coordination dynamics and their regulatory constraints carve out reality at different joints from those of folk psychology. Neither our ordinary intuitions nor our classical views of types and kinds would have gathered humans and artificial neural networks under one class. But neither would our ordinary intuitions have classified humans and tornadoes as alike (as dissipative structures).

The invariance in both cases is regulated by a more encompassing set of interdependencies, by the constraint regime of a shared domain that is contextually generated and emphatically not epiphenomenal. As suggested by the attractor concept, self-organized possibility space modifies a system's actions once it is pulled into the attractor's basin. Lesioning human and silicon neural networks below the feedback units—below the constraint regime—reveals the presence of top-down control. It reveals, that is, the organization of complex attractors with effectively comparable constraint architectures in the middle layer of both the neural network and in human association cortices. These interdependencies, generated by the enabling constraints of the training set, especially recursive feedback, can be said to sweep across biological and electromechanical laws and support their alikeness. Critically, however, because they are contextually constrained, the interdependencies hold only under these conditions, in this context, given that training set, and so on.

With contextual specifications spelled out front and center, the approach presented in this book explains why those constraints continue to hold even when different causal mechanisms and material substrates (silicon and wetware) are at work, or when lesioning the network or anatomical malfunction threatens to undermine its unity of type. This perspective offers a more richly dimensioned understanding of realization relations and multiple realizability. Its robustness supports counterfactuals, but only as conditional upon a specified context. Under those conditions, the concept of governing constraint regimes renders top-down causation effective as meaningful, even if only for a range of realizations, under a range of conditions.

This work has proposed that we take seriously the possibility that real relations of constraint generate, constitute, and govern those interdependencies. In addition to looking inward toward components, the logic of explanation appropriate to complex dynamical systems must also look upward (Wimsatt 1974, 1976), to what Lange calls a shared dimension of constraint. Which dimension of constraint, I would add, can bring about effects—even if not as efficient cause. Stated otherwise, explanations of complex systems must look outward to context and backward to history in which those interdependencies were formed and in which they are embedded—as well as inwards to the system's components and local attractors that realize and specify its current possibility space.

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