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Diamonds and Corkscrews:

A Hybrid Account of Realization

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Declaration

This dissertation is my own work and contains nothing which is the outcome of work done with others, except as specifically noted in the text and Acknowledgments.

This dissertation has not previously been submitted for any other degree or professional qualification.

I, David DesRoches-Dueck, make this declaration in accordance with the requirements set forth by the University of Edinburgh under the Postgraduate Assessment Regulations for Research Degrees.

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Abstract

Contemporary work in the metaphysics of realization has produced two central theories as to what it is for an individual to realize a kind. According to the 'flat theory' of Lawrence Shapiro, an individual realizes some kind by exemplifying or instantiating the properties that define realizations of that kind. With Carl Gillett's, 'dimensioned theory', on the other hand, an individual takes part in the realization of some kind merely by contributing causally towards the properties that define realizations of that kind.

Both views are vulnerable to objections. Flat realization is focused on the realization of functional kinds, and, therefore, is poorly suited to describe the realization of scientific or compositional kinds. The dimensioned view handles compositional kinds very well, but has difficulty delineating limits as to what may count as a causal component for sake of realization. If everything qualifies as a causal component of realization, every individual with different causal components begins to resemble a unique realization. If every individual qualifies as a unique realization, every kind constituted by more than one individual will be constituted by more than one realization. This threatens to trivialize the realization thesis, as every kind becomes multiply realizable.

In order to resolve these problems, I develop a two-level theory of realization inspired by Lewis' 'Mad Pain and Martian Pain'. According to Lewis, pain should be identified only contingently with the physical properties of typical pain. It is also the case, according to Lewis, that pain should be identified only contingently with the functional properties of typical pain. Accounting for this dual contingency suggests two different ways in which a causal role may be fulfilled. On the one hand, a causal role can be fulfilled in the sense in which an individual's internal systems and structures are understood to produce certain aggregate, object-level capacities. On the other hand, a causal role can also be fulfilled in the sense in which certain object-level capacities are understood as the instantiation of psychological or conceptual abilities. If these different senses of role fulfilment qualify as different ways of realizing a causal role, there will be different, but compatible, ways in which an individual may be understood to realize a particular kind.

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Introduction

Not many people in Canada still use wood-burning stoves as their primary source of heat. I do. When the outside temperature dips below - 20 °C, however, this stove has to be kept very hot in order to keep the entire building at a comfortable temperature. This heat is distributed primarily through convection, and so the stove is centrally located in the middle of a large room. As a result, the potential for accidental contact with the stove is rather high. In the course of daily comings and goings, I have sometimes come into contact with the stove when it is hot. Needless to say, the contact often results in the experience of pain, an exclamation to that effect, and the rapid withdrawal of the affected limb. On occasion, I have also witnessed houseguests inadvertently come in contact with the stove, exclaim, and manifest the same sort of behavioral withdrawal. When this occurs, I attribute pain to that person.

Drawing a connection between the causes and effects of my experience and those of another seems to warrant the attribution of my experience to that person. In fact, I may also suppose that I can identify similar experiences in nonhuman creatures, purely in virtue of their behavioral reactions to unpleasant stimuli. A mollusc, for example, may react to noxious stimuli with withdrawal and protection behaviors that are analogous to the causes and effects of human pain. Under such circumstances, I may consider it appropriate to attribute pain to the mollusc.

There appears to be less justification, however, for attributing pain to a mollusc than to another human being. As members of the same species, two human beings will share not only their behavioral reactions to noxious stimuli, but many of the physiological systems by which those reactions are produced. Molluscs, on the other hand, differ radically from human beings in the way their bodies produce reactions to noxious stimuli. If this internal difference is wholly or even partly constitutive of experience, parallels in the way humans and molluscs react to noxious stimuli may not derive from a similarity in human and mollusc experience. Just because the mollusc exemplifies the causes and effects of pain, in other words, does not mean the mollusc is actually in pain.

Determining the sort of physical properties that are able to instantiate cognitive properties is to determine the realization of cognitive properties. The thesis of multiple realization is the

thesis that single cognitive kind can be instantiated via or 'realized by' distinct physical kinds. Were humans and molluscs to share a similar cognitive state of pain, their distinctive physical manifestations of that state suggest that the state of pain may be realized in different ways: One way of realizing pain would be via the physiology of human beings, while another way of realizing pain would via the physiology of molluscs. Although the physical realization of pain would, in this case, differ, the multiple realization hypothesis suggests that the cognitive state thereby instantiated would be the same. By allowing that different physical states may sometimes produce the same cognitive state, multiple realization encapsulates the idea that there can be sameness in spite of physical differences.

This thesis addresses the problem of how we should conceive of the realization relation. In doing so, the thesis develops an idea of the circumstances under which we should consider two realizations to be the same or different. As knowing the circumstances under which two realizations should be considered the same or different is closely related to the idea of multiple realization, the thesis may also be understood to develop a position on the plausibility of multiple realization.

Functionalism and Realization

The concept of realization first appeared during development of the functionalist theory of mind. Functionalism asserted that mental states could be defined in terms of their causal relations to stimuli, behavior, and other mental states. As functionalists defined cognitive states entirely in terms of these causal relations, reference to the physical properties of cognitive states was unnecessary. Any physical properties could be compatible with a functional interpretation of cognitive states, provided those physical properties instantiated the proper causal relations. In a typical functionalist narrative, various artifactual examples would be drawn upon to bolster the claim that physical difference was compatible with functional similarity. Such an example could take the form of two carburetors which, though made of different materials, would function in the same way. As a result, a functionalist might use such an example to claim that the kind *carburetor* was a kind that supported different, or multiple, physical realizations.

Introduction

In general, the plausibility of multiple realization will tend to reflect a tension between the specificity of some functional description and the physical constraints imposed by nomological possibility. Some functional descriptions will be quite general. As a result, the type so described will allow for instantiation by many different physical types. The shape and mass of a paperweight, for example, does not matter so long as that paperweight is able to prevent paper from blowing away. Other functional descriptions may pick out roles so narrowly circumscribed those roles can only filled by one or few physical types. The functional role consistent with being able to scratch any known surface, for example, is a role that can only be filled by a diamond. Understanding the dynamic between functional description and physical possibility is the key to assessing the plausibility of multiple realization.

As a result, theories of realization may be assessed in terms of which component of realization - the functional component or the physical component - is given priority. Too great an emphasis on either the physical or the functional properties of realization is apt to have significant consequences for the possibility of multiple realization. Where the physical properties of realizing individuals exert too great an influence on the realization relation, too many physical differences may be allowed to produce differences in realization. If many physical differences are allowed to produce differences in realization, many kinds will qualify as multiply realized. If many kinds are multiply realized, the idea that one kind in particular is multiply realized may cease to have much significance.

On the other hand, one can also allow functional properties to exert too great an influence on the realization relation. The danger, when this occurs, is that too great an emphasis on function will allow too many physical kinds to count as instantiations of the relevant function. This becomes particularly problematic when the function described is relatively general. If the kind *breadbox*, for example, is defined solely in terms of the ability to contain bread, a great many physical kinds will count as realizations of *breadbox*. Although a countertop breadbox will qualify under this description, so will bread bags, garbage bags, and the White House. If these physical kinds all instantiate the function in the same way, these physical kinds would also qualify as the same realization of that function. In such a scenario, *breadbox* would be univocally realized and, therefore, not an example of multiple realization. The danger, then, is

that an improper emphasis on the functional properties of realized kinds will result in few or no kinds that are multiply realized.

An important question for realization, then, is precisely how much functional similarity is supposed to survive what sort of physical differences. The most oft-cited early appearance of the realization thesis, that in Hilary Putnam's *Psychological Predicates*, does not address this issue. In fact, Putnam's use of the concept of realization largely assumes the realization thesis in course of an argument for functionalism.[1] Moreover, precisely what is being assumed by the concept of realization is rather unclear. Putnam, at one point, refers to the 'physical realization' of sense data in order to contrast this with the more abstract inputs and outputs characteristic of a machine table.[2] At another, he refers to the 'physical realization' of entire systems, and contrasts these with the sort of functional description that is appropriate to probabilistic automata.[3] Although Putnam's use of 'realization' suggests that physical realizations are to be understood as instantiations of functional concepts, there is no mention of the precise relation between physical and functional properties.

The perceived utility of the concept of realization resulted in its rapid adoption within the philosophy of mind, although there remained little consensus as to precisely what the concept was supposed to entail. Putnam's use of 'realization' suggests that realizing properties and realized properties will be entirely different sorts of properties, while Jaegwon Kim's more reductive analysis suggests that realizing and realized properties may be different ways of understanding properties that are largely the same.[4] Joseph Levine attributes realizing and realized properties to the same individual, while William Lycan allows that realizing and realized properties may sometimes by properties of different individuals.[5] These rather substantive disagreements as to the nature of the realization relation suggest that the status of realization within the philosophy of mind is far from settled.

Addressing the second of these two questions; that of whether realizing and realized properties should be considered properties of the same individual, forms a substantial component

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[1] Putnam 1967 is the canonical early reference to the realization thesis, although Putnam 1960 also invokes the idea of the 'physical realization' of a Turing Machine.
[2] Putnam 1967, p. 57.
[3] *Ibid*, p. 54.
[4] Kim 1992 and 1993.
[5] Levine 1993 and Lycan 1987.

of this thesis. Although this understanding of realization is seemingly at odds with Putnam's original intention for the concept, I will argue that theoretical considerations justify the change. In particular, I will argue that the realization relation becomes more scientifically defensible when it diverges from the meaning of its original use.

Three Theories of Realization

Three theories of realization are considered in this thesis. The first theory is that of Hilary Putnam, and is based on the idea of realization as functional isomorphism. By Putnam's lights, realization is a matter of mapping functions to physical systems. When we have different physical systems that nonetheless support the same function, we will have identified different physical realizations of that function. The problem with this view of realization is that any physical system will be composed of a vast number of tiny entities. Providing these entities are individuated in an appropriate fashion, almost any physical system may be interpreted as the instantiation of almost any function.

Suppose we choose a specific function, such as an algorithm designed to add two numbers. We might be inclined to say that a calculator implements this algorithm in virtue of the fact that a certain pattern of activity that takes place inside the calculator. By Putnam's lights, the calculator and the algorithm would be functional isomorphic, and we would be justified in calling the calculator a realization of the algorithm. The problem is that a different physical system, such as a pail of water, also contains patterns of activity between its molecular, atomic, and subatomic components. It is correspondingly likely, then, that some pattern of activity within the water would correspond to our algorithm. If this were the case, our pail of water would be functionally isomorphic to our algorithm, and, as a result, would qualify as a realization of that algorithm.

Lawrence Shapiro's 'flat' theory of realization, on the other hand, suggests we do away with the idea of functional isomorphism in favor of a more causal approach to realization. Shapiro's approach specifies that a physical individual realizes a functional kind when that individual possesses the causal properties that are relevant to the individuation of that kind. Physical individuals with properties causally relevant in the same way to the realization of the

same function qualify as identical realizations of that function, while physical individuals with properties that realize the same function in different ways would count as different realizations of that function.

Shapiro's way of describing the realization relation sets up a dilemma for multiple realization, however. In cases where realizers do not differ in the properties that are causally relevant to realization, we will have realizers that qualify as the same realization of the same function. There will be no multiple realization in this case, as multiple realization requires different realizations of some function. In cases where individuals do differ in the properties that are causally relevant to realization, on the other hand, those individuals will qualify as different realizations of some function. The problem is that where functions are defined by their causal properties, realizations that differ in their causal properties will be realizations of different functions. There will be no multiple realization in this second case either, then, as multiple realization requires different realizations of the same function.

Carl Gillett disputes the idea that there must always be a one-to-one correspondence between a realization and its realizer via his 'dimensioned' approach to realization. Gillett notes that, in the sciences, it is often the case that the properties and powers of some kind are not possessed by the individuals that are causally responsible for those properties and powers. A diamond, for example, possesses the property of hardness. The properties that are causally responsible for that hardness, however, are the bonding and alignment properties of a population of carbon atoms. If the relation between carbon atoms and diamond qualifies as a realization relation, two claims may be made. Firstly, the properties of some realization may be different than the properties of its realizers. Secondly, the individual possessing realizing properties may be a different individual than that possessing the properties realized.

In suggesting that some individuals can be realized by their causal components, however, the dimensioned view runs the risk of trivial multiple realization. Where the components of a realization serve as its realizers, it is necessary to specify a limit at which smaller and smaller causal components become irrelevant to realization. Without such a specification, each realization begins to look different, with respect to some causal component, from every other realization. As any two physical individuals, no matter how similar, are apt to differ compositionally, two similar physical individuals that differ in composition may also qualify as

different with respect to realization. If every individual constitutes a different realization from every other individual, the threat of trivial multiple realization begins to look credible.

Lewis as a Model for the Positive Thesis

In response to the perceived deficiencies of flat and dimensioned approaches to realization, I develop a hybrid theory of realization based on the idea that there are different ways in which causal properties fulfill causal roles. This hybrid approach is introduced by, and modeled upon, David Lewis' approach to pain in the paper 'Mad Pain and Martian Pain'. According to Lewis, the concept of a mental state is the concept of a state that stands in certain causal relations to other states. For pain, it is the concept of a state that is typically caused by noxious stimuli, and typically results in withdrawal and protection behaviors. Whatever physical state happens to possess these causal relations, for Lewis, qualifies as pain.

The result is a two-level theory of pain. At one level, pain may be described physically in terms of the physical state that possesses the causal relations that define the pain-role. The functional properties of pain will be contingent under this description, however, as Lewis allows that the physical properties typically identified with pain will sometimes produce atypical causal results. At another level, pain may also be described functionally in terms of the causal relations that define the pain-role. The physical properties of pain will be contingent under a functional description, according to Lewis, because any atypical physical properties can qualify as pain as long as those properties stand in the appropriate causal relations.

Lewis's two-level approach to pain suggests two senses in which causal roles may be fulfilled. In one sense, a causal role may be fulfilled in terms of the way causal structures within an individual produce an external causal potential for that individual. In another sense, a causal role may be fulfilled in terms of the way an external causal potential may be understood as the instantiation of a specific function or psychological state. If realization is intended to describe the way in which causal properties fulfill a causal role, this will mean that there are different ways of realizing a causal role.

Introduction

Lewis' approach to pain suggests a method of connecting flat and dimensioned approaches to realization. As the external causal role identified with some kind *x* may be implemented in a physically unconventional fashion, we will not be able to account for the realization of *x* solely in terms of the internal causal properties of realizers of *x*. As a result, the internal causal properties of realizers of *x* will be contingent to the realization of *x*. In other instances, physically conventional members of another kind *y* may exemplify an unusual or unconventional external role. As a result, we will not be able to account for the realization of *y* solely in terms of the external causal relations typically exemplified by realizers of *y*. The external causal role of realizers of *y*, then, will also be contingent to the realization of *y*. Employing a two-level theory that allows for contingency in both the internal and external causal properties of realization provides a means for connecting flat and dimensioned views, and defusing the more serious problems faced by those views when considered in isolation.

The positive thesis, then, acknowledges that there is something right about both flat and dimensioned approaches to realization. The flat view strongly emphasizes the idea of a distinction between physical differences and the sort of physical differences that are relevant to realization. In doing so, the flat view acknowledges the difference between properties that are accidental and those that are essential with respect to some kind. Although this understanding of realization ultimately produces a dilemma, it also results in a very robust theory of realization. The dimensioned view, on the other hand, focuses more closely on the entities that actually explain how the properties that define a realization come about. Through this wider understanding of causal role fulfillment, the dimensioned view demonstrates how the philosophical sense of realization may be extended to, and informed by, science.

The positive thesis, then, may be understood as a way to incorporate both flat and dimensioned approaches to realization. The danger with this sort of two-pronged approach is that the result may be viewed as a nothing more than an ad-hoc combination of two otherwise dissimilar theories. Applying the combined result, then, would be little more than a matter of specifying the conditions under which the first theory should be applied, and the conditions under which the second theory should be applied.

I believe the hybrid view avoids this unfortunate outcome by emphasizing the contingency of realizing properties. Some individuals will have the internal causal systems that

correspond to a particular kind but not play the external role that is typical for that kind, while other individuals will play the external role that is identified with some kind without possessing the internal causal systems that are typical for that kind. As a result, a theory of realization that seeks to accommodate these atypical situations must allow for contingency in both the internal causal systems as well as the external role of realization.

This lack of symmetry between the internal causal properties of realizers and their external causal role is not only a characteristic of the sort of strange and fantastical kinds that Lewis envisions in 'Mad Pain and Martian Pain'. On the contrary, the thesis asserts that a similar disconnection between internal causal properties and external role is also sometimes a characteristic of the realizers of robust scientific kinds. Of course, the sort of realization that concerns Lewis – the realization of 'mind' – is not obviously one of these robust scientific kinds. As what makes certain properties qualify as cognitive properties remains contentious, the application of the realization thesis towards the concept of mind has recently and appropriately been criticized as too vague and ill-defined to be of much philosophical value. Although the theory of realization developed in this thesis allows for the realization of cognitive properties, the thesis also suggests that the idea of realization gains clarity and is rendered more useful by interpreting it in the context of, and applying it to, the realization of scientific kinds.

The nature of the project, in essence, is to describe a theory of realization that connects the concepts utilized in scientific practice to the original, philosophical sense of realization. This is accomplished by identifying realizations in terms of the causal roles they fulfill, and then exploring the different ways in which causal roles can be understood to be fulfilled. The idea of multiple realization is regarded as a constraint on this theory, insofar as the aim of the thesis is to sketch out a middle ground between too many kinds that qualify as multiply realized and too few. Where too few kinds admit of different realizations, the thesis of multiple realization becomes difficult to substantiate. Where too many kinds allow for multiple realization, multiple realization becomes unremarkable and as a result; trivial.

Introduction

An Outline

The thesis may be roughly divided into three sections of three chapters each. The first section of the thesis, comprising chapters 1 through 3, discusses some of the problems with Putnam's original idea of realization as functional isomorphism, and evaluates Shapiro's flat theory as a solution to these problems. The second section of the thesis, comprising chapters 4 through 6, presents Gillett's dimensioned view of realization, and assesses its merit in comparison to the flat view. The final section of the thesis, comprising chapter 7-9, presents my alternative, two-level view of realization. As noted, this two-level or hybrid account may be understood as an attempt to capture what is right about flat and dimensioned approaches to realization. In particular, it may be understood an attempt to capture the dimensioned view's inclusive approach to realization while acknowledging flat realization's insistence that there are limits as to what may count as relevant with respect to realization.

I set the groundwork for a useful theory of realization in chapter 1 by discussing two problematic ideas that have sometimes influenced the conception of realization. The first idea is that identifying a kind as a functional kind will always bring to light different ways of implementing that function. If there are always different ways of implementing every function, functional kinds begin to look like kinds that are naturally or inherently multiply realizable. This idea is problematic because the extent to which a functional kind is multiply realizable will be a factor of the specificity of the function that defines that kind. Some functions are more general than others, and the mere characterization of some kind in functional terms should not say anything about the extent of its realization. The second problematic idea discussed in chapter 1 is the idea that manifest physical differences between two realizations of some kind should warrant their classification as different realization of that kind. This idea is problematic because the physical differences that are relevant to realization are a factor of the properties that define a particular kind. Physical differences, no matter how great, will be irrelevant to realization if they are irrelevant with respect to the properties that define that kind.

Chapter 2 lays out Putnam's original account of the realization thesis, and presents Shapiro's alternative to that account. According to Putnam, we should understand realization in terms of the idea of functional isomorphism. In other words, some individual should be understood as the realization of some kind if that individual is functionally isomorphic with

respect to that kind. The problem with this idea is that the functional organization of some physical object is not something that can be independently determined. Any physical object may be understood as isomorphic with respect to some function, providing that object is interpreted in an appropriate way. Without some understanding as to how this interpretation should occur, the idea of functional isomorphism will be an inadequate basis on which to ground a theory of realization.

Shapiro's counterproposal is that an understanding of realization should begin with an understanding of the function being realized. When this function is isolated, realizing properties become the properties that figure in the production of that function. Identical realizations of the same function would share these realizing properties, while different realizations of the same function would not. Shapiro's formulation produces a dilemma for standards accounts of multiple realization. Where two individuals carry out a function in the same way, they will qualify as the same realization of that function. Where two individuals carry out a function in different ways, they will qualify as different realizations, but of different functions. Neither case will qualify as multiple realization, as in neither case will there be different realizations of the same function.

The understanding of realization that leads to this dilemma is the focus of chapter 3. The second horn of Shapiro's dilemma specifies that realizers that differ in their causally relevant properties will produce realizations of different kinds. As the realizers of functional kinds clearly do differ in their causally relevant properties, accepting the dilemma implies that functional kinds do not constitute valid kinds. The idea that functional kinds do not constitute valid kinds may originate in the idea that functional kinds are unified by properties that are extrinsic to realizers of those kinds. The class of corkscrews, for example, is very heterogeneous in terms of the causal properties by which corks are removed. For this reason, the class of corkscrews is only unified by the extrinsic properties that define the ability to remove corks.

Understanding valid kinds in terms of causal uniformity is rendered problematic, however, by scientific kinds whose realizers do not exemplify this causal uniformity. The phenomenon of isotopic isomerism in water, for example, indicates that the realizers of water will differ in terms of their causally relevant properties. Appreciating this causal heterogeneity

does not cause us to doubt water's validity as a kind, however. Instead, water qualifies as a kind because its properties are generally stable in the context in which it is typically encountered.

The second horn of the dilemma is also challenged by Gillett's 'dimensioned' approach to realization, which is the subject of chapter 4. The standard or 'flat' approach to realization understands an individual to realize a kind where that same individual possesses the causal properties that are relevant to realizations of that kind. According to Gillett, this understanding of realization is challenged by the sciences, where the properties and powers of some kind are typically explained in terms of the properties and powers of components of that kind. If the causal relation between an individual and its components counts as a realization relation, we will have to allow that some individuals are realized by their components.

The idea that individuals are sometimes realized by their components will require us to reject two principles that are implicit in the standard or flat approach. The first principle, which Gillett calls the principle of individualism, requires the individual possessing realized properties to be the same individual as the individual possessing realizing properties. The second principle, or principle of causal powers, requires realized and realizing properties to be causally equivalent. The dimensioned view allows exceptions to both principles, as understanding a realization to sometimes be composed of its realizers contravenes both principles.

Chapter 5 considers whether or not the flat account can be interpreted in such a way as to describe the compositional cases that provide much of the motivation for preferring dimensioned over flat views. The chief strategy for the flat view, in this respect, involves interpret the causal contribution of many individual realizers as a single, structured realizing property called COMBO. If many small individuals were accounted for within COMBO, flat realization would have a way of describing compositional relations without abandoning the idea of a one-to-one correspondence between realizer and realization.

The COMBO move is unlikely to prove popular to advocates of flat realization, however. The flat view begins any analysis of realization by identifying the function that corresponds to some kind. When this function is determined, realizing properties are identified in terms of the subsystems that produce that function. Properties that have little ability to influence this function, as a result, will have little bearing on realization. As the COMBO response requires

that we explain the realization of macroscopic entities by reference to their microscopic constituents, the COMBO response is unlikely to be attractive to advocates of flat realization.

Chapter 6 explores how the dimensioned view fares against the triviality issue. Trivial multiple realization occurs when minor differences that are not obviously relevant to some kind produce different realizations of that kind. Where many differences lead to differences in realization, many kinds become multiply realized. If many kinds are multiply realized, the idea that some kind or other is multiply realized loses significance.

The flat view forestalls the triviality worry by holding to the principles of individualism and causal powers. This means that realizers, under the flat view, will be individuals that wholly possess the properties that define realizations of some kind. As such individuals will presumably possess other properties that are inert with respect to that kind, trivial differences between realizing individuals need not entail differences in realization. By dispensing with the two principles, however, the dimensioned view also dispenses with this method of defense against the triviality worry.

Chapter 7 suggests that an effective theory of realization should be a causal theory. In particular, we should think of realization in terms of the way causal properties fulfill a causal role. Although both flat and dimensioned views of realization are amenable to a causal interpretation, they differ in terms of the way in which they understand causal role fulfillment. The flat view understands role fulfillment in what I term an 'externalist' sense, such that fulfilling a causal role becomes a matter of identifying a certain capacity. As the ability of an individual to exemplify a certain capacity tends to be measured by an individual's affect on their environment, externalist senses of role-fulfillment emphasize the extrinsic properties of realization. The dimensioned view, on the other hand, understands role fulfillment in an 'internalist' sense. Understanding role fulfillment in an 'internalist' sense takes the external capacity identified with some kind for granted, such that role fulfillment becomes a primarily a matter of identifying the internal causal systems that produce that capacity.

These different ways of understanding the idea of role fulfillment suggest that the bare question as to what fulfills a certain causal role may be ambiguous. One way of interpreting the role-question is as a 'which' question that is addressed by identifying the capacity that identifies

a certain causal role. Another way of understanding the role-question is as a 'how' question addressed by identifying the causal systems that produce a certain capacity. If questions of realization sometimes demand a 'which' response, and at other times demands a 'how' response, a comprehensive theory of realization will have to address both externalist and internalist interpretations of causal role fulfillment.

One way in which this could be done was suggested by David Lewis in paper Mad Pain and Martian Pain. Development of a two level view of realization based on Lewis' model is the topic of chapter 8. According to Lewis, a state such as pain should be defined in terms of the physical state that occupies a certain causal role for some population. This causal role is given by the factors that typically cause pain, as well as the factors that typically result from pain. As not every population can be expected to have the same physical properties, the properties of the physical state that actually plays the pain-role will be contingent. As not every pain experience will be characterized by the same causal role, the functional properties of pain will also be contingent.

Lewis' approach to pain suggests two different ways in which causal roles may be fulfilled. On the one hand, a causal role may be fulfilled in terms of the way causal structures within an individual produce a certain external capacity. On the other hand, a causal role may also be fulfilled in terms of the way an external capacity is understood as the instantiation of a psychological state. If realization is meant to capture the idea of causal role fulfillment, this will mean that there are two ways of realizing a causal role.

The resulting two-level approach to realization effectively deals with many problem cases that occur in realization. One type of problem case occurs where an individual has the internal causal systems that are typically identified with some kind, in the absence of the external role that is typical for that kind. Another type of problem case occurs when an individual has the external role that is typical for some kind, without the internal systems that are typical for that kind. A two-level approach to realization will be able to accommodate both types of problem case, as the two-level view allows that both the internal systems as well as the external role of a realization may be contingent.

Introduction

Allowing that both the internal and external properties of realization may be contingent also allows the hybrid view to explain some of the problems with flat and dimensioned approaches to realization. As the hybrid view identifies realizations by their external role, the hybrid view allows realizing kinds that differ in their causally relevant properties to sometimes qualify as realizers of the same kind. This denies the second horn of Shapiro's dilemma and thereby the dilemma itself. By identifying realizations in terms of their external role, the hybrid view also accepts the sort of causal differences within a realization that produces a triviality problem for the dimensioned view.

In the ninth and final chapter of the thesis, I dispense with the Martian intuition employed by Lewis and demonstrate the application of the hybrid approach to an empirical understanding of pain. Phantom pain suggests that some varieties of pain will possess the functional properties of pain without the physical properties of pain. For phantom pain to qualify as pain, then, the physical properties of pain must be contingent. Pain asymbolia, on the other hand, suggests that other varieties of pain will possess the physical properties of pain but not its functional properties. For pain asymbolia to qualify as pain, the functional properties of pain must also be contingent. As only the hybrid view allows for contingency in both the physical and functional properties of pain, only the hybrid view is able to describe the various ways in which pain may be realized.

Importantly, dispensing with the Martian intuition is not fatal to the possibility of multiple realization. To illustrate this contention, I end the chapter with an example of one form that multiple realization might take under the hybrid view.

Final Notes

There are a number of philosophical concepts, not directly related to realization, that are drawn upon in the course of the thesis. Realizations are referred to as similar or different, with little elucidation as to what the concepts of similarity and difference are supposed to entail. Kinds are referred to as more or less robust, although no analysis is provided as to how robustness should be conceived. Explanations are referred to as better or worse, without any attempt to indicate what makes for a good explanation. I realize that many of these concepts are contentious in their

own right, but as the purpose of the thesis is to give an account of realization, I feel justified in leaving the elucidation of these additional concepts to people better qualified than I.

In term of style, the thesis follows a few contemporary conventions. Italicization is used, mostly, but not always, to indicate a kind. Identical references that are not italicized are intended to indicate tokens. In other words, reference to a corkscrew that qualifies as a *corkscrew* is intended to refer to the way in which some token corkscrew qualifies as a member of the kind *corkscrew*. I have also followed the convention of referring to spatiotemporal objects as 'individuals'. An individual, in this sense, could refer to any metaphysical object, and not merely to physical objects or physical objects with cognitive properties.

I should also note that many examples in the thesis are intended as superlatives or absolutes. Diamond, for example, is frequently used as an example of the hardest material possible. It is used in this capacity, then, regardless of whether or not it is, in fact, the hardest material possible. According to PhysOrg.com, researchers at the University of Nevada have come up with an even harder material than diamond that goes by the name 'Wurzite Boron Nitrite' (w-BN).[6] As this new material is less well known (and certainly less pleasant-sounding) than diamond, I have opted to continue to use diamond as an example of the hardest material possible. Finally, I will note that I sometimes draw attention to interesting labels by putting them in single quotes ('Wurzite Boron Nitrite'), whereas I reserve double quotes for speech and textual quotation.

[6] "Scientists Discover Material Harder Than Diamond" accessed Oct 11, 2012. <http://phys.org/news153658987.html>

Chapter 1

Top

Two Misconceptions about Realization

In philosophy, the idea of multiple realization has been rather succinctly characterized as the idea that there can be sameness in spite of physical differences. In particular, multiple realization is associated with the idea that two individuals can be the same at some sort of conceptual or cognitive level even though those individuals may be different in their physical properties. Understood in this somewhat superficial way, multiple realization appears trivially true. It is a simple matter to find two individuals that are comparable in some conceptual sense, though differing in some physical detail. The more interesting and difficult question is precisely how much conceptual similarity is supposed to endure what sort of physical differences.

The following chapter begins an investigation into realization by identifying two common misconceptions about realization. The first misconception is the idea that the apprehension of some function will automatically reveal different ways that function may be realized, and, as a result, imply the multiple realization of that function. Understanding the function of a paperweight, for example, seems to reveal many different individuals that might qualify as a realization of *paperweight*, and, as a result, the multiple realization of *paperweight*. It will become clear, however, that the mere characterization of some type in functional terms does not allow us to conclude anything about the extent of its realization. Some functional descriptions are more general than others, and the extent to which any functional type is actually realized will be determined by the relation between its functional description and the nomological possibilities the world affords.

The second misconception is the idea that overt physical differences between two tokens of the same kind will always imply that those tokens are different realizations of that kind. The apparent differences between wrist watches and pocket watches, for instance, may be taken to imply that wrist watches and pocket watches should qualify as different realizations of the kind *watch*. This is not necessarily the case, however, as precisely which differences count as significant from the standpoint of realization depends on the type at issue. Where too many physical differences are allowed to count as differences for the purpose of realization, the

number of realizations quickly proliferates. This dilutes the force of the realization thesis, as every kind begins to look multiply realizable. Understanding the proper role of physical properties in the metaphysics of realization allows us to distinguish between trivial and non-trivial versions of the multiple realization thesis.

Understanding the implications of these misconceptions is necessary in order to establish an effective starting point from which to evaluate the different theories of realization.

1.1 Nomological Constraints on Realization

Top

We should begin a discussion of philosophical realization by noting that the topic is somewhat encumbered by its history. That history typically draws inspiration from artifacts such as carburetors in order to form hypotheses as to the cognitive abilities of aliens made of green slime. Carburetors figure into the discussion as archetypes of functional systems. What makes something a carburetor, after all, does not depend on what something is made of. On the contrary, carburetors are defined by their ability to perform a certain function.

The purpose of introducing such examples, as any student of the philosophy of mind should know, is to make the point that cognitive properties may be defined by their function in the same way that carburetors are defined by their function. If cognitive properties are defined in functional terms, any physical implementation that replicates the appropriate functional relations would possess those cognitive properties. An alien whose cognitive apparatus was constructed of green slime would possess humanlike cognition, under these circumstances, so long as that green slime possessed the appropriate functional organization. Mind, were this the case, would be multiply realized in human brains and green-slime aliens.

The argument implied by this rather far-fetched story merits some examination. In particular, we should be wary of the move from the characterization of some kind as a functional kind to the multiple realization of that kind. It is certain that the thesis of multiple realization (MR) derives much intuitive plausibility from the way in which technological artifacts are created in order to achieve or ‘realize’ functional kinds. Our homes are filled with a wide range of consumer products that appear to owe their identity more to their abilities than to the specifics

of their construction. What makes something into a mousetrap or generator, for example, seems to have little to do with the material an object is made of. Rather, identity is conferred by the object's ability to perform a particular function. Mousetraps qualify as mousetraps because they trap mice, while generators qualify as generators because they generate electricity. Individuals qualify as members of these kinds not in virtue of their physical properties, but in virtue of their functional properties.

The mere characterization of some kind in functional terms, however, does not warrant the conclusion that that kind is multiply realizable. Some functional descriptions are more general than others, and, as a result, permit more variety in the way the function is fulfilled. A kind such as *timekeeping device*, characterized in functional terms, will presumably include the realization of watches, clocks, and sundials. Other functional descriptions will be more specific, and consequently allow less latitude in the way a function is fulfilled. The kind *watch*, for example, presumably picks out only those timekeeping devices that are worn on the wrist or carried on a chain.

If one understands the concept of realization to indicate the way in which a function is fulfilled, kinds such as *watch* will permit less variety in their realization than kinds such as *timekeeping device*. This is because adding detail to a functional description narrows the range of individuals able to fulfill that function. The kind *hitler's watch*, for example, may be so specific that it has but a single realization. Although *timekeeping device*, *watch*, and *hitler's watch* are all kinds that are characterized in functional terms, the potential for variety diminishes as the functional description grows more specific.

We should not, for this reason, assume that the mere characterization of some kind in functional terms implies anything about the extent of its realization. For a kind such as *hitler's watch*, the potential for difference is narrowly circumscribed by the specificity of the description that defines the kind. If the thesis of multiple realization is to be understood as an empirical hypothesis, the extent of realization will be similarly circumscribed by the nomological possibilities the world affords. These nomological constraints on realization are especially apparent when we consider variations in the realization of physical or chemical kinds. In physics and chemistry, differences in realization may be very limited. Consider a kind defined by the property *faster than a photon*. Although the kind *faster than a photon* does not impose any

physical constraints on potential realizers of that kind, there will be, as a matter of empirical fact, few or no ways of realizing that kind.

Considerations such as these suggest limitations on the potential for alien cognition of the green-slime variety. It is certainly possible that cognitive functions, like many functions, may be brought about in different ways. The potential for cognitive variety, however, will always be subject to nomological constraints. If humanlike cognition requires certain functional relations that green-slime is nomologically incapable of instantiating, green-slime cognition will be nomologically impossible. For this reason, characterizing mind, or any other kind, in functional terms implies nothing about the extent of that kind's realization.

1.2 Property Relevance

Top

What does it mean, then, for something physical to realize something functional? As a first pass, we might think that physical individuals realize a functional kind when they embody or exemplify the functional properties that define that functional kind. Something that is able to trap mice, we might think, qualifies as a realization of the kind *mousetrap*. We run into problems, however, if we suppose that every physical individual able to instantiate some function should qualify as a different realization of that function.

The idea that every distinct individual should qualify as a distinct realization may initially appear warranted. If a physical individual, s_1, qualifies as a realization of the kind *mousetrap*, and a different individual, s_2, also qualifies as a realization of the kind *mousetrap*, it may appear as if we are dealing with both different physical individuals and different realizations. This is not necessarily the case. Realizations are distinguished qualitatively, rather than quantitatively. For this reason, different individuals that are qualitatively identical with respect to some kind will qualify as identical realizations of that kind. My brain and yours may both qualify as realizations of the kind *mind*, for example, while also qualifying as identical realizations of that kind. This is because any differences between my brain and yours are not differences that are apt to be significant with respect to the properties that define realizations of *mind*. Were my brain and some computer to both qualify as realizations of *mind*, on the other hand, they would also presumably qualify as different realizations of *mind*. This is because the manifest differences

with respect to the way brains process information and the way computers process information is significant with respect to an information-processing kind like *mind*.

Functional kinds are defined by their functional properties. For something to realize a functional kind, then, is for something to instantiate the kind through the possession of the relevant set of functional properties. Realizations of the same functional kind are only differentiated with respect to the functional properties that define that kind. Properties that fall outside of this functional specification, by the same token, should be understood as inert with respect to the realization of that kind. Two individuals that differ with respect to properties that are functionally inert in this way will not necessarily differ with respect to realization.

Intuitively, some properties of an individual will be type-relevant and some will not. Suppose I purchase two watches from a shop. The watches are identical in all respects, save for the fact that one is black and the other is white. Although both artifacts may realize the functional specification for *watch*, they would be wrongly classified as different realizations of *watch* . This is because watches do not qualify as watches in virtue of their color. On the contrary, watches qualify as watches in virtue of their functional profile. For the kind *watch*, that profile may reference portability and timekeeping ability. If these are the criteria that define what it is to be a watch, only differences that register within these criteria will constitute the sort of differences that are relevant to differentiating realizations of the kind *watch*. For the two watches in our example, it will mean that a difference in color is not relevant to individuating watches in terms of their function as watches. Two watches that differ with respect to color, then, should be considered identical realizations of the kind *watch*.

Precisely what properties are significant to realization, then, will be a relational matter. As kinds are defined by different specifications, a property which is non-differentiating with respect to the realization of one kind may be differentiating with respect to another. Suppose we are considering whether or not some individual, *s*, qualifies as a realization of the kind *pocket watch*. As pocket watches differ from other watches in that they are designed to hang from a chain or fob, whether or not *s* possesses the property of hanging from a chain or fob will be relevant to the realization of *pocket watch*. At a different time, we may wish to assess whether *s* qualifies as a realization of the kind *paperweight*. As realizations of *paperweight* are determined by their mass, whether or not *s* possesses the property of hanging from a chain or fob will be

irrelevant to the realization of *paperweight*. The difference between the properties that define kinds like *pocket watch* and *paperweight* demonstrates how the relevance of some property to realization is a factor of the kind in question. In the foregoing example, it accounts for why a specific property can be relevant to the realization of one kind while irrelevant to the realization of another.

The same point about property relevant will also govern the realization of cognitive properties. A single realization of pain, for example, is intuitively compatible with differences in the physical properties of that realization. At one level of detail, these differences may be embodied in a single nociceptor that fails to reach its action potential from one moment to the next. At another level of detail, physical difference may be embodied by some electron that changes path from one nanosecond to the next. In either case, a change in the physical properties of pain is intuitively compatible with uniformity in the experience of pain. For the realization of cognitive properties, this means that a change in the physical properties of realization will be intuitively compatible with uniformity in the realization itself.

Physical difference is compatible with cognitive uniformity because physical kinds and cognitive kinds are individuated in different ways. Physical kinds are individuated by their physical properties, while cognitive kinds are individuated by their cognitive properties. For this reason, no physical difference, no matter how large, can be considered automatically relevant to realization.

The danger of allowing physical properties to exert unwarranted influence in determining differences in realization is the danger of trivialization. Where too many physical differences are allowed to produce differences in realization, the number of realizations for any kind quickly proliferates. Where the number of realizations proliferates, many kinds can be shown to be multiply realized. Where many kinds can be shown to be multiply realized, the fact that some kind or other happens to have multiple realizations may cease to be significant. This triviality issue will be explored in greater detail in Chapter 6.

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Chapter 1. Two Preliminary Ideas about Realization

In order to develop a robust theory of realization, it is necessary to recognize the inherent limitations of two ideas that often surround the metaphysics of realization. The first idea is the idea that isolating a particular function will always highlight different ways of implementing that function and this will, in turn, imply the multiple realization of that function. This is not the case. When functions are defined in greater detail, the potential ways of implementing that function will be reduced. The functional profile for the kind *watch* is narrower than the functional profile for the kind *timekeeping device*, so the potential ways of realizing *watch* will be fewer than for *timekeeping device.* The fact that both kinds are specified in functional terms does not equate them from the standpoint of realization.

The second idea is the idea that substantive physical differences between two realizations of the same kind will suggest that they are, in fact, different realizations of that kind. This is also not necessarily the case. Differences in the realization of some kind should be assessed relative to the properties that define that particular kind. Where physical differences are not type-relevant, there is no warrant for predicating differences in realization.

Chapter 2 Top

Putnam's Realization and Shapiro's Alternative

Hilary Putnam's early formulation of the realization thesis suggests that the concept of realization is best understood in terms of functional isomorphism. Put another way, Putnam's thought is that realization is a matter of mapping functions to physical systems. Different physical systems that support identical mappings, under this formulation, become different realizations of the same function.

Putnam's formulation runs into problems, however, by failing to take into account the causally efficacy of actual realizations. There are apt to be many functional isomorphic mappings that exist between two physical systems. In the absence of some additional constraint, there is no way to ensure the mapping one happens to identify will have the causal properties that distinguish realizations of some type from mere simulations of that type.

Lawrence Shapiro proposes that we rectify this problem by first identifying the function we are interested in. Once this function is determined, we will be in a position to identify the properties that causally contribute to the performance of that function. Shapiro suggests that we define realizations in terms of these causally contributing properties, and that different realizations of the same function will be represented by individuals that carry out the same function in causally distinct ways.

Adopting this suggestion, however, produces a dilemma for multiple realization. If functional kinds are defined by their causal properties, realizing kinds that differ in their causally relevant properties should qualify as realizers of different kinds. At the same time, realizing kinds that do not differ in the properties that are causally relevant to realization should qualify as identical realizations of the same kind. In neither case will we have multiple realization, as in neither case will we have different realizations of the same kind.

2.1 Realization as Functional Isomorphism Top

The introduction of the realization thesis is typically associated with a series of papers written by Putnam in the sixties.[7] Putnam's intention, in those papers, was to argue against theories of mind/brain type-identity by putting forth a theory of mind that would become known as functionalism. The theories of type-identity that Putnam targeted sought to identify cognitive processes with physiochemical states of the brain and central nervous system. Putnam pointed out that the manifest variety of cognitive creatures rendered the possibility of a single physiochemical kind underlying any and all manifestations of a cognitive state highly unlikely. A plausible alternative, argued Putnam, was that a single cognitive kind might correspond to a variety of distinct physical kinds.

Putnam developed this idea by comparing cognitive states to the internal operation of a Turing machine.[8] A Turing machine is a theoretical construct that is described by a series of formal states and the conditions under which those states undergo change. The operation of the machine is captured by a set of instructions or machine table. This machine table specifies the conditions under which a change of state occurs, as well as the outcome of that change. As the Turing machine is completely defined by the functional properties embodied in its machine table, a Turing machine is fundamentally medium-independent. If cognitive states were like Turing machine states, cognitive states might be similarly medium-independent.

The thought behind Putnam's suggestion that cognitive states are Turing machine states was the idea that cognitive states and processes are fundamentally functional states and processes. Although a brain may be described in terms of its physical properties, the mind is typically described in terms of its abilities. Correctly characterizing those abilities will involve understanding the way in which the cognitive system is organized in order to bring about the effects that it does. For Putnam, understanding the nature of cognitive organization is a matter of ascertaining the crucial states of the system, and determining the conditions under which those states undergo change. If the states and changes of state within our cognitive system mirror that of another system, the two systems would be isomorphic in their function. In other words,

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[7] Especially Putnam 1960 and Putnam 1967.
[8] Putnam 1967, pp. 54-56.

"[t]wo systems are functionally isomorphic if there is a correspondence between the states of one and the states of the other that preserves functional relations."[9]

Putnam elaborated the idea of functional isomorphism in terms of the sequential relations that might exist between two computer systems; system 1 and system 2. According to Putnam, functional isomorphism occurs when the sequence of state-changes within one system functionally corresponds to the sequence of state-changes within the other. Within system 1, we may observe that state A is always followed by state B. Within system 2, on the other hand, we may observe that the functional equivalent of state A is always followed by the functional equivalent of state B. Some theory will qualify as the correct functional description of system 1 when all references to system 1 are replaced by references to system 2, and all operators that define state relations are similarly reinterpreted in a way that reflects that mapping.

Putnam's formulation has been described as the 'simple mapping account' of realization.[10] The account asserts that some individual F realizes a function G if there is a structure-preserving mapping that exists between the physical states of F and the functional states of G. In order to have a structure-preserving mapping, two conditions must obtain. The first condition is that there must be a mapping between the physical states of F and the functional states of G. The second condition is that the process of state-change that occurs in F must match the process of state-change that occurs in G. We can summarize the idea of realization as functional isomorphism in the following way:

> (R-FI) An individual F realizes a function G if the states of F map onto the states of G in a way that preserves functional relations.

Putnam's thought is that we can give substance to the idea of realization by identifying functional parallels between physically dissimilar systems or processes. These systems, when functionally isomorphic, would count as realizations of the same function. When I touch a hot stove, for example, I am apt to experience certain disagreeable sensations and withdraw from the stove. In the same way, a mollusc subject to a noxious stimulus may also experience disagreeable sensations and withdrawal from that stimulus. If I am able to identify the properties of state and state-change in the mollusc with the properties of state and state-change that hold in

[9] Putnam 1975, p. 127.
[10] Godfrey-Smith 2009, p. 284.

my own case, I will have identified a functional isomorphism between myself and the mollusc. By Putnam's formulation, the mollusc and I would realize the same function.

2.2 A Problem with Functional Isomorphism

Top

The fundamental problem with Putnam's account of realization as functional isomorphism is that the plausibility of understanding realization in terms of functionally isomorphic mappings directly reflects the plausibility of the mappings chosen. It is sometimes the case, for instance, that we can identify a functional isomorphism between the states of some physical system F and the states of some functional system G and are disposed to call F a realization of G. In other situations, however, we can identify a functional isomorphism between the states of some physical system F and the states of some functional system G and are not disposed to call F a realization of G. If this is the case, it cannot be the functionally isomorphic mapping alone that makes F a plausible realization of G.

We can illustrate the independence of realization from functional isomorphism by comparing actual realizations of some type with mere representations or simulations of that type. Suppose we are interested in identifying realizations of the type *garlic press*. Presumably, we could explain what it is to be a realization of the type *garlic press* in terms of a sequence of transitions between states. That sequence may look something like the following:

s_1 = arms open, garlic inserted

s_2 = arms closed

s_3 = crushed garlic removed

If we were to compare this sequence of steps with the operation of an actual garlic press, we may find that there is functional isomorphism between our sequence and the physical states of the actual press. Corresponding to step s_1, for example, we may find a certain physical state in the actual garlic press. Steps s_2 and s_3 may be similarly matched with additional physical states of the press. Moreover, we may also find that sequence of physical state-changes in the actual garlic press mirrors that of sequence s_1 - s_3. According to the simple mapping account, identifying this functional isomorphism between a physical individual and a functional type-

specification allows us to claim that our physical individual realizes that type-specification. In this case; the claim would be that our physical individual qualifies as a realization of the kind *garlic press*.

We expose a problem, however, when we hold our artifact up to a mirror, and proceed to evaluate the resulting reflection as another possible realization of *garlic press*. What we are apt to find is a functional isomorphism between the reflected states and the sequence of states specified in s_1 - s_3. State s_1 requires the arms of a garlic press to be open and garlic inserted, and to this we map a reflection of our garlic press with arms open and garlic inserted. State s_2 requires the arms of a garlic press to close, and to this we map a reflection of our garlic press with arms closed, and so on. Moreover, the sequence of state changes that occur in our reflection are apt to match those specified in the sequence s_1 - s_3. The reflection of the garlic press with arms closed follows the reflection of our garlic press with arms open and garlic inserted, just as our functional specification requires state s_2 to follow state s_1 According to the simple mapping account, a reflection of a garlic press should qualify as a realization of *garlic press* in the same way as the actual artifact would.

A similar version of the problem arises whenever we compare a suitably complex physical system to the sequence of states and state-changes intended to specify realizations of *garlic press*. Beaches or pails of water, for example, are complex physical systems composed of vast numbers of small entities. Each grain of sand or droplet of water is itself composed of still smaller entities. Providing that we go about individuating these entities in the right way, we will always find a physical analogue for the system of states and state-changes specified in s_1 - s_3. A certain population of water droplets, for example, might correspond to state s_1, while a different population of water droplets might correspond to state s_2. Identifying such a correspondence between the water droplets and the state changes of $s_1 – s_3$, however, does not cause us to suppose the pail of water is somehow a realization of *garlic press*.

The problem originates in the mapping account's requirement for functional isomorphism. The attribution of functional isomorphism demands nothing more than that we identify some mapping between the states of a functional system and the states of a physical system. As John Searle points out, however, syntax is not something that is intrinsic to physical

systems.[11] For this reason, there can be no objectively identifiable mapping for a given physical system. If there are a vast number of different ways in which any physical systems may be partitioned, there will be a vast number of possible mappings from functional states to physical states. If realization were nothing more than the ability to find a physical state that corresponds to a functional description, realizations of that functional description would be easy to come by. It seems clear; however, not all of these functionally isomorphic physical mappings should qualify as realizations of the relevant function.

Realizations differ from functional isomorphic mappings in terms of their causal properties. Although one could maintain functional isomorphism between the states of an actual garlic press and the reflection of that garlic press in a mirror, only the former would actually press garlic. What makes an individual into the realization of *garlic press*, then, is not the functional isomorphism that may exist between the physical states of that individual and some abstract functional description. On the contrary, a physical system qualifies as a realization of *garlic press* in virtue of having the right causal connection to the world. In the case of *garlic press*, that connection is specified in terms of the ability to produce crushed garlic. As reflections of garlic presses have no such ability, reflections of garlic presses should not qualify as realizations of *garlic press*.

2.3 Shapiro's View

Top

Lawrence Shapiro agrees that identifying functional isomorphic mappings is not helpful in determining genuine cases of realization.[12] According to Shapiro, any system of sufficient complexity may be used to simulate or represent the functional organization of any other system. A computer used in climatology, for instance, may be used to replicate the states and state-changes associated with a hurricane. It is precisely in virtue of establishing functional isomorphism with the hurricane that a climatology computer constitutes a useful tool for predicting the development of hurricanes. Establishing this functional isomorphism, however, does not cause the simulator to qualify as the simulated system.

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[11] Searle 1990, p. 26.
[12] See Shapiro 2000 and 2004.

To illustrate this point, Shapiro considers the sort of functional isomorphism that may hold between an actual mousetrap and a representation of the mousetrap's operation. In order to establish functional isomorphism, letter variables are assigned to different states of the mousetrap and written down on slips of paper. The state 'mouse present' is assigned the label *A*, and so an *A* is written on the first slip of paper. On a different slip of paper, a *B* is written to represent the state 'mouse trapped'. Additional slips of paper are similarly assigned labels which represent other states of mousetrap operation. So, a *C* is written on a third slip to represent 'mouse dead', while a *D* is written on a fourth slip to represent 'mouse removed'. The process of by which the trap operates, then, is represented by the sequence:

$$A \rightarrow B \rightarrow C \rightarrow D$$

Although we may have established functional isomorphism between the states of an actual mousetrap and our slips of paper, we have clearly not managed to transform the slips of paper into an actual mousetrap. This is due to the fact that our representation lacks the sort of causal properties that actual realizations of *mousetrap* possess. An actual realization of *mousetrap* will be able to catch and kill mice; slips of paper cannot.

Shapiro's critique of functional isomorphism as the basis of realization focuses attention upon the correspondence relation in Putnam's original formulation of MR.[13] Specifically; it reveals that mere correspondence is far too weak a claim upon which to ground any adequate notion of type-identity. Although correspondence may allow us to pick out a variety of different properties that hold between two systems, it will not grant any additional significance to those properties that may be most relevant to the identity of some kind. The property most relevant to the individuation of mousetraps, in our example, is the property of catching mice. Shapiro notes that the problem confronting realization is not the relatively easy task of identifying functional isomorphism between a function and a physical system, the problem is the much more difficult task of identifying which of many functional isomorphisms is relevant to the type at issue.

The most effective course of action, recommends Shapiro, is to abandon the idea that an unqualified appeal to functional isomorphism can get us any closer to a proper account of realization. Instead, he suggests, we should begin by identifying the particular capacity of a

[13] Shapiro 2000, p. 638.

system we are interested in.[14] Although identifying this capacity will be contingent upon our needs and interests, it will serve to determine a unique function for every system. Once this function has been determined, we will be in a position to ascertain the properties of the system that causally contribute to the performance of that function. These causally contributing properties will be the realizing, or R-properties of that function. According to Shapiro:

> (R-S) A physical individual F realizes a function G if the causal properties which individuate G are possessed by F.

For two individuals to represent different realizations of the same function is for two individuals to carry out the same function while differing in their R-properties. We legitimately claim some type has been multiply realized, then, when we identify different ways of implementing the same function.

> (MR-S) To say that a kind is multiply realizable is to say that there are different ways for individuals F_1 - F_n to realize the same function G.

Shapiro deploys this conception of realization against a variety of test cases involving realizations of the kind *corkscrew*. The discussion begins with a consideration of what should be said in the case of two corkscrews that differ only with respect to their constitution. Suppose we have two identical corkscrews; save for the fact that one is made of steel and the other of aluminum. Our initial inclination may be to consider these corkscrews different realizations of the kind *corkscrew* in virtue of their compositional differences. Shapiro claims that this inclination is mistaken, as we are not entitled to assume that a difference in the physical properties of the two corkscrews will translate into a difference in their functional properties. As these functional properties are the properties that define what it is to be a corkscrew, two corkscrews that differ in their physical properties while being alike in their functional properties should count as identical realizations of *corkscrew*. Physical differences are only relevant to realization, according to Shapiro, when they produce differences in the properties which define a kind.

Suppose we subject a corkscrew to a functional decomposition in order to determine the properties that causally contribute to the function of removing corks. What we are liable to find

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[14] Identified as 'functional decomposition' in Shap 2000, p. 52 and 'task analysis' in Shapiro 2004.

is that certain parts of the corkscrew must have certain properties in order for the corkscrew to function as a corkscrew. The central screw, for example, will have to be rigid enough to penetrate a cork. It will not matter what material the screw happens to be made of, as long as that material is rigid enough for the screw to function in this way. The physical properties of the screw, in other words, are irrelevant so long as the proper functional specification is met.

Shapiro emphasizes the difference between realizing and non-realizing properties by comparing the physical properties of a corkscrew to its phenomenological properties. It does not make a difference to realization if a corkscrew is blue or red, for example, because the color of a corkscrew makes no difference to a corkscrew in terms of its function as a corkscrew. Two corkscrews that differ only in color should qualify as the same realization of *corkscrew*, because two corkscrews that differ in color will be the same with respect to their corkscrew-related properties. In the same way, Shapiro asserts, two corkscrews that differ only in composition should also qualify as the same realization of *corkscrew* if the two are identical with respect to their corkscrew-related properties.

This is not, of course, to assert that the composition of a corkscrew is irrelevant in some sort of unqualified or unconditional sense. A corkscrew-shaped object made of toothpaste, for example, will clearly be incapable of removing corks. As the ability to remove corks defines what it is to be a corkscrew, we may feel that there are cases where a difference in the first-order properties of an individual produces a functional difference significant enough for that individual to fail the relevant type-specification.

Shapiro believes that this impression is misleading. Any functional analysis applied to a functional kind will only identify functional processes. If we analyze a steel corkscrew in order to understand why it is effective at removing corks, we may discover that effectiveness derives from the corkscrews rigidity. What we are not apt to find, says Shapiro, is that a steel corkscrew is effective at removing corks simply because it happens to be made of steel. A corkscrew-shaped object made of steel foil, for example, would be incapable of removing corks. This would be because a corkscrew-shaped object made of foil would lack the necessary rigidity. The only contribution of steel towards the properties of a corkscrew, then, takes place when steel instantiates rigidity. For this reason, the physical composition of an individual is only contingently related to that individual's realization of a functional kind.

In fact, any properties that do not play a functional role in cork removal will only have the potential to contingently affect the realization of *corkscrew*. Color, Shapiro notes, is not a property that typically plays a role in the removal of corks. For this reason, two corkscrews that differ in color should count as the same realization of *corkscrew*. One could presumably invent unusual scenarios; however, where color does make a difference as to whether or not an individual is able function as a corkscrew. As darker colors absorb more electromagnetic radiation than lighter colors do, one could conceivably imagine a scenario under which the heat absorbed by a black corkscrew would cause certain critical corkscrew components to fail. Should we then allow that color does, in rare cases, determine whether or not a particular artifact qualifies as a realization of *corkscrew*?

If we accept Shapiro's theory, we need not. Again, any functional analysis applied to functional kinds such as *corkscrew* will only identify further functional processes. Decomposing these into their component processes will reveal still further functional processes. Properties that are typically understood as non-functional, such as color, will only affect the realization of a functional kind to the extent that they produce functional differences. Color, in the above example, produces a change in realization by producing a change in rigidity. For this reason, color will remain only contingently related to the realization of functional kinds such as *corkscrew*.

Shapiro's proposal that a plausible account of realization should emphasize the type-relevance of realizing properties is a valuable one. If our kind is a functional kind, and the individuals under consideration are identical from a functional standpoint, those individuals should qualify as the same realization of that kind. Corkscrews that differ only with respect to color may count as different corkscrews, but they should not count as different ways of being a corkscrew. Again, this is because corkscrews that differ only with respect to their color may not differ with respect to their corkscrew-related abilities.

Conceptions of realization that allow many differences to count as differences in realization may be failing to distinguish between differences that are type-relevant and those which are not. This inclusiveness is problematic, as, intuitively, not every property an individual possesses will be relevant to whether or not that individual qualifies as a member of a certain kind. Color is irrelevant to determining realizations of *corkscrew*, for example, because the color

of an individual does not affect its ability to remove corks. Shapiro's solution to the permissiveness worry requires attention to the properties that define a kind, as realizations of the same kind should only count as different realizations of that kind where they differ with respect to the properties that define that kind. Differentiating realizations on any other basis, by the same token, will lack justification.

2.4 The Dilemma

Top

Accepting Shapiro's conception of realization, however, leads to a problem for multiple realization. The class of corkscrews, for example, differs substantively in terms of the way that different corkscrews remove corks. A winged corkscrew uses a rack-and-pinion arrangement in order to draw the cork from a bottle, while a waiter's corkscrew uses a second-class lever with the fulcrum braced on the rim of a bottle. Other corkscrews dispense with the screw mechanism entirely in favor of teeth which grip the edges of the cork, while still others inject gas through the cork in order to force the cork out under pressure. Our initial intuition may be to count these artifacts as different realizations of the kind *corkscrew*, and thereby assert that the kind *corkscrew* is multiply realized in virtue of this variety.

For Shapiro, however, variety within the class of corkscrews does not mean that the kind *corkscrew* is multiply realized. The principle for multiple realization embodied in MR-S stipulates that a kind is multiply realized only where we can identify 'different ways' to the performance of the same function. Shapiro does agree that the various types of corkscrew should qualify as different realizations. Waiter's and winged corkscrews; for example, utilize different mechanisms that draw upon different mechanical principles. Moreover, these mechanical differences compel different manipulations on the part of corkscrew-users. A winged corkscrew, for example, requires a user to push down in order to draw the cork. A waiter's corkscrew, on the other hand, requires a user to pull up in order to draw the cork. In fact, if one were to compare the steps involved in using a waiter's corkscrew with those involved in using a winged corkscrew, there would be little resemblance between the two. It seems clear, Shapiro accedes, that these differences in mechanical structure and user-manipulation should constitute 'different ways' of removing a cork.

The problem, asserts Shapiro, is justifying why we should consider these different realizations to be realizations of the same kind. As noted, winged and waiter's corkscrews employ different mechanisms that draw upon different mechanical principles. This means that the properties that are causally relevant to the individuation of waiter's corkscrews will be different than the properties that are causally relevant to individuation of winged corkscrews. If functional kinds are defined by their causal properties, this will indicate that waiter's corkscrews and winged corkscrews are different functional kinds.

Shapiro takes this line of reasoning to indicate a serious dilemma for standard conceptions of multiple realization:

"Either the realizing kinds truly differ in their causally relevant properties or they do not. If they do not, then we do not have a legitimate case of multiple realizability and [the multiple realizability thesis], in this given instance, is false. If the realizing kinds do genuinely differ in their causally relevant properties then, it seems, they are different kinds. But if they are different kinds then they are not the same kind and so we do not have a case in which a single kind has multiple realizations."[15]

Shapiro's dilemma asks us to consider whether our realizing individuals truly differ in their causally relevant properties. If there is no difference in these causally relevant properties, we should consider our individuals to be the same realization of the same kind. Color is not causally relevant to the realization of corkscrews, so two corkscrews that differ only in terms of color qualify as identical realizations of the kind *corkscrew*. If such individuals qualify as the same realization of the same kind, we will not have the case where a single kind has different realizations. As multiple realization requires different realizations of the same kind, this case will not qualify as a case of multiple realization.

If our realizing individuals do happen to differ in their causally relevant properties, on the other hand, we will be in a position to claim that we are dealing with different realizations. As functional kinds are defined by their causal properties, however, a difference in causally relevant properties suggests a difference in kind. Winged and waiter's corkscrews may qualify as different realizations, but, according to Shapiro, they should also qualify as realizations of different kinds. As the thesis of multiple realization requires us to have different realizations of the same kind, this second type of case will also not qualify as a case of multiple realization.

[15] Shapiro 2000, p. 647.

At first glance, the dilemma does appear to overlook the rather obvious feature that all corkscrews have in common. That feature is, of course, the ability to remove corks. The dilemma appears to go wrong, then, in construing the function that defines *corkscrew* too narrowly. Winged and waiter's corkscrews will qualify as members of the same kind, providing our understanding as to what constitutes that kind is suitably general. The properties that specify what it is to be a corkscrew need not require the possession of rigidity, or components such as a screw and one or more levers. Instead, we can identify members of the kind corkscrew merely in virtue of their ability to remove corks. If we adopt this revised conception of the function that defines *corkscrew*, it will again appear that the various corkscrews realize a common function. That function is the function of removing corks.

Suppose we identify this more general functional kind with the label 'cork remover'. We would then be in a position to claim that, though mechanically dissimilar, waiter's and winged corkscrews constitute different ways of realizing *cork remover*. This objection to Shapiro, then, would represent an attack on the second horn of the mooted dilemma. That horn asserts that individuals that truly differ in their causally relevant properties constitute realizations of different kinds. The objection under consideration disputes this assertion by suggesting that realizations of the same kind sometimes will differ in their causally relevant properties, in the same way that waiter's and winged corkscrews, though realizations of the kind *cork remover*, differ in the way they remove corks.

2.5 Valid and Invalid Kinds

Top

Shapiro's response to the mooted objection contends that any functional specification general enough to encompass both winged and waiter's corkscrews will, in fact, be so general as to undermine the force of the theory that condones it. It is certainly the case that both winged and waiter's corkscrews are capable of removing corks. In this sense, it would appear that winged and waiter's corkscrews will qualify as different realizations of the same general kind. As other corkscrews that dispense with the screw mechanism in favor of toothed levers or gas injectors are similarly capable of removing corks, these too would count as different realizations of the more general kind *cork remover*.

Of course, one might also brace the bottle in a vice and use a forklift to extract the cork. This possibility would, it seems, also make the vice/forklift combination into a realization of *cork remover*. Shapiro's position is that any theory that classifies winged corkscrews, gas-injecting corkscrews, and vice/forklift combinations as realizations of the same kind is not claiming anything very interesting. This is due to his conviction that any kind which allows such heterogeneous membership will be too ill-defined to possess much philosophical interest.

Shapiro justifies this conviction with a quote from Fodor to the effect that functional taxonomies are justified by "…the power and generality of the theories that we are able to formulate when we taxonomize in that way".[16] According to Shapiro's interpretation of Fodor's standard, grouping individuals as members of the same kind will be justified by the theoretical benefits such a grouping accords. In terms of our example, grouping winged and waiter's corkscrews as members of the same kind should tell us something interesting about the class of individuals that qualify as cork removers. In particular, it should tell us something about the laws which apply to members of that kind.

The problem with a kind like *cork remover* is that it is so general that an analysis of the kind is unlikely to reveal any functional laws that apply to members of that kind. Insofar as winged and waiter's corkscrews differ radically with respect to the causal properties brought to bear on cork removal, the only property they are apt to share is that of cork removal itself. Defining realizations of *cork remover* in terms of the ability to remove corks, however, sounds analytic. It seems to assert nothing more than that members of the kind *cork remover* are characterized by the ability to remove corks, and that the ability to remove corks qualifies an individual as a member of the kind *cork remover*. According to Shapiro, kinds such as this will lack validity because there is nothing substantive that can be understood by classifying things in such a way.

Shapiro contrasts the generality of functional kinds like *cork remover* with the sort of inter-level causal integration he attributes to scientific kinds. At common levels of description, the causal properties of scientific kinds are very stable. Ceteris paribus; all samples of water freeze at zero degrees Celsius, samples of diamond will scratch any known surface, and a

[16] Fodor 1968, p. 119.

volume of lead will have a greater mass than an identical volume of aluminum. These macro-level regularities only hold true, however, in virtue of regularities in the atomic constituents of these substances. It is the causal properties of these constituents that guarantee, or make possible, the causal properties of the scientific kinds that result.

Shapiro's understanding of the validity of kinds, at this juncture, parallels that of Jaegwon Kim in the latter's celebrated discussion of jade.[17] Kim's prerequisite for kind-hood turns on the issue of projectability. For something to constitute a valid kind, according to Kim, is for the laws that govern that kind to project from known instances of the kind to unknown instances of that kind. If a kind fails to figure into projectable laws, Kim asserts, that kind fails the test of nomic kind-hood. With this standard in mind, Kim considers whether jade qualifies as a valid kind. Historically, he notes, it was assumed that jade constituted a mineral kind. Modern chemistry, however, reveals jade to be a conjunction of two mineral kinds with different molecular structures. Samples of jade that were previously believed to be homogenous have turned out to be composed of either jadeite or nephrite. Kim considers the question as to whether jade, as a disjunction of different mineral kinds, be considered a kind in its own right.

In order to resolve this question, Kim considers the sorts of laws into which samples of jade might figure, such as a law that specifies 'all jade is green'. We might suppose that 'all jade is green' should qualify as a law, in virtue of the fact that any and all samples of jade up to the present time have been green. Kim notes that generalizations, not laws, are authenticated by eliminating potential falsifiers. As all samples of jade up to the present time have been green, the assertion that 'all jade is green' will have few falsifiers, and therefore should constitute a valid generalization. What gives some generalization the additional force consistent with being a law, however, is the degree of positive confirmation that generalization also happens to possess.

In this respect, Kim notes, 'all jade is green' is not well confirmed by its positive instances. It is possible that every sample of jade examined up until the present time has, in fact, been a sample of jadeite. If we now happen to come across a sample of nephrite, we would not be justified in assuming the properties heretofore observed only in jadeite apply to this new mineral kind. We are not entitled to assume, in other words, that the properties we have

[17] See Kim 1993, p. 319. The issue is also discussed in Shapiro 2004, p. 157.

attributed to samples of jade up to the present will continue to accrue to samples of jade in the future. Laws describing the properties of jade will fail to project from observed instances in the past to unobserved instances in the future. This absence of projectability indicates jade is an invalid or trivial kind.

The idea behind both Shapiro's and Kim's conception of kinds is that valid kinds will be distinguished by the causal symmetry that exists between the macro-properties of the kind and the micro-properties possessed by components of the kind. It is the uniformity in causal micro-properties that results in, or explains, the uniformity observed at more common levels of description. Suppose, for example, we are interested in determining why all samples of water freeze at zero degrees Celsius. A scientific investigation of those samples may reveal that the freezing properties of water originate in the orientation and bonding characteristics of hydrogen and oxygen atoms. As a result, we may propose to identify water with molecules of H_2O.

Water would qualify as a valid kind, according to Shapiro and Kim, because the causal properties of water are wholly explained by the causal properties of the H_2O molecules composing water. The properties water exhibits at common levels of description, in other words, are explained by the properties the components of water exhibit at more detailed levels of description. This explanatory uniformity is law-like in that it supports inductive inferences from the identification of water to the possession of properties such as 'freezes at zero degrees Celsius'. It is this inter-level explanatory uniformity, then, that provides the theoretically significant property distinguishing valid from invalid kinds.

Trivial kinds, by this standard, fail to exhibit the required inter-level symmetry. For trivial kinds, there will be no obvious connection between the micro-properties possessed by components of the kind and the properties of the kind itself. The properties of *rubbish*, for example, cannot be ascertained by examining the properties of the components of rubbish. An inspection of a nearby bin may reveal such rubbish as apple cores, empty bottles, and bent paper clips. Although these items may all qualify as rubbish, they differ in terms of the properties of their components. Apple cores will be largely composed of carbohydrates and water, empty bottles of refined hydrocarbons, and bent paper clips of alloyed steel. As these materials possess different properties, there is unlikely to be any micro-level property which somehow explains why rubbish qualifies as rubbish. *Rubbish* would constitute a trivial kind, by Shapiro's standard,

as the properties of rubbish are not determined or guaranteed by the micro-properties of the components of rubbish.

Functional kinds will presumably fail to qualify as valid kinds, for Shapiro, because functional kinds also lack the inter-level causal symmetry characteristic of valid kinds. A functional kind may give the impression of a valid kind, as members of a functional kind will be superficially unified by their performance of a common function. In this way, the class of corkscrews appears to qualify as a valid kind because all corkscrews share the ability to remove corks. This uniformity is misleading, however, and disappears as soon as one looks for uniformity in the components of members of a functional kind. As functions may be carried out by very different physical systems that employ very different mechanical principles, there are unlikely to be any micro-properties which the components of a functional kind have in common.

Without unifying micro-properties in the components of functional kinds, the regularities observed in functional kinds lack the potential to be captured and expressed by laws. As the members of functional kinds differ in the way they achieve the function that defines the kind, realizations of functional kinds will instantiate the same function in causally distinct ways. If realizations instantiate the same function in causally distinct ways, those realizations will fall under different causal laws. If realizations of the same function fall under different causal laws, realizations of the same function will not be unified under the same causal law.

This lack of causal unity in the realizers of functional kinds is what makes generalizations about functional kinds largely analytic. As noted, variety within the individuals that qualify as corkscrews means that little can be said about those individuals save for the fact that they remove corks. This analyticity is uninformative as any purported 'law' derived from such a kind will fail to support useful inferences. The fact that some corkscrew happens to be made of aluminum, for instance, permits neither the inference that corkscrews tend to be made of aluminum, nor the inference that things made of aluminum tend to be corkscrews.

Shapiro's idea that valid kinds will be distinguished by the causal symmetry that exists between the macro-properties of the kind and the micro-properties possessed by components of the kind suggests that Shapiro implicitly attributes two characteristics to valid kinds. The first characteristic is that valid kinds will be united by the intrinsic properties of their realizers. It is

this attribute that leads to the impression that scientific kinds are inherently stable. Where a kind is populated by individuals that possess their type-relevant properties intrinsically, the properties of that kind become predictable. In Shapiro's opinion, "Macrolevel laws about water are true because certain microlevel laws about water are true."[18] The suggestion, in this passage, is that the behavior of water is predictable because the behavior of H_2O molecules is predictable. The behavior of H_2O molecules is predictable because nothing extrinsic to molecules of H_2O factors into an explanation of water.

Clearly, functional kinds will not possess this characteristic. As noted, the realizers of functional kinds are unified by the performance of a common function. In the case of realizers of *corkscrew*, this will be the function of removing corks. As a function describes a state-of-affairs outside of the individual that performs that function, realizers of functional kinds will be united by their extrinsic properties.

The second characteristic implicitly attributed to valid kinds is that valid kinds will be realized by individuals that are causally uniform. It is this impression of uniformity that leads to the expectation that valid kinds will be described by identities. Shapiro takes this tack when he validates water as a kind by proclaiming that "[w]hatever is H_2O is water and whatever is not is not."[19] Again, functional kinds will not possess this characteristic because functional kinds are realized by individuals that are causally heterogeneous. As Shapiro notes, a functional kind such as *corkscrew* will be populated by many individuals that differ in the mechanical principles by which they remove corks. As this difference demonstrates the causal heterogeneity of the class of corkscrews, *corkscrew* will not qualify as a valid kind.

If functional kinds like corkscrew do not qualify as valid kinds, they cannot constitute a counterexample to the second horn of Shapiro's dilemma. The second horn of that dilemma states that realizing kinds that differ in their causally relevant properties should constitute realizations of different kinds. However, it only becomes plausible to make this assertion where realizers are understood to be causally uniform individuals that possess their type-relevant properties intrinsically. If the properties of a kind are understood to be nothing more than the

[18] Shapiro 2000, p. 643.
[19] *Ibid*, p. 643.

collective effect of such realizers, predicating a difference in realizers is the same thing as predicating a difference in kind.

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According to Putnam, a theory of realization should be based on the idea of functional isomorphism. Functional isomorphism occurs when the same function may be mapped to physically distinct systems. When we have different physical systems that nonetheless support identical functional mappings, we will have identified different realizations of the relevant function. The problem with Putnam's idea is that any suitably complex physical system can be interpreted in such a way as to support almost any functional mapping, with the result that any suitably complex physical system would qualify as a realization of that function.

Shapiro suggests that we discard the notion of functional isomorphism and instead focus on the function that defines some kind. When this function is ascertained, the causal processes that figure into the performance of that function will constitute the realizing properties of that kind. This conception of realization produces a dilemma for standard accounts of multiple realization. If realizing kinds do not differ in their causally relevant properties, we will appear to have the same realization of the same functional kind. If functional kinds are defined by their causal properties, however, realizing kinds that do differ in their causally relevant properties will constitute realizations of different kinds. In neither case will we have multiple realization, as in neither case will be have different realizations of the same kind.

Functional kinds contest the second horn of this dilemma, however, as functional kinds are realized by individuals that differ in their causally relevant properties. Sustaining the dilemma for multiple realization, therefore, requires sustaining the claim that functional kinds do not constitute valid kinds. Shapiro's idea that functional kinds will not constitute valid kinds appears to derive from two characteristics implicitly attributed to the realizers of valid kinds. The first characteristic is that valid kinds are unified by the intrinsic properties of their realizers, while the second characteristic is that the realizers of valid kinds will be causally uniform. It is only where realizers understood to by causally uniform individuals that possess their type-

relevant properties intrinsically that it becomes plausible to assert that a difference in realizing kinds must result in a difference in kind.

As we will see in chapter 3, however, many valid scientific kinds are, like functional kinds, unified by properties that are extrinsic to realizers of those kinds. It is also true that the realizers of some valid scientific kinds are causally heterogeneous. If this is the case, we should not disqualify functional kinds from the question of realization merely because the realizers of functional kinds are unified by properties that are extrinsic to the realizers of functional kinds, or because the realizers of functional kinds are causally heterogeneous.

Chapter 3

Top

Realization and Kinds

The second horn of Shapiro's dilemma asserts that individuals that differ in their causally relevant properties should constitute realizations of different kinds. As the realizers of functional kinds do appear to differ in their causally relevant properties, the second horn of the dilemma implies that functional kinds will not qualify as valid kinds.

Functional kinds will not qualify as valid kinds, for Shapiro, because functional kinds are unified by properties that are extrinsic to the realizers of functional kinds. What makes something a corkscrew or paperweight, in other words, will be a state-of-affairs that is extrinsic to the individual that qualifies as a corkscrew or paperweight. For a corkscrew, it will be the ability to remove corks. For a paperweight, it will be the weighting of paper. The result of Shapiro's implicit emphasis on the intrinsic properties of the realizers of valid kinds is a theory that largely fails to take into account the extrinsic properties of realizing kinds.

Functional kinds also fail to qualify as valid kinds because the members of functional kinds are causally heterogeneous. The class of corkscrews, for example, demonstrates considerable variety in the means by which corks are removed. As this variety indicates the properties that are causally relevant to cork removal will differ from corkscrew to corkscrew, Shapiro's view will consider the realizing properties of the various corkscrews to also differ.

The first two sections of the following chapter are intended to challenge the expectation that valid kinds are composed of individuals that possess their type-relevant properties intrinsically. If scientific kinds are sometimes unified by the extrinsic properties of their realizers, the idea that valid kinds are only composed of individuals that possess their type-relevant properties intrinsically becomes less plausible. If this latter idea becomes less plausible, the distinction Shapiro draws between valid kinds and functional kinds also becomes less plausible.

The final two sections of the chapter take issue with the idea that individuals that differ in their causally relevant properties will constitute realizations of different kinds. As this idea

represents the second horn of Shapiro's dilemma, the latter two sections are intended to directly dispute the validity of the dilemma and the view of realization wherein the dilemma originates. This is accomplished by noting that the realizers of reputable scientific kinds sometimes only demonstrate uniformity at relatively general levels of description. If the level of description grows more detailed, the realizers of those kinds can be shown to be causally heterogeneous. As a result, we should not allow that realizing kinds that differ in their causally relevant properties will always constitute realizations of different kinds.

3.1 Extrinsic Properties within Biological Kinds

Top

The idea that many reputable scientific kinds are unified by properties extrinsic to realizers of that kind is not particularly intuitive. It is much more conventional to suppose that scientific kinds are unified by properties that are intrinsic to realizers of those kinds. For this reason, we tend to think of the kind *elephant* as defined by a collection of mammals with trunks and tusks, or the kind *water* as defined by a collection of molecules composed of hydrogen and oxygen atoms.

The claim that water is H_2O, for example, purports to identify the macroscopic properties of water with the microscopic properties possessed by a collection of H_2O molecules. The motivation for proposing that H_2O is water is the idea that the properties of H_2O molecules somehow illuminate or explain the properties of water. In order to understand water as a kind, under this construal, we have to look no further than the intrinsic properties of its chemical constituents. There is an expectation that, by identifying a kind with properties intrinsic to realizers of that kind, we eliminate variability from our taxonomic practices.

The idea that some groupings are more metaphysically robust than others appears to originate directly in personal experience. We can see with our own eyes, for instance, what two elephants have in common. That quality, whatever it is, is a quality that an elephant and a housecat seem to lack. Moreover, these similarity judgments do not seem purely subjective; in some sense it seems independently correct to group the two elephants together. The attribution of similarity to a pair of elephants, in this case, would appear to reflect a natural or preexisting condition.

Chapter 3. Realization and Kinds

Historically, metaphysical essentialists took biological kinds as the archetype of scientific kinds. Such a view is no longer fashionable. The main reason biological kinds are no longer considered archetypal scientific kinds is that most biologists no longer believe that biological kinds are constituted by individuals who possess their type-relevant properties intrinsically. Although it was once commonplace to suppose that the properties which make an individual a member of *Elephas maximus* were properties inherent within that individual, this view has fallen out of favor.

On the contrary, modern biology categorizes kinds by their relational properties. In biological systematics, the vast majority of species are taxonomized cladistically. That is to say; what determines the classification of a particular species is not so much the morphology that species exhibits, as the ancestor from which that species descended. In order for two elephants to be members of the species *Elephas maximus*, then, those elephants must be related to a common ancestor. It is this relational feature, rather than something intrinsic to the realizing individual, that causes contemporary biologists to deem an individual the realization of *elephas maximus*.

The role of relational properties in the classification of biological kinds may be illustrated by considering the case of the common fruit fly (*drosophila melanogaster*). Fruit flies differ somewhat in terms of their body color: those found in the wild tend to have brown bodies, while other types bred in the laboratory may have black bodies. In *drosophila melanogaster*, the specific gene that determines whether a fly happens to be have a brown body or a black body comes in two different forms, or alleles. One allele tends to produce fruit flies with black bodies, while the other, dominant allele produces individuals with brown bodies. This means that flies with two black body alleles will have bodies that are black in color, while flies with two brown body alleles will have bodies that are brown.

As the brown-body allele is dominant, flies possessing one brown-body allele and one black-body allele will also have brown bodies. Because this combination of alleles is what determines the genotype for *drosophila melanogaster*, it is possible for two fruit flies to differ in their genotype while at the same time being largely similar in their physical characteristics. In the case of *drosophila melanogaster*, then, the physical similarity of two individuals is irrelevant

to their biological classification. Instead, what makes two fruit flies into different fruit flies is their extrinsic relations to the individuals from which they inherited their alleles .

The idea that biological kind-hood derives from one's ancestors is one of the fundamental principles of evolution. Another such principle is the idea that biological categories are inherently mutable. The Darwinian story tells us that all life on earth originated from a single ancestor, somewhere in the neighborhood of 3 or 4 billion years ago. Random mutations within ancestral biological populations over the course of successive generations eventually gave rise to the speciation of those ancestral populations. Further mutations within these species eventually resulted in the phyletic divergence of entire groups. Although these species may be formally distinguished from one another in terms of their heritable characteristics, phenotypic variation within each species may be vast. It is this phenotypic variation that produces the phenomena of evolution by natural selection. The Darwinian story, in other words, is premised on the assumption of biological diversity.

This diversity fits poorly with the idea that biological kinds are composed of individuals that possess their type-relevant properties intrinsically. If species were constituted by such individuals, one would expect to find some sort of characteristic or feature among the individuals of a species that would serve to identify them as members of that species. It is unusual, however, for biologists to find characteristics that are common to all members of a particular species. Where common characteristics within a species are found, they are rarely characteristics that are unique to a particular species.

Furthermore, any intrinsic property that is intended to be identified with a particular species would have to be possessed by all generations of ancestors and descendants within that species in order for that property to be indicative of kind-hood. If this were the case, ancestors who possessed this species-specific intrinsic property would pass that property to current generations which would, in turn, pass the same property to their descendents. The resulting species would presumably exhibit a degree of homogeneity and stability over evolutionary time, as variation could only take place within that species' nonessential properties.

The picture that emerges from biology, however, is the antithesis of such stability. As biological populations move through evolutionary time, certain traits disappear while new traits

continually form. Given this transience, what appears to constitute an essential trait of some species in one epoch may not appear as an essential trait of that species in another. For this reason, the traits biologists identify with given species will tend to be implicitly or explicitly connected to the geographical and temporal context in which that species is examined. Darwinism explains this changeability by positing variation in all of a species' traits, rather than variation in some nonessential subset of these.

Of course, one might object to this line of reasoning and maintain that there remains a strong sense in which *drosophila melanogaster*, *elephas maximus*, and every other species does possess its type-relevant features intrinsically. The information which identifies the genotype of a biological individual, after all, will be encoded in the nucleotide sequences of that individuals' DNA. For a fruit fly, those nucleotide sequences may specify whether the phenotype develops a black body or a brown body. For an elephant, those sequences may specify whether the phenotype develops larger or smaller ears. As this information is present within the very cells which compose that individual, it would seem that there is a sense in which every biological individual does possess its type-relevant features intrinsically.

The idea that biological individuals do possess their type-relevant features intrinsically could be expanded by noting that phenotypic diversity in biological populations is often produced as a result of environmental factors. This sort of environmental variation, known as ecophenotypic variation, is particularly pronounced in some plants. The narrowleaf hawkweed (*hieracium umbellatum*), for example, varies radically in its phenotypic expression as geographic and environmental circumstances change. Those growing in rocky areas in Sweden tend to be bushy plants with broad leaves and expanded flower clusters, while those growing in sandy areas in Sweden tend to be balder plants with narrow leaves and tight flower clusters. Although these plants are members of the same scientific kind, they exhibit considerable phenotypic variation as a result of environment differences. The type-relevant features of *hieracium embellaturm* encoded within the plants themselves, then, may be more homogenous and stable than the resultant phenotypic populations demonstrate.

The idea that biological individuals do possess their type-relevant features intrinsically in virtue of their intrinsic possession of a certain DNA sequence may be easily refuted by calling attention to the identity conditions of that sequence. Genetic information is, by definition,

hereditary information. A DNA sequence that calls for black bodies or long ears, then, becomes genetically significant where it has been inherited from a previous population of that kind. As the particular sequence that is understood to be significant can only be isolated by considering the hereditary context into which an individual figures, the significance attached to some DNA sequence will also be a factor of the hereditary context into which an individual figures. As this hereditary context will be an extrinsic property of an individual, there is a strong sense in which scientific kind-hood will remain an extrinsic property of biological individuals. Although an individual's DNA may be an intrinsic property of that individual, that property is only relevant to kind-hood for reasons that will be extrinsic to that individual.

These sorts of factors counsel against the idea that biological kinds consist of individuals that possess their type-relevant properties intrinsically. Willard Van Orman Quine famously observed that our notion of 'kind' bears a striking resemblance to our notion of 'similarity'. In order for an individual to qualify as a member of some biological kind, according to Quine, that individual must, first and foremost, appear similar to other members of that kind. As similarity judgments are invariable subjective, membership within a kind will be the result of a triadic relation involving an individual, the similarity of that individual to a kind, and the agent or agents assessing that similarity.[20] Once we acknowledge that membership within a kind partly results from the external similarity judgment of some agent, however, we abandon the principle that the identity of kinds originates in the intrinsic properties of the individuals constituting that kind.

3.2 Extrinsic Properties within Chemical Kinds

Top

If the idea that extrinsic properties play a role in the determination of biological kinds is counterintuitive, the idea that extrinsic properties play a role in the determination of chemical kinds is even more so. This is because the properties we associate with chemical kinds are typically understood to be nothing more than the molar-level expression of properties intrinsically possessed by the constituents of chemical kinds. If water is H_2O, we expect that the properties of water will be nothing more than the molar-level expression of the properties of

[20] Quine 1969, p. 161.

many H_2O molecules. As a result, the idea that the properties of chemical kinds derive from the extrinsic properties of realizers of those kinds appears dubious. Even a conventionalist such as Quine denies that the identity of chemical kinds comes about via the sort of similarity judgments he attributes to the taxonomy other kinds. Quine's reticence is due to his belief that chemistry possesses what he calls a 'lusty similarity', and this more objective sort of similarity is what prevents one from "..rationalizing a single notion of relative similarity" for the classification of all kinds.[21]

In some branches of chemistry, however, the contribution of subjective judgment to the classification of kinds is quite overt. One such branch is the field of combinatorial chemistry. Combinatorial chemistry is a discipline devoted to the synthesis of molecular structures with practical – often pharmacological – application. In order to achieve these goals, chemical structures with known properties are subject to transformative physical and chemical processes in the laboratory. Sometimes, the target of chemical synthesis is the recreation of naturally occurring, though perhaps rare, chemical structures. At other times, the goal of chemical synthesis is the creation of new chemical compounds that offer the potential to improve upon the properties of existing compounds.

In order to develop the new compounds, target areas are mapped in design space. These target areas consist of existing compounds with known properties. The goal of synthesis is to map regions near the target area in order to ascertain the ability of novel compounds to improve upon the properties of known compounds within the target area. Typically, some stages of the synthetic process will be more significant than others. These stages or 'functional group transformations' mark successive phases in the transformation from elementary structures to intended objectives in design space.

The central problem faced by combinatorial chemistry is the problem of paring down the vast number of possible chemical permutations to those most likely to prove useful. The process of synthesis from simple to more complex structures usually takes place via successive generations, where each generation is marked by a functional group transformation. As the variability at each functional group transformation, as well as the number of transformations

[21] *Ibid*, p. 54.

themselves is typically quite large, the total number of possible permutations is enormous. For this reason, it is only practical to actually synthesize a small fraction of the total number of possible permutations. In order to deal with this vast number of permutations, most combinatorial possibilities are first mapped to a virtual library from which candidates for actual synthesis are selected.

The process of selecting which of these virtual compounds are actually synthesized will depend on the potential of some candidate compound to improve upon the properties of an existing compound. At this point, an assessment of similarity between potential and extant compounds becomes necessary. There is not, however, an accepted set of criteria that govern such assessments. Instead, the assessment will depend upon the disposition of the chemist and the investigative context within which the assessment takes place. If one is interested in the pharmacological properties associated with ligand formation, selection criteria are apt to emphasize the binding affinity of biomolecular compounds. If one is interested in the energy potential of arenes, primary selection criteria may differentiate compounds that possess an aromatic ring. As these different criteria taxonomize the design space in different ways, the synthesis of new chemical kinds becomes an interest-relative activity.

Nalini Bhushan and Stuart Rosenfeld note that the field of combinatorial chemistry contains an important insight for the metaphysics of kinds. In particular, they note that combinatorial chemistry demonstrates how an assessment of similarity on the part of a human agent can play an important role in determining the nature of a chemical kind.[22] Chemical compounds selected for synthesis are selected based on the judgment of a particular chemist and that chemist's assessment of the potential properties the new compound would possess. If that chemical kind then comes into being, the explanation for its existence would implicate the interests of the relevant chemist. The role of similarity judgments in determining the taxonomic status of synthetic chemical kinds echoes Quine's observations about the role of similarity judgments in determining the taxonomic status of biological kinds. In both synthetic chemistry and evolutionary biology, the taxonomic status of an individual seems to depend, at least in part, on properties that are extrinsic to the individual realizing that kind.

[22] See Bhushan and Rosenfeld 2000.

From the standpoint of taxonomic validity, there is nothing that distinguishes synthetic chemical kinds from naturally-occurring chemical kinds. Traditional laboratory investigation into the subatomic, atomic, and molecular properties of chemical compounds is no less productive for being carried out on synthetically produced compounds. By Fodor's standard of legitimacy, whereby taxonomies are validated by their theoretical benefits, synthetic compounds and their naturally occurring counterparts will be equally robust. Even employing Quine's stricter standard, whereby kinds are validated to the degree they facilitate inductive inference, the kinds created by synthetic chemistry are on par with those occurring naturally.[23]

Synthetic kinds facilitate a similar level of inductive inference because synthetic kinds are created from the same atomic constituents as naturally occurring kinds. As these atomic constituents have the same bonding properties when they form the synthetic compounds as they do when they form natural compounds, the resulting compounds will behave in predictable ways. As this predictability is the basis upon which inductive inference is founded, synthetic and naturally occurring chemical kinds will facilitates a similar level of inductive inference.

Moreover, it is difficult to understand how there could be anything in the process of synthesis itself which somehow marks the kinds that result as less valid than their naturally occurring counterparts. This parity can be illustrated by considering the equivalence, from a scientific standpoint, of a chemical occurring naturally and the same chemical produced synthetically. We might think that ethanol, for example, is a valid chemical kind due to the stability of its chemical properties. One of those properties will be the fact that all ethanol burns with a blue flame, while another will be the fact that all ethanol is miscible with water. If one so desires, one can synthesize ethanol from sugar by intentionally combining yeast with fruit pulp. This type of chemical synthesis, better known as fermentation, has been practiced by human beings since antiquity.

This same chemical transformation of fruit pulp into alcohol also occurs naturally through a process called carbonic maceration. There is nothing in the molecules of C_2H_5OH produced via fermentation, however, that differentiates them from molecules of C_2H_5OH produced via carbonic maceration. Both compounds burn with a flue flame and are miscible

[23] Quine 1969, p. 41.

with water. If the molecules produced via the two processes are identical from a chemical standpoint, there should be nothing that differentiates the processes that produced them from a taxonomic standpoint. For taxonomic purposes, the origin of a chemical kind is irrelevant.

Understanding the role of extrinsic properties in the taxonomic classification of the kinds produced via chemical synthesis encourages a reassessment of the idea that the realization of scientific kinds is somehow different, in principle, from the realization of functional kinds. The second horn of Shapiro's dilemma states that individuals that differ in their causally relevant properties will constitute realizations of different kinds. This assertion implies that the idea that functional kinds do not constitute valid kinds, as the realizers of functional kinds do differ in their causally relevant properties. As the realizers of functional kinds are unified by their extrinsic properties, Shapiro's view may be understood to be in opposition to the view that the realizers of valid kinds will be unified by their extrinsic properties.

It does appear however, that many valid kinds are unified by the extrinsic properties of realizers of that kind. The morphological similarity of biological individuals, for example, plays no part in the classification of biological kinds. Instead, biological kinds are unified in virtue of relation to a common ancestor. As the relation to a common ancestor is clearly an extrinsic property of the individuals that comprise a biological kind, we may say that biological kinds are unified by properties that are extrinsic to realizers of biological kinds.

The field of chemical synthesis also suggests that even kinds as scientifically reputable as chemical kinds may come by some of their identity conditions extrinsically. Synthetic chemists, in our example, use similarity judgments to determine which of a range of potential chemical kinds will be selected for synthesis. As the particular methodology of this judgment is apt to vary with respect to the goals and interests of the relevant chemist, the kinds that actually come into being will be subjectively determined. For this reason, any ontology of the resulting chemical kinds must take into account factors that are extrinsic to realizers of those chemical kinds. What makes something into a valid kind in the field of synthetic chemistry, in other words, cannot simply be read off of the intrinsic features of realizers of that kind. Instead, what makes something a kind in synthetic chemistry is, at least partly, a desire on the part of some agent or agents to treat a particular grouping as useful in some way.

If the extrinsic properties of realizing individuals play a prominent role in the taxonomy of some scientific kinds, the extrinsic properties of realizing individuals should also play a prominent role in any theory of realization. Although the extrinsic properties of functional individuals are the only properties by which functional kinds are unified, we cannot exclude functional kinds from a theory of realization on that basis. Instead, the account we endorse should treat the intrinsic and extrinsic properties of realizing individuals as equally valid from the standpoint of realization. As Shapiro's account implies that the extrinsic properties of realizing individuals are not as significant as their intrinsic properties, Shapiro's account will fail to properly account for the different forms realization may take.

3.3 Isotopic Isomerism and Water

Top

Shapiro's account of realization assumes a strong connection between the properties of realization and the properties intrinsically possessed by realizers of some kind. This assumption partly underwrites the second horn of the dilemma, which states that realizing kinds that differ in their causally relevant properties will constitute realizations of different kinds. Extrinsic properties are typically considered to be more changeable than intrinsic properties. If valid kinds were sometimes unified by the extrinsic properties of their realizers, one could not confidently assert that a difference in the causal properties of realizing kinds would be indicative of a difference in kind.

The causal uniformity of many scientific kinds, however, does appear commonsensical. This is especially true for chemical kinds. With a chemical kind, we expect that the properties that define the kind will be possessed, in part, by every realizer of that kind. If water is understood to be realized by molecules of H_2O, this means that the properties of water will be possessed by each and every molecule of H_2O. It is this expectation of uniformity in water's realizing kinds that leads Shapiro to assert that "[w]hatever is H_2O is water and whatever is not is not."[24]

[24] Shapiro 2000, p. 643.

The understanding that chemical kinds are made up of uniform realizers is strongly associated with the stability attributed to chemical kinds. The properties of different samples of water, for example, are expected to be identical under identical conditions. If a sample of water appeared to possess a certain property today and lack that same property tomorrow, we would not think the properties of water had somehow changed. On the contrary, we would tend to think that some impurity been added to the water and the consequent lack of uniformity explained the change.

The apparent uniformity of chemical kinds may be contrasted with the instability and heterogeneity Shapiro attributes to functional kinds. Given the manifest variety of functional kinds such as *corkscrew*, the only property realizers of functional kinds are apt to have in common is the function that defines the kind. Such kinds lack validity, according to Shapiro, because there is no significant property that unifies realizers of the kind. On the contrary, the causal heterogeneity exemplified by the realizers of functional kinds such as *corkscrew* suggests that functional kinds are primarily kinds by convention, and, as such, do not underwrite any useful generalizations about that kind.

Heterogeneity in the realization of chemical kinds, however, is much more widespread than our initial intuitions may suggest. This largely overlooked heterogeneity is often a necessary condition for chemical kinds to manifest their distinctive molar-level properties. We do not typically associate heterogeneity with the realization of chemical kinds, however, as it is much simpler to conceive of chemical kinds in terms of identities. These identities give the impression that chemical kinds are, contrary to fact, realized univocally.

Water, in our example, is a familiar chemical kind identified with molecules of H_2O. If only molecules of H_2O compose water, it seems that water will be realized univocally. Strictly speaking, this is not actually the case. Water is not univocally realized by uniform molecules of H_2O because molecules of H_2O must structurally differ in order for water to possess its distinctive molar-level properties. This phenomenon, known as isotopic isomerism, challenges the expectation that chemical kinds are kinds that are realized univocally.

Chemical elements, as we learn in school, are nominally identified by their atomic number. This atomic number corresponds to the number of protons contained in the nucleus of

an atom of that element. Hydrogen (H), the lightest of all elements, contains but a single proton in its nucleus and is thus assigned the atomic number 1. Most hydrogen possesses a nucleus that consists of nothing more than this single proton, and is termed protium and represented by the notation ^{1}H. Other variants of hydrogen, such as deuterium (^{2}H or D) and tritium (^{3}H or T), possess nuclei where the single proton has bonded with one or more neutrons. These subatomic variations in neutron content are known as isotopes.

Although elements are formally identified by their atomic number, elements are more accurately identified as families of isotopes. This is certainly true for oxygen (O), which is found to naturally occur in three isotopic variations. Although formally identified by the atomic number 8, the nucleus of naturally-occurring oxygen atoms may contain either 8, 9, or 10 neutrons. These isotopes of oxygen are correspondingly identified by the respective notations ^{16}O, ^{17}O, and ^{18}O.

The presence of isotopic variation renders the claim that chemical kinds are realized univocally to be problematic. This is because common chemical kinds that appear atomically uniform are often made up of compounds containing a heterogeneous collection of different isotopes. These compounds, known as isomers, possess the same molecular formula but differ in their more detailed chemical formula. Water, for example, is nominally identified with individuals with the molecular formula H_2O. This identity gives the impression that water is a chemical kind possessing a single and uniform realization.

The real picture, however, is considerably more complicated. All samples of hydrogen found in nature exemplify isotopic variation. For this reason, the hydrogen present in a given sample of water will also exemplify isotopic variation. As the oxygen present in that sample will similarly exemplify isotopic variation, the composition of water at the atomic level will demonstrate considerable variety. Samples of water which are commonly identified with uniform molecules of H_2O may instead by composed of isomers as diverse as $H_2{}^{17}O$, $H_2{}^{18}O$, $HD^{16}O$, $D_2{}^{17}O$, $T_2{}^{18}O$, and so on.[25] As the isotopes that compose these isomers are either naturally present or produced as the result of natural processes, all would seems to have a similar and equal claim to being a ‘natural’ component of water.

[25] Weisberg 2006, p. 340.

Once the matter of isomers has been raised, maintaining the idea that water is univocally realized by molecules of H_2O becomes considerably more difficult. One possible move to recapture the idea of univocal realization is to point out that certain isomers are much more prevalent than others. With this idea in mind, one could simply stipulate that water is univocally realized by the predominant isomer $^{1}H_2{}^{16}O$. The trouble with this sort of move is that any macroscopic sample of water will still contain a vast number of isomers that are not $^{1}H_2{}^{16}O$. The isomer $HD^{16}O$, for example, is a relatively rare isomer that constitutes only 0.03% of the earth's water. Michael Weisberg points out, however, that this fact still means that a single sip of water will contain 1.8×10^{22} molecules of $HD^{16}O$.

Moreover, the philosophical benefits of identifying water with a single dominant isomer would be severely reduced by the philosophical problems such a move would also incur. If water were identified with all and only molecules of $^{1}H_2{}^{16}O$, and that isomer constituted 99% of water, we would still be unable to encounter unadulterated water outside of the laboratory. Whatever would fill our lakes and flow from kitchen taps, then, would not qualify as water.

Another possible move to restore the idea of the univocal realization of water would be to claim that H_2O is actually an abstract or higher-order term. The idea here would be that H_2O is the chemical equivalent of a genus, in that the compound serves as a label which identifies a family of instantiating isomers. The label H_2O, then, actually corresponds to the group of related isomers $\{H_2{}^{17}O, H_2{}^{18}O, HD^{16}O, D_2{}^{17}O, T_2{}^{18}O, \ldots\}$ in the same way as the genus *felis* corresponds to the group of related mammals {*felis catus*, *felis tigris*, *felis pardus*, …}. Water then, would again be univocally realized by H_2O in much the same way as the family of cats is univocally realized by the genus felis.

This move to restore the univocal realization of water, however, is prevented by the diverse range of properties that isomers of water exhibit. It is certainly the case that the isotopes that distinguish various isomers are typically very much alike in their properties. Isotopes of the same element share the same number of protons, and this means that different isotopes of the same element will tend to exemplify the same electronic structure. As this electronic structure is largely responsible for the chemical behavior of the relevant atom, isotopes of the same element will tend to manifest the same behavior. This is not, however, the case with hydrogen. Hydrogen is a very light element that contains a relatively small number of subatomic

components. For hydrogen, isotopic variation in the number of neutrons present within the nucleus has a proportionately large effect on the atom's overall mass. This produces a phenomenon known as the kinetic isotope effect, where isotopes with larger masses react more slowly than other isotopes of the same element.

As a result of the kinetic isotope effect upon the hydrogen in water, pure isomers of water will vary substantially with respect to their properties. In fact, pure isomers within water need not possess any of the properties associated with common samples of water. The macro-properties we associate with water only occur as a result of the intermixing of the different isomers composing water.

The binding properties of hydrogen and oxygen atoms in molecules of $D_2{}^{16}O$, for example, are much stronger than the binding properties of hydrogen and oxygen in other isomers of water. Although this strength makes pure $D_2{}^{16}O$ particularly useful for moderating the high neutron output produced in nuclear fission reactions, it also lends pure $D_2{}^{16}O$ other notable properties. Pure $D_2{}^{16}O$ has both a higher freezing point and a higher boiling point that ordinary water. Pure $D_2{}^{16}O$ also disrupts the normal activity of enzymes, rendering pure $D_2{}^{16}O$ highly toxic to human beings. If we wish to maintain that water is univocally realized by H_2O, however, and understand H_2O as a term denoting a family of isomers, we would have to accept the claim that water is sometimes pure $D_2{}^{16}O$. We would correspondingly have to revise our conception of the molar properties of water, as we could no longer claim that water is good to drink or that water freezes at zero degrees Celsius.

3.4 Reassessing the Validity of Kinds

Top

The most accurate way of describing the realization of water, then, is to claim that the molar properties of water are realized through the heterogeneous causal contributions of water's various isomers. If this is the proper way to understand the realization of water, however, we must abandon the idea that water is realized univocally by uniform molecules of H_2O. The idea that a reputable scientific kind such as water is realized via a collection of realizers with varying causal properties suggests a problem for Shapiro's dilemma and the conception of realization that produces that dilemma.

That dilemma asks whether realizing individuals truly differ in the properties that are causally relevant to realization. If they do not, we should consider those individuals the same realization of the same kind. As color is not causally relevant to the function of cork removal, for example, color is not a basis upon which to distinguish realizations of *corkscrew*. If realizing individuals do differ in their causally relevant properties, however, those individuals should be considered realizations of different kinds. Winged and waiter's corkscrews, for example, differ in the properties that are causally relevant to cork removal. For this reason, the dilemma understands realizations of winged and waiter's corkscrews to be realizations of different kinds. In neither case will we have multiple realization, according to Shapiro, because in neither case do we have a single kind with different realizations.

The phenomenon of isotopic isomerism casts doubt on the account of realization that produces this dilemma by demonstrating that realizing kinds that differ in their causally relevant properties can indeed be realizations of the same kind. Typically, chemical kinds are identified with realizers of some uniform type. Shapiro's claim that 'whatever is H_2O is water and whatever is not is not' is an identification of this sort. A more detailed investigation of this identity, however, exposes a more complex picture of water's realization.

Samples of water that are typically identified with collections of uniform H_2O molecules are instead constituted by families of isomers. As these isomers are separable and causally diverse, the molar-level properties associated with water should be understood as contingent upon the heterogeneous realization of water. According to Shapiro's account of realization, causal heterogeneity at the molecular level would indicate that realizations of H_2O molecules will be realizations of different kinds. As water is realized from H_2O molecules, water itself would then be realized by individuals that differ in their causally relevant properties. As a result, the realization of water, according to the strictures of Shapiro's account, would constitute the realization of different kinds.

Understanding the heterogeneous realization of water does not change our perception of water's validity as a kind, however. Although the properties of water could vary with respect to the ratio of its instantiating isomers, we understand the properties of water to be quite stable. This relative stability permits certain generalizations to be made about water, such as that it is good to drink and that it freezes at zero degrees Celsius. These generalities, in turn, facilitate

inductive inference; such as that if *x* is water, *x* freezes at zero degrees Celsius. These inferences are not justified because they conform to laws and, as a result, must be true. A sample of water created in the laboratory that is primarily composed of the isomer $D_2{}^{16}O$ will not freeze at zero degrees Celsius. Inferences that appeal to the properties of some kind are justified because they are valid within the context of their attribution. The fact that a certain laboratory sample of water fails to freeze at zero degrees Celsius does not change the fact that, in most contexts, water does freeze at zero degrees Celsius. As long as we remain within that everyday context, then, we would be justified in asserting that water freezes at zero degrees Celsius.

If the referent of kind-terms depends on contextual factors, we would expect to see that referent change as the descriptive context changes. According to Weisberg, this is precisely what takes place. Working chemists, Weisberg notes, employ kind-terms that pick out different chemical compounds as those terms are used in different explanatory contexts.[26] The referent of 'water', for instance, may be used to pick out either a single isomer of a combination of isomers. At other times, 'water' may be used to refer to the particular isomer that is most prevalent in a sample of water. Although we tend to think of chemical kinds such as water in terms of identities, Weisberg points out that what 'water' actually refers to will vary in scientific contexts. This contextual understanding of realization will be developed in more detail in chapter 8.

If we adopt this contextual way of assessing the validity of kinds, we will be in a position to reject Shapiro's dilemma. The second horn of that dilemma specifies that if realizing individuals truly differ in their causally relevant properties, those individuals must qualify as realizations of different kinds. Understanding the role of isomerism in the realization of water, however, suggests that this horn of the dilemma is incorrect. The various isomers that realize water do differ in their causally relevant properties, yet this does not cause us to consider water invalid as a kind. On the contrary, water qualifies as a kind because the properties of water are understood to be stable in the context in which water is typically encountered.

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[26] *Ibid*, p. 343.

The second horn of Shapiro's dilemma asserts that realizing individuals that differ in their causally relevant properties will constitute realizations of different kinds. Functional kinds constitute a counterexample to this horn, however, as the realizers of functional kinds do vary in terms of the properties that are causally relevant to realization. As a result, accepting the dilemma requires accepting the idea that functional kinds do not constitute valid kinds.

One of the reasons for rejecting the validity of functional kinds will be the idea that functional kinds are unified by properties that are extrinsic to the realizers of functional kinds. This appears a poor rationale for rejecting functional kinds from an account of realization, however, as many reputable scientific kinds are also unified by properties that are extrinsic to realizers of those kinds. In the field of chemical synthesis, for example, chemical kinds are created in response to subjective considerations that are extrinsic to the individuals realizing those kinds. Faced with a vast number of possible chemical permutations, chemists select compounds for synthesis based on their assessment of the potential properties the new compound would possess. If the chemical compounds created through synthesis are scientifically indistinguishable from naturally occurring chemical compounds, the former should have the same claim to validity as the latter.

Shapiro's distinction between valid and invalid kinds is ultimately not sustainable, as even chemical kinds will demonstrate causal heterogeneity in their realizing kinds. The properties of water, in our example, are typically identified with the collective effect of causally uniform H_2O molecules. This uniformity, however, is not a characteristic of water at the molecular level. The various isomers that compose water differ in their causal properties, and only produce the molar properties associated with water in combination. From the standpoint of isotopic isomerism, water is heterogeneously realized. Coming to understand the causal heterogeneity of water does not cause us to doubt water's validity as a kind. Instead, water remains valid as a kind because the properties of water are understood to be stable in the context in which water is typically encountered.

A theory of realization that allows realization only where the realizers of a kind possess their type-relevant properties intrinsically will have limited applicability. If that same theory also only allows realization in kinds that are constituted by causally uniform realizers, the theory's applicability to actual kinds becomes even more restricted. We should, as a result,

abandon Shapiro's conception of realization in favor of a theory that better accounts for the different forms realization may take.

A more promising approach to realization may be that of Carl Gillett and his 'dimensioned' view, which forms the topic of chapter 4.

Chapter 4

Top

Dimensioned Realization

Understanding the way in which the properties of some causal or functional type derive from the physical properties of its realizing kinds is to understand the functional role played by those realizing kinds. Functionalism in the philosophy of mind is predicated upon this idea of causal role-playing. More specifically; functionalism is predicated on the idea that what makes something a cognitive state is the causal role played by that state within a properly functioning cognitive economy. The causal role of a cognitive state may be understood in terms of the causes that typically bring about that state, as well as the effects that typically follow from that state. Realization is intended to describe the way in which the physical properties of these causes and effects fulfill a certain causal role.

A description as to how something with physical properties is able to play a causal role may take different forms, based on the explanatory requirements of that description. If our interest lies in how a brain is able to play the causal role of mind, a description of causal role-playing may involve a description of how the cognitive properties of a mind are instantiated in, or exemplified by, the physical properties of a brain. A brain fulfills the causal role of mind, in this case, because the brain qualifies as an instance of mind. Another explanation of causal role-playing, however, may involve a description of how the cognitive properties of a mind are produced by, or arise in virtue of, the physical properties of brain components. A brain fulfills the causal role of mind, in this latter case, in the sense that the cognitive properties of mind are the result of brain processes.

There is an important difference, however, between realization in the first sense where a brain qualifies as an instance of mind, and realization in the second sense where brain processes result in the properties of mind. The difference is that the first conception of realization implies a one-to-one relationship between a realization and its realizer, while the second implies a one-to-many relationship between a realization and its realizers. In the debate over the nature of realization, the first type of realization has been labeled ‘flat’ realization, while the latter has

been termed ‘dimensioned’ realization. Which of these two views better captures our metaphysical expectations about realization relation is a matter of some contention.

The following chapter explores the dimensioned conception of realization put forward by Carl Gillett. According to Gillett, science provides many examples where a kind and the components that best explain the properties of that kind differ in their powers and properties. As the explanatory relation between these components and the kind itself is the same causal role-playing relation associated with the realization relation, a scientifically informed account of realization should not expect some realization and its realizers to always be equivalent in their powers and properties.

Accepting Gillett’s contention that realizations may sometimes stand in a one-to-many relation with their realizers allows our theory to embrace the scientific examples Gillett cites, giving theoretical weight to our account of realization. Accepting the dimensioned view also provides a philosophical alternative to Shapiro’s view, allowing us to reject the dilemma and reestablish the possibility of multiple realization.

4.1 Realization as Causal Contribution

Top

Functional individuals must possess certain causal properties in order to carry out their functions. Corkscrews, for example, must be rigid in order to function as corkscrews. Every individual that qualifies as the realization of *corkscrew*, then, must possess the property of rigidity. If we make the further supposition that every corkscrew is realized by a single physical individual, we will conclude that a realizer of *corkscrew* will possess the property of rigidity. It is this idea of a property shared by both a realization and its realizer that motivates Shapiro’s view of realization. Individuals realize a functional kind in virtue of possessing the causal properties appropriate to realizations of that kind. If rigidity is part of our type-specification for *corkscrew*, every individual that qualifies as a realizer of *corkscrew* must possess the property of rigidity.

As Shapiro takes the shared causal properties of realizer and realization to explain how functional individuals are able to perform the functions they perform, he understands such properties to constitute the realizing properties of the relevant function. We rightfully claim that

a physical individual realizes some function, according to Shapiro, when that individual possesses the causal properties appropriate to that function. We rightfully claim that two physical individuals realize different functions, by the same token, when those individuals differ in the causal properties brought to bear in fulfilling some function. Some type may be described as multiply realized, by this standard, when different physical individuals with different causal properties fulfill the same function.

Shapiro's expectation that individual realizers will wholly fulfill the causal specification that defines realizations of a particular kind ensures that minor differences will typically fail to exert much influence on the realization relation. Under flat realization, for example, a steel corkscrew and an aluminum corkscrew will individually qualify as realizers of the kind *corkscrew*. As each artifact instantiates the causal properties appropriate for the kind *corkscrew*, each artifact qualifies as a realizer in its own right. If the two artifacts instantiate the causal properties that define realizations of *corkscrew* in the same way, they may also qualify as the same realization. The fact that the lever of one corkscrew is made of aluminum and the lever of the other is made of steel will be of little significance to realization, under the flat view, because the composition of the lever is not apt to change whether the entire corkscrew is able to remove corks. The influence of the causal properties of some part of the corkscrew on realization, in other words, is contingent upon the influence of the causal properties of every other part of the corkscrew on realization.

The expectation that realizers will individually fulfill the causal specification for some kind would seem to provide much of the rationale for the second horn of Shapiro's dilemma. That horn maintains that if realizing kinds differ in their causally relevant properties, they will realize different kinds. This stipulation gains plausibility if we expect, as Shapiro does, that realizers will individually fulfill the causal specification for some kind. Suppose we have two realizers that differ in their causally relevant properties. If these realizers are understood to individually qualify as realizations of some functional kind, they will instantiate realizations that must also differ in their causally relevant properties. If functional kinds are defined by their causal properties, these realizations would have to differ in kind. As a result, realizers that differ in their causally relevant properties would result in realizations of different kinds.

This disagreement over the causal mereology of realization amounts to a disagreement over how to understand the idea of causal relevance. The idea of causal relevance that Shapiro has in mind is based on the idea of equivalence. A physical individual realizes some kind when that physical individual is causally equivalent to a realization of that kind. If a physical individual exemplifies the causal properties that are appropriate for the kind *corkscrew*, that individual may be described as a realizer of *corkscrew*. This understanding of causal relevance gains credibility from early formulations of the realization thesis. Those formulations used the concept of realization to describe the way in which a physical individual such as the brain could be understood as the functional equivalent, or realization, of mind. A brain would realize mind, under this construal, where brain and mind were equivalent in their causal properties.

There is another way of understanding causal relevance, however, that is inspired less by original formulations of functionalism than it is by analytical chemistry. In chemistry, it is often the case that the observable, molar-level properties of a kind are not possessed by the individuals that best explain the properties of that kind. Water, for example, has a higher boiling point than that of ammonia. If we ask chemists why water possesses this property, they are apt to say that the boiling point of water derives from the properties of hydrogen atoms. Boiling point refers to a phase transition, in this case; a change of state from liquid to gas. Hydrogen is capable of forming a greater number of bonds with oxygen than with nitrogen, and so molecules of H_2O do not separate as easily from one another as do molecules of HN_3. As phase transition takes place when separation of this sort occurs, samples consisting of H_2O will not change phase as readily as samples of HN_3. The chemical explanation as to water's boiling point, then, involves an explanation of the causal properties of water's constituents.

The properties possessed by water, of course, clearly differ from the properties of water's constituents. Water has the property of having a higher boiling point than ammonia. A single molecule of H_2O, on the other hand, has no such property. Whether or not a molecule of H_2O happens to be part of a liquid or a gas will depend on that molecule's relation to other molecules of H_2O. For this reason, it would be nonsensical to describe a single molecule of H_2O as possessing a boiling point. Although the properties of some H_2O molecule are not equivalent to the properties of water, a chemical explanation recognizes that the properties of some H_2O molecule are causally relevant to an explanation of water. A description that explains the causal

properties of some kind by citing the causal properties of components of that kind, however, is seemingly at odds with Shapiro's expectation that realizers and realizations will be causally equivalent.

4.2 Dimensioned Realization

Top

Carl Gillett holds that it is often the case that the powers and properties which identify a scientific kind are not possessed by the individuals that best explain those powers and properties. If we understand these explanatorily relevant individuals to be the realizers of that kind, we would have to assert that the properties of realizers result in, but are not always equivalent to, the properties of a realization.

As an illustration, Gillett considers the way in which a scientific explanation would go about describing the realization of a diamond. A diamond results when a collection of carbon atoms assumes a very tight, lattice-like arrangement. The tightness of this arrangement is only possible if the carbon atoms assume very specific orientations with respect to one another. Once this arrangement is achieved, the position of each carbon atom within the structure becomes fixed by the corresponding position and orientation of neighboring carbon atoms.

Gillett notes, however, that the properties of diamond are significantly different from the properties of the carbon atoms composing that diamond. A diamond has the well-known property of hardness, for example. An atom of carbon, on the other hand, is made up of tiny subatomic particles whirling around in mostly empty space. Hardness, then, does not appear to be a property that could be ascribed to an individual carbon atom. In the much the same way, the properties of some carbon atom cannot be ascribed to the diamond the atom composes. Carbon atoms possess a distinctive electronegativity as a result of having six protons and six electrons. Although it is the electromagnetic charge of carbon atoms that produces the strong covalent bonding distinctive of diamond, the electromagnetic charge of some carbon atom is not equivalent to the electromagnetic charge of some diamond. Nonetheless, chemists accept that it is the property of electromagnetic charge possessed by carbon atoms that results in the properties of diamond.

Gillett also points out that this difference between the properties of carbon atoms and the properties of diamond confers different causal powers on carbon atoms and diamonds. The property of hardness that the diamond possesses confers upon the diamond the power to scratch any known surface. Some carbon atom within the diamond, of course, has no such power. Instead, some carbon atom possesses the power of causing its neighboring carbon atoms to remain in a tight spatial arrangement. It is the power of causing its neighboring carbon atoms to remain in a tight spatial arrangement that results in the diamond's power to scratch any known surface. The difference with respect to the causal powers of realizers and realizations in the diamond case, then, parallels the situation with respect to the properties of realizers and realizations in the diamond case. Although it is the causal power of carbon atoms that results in the causal powers of diamond, the causal power of some carbon atom is not equivalent to the causal power of diamond.

Gillett claims that the relationship between carbon atoms and diamond illustrates a paradigm case of scientific realization that will not qualify as realization according to standard formulations of the thesis.[27] On the contrary, standards accounts of realization assume that the causal/functional profile of a realizer will closely resemble the causal/functional profile of the ensuing realization. This means that any power or property that is characteristic of some kind will be expected to be a power or property of that kind's realizers. A functional specification that calls for rigidity, in other words, will require every realizer of that specification to possess the property of rigidity.

If we understand a diamond to be realized by a collection of carbon atoms, however, the powers and properties possessed by a realization can clearly differ from the powers and properties of that kind's realizers. Diamond possesses the property of hardness, but a carbon atom does not. A carbon atom has the power of maintaining the alignment of neighboring carbon atoms, but diamond does not. Gillett believes that any account of realization that cannot accommodate the carbon/diamond example, and many similar cases drawn from the sciences, will fail to properly reflect the scope of realization.[28]

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[27] Gillett 2002, p. 319.
[28] *Ibid*, p. 320.

This more inclusive understanding of the various forms realization can take Gillett labels 'dimensioned' realization. Gillett contrasts this conception of realization with the more conservative or 'flat' view of realization Shapiro advocates. The difference between the two conceptions, according to Gillett, lies in the degree of ontological depth one permits between realizers and realizations. Flat views of realization do not allow for realizations and their realizers to involve different powers or individuals. For some kind to possess the power to scratch any known surface is for the realizers of that kind to possess the power to scratch any known surface. For an individual to qualify as a realization of *corkscrew* is for that same individual to qualify as a realizer of *corkscrew*. As a result, flat views will assume a high level of causal isomorphism holds between a realization and its realizers.

Dimensioned views of realization, on the other hand, recognize that some instances of realization involve not only different properties, but also different individuals and powers. In the diamond case, the individual possessing the property of hardness is not the same individual as possesses the properties that explains that hardness. The property of hardness is possessed by the diamond, while that hardness is explained in terms of the properties possessed by some carbon atom. Moreover, the causal powers possessed by a diamond are not the same as the causal powers possessed by some carbon atom. Diamond has the power to scratch any known surface, while a carbon atom possesses the power of maintaining the alignment of its neighboring carbon atoms. As only dimensioned realization addresses cases of realization involving different individuals and powers, Gillett maintains that only dimensioned realization is able to properly reflect the variety of forms realization can take.

4.3 Two Principles

Top

The difference between flat and dimensioned views of realization hinges upon two related principles. Both principles concern how we should understand the metaphysical relationship between realized and realizing properties. Flat views of realization require the individual within which realized properties inhere to be the same individual within which realizing properties inhere. We may call this the 'principle of individualism', and articulate it, following Gillett, in the following fashion;

(PI) A property instance X realizes a property instance Y *only if* X and Y are instantiated in the same individual.

Realizing and realized properties, by this formulation, are properties of the same individual. If rigidity is one of the properties that realize *corkscrew*, a flat conception of realization will require the individual that is a corkscrew to possess the property of rigidity.

Clearly, a component of some realization will constitute a different individual than the realization itself. For this reason, there is no possibility for the components of a realization to qualify as its realizers under the principle of individualism. Early formulations of the multiple realization thesis implicitly endorsed the principle of individualism. The paradigm case of brain realizing mind, as a case in point, is consistent with the principle of individualism. In that example, the physical properties of the brain are deemed to realize the conceptual or functional properties of mind. The same individual, in other words, possesses both the realizing properties of a brain and the realized properties of mind.

This principle need not hold in the case of dimensioned realization, as Gillett would allow that the contributions of many individual realizers are sometimes required to account for the properties of a single realization. In the carbon/diamond case, Gillett asserts that the properties of many individual carbon atoms are required in order to realize the properties of a single diamond. In the carbon/diamond case, then, the individual possessing realizing properties is some carbon atom, while the individual possessing realized properties is the diamond. As the individual possessing realizing properties is different that the individual possessing realized properties, the principle of individualism is contravened.

The second principle to which advocates of the flat view implicitly adhere concerns the relation of causal powers between a realization and its realizers. Flat realization assumes that the causal powers of realizers will closely resemble the causal powers of the resulting realization. We may call this the 'principle of causal powers', and articulate it, again following Gillett, in the following fashion;

(PC) A property instance X realizes a property instance Y only if the causal powers individuative of the instance of Y match causal powers contributed by the instance of X (and where X may contribute powers not individuative of Y).

The principle states that any realizer of some kind will possess the causal powers that match the causal powers of realizations of that same kind. If the power to scratch any known surface a causal power of diamond, a flat conception of realization will require every realizer of diamond to possess the power to scratch any known surface.

This sort of equivalence in causal powers is not necessary if one assumes the dimensioned view of realization. Although a diamond has the power to scratch any known surface, an individual carbon atom has no such power. Instead, a carbon atom has the power of maintaining the alignment of its neighboring carbon atoms. As it is this causal power that results in the causal powers of the diamond, the dimensioned view allows that the causal powers of realizers may be different from the causal powers of realizations. In doing so, the dimensioned account accepts that some cases of realization will violate the principle of causal powers.

In allowing that some cases of realization will violate both principles (PI) and (PC), the dimensioned view endorses a more liberal conception of realization than that condoned by the flat view. Although it is sometimes the case that realized and realizer properties are properties of the same individual, the dimensioned view also allows cases of realization where realized and realizer properties are properties of different individuals.[29] The property of hardness is a property possessed by some diamond, while the properties of bonding and alignment that result in that hardness are properties of individual carbon atoms. The dimensioned view also differs from the flat view in allowing cases of realization where realizers and realizations possess different causal powers. Although the powers of carbon atoms may result in the diamond's power to scratch any known surface, no single carbon atom has the power to scratch any known surface.

The primary advantage of rejecting the two principles, according to Gillett, is that it permits our account of realization to encompass the sort of compositional cases that are common in the sciences. In particular, it allows us to accommodate those cases where the properties of some scientific kind are understood to be emergent properties of the kind's constituents. The hardness possessed by diamond, in our example, is the collective result of the properties of many constituent carbon atoms. The idea that carbon atoms realize the diamond, however, contravenes

[29] Gillett 2003, p. 594.

both principle (PI) and (PC). An account of realization that insists on (PI) and (PC), according to Gillett, must deny that carbon atoms realize diamond. Insofar as a vast swath of similar compositional examples drawn from the sciences will also contravene principles (PI) & (PC), Gillett concludes that principles (PI) & (PC) lack empirical justification. As the flat account of realization implicitly accepts both principles, the flat account of realization will similarly lack empirical justification.

In order to better address the realization of scientific kinds, Gillett proposes a conception of realization that dispenses with principles (PI) & (PC). The resulting formulation, he believes, better reflects the variety of metaphysical forms that realization may take:

> (R-D) "Property/relation instance(s) F1-F*n*, realize an instance of property G, in an individual *s*, if and only if *s* has powers that are individuative of an instance of G in virtue of the powers contributed by F1-F*n*, to *s* or *s*'s constituent(s), but not vice versa."[30]

The differentiating claim that distinguishes dimensioned from flat realization is brought forth in the idea that the property (G) of some individual (*s*) may be realized in virtue of the properties of *s*'s constituents (F1-F*n*). In such cases, it will be the collective contribution of these constituent properties (F1-F*n*) which together realize the property (G), rather than some property possessed by a single realizer (F1) of s. In the diamond example, the properties of alignment and bonding which each carbon atom possesses collectively result in the hardness of the diamond. The property of hardness, however, is not equivalent to any property possessed by some carbon atom. The formulation reflects the idea that the property of hardness (G) possessed by the diamond (*s*) is individuated by the properties of its constituent carbon atoms (F1-F*n*), but not vice versa.

In addition to accommodating cases of scientific composition, accepting the dimensioned view of realization also undermines the plausibility of Shapiro's dilemma. The second horn of that dilemma asserts that realizing kinds that differ in their causally relevant properties will realize different kinds. Again, this horn of the dilemma only becomes plausible if we assume, in accordance with the flat view, that realizers will individually fulfill the causal specification of some kind.

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[30] *Ibid*, p. 594.

Suppose that we have two realizers of the kind *corkscrew* that differ in their causally relevant properties. If we understand these realizers to individually qualify as realizations of the kind *corkscrew*, we will be dealing with two realizations that also differ in their causally relevant properties. If kinds are defined by their causal properties, two realizations that differ in their causal properties will be realizations of different kinds. Consequently we would assert, in accordance with the second horn of the dilemma, that realizers that differ in their causally relevant properties will produce realizations of different kinds.

This line of reasoning becomes less plausible if we no longer assume that realizers must be causally equivalent to some realization. Two components of the same corkscrew, for example, might differentially contribute to the causal properties that specify realizations of *corkscrew*. The screw could contribute the property of cork-grasping, while an arm of that same corkscrew could contribute force or leverage. As both screw and arm contribute to the properties that define realizations of *corkscrew*, both screw and arm could qualify as realizers of *corkscrew* under the dimensioned view. Although both screw and arm may qualify as realizers of *corkscrew* under the dimensioned view, their causal contribution to the realization of *corkscrew* would differ. Insofar as it is possible, under the dimensioned view, for realizers that differ in their causally relevant properties to take part in the same realization, it would not be the case that realizers that differ in their causally relevant properties must produce realizations of different kinds.

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Original formulations of the realization thesis conceived of realization in terms of a one-to-one relation between realizer and realization. The idea was that individuals would realize a kind in virtue of possessing the causal properties that were appropriate to realizations of that kind. Carl Gillett has challenged this view of realization by noting that, in the sciences, it is often the case that the properties and powers of some kind are best explained in terms of the kind's components. If the causal relation between a realization and its components can be a realization relation, we will have to allow that individuals are sometimes realized by their components.

Chapter 4. Dimensioned Realization

Understanding the relation between a realization and its components to constitute a realization relation will mean dispensing with two principles that govern the standard or 'flat' view of realization. Firstly, the principle of individualism requires the individual in which realized properties inhere to be the same individual in which realizing properties inhere. If the components of an individual sometimes qualify as its realizers, however, realized properties will be properties of the individual that qualifies as a realization, while realizing properties will be properties of the components of that realization. Secondly, the principle of causal powers asserts that the causal powers of realizers will closely resemble the causal powers of the realizations. If the components of a realization produce the causal powers of that realization collectively, however, no realizer will have causal powers that resemble that of the resulting collectivity.

One of the chief virtues of adopting the dimensioned approach is that it expands the empirical reach of our account of realization by accommodating cases of scientific composition. If the properties of diamond are realized by the properties of a population of carbon atoms, we should allow that the principles of individualism and causal powers do not represent legitimate constraints on realization. Adopting the dimensioned approach to realization also undermines the second horn of Shapiro's dilemma for standard accounts of multiple realization. That horn asserts that realizing kinds that differ in their causally relevant properties will realize different kinds. If the components of a single realization can qualify as realizers while being diverse in their causal properties, however, it cannot be the case that a difference in the causal properties of realizing kinds always makes for a difference in kind.

Whether the flat account of realization can be interpreted in such a way that it also accounts for the realization of compositional kinds is the subject of chapter 5.

Chapter 5 Top

A Problem for Flat Realization

The carbon/diamond example and similar compositional examples would appear to leave the advocate of flat realization at an explanatory disadvantage. Unless there is a way of explaining compositional cases in a way that is consistent with principles (PI) and (PC), the flat account may have to concede to Gillett's charge that it fails to generalize over all apparent cases of realization.

The following chapter evaluates whether the flat view can respond to this descriptive challenge by interpreting compositional kinds in a way that is consistent with the principles of flat realization. One way this could happen is for the flat view to interpret realizing properties as single, complex properties that hold over and across many smaller members of a population. If this were the case, a single realizing individual under the flat view might possess the same causal properties as would be possessed by many realizing individuals under the dimensioned metaphysics. This move would permit flat realization to describe cases of scientific composition as cases of realization without giving up the idea that realizing and realized properties must be properties of the same individual.

5.1 Plurality and the 'COMBO' Response Top

Diamonds possess the property of hardness. If we ask a chemist why diamonds possess this property, they are apt to say that the property of hardness, like the rest of the diamond's properties, originates in the bonding and alignment properties of carbon atoms. From the perspective of the chemist, the properties of a kind are explained in terms of the properties of the individuals that compose that kind. It would appear that a scientifically-informed description of the realization of diamond, then, should identify the properties of diamond with its many realizing carbon atoms.

Chapter 5. A Problem for Flat Realization

Understanding the properties of the diamond to be realized by the properties of many carbon atoms presents a problem for flat realization, however. As the property of hardness is possessed by the diamond while the property that realizes that hardness is possessed by some carbon atom, understanding hardness to be realized by many carbon atoms will violate the principle of individualism (PI). As the realized power of hardness also differs from the power of some carbon atom to maintain the bonding and alignment of its fellow carbon atoms, understanding hardness to be realized by many carbon atoms will also violate the principle of causal powers (PC). If the flat view is committed to the idea that principles (PI) and (PC) apply to all cases of realization, the flat view may be unable to describe cases of scientific composition as cases of realization.

One way for the flat view to avoid this problem is to re-conceive what we take to be realizing properties in compositional cases. In the carbon/diamond example, the dimensioned view understands realizing properties to be those properties of alignment and bonding individually possessed by a vast collection of carbon atoms. As these realizing properties are numerous, they only realize the hardness of diamond collectively. As an alternative, the advocate of flat realization could characterize the population of carbon atoms and their attendant properties and relations as a single, complex entity. The hardness of diamond, under this new interpretation, would be realized in virtue of this single, complex entity. A move of this sort would allow flat realization to describe cases of scientific composition as cases of realization, while maintaining the idea of a one-to-one correspondence between realizer and realization.

This single, complex realizer, which Gillett dubs ‘COMBO’, would now realize the properties of the diamond in a way that is consistent with the principles of flat realization. Diamond possesses the property of hardness, and so does COMBO. Diamond has the power to scratch any known surface, and so does COMBO. The principle of individualism is maintained, as realizing and realized properties are properties of the same individual. The principle of causal powers is also maintained, as the causal powers possessed by the diamond are causal powers possessed by COMBO. It would not be necessary, under this new interpretation, to abandon flat realization in order to account for the sorts of compositional relations exemplified by the diamond/carbon example.

5.2 Gillett's Initial Critique of 'COMBO' Top

Gillett considers the COMBO response but asserts that it does little to augment the descriptive power of flat view. The response does allow a single individual to possess both realizing and realized properties in a way consistent with flat realization. The problem is that Gillett believes the COMBO response only achieves this result by postponing, rather than addressing, the explanatory problem exemplified by compositional kinds.

The COMBO response is designed to provide the advocate of flat realization with a way of addressing the issue of plurality. The properties of diamond, in our example, come about through the contribution of many individual carbon atoms. These carbon atoms also possess properties that are different from the properties possessed by diamond. By interpreting the collective contribution of these carbon atoms in terms of a single, complex property, the COMBO response identifies the realizer of diamond with a single physical individual. This allows the advocate of flat realization to maintain the principles of individualism and causal powers by claiming that a single entity continues to possess both realizing and realized properties.

The trouble with this strategy, says Gillett, is that we are now faced with the problem as to how we should account for the realization of COMBO. Inquiring into the realizing properties of COMBO appears to reintroduce the same plurality problem COMBO was intended to solve. Every carbon atom composing COMBO, we might note, is itself composed of many entities. An individual carbon atom will be composed of six protons and six electrons, and these protons and electrons will themselves be composed of quarks and leptons. If these quarks and leptons are the entities that explain the causal properties of COMBO, then these entities should qualify as the realizers of COMBO.

The original problem confronting flat realization now recurs in a different form: Rather than reconciling the realization of a diamond with the many carbon atoms which are the diamond's realizers, flat realization is faced with the analogous problem of reconciling the realization of COMBO with the many quarks and leptons which are COMBO's realizers. This reconciliation is again complicated by the qualitative and quantitative differences that exist

between realizing and realized properties. Such differences reintroduce the challenge to the validity of the principles of individualism and the causal powers.

Describing the realization of COMBO challenges the principle of individualism because realizing and realized properties are again properties of different individuals. In our example, COMBO possesses the property of hardness. Yet the properties that causally explain that hardness are the properties of charge and spin possessed by some quark or lepton. If the properties of charge and spin possessed by quarks and leptons realize the property of hardness possessed by COMBO, realizing and realized properties will be properties of different individuals. Realizing properties will be possessed by some quark or lepton, while realized properties will be possessed by COMBO.

The realization of COMBO also challenges the principle of causal powers because the causal powers of realization and realizers will differ. According to the example, COMBO possesses the power to scratch any known surface. As quarks and leptons only produce the powers of COMBO collectively, some individual quark or lepton will possess no such power. Instead, some quark or lepton has the power of exerting electromagnetic force over its neighboring particles. As the power of exerting an electromagnetic force is not equivalent to the power of scratching any known surface, the causal powers of realizers and realization in the COMBO case will differ.

In light of these considerations, Gillett does not believe the adoption of a COMBO-style interpretation of compositional kinds offers much value for flat realization. The COMBO strategy was intended to nullify the explanatory advantage of the dimensioned view by interpreting the realization of compositional kinds in a way that was consistent with flat realization's idea of a one-to-one relationship between realization and realizer. The problem is that hypothesizing the existence of COMBO implies a level of description at which the properties and powers of COMBO are themselves explained, and this level of description seems to be one at which the qualitative and quantitative disparity between realization and realizers will reappear.

5.3 Shapiro's Reply

Top

Shapiro notes the problem posed by the COMBO strategy, but does not offer a direct response to it.[31] Instead, he asserts that the level of detail implied by the COMBO response presents substantive philosophical problems for both flat and dimensioned views. For flat realization, that problem is the problem of reconciling the causal contribution of many tiny particles with a single realization. The problem for dimensioned realization, however, is explaining how multiple realization may still occur when the nature of fundamental particles seems to entail that everything is ultimately realized in the same way.

As noted, the point of introducing the COMBO response is to demonstrate flat realization's inability to effectively deal with cases of apparent realization that go beyond the numerical and causal equivalence of realizer and realization. Although the advocate of flat realization may initially deal with compositional types by interpreting the contribution of many realizers in terms of a single, complex structural property called COMBO, this move may be little more than a temporary solution. A critic of flat realization may simply ask after the entities that then realize COMBO. Asking after the realization of COMBO presents a fresh challenge to the principles of individualism and causal powers by reintroducing the plurality worry facing flat realization. As the entities that realize COMBO are presumably a collection of fundamental particles such as quarks and leptons, flat realization will be unable to escape the problem of reconciling many causally contributing realizers with a single realization.

Shapiro believes, however, that introducing this fundamental level of description is a strategic error on the part of dimensioned realization. It is an error because recognition of this basic level cuts against the possibility of multiple realization. According to contemporary physics, quarks, leptons, and similar particles are the basic building blocks of matter. As such; any individual could be described as realized, in the most basic sense, by some combination of these particles. The problem is that the matter at this level of description demonstrates a high degree of uniformity. There are but a few elementary particles, each of which possesses only a few basic properties. By Shapiro's lights, this commits dimensioned realization to the claim that everything is realized univocally:

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[31] Shapiro 2004, p. 43.

> "Gillett's criticism of the COMBO defense depends on the fact that realizers are themselves always realized ultimately by a handful of basic properties—properties that belong to individuals that differ from those in possession of the realized properties. But if this is so, Gillett is committed to the claim that, ultimately, every property is realized in the same way. Talk of multiple realizability, on the dimensioned account, vanishes, for, it turns out, the same properties that realize, say, a digital watch also realize an analog watch (as well as everything else under—and over—the sun)."[32]

For this reason, Shapiro believes that raising the COMBO objection may prove equally damaging to flat and dimensioned view of realization. For the flat view, introducing the COMBO objection and the causal properties of basic particles makes it difficult to understand why kinds and their realizers should be qualitatively and quantitatively alike in their powers and properties. For dimensioned realization, introducing the COMBO objection and the causal properties of basic particles suggests the ultimate univocality of every case of realization. As a result, Shapiro recommends we set the COMBO objection to one side. If the COMBO objection provides no help in deciding between flat and dimensioned views, there is nothing to be gained, by Shapiro's lights, from exploring the COMBO objection.

5.4 Univocal Realization and Kinds

Top

Shapiro's belief that a focus on fundamental particles negates the possibility of multiple realization appears to ignore one of the central claims of the dimensioned view. That claim concerns exactly what may count as a realizer for the purposes of dimensioned realization. According to Gillett's explicit assertion, both properties and relations may qualify as realizers under the dimensioned view.[33] Although Shapiro acknowledges this assertion, the objection he offers to the COMBO response appears to disregard the potential role of relational properties within the dimensioned metaphysics.

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[32] *Ibid*, p. 44.

[33] See Gillett 2002, pp. 318-322. The same point is reiterated in Gillett 2003, pp. 594-602.

Chapter 5. A Problem for Flat Realization

Shapiro's reply to COMBO claims that when one conceives of realizers as elementary physical particles, one is committed to the claim that everything is realized in the same way. It is true, of course, that the level of description at which COMBO operates exhibits uniformity. Modern physics only posits a handful of fundamental particles, each of which possesses only a handful of basic properties. The crucial factor in determining what realizations these particles form, however, will be their relational properties. As a consequence, the supposition that every realization is ultimately composed of similar entities need not lead to the conclusion that accepting the level of detail implied by COMBO means accepting that everything is ultimately realized in the same way.

The importance of relational properties to realization can be illustrated by examining the way in which the arrangement of uniform individuals may result in realizations of different kinds. Suppose we have a collection of lego bricks and use these bricks to build a small working excavator. It would appear that, under the dimensioned account of realization, the excavator is realized by the lego bricks. Although excavator and lego bricks are not equivalent in their properties and powers, such a difference is permissible under the dimensioned view. The excavator may have the power of digging in soft sand, for example, while some lego brick may have the power of maintaining the alignment of its neighboring bricks. This case qualifies as an example of realization, according to the dimensioned view, because we have a very clear idea of how the properties and relations of the lego bricks result in the properties of the excavator.

If one wished, one could disassemble the excavator and use the very same bricks to build a crane. It would then appear that, under the dimensioned account of realization, the properties and relations of our collection of lego bricks now realize a crane. The crane and excavator will clearly qualify as realizations of different kinds. After all, excavators and cranes operate in accordance with different mechanical principles and differ radically with respect to their properties and powers. The excavator, for example, possesses a bucket. This bucket confers upon the excavator the ability to dig. The crane, on the other hand, possesses a hook that confers upon the crane the ability to lift. How do we account for the fact that realizations of different kinds have been formed by individuals of some uniform type?

We can account for the differences between excavator and crane by drawing attention to the different ways in which the lego bricks have been arranged. If we understand the formation

of the excavator and crane as instances of realization, we explain the difference in kind by drawing attention to the extrinsic properties of our realizing individuals. The realizing individuals, in this case, will be our collection of lego bricks. It is the arrangement of these bricks that explains why, in the first case, they form an excavator and why, in the second case, they form a crane. As the arrangement of some lego brick within a collection of other bricks will be an extrinsic property of that brick, the formation of an excavator or crane by the same collection of lego bricks will be explained by drawing attention to the extrinsic properties of its realizing individuals.

Shapiro's criticism of the COMBO response seems to ignore the crucial significance of extrinsic properties to some forms of realization. That criticism charges that, by raising the issue of realization by elementary particular, the dimensioned view is committed to the claim that everything is realized in the same way. If we allow that the extrinsic properties of realizers may be essential to the identity of the realization formed, however, it is difficult to see the how the dimensioned view could be committed to this claim.

Taking these extrinsic properties into account will mean that realizations of different kinds may not be 'realized in the same way' even where those realizations are composed of identical physical entities. In our example, the realization of a crane and the realization of an excavator are not realized in the same way because the extrinsic properties of lego bricks are essential to the identity of the realization that results. In the same way, two physical individuals composed of similar elementary particles may not be realized in the same way if the extrinsic properties of those particles are essential to the identity of the realization that results.

An illustration of the way in which the extrinsic properties of lego bricks figure into the realization of toy cranes and excavators may not be particularly convincing to advocates of flat realization. As noted in Chapter 2, Shapiro's account esteems the sort of inter-level causal symmetry that is more characteristic of scientific kinds. Water, for example, is a kind that is agreeable to the flat account of realization because the molar properties of water are typically associated with the collective effects of a uniform population of H_2O molecules. As noted in Chapter 3, however, the realizing properties of water may not be as uniform as one might expect. Samples of water which are commonly believed to be composed of uniform molecules of H_2O

are instead composed of isomers with divergent causal properties. Rather than uniformity, the molar-level properties of water reflect the heterogeneity of water's realizing kinds.

Even where realizing kinds are highly uniform, uniformity in realization is not guaranteed. Again, this is due to the fact that the extrinsic properties of realizers are sometimes essential to the identity of the realization formed. In our example, this was illustrated by showing how the extrinsic properties of lego bricks were essential to the realization of either excavator or crane. The importance of extrinsic properties to realization, however, can also be illustrated with the realization of scientific kinds.

Diamond, for example, should qualify as a valid kind by the standards of flat realization, as diamond has stable properties and is defined by the possession of a certain molecular structure.[34] In a previous example, we noted that diamonds are formed when a population of carbon atoms assumes a particular lattice-like arrangement. Each carbon atom within a diamond is also highly uniform, as each carbon atom possesses a nucleus of six protons and four neutrons surrounded by six orbiting electrons. As diamond is wholly composed of such atoms, diamond has a strong claim to being a scientific kind realized entirely by individuals of a uniform type.

The carbon atoms that realize diamond, however, could realize an entirely different scientific kind if their extrinsic properties are altered. In addition to being the sole component of diamond, carbon is also the sole component of other kinds with properties much different from those of diamond. These related kinds, known as carbon allotropes, possess the same chemical composition but differ in their structural properties. Diamond lies at one of the scale of carbon allotropy. Diamond is a very hard carbon allotrope that possesses the properties of being an electrical insulator and thermal conductor. At the other end of the scale, however, we find the carbon allotrope graphite. Graphite differs from diamond in that it is a very soft carbon allotrope and possesses the properties of being an electrical conductor and thermal insulator.

Although both diamond and graphite are wholly composed of carbon atoms, the properties and powers of diamond are not the properties and powers of graphite. Graphite has the power to moderate nuclear chain reactions, while diamond does not. Diamond possesses the property of hardness, while graphite does not. In terms of their molar-level properties and

[34] Shapiro 2000, p. 643.

powers, then, diamond and graphite qualify as realizations of different kinds. Yet the differences between diamond and graphite cannot be explained by a difference in their realizing individuals, as both diamond and graphite are wholly realized by carbon atoms.

Instead, the difference between diamond and graphite is explained by the extrinsic properties of their realizing individuals. The carbon atoms within diamond are covalently bonded into a dense tetrahedral honeycomb. As a result, diamond resists distortion from any angle. The carbon atoms within graphite, however, are layered into sheets with no covalent connection. As these sheets are relatively distant from one another, they are prone to slide apart. The arrangement of carbon atoms, in other words, produces different properties. The kinds that embody these arrangements, as a result, are kinds that possess different properties. Even though diamond and graphite are wholly composed of uniform carbon atoms, we should not say that diamond and graphite are not realized in the same way.

Drawing attention to the extrinsic properties of realizers disputes Shapiro's interpretation of the consequences for dimensioned realization when raising the issue of basic particles. Shapiro's view was that, in raising the prospect of realization by basic particles, the dimensioned view would be committed to the claim that everything is ultimately realized in the same way. This claim is undermined by drawing attention to the realization of some scientific kinds. The composition of diamond and graphite by uniform atoms of carbon, for example, does not mean that diamond and graphite are realized in the same way. On the contrary, it is the relational properties that hold between carbon atoms that forms the crucial factor in determining the realization that results. Uniformity in some realizing kind, in other words, does not preclude diversity in realization.

Shapiro's disposition against the possibility of multiple realization in the COMBO case may originate in flat realization's implicit assumption that realizing properties will be properties that are intrinsic to some realizer. We saw in chapter 2 how this implicit assumption seemed to lead to the conclusion that functional kinds, which are unified by their extrinsic properties, would not constitute valid kinds. The result was the dilemma, as Shapiro claimed that realizing kinds that differed in their causally relevant properties would constitute realizations of different kinds.

This assumption of the importance of intrinsic properties may derive from flat realization's commitment to the principle of individualism. With the principle of individualism, realizing and realized properties must be properties of the same individual. In order for some individual to qualify as a realizer of *winged corkscrew*, for example, that individual must itself possess the properties appropriate to realizations of *winged corkscrew*. If realizations of *winged corkscrew* must possess two levers and a pinion gear, the principle of individualism will require every realizer of *winged corkscrew* to possess two levers and a pinion gear. As long as the principle of individualism governs cases of realization, whatever constitutes a realizing property will tend to be a property that is intrinsically possessed by realizers of that kind.

As the relational properties between two components of the same realization do not register under the principle of individualism, the flat view will dispute their status as realizing properties. In consequence, the flat view will tend to overlook the possibility that the extrinsic properties of realizers can constitute realizing properties. If realizations are sometimes composed of realizers, however, and some realizations owe their identity to the arrangement of these components, the expectation that realizing properties are always properties intrinsic to realizers will be mistaken.

5.5 'COMBO' Redux

Top

Shapiro declines to directly engage Gillett's argument in the COMBO case, preferring instead to rely on the charge that the level of detail implied by COMBO presents problems for both flat and dimensioned realization. There is a way of employing the COMBO strategy, however, that circumvents Gillett's initial critique. With the COMBO response, the realizing properties of diamond are identified with a complex property that represents the collective causal contribution of a population of carbon atoms. Understanding realizing properties in this way allows the COMBO response to restore the one-to-one relation between a realization and its realizer in a way that is consistent with the principles of flat realization. Gillett's response to COMBO draws our attention to a further level of detail, that of quarks and leptons, which presumably become necessary in order to explain the realization of COMBO. The idea is that once we acknowledge

that COMBO is itself realized from entities that differ quantitatively and qualitatively from COMBO, we reintroduce the plurality worry with which flat realization is unable to cope.

As Gillett's strategy for overcoming the COMBO defense involves a modification and reintroduction of the plurality worry, it is presumably open to flat realization to respond to Gillett's move with a modification and reintroduction of its defense against the plurality worry. If COMBO stands for a single, multifaceted property that reflects the individual causal contributions of a collection of carbon atoms, another physical property, call it '$COMBO_2$', could stand for a single, multifaceted property that reflects the individual causal contributions of a collection of quarks and leptons. When Gillett enquires after the realizer for COMBO, flat realization could respond that the realizer of COMBO is simply the single, multifaceted property embodied by $COMBO_2$. $COMBO_2$ may be understood to realize the properties of COMBO, then, in much the same way as COMBO may be understood to realize the properties of diamond.

In proposing the realization of COMBO by $COMBO_2$, the advocate of flat realization again addresses the plurality worry by offering a reconception of realizing properties. The realizing properties for COMBO, in this case, are understood to be represented in the single, structured property called $COMBO_2$. As the realizing properties of $COMBO_2$ and the realized properties of COMBO are properties of the same entity, the principle of individualism is maintained. As every power possessed by COMBO is also possessed by $COMBO_2$, the principle of causal powers is also maintained. Supposing that COMBO is realized by $COMBO_2$ would then allow flat realization to claim that it is unnecessary to move to a dimensioned view in order to account for the class of compositional kinds. Instead, the realization of compositional kinds would be fully explained within the compass of flat realization.

The proposed move on the part of flat realization to reconceive realizers in a way that avoids the descriptive difficulty posed by compositional examples is like to prove unattractive to advocates of the flat view, however. The move will be unattractive because it requires flat realization to reject the generality that distinguishes flat realization from its dimensioned alternative. Supposing that there are complex, multifaceted physical properties such as COMBO and $COMBO_2$ does allow the advocate of flat realization to claim that a single entity possesses realizing and realized properties. With this claim in place, the COMBO response is able to describe the realization of compositional kinds in a way that is consistent with the principles of

individualism and causal powers. In addressing the compositional worry via the COMBO response, however, the flat view abandons its unique understanding of the level at which the properties of a realization are properly assessed.

According to Shapiro, the flat view defines realization in terms of the realizing, or R-properties, that causally contribute to the performance of some function. Identifying these properties begins by examining a system in order to isolate the particular function one is interested in. Once this function is determined, the system is subjected to a functional decomposition in order to determine the subsystems that figure into the performance of that function. These causally contributing subsystems will qualify as the realizing properties for that kind.

Crucially, Shapiro's explanation of this process suggests that the properties that are causally relevant to realization will be assessed in a fairly general way. The analysis of steel and aluminum realizations of *corkscrew* is instructive in this regard. In that analysis, a question is posed as to whether two corkscrews that differ with respect to their constitution amount to different realizations of the kind *corkscrew*. Shapiro believes that they will not, as two corkscrews that differ with respect to constitution may be similar from the standpoint of rigidity. Rigidity, in other words, screens off any difference between steel and aluminum realizations of *corkscrew*.

The conclusion to be drawn from the example is that flat realization will not consider a level of detail that picks out the composition of some corkscrew to be a level of detail that is relevant to the realization of *corkscrew*. Composition is irrelevant to corkscrews because flat realization assesses relevance from the standpoint of the capacity that defines a functional kind. Corkscrews must be rigid in order to remove corks, so rigidity is relevant to the realization of corkscrews. Corkscrews need not be made of steel in order to remove corks, so composition is not directly relevant to the realization of corkscrews. So long as the composition of a corkscrew meets the relevant rigidity requirement, flat realization deems the precise nature of that composition immaterial.

If the advocate of flat realization were to endorse the COMBO response, this endorsement would be at odds with flat realization's emphasis on such general levels of

functional description. With COMBO, it is the collective properties of carbon atoms that become relevant to the realization of hardness in the diamond. With $COMBO_2$, it is the collective properties of quarks and leptons that become relevant to the realization of hardness in the diamond. The level of detail described in COMBO and $COMBO_2$ may be consistent with dimensioned realization's emphasis on the properties that result in realizations of a certain kind, as the properties of carbon atoms, quarks, and leptons certainly do result in the properties of diamond.

The same level of detail will be antithetical to flat realization, however, as the level of detail at which quarks are described is not the level at which one kind is typically distinguished from another. The flat account identifies the properties that are relevant to realization by identifying the properties that affect the ability of an individual to qualify as a realization of a particular kind. If the composition of a corkscrew does not affect that individual's ability to remove corks, the composition of a corkscrew should be irrelevant to the realization of *corkscrew*.[35] As minor differences in the properties of some quark or carbon atom are unlikely to affect the molar-level properties that define realizations of *diamond*, the flat account is unlikely to hold that the idiosyncratic properties of some quark or carbon atom is relevant to realizations of *diamond*. After all, if the flat account declines to consider the distinct contributions of steel or aluminum relevant to the realization of *corkscrew*, it should be even less apt to consider a level of greater detail relevant to the realization of *diamond*.

For this reason, it is doubtful that anyone committed to the flat view will be interested in availing themselves of the COMBO response. Once one acquiesces to the idea that diamond is realized by a complex, multifaceted property such as COMBO, one tacitly accepts dimensioned realization's contention that realizations may be assessed in fairly detailed terms.

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The qualitative and quantitative disparity between the properties of scientific kinds and the properties of the entities that appear to realize those kinds leaves the advocate of flat realization

[35] Shapiro's pronouncement is that "..judgments of sameness and difference between realizations might be relativized to those properties that make a difference to how a functional kind functions." Shapiro 2004, p. 52.

at an explanatory disadvantage. One potential way for flat realization to address compositional relations while maintaining the principles of individualism and causal powers is to understand the causal contributions of many individual entities in terms of a single, structured realizing property on the model of COMBO. This move would allow the flat view to describe cases of scientific composition while maintaining the idea of a one-to-one relation between a realization and its realizer.

Gillett suggests a move of this sort provides no substantive fix for flat realization, however, as one may reintroduce the plurality problem by simply asking after the entities which then realize COMBO. As these entities are likely to be a vast collection of fundamental particles, the plurality problem for flat realization recurs. Shapiro's position is that any explanatory strategy that invokes realization by fundamental particles presents a problem for both theories of realization. Although the idea of such particles as COMBO's realizers causes the plurality problem facing flat realization to recur, realization by fundamental particles also jeopardizes dimensioned realization's commitment to multiple realization. Multiple realization is jeopardized, according to Shapiro, because the uniformity of fundamental particles threatens to make every realization appear as if it is realized in the same way.

Shapiro's argument against the dimensioned view is not effective, however, as a consideration of the extrinsic properties of realizers entails that even realizations composed of identical physical entities need not be realizations that are realized in the same way. In any case, the employment of a COMBO-style response is unlikely to present an attractive option for adherents of flat realization. Flat realization understands realizing properties to be those properties that directly determine what it is for an individual to qualify as a realization of a certain kind. As the COMBO response invokes a level of description much more detailed than this, the COMBO response will be unappealing to advocates of flat realization. If flat realization fails to employ the COMBO response, however, flat realization will also fail to persuasively address the realization of compositional kinds.

Although this explanatory issue provides further reason to abandon the flat view of realization, dimensioned realization's approach to describing compositional kinds also gives rise to a problem. It is that problem to which we turn in chapter 6.

Chapter 6 Top

A Problem for Dimensioned Realization

Dimensioned realization avoids the explanatory problem faced by the flat view because the dimensioned view has a different understanding of the properties that are causally relevant to realization. As the dimensioned view does not require causal equivalence between a realization and its realizers, the components of a realization may sometimes qualify as its realizers. Allowing the relation between a realization and its components to count as a realization relation restores the possibility of multiple realization by denying the second horn of Shapiro's dilemma. After all, it the components of a realization may sometimes constitute its realizers, we should not expect realizing kinds that differ in their causally relevant properties to always qualify as realizations of different kinds.

Allowing the components of a realization to serve as its realizers is achieved by denying that the principles of individualism and causal powers will govern all cases of realization. Rejecting the two principles, however, also presents the dimensioned view with a potential problem. Under the flat view, the two principles serve to demarcate what is able to qualify as a realizer for the purposes of realization. The dimensioned view's rejection of the principles, then, also serves as a rejection of the flat view's limitations on the nature of realizers. Where a great many individuals are allowed to count as realizers, however, a great many factors will have the potential to produce a difference in realization. This, in turn, raises the possibility that accepting the dimensioned view will lead to very trivial instances of multiple realization.

The problem occurs as follows: If we allow that realizations can be composed of their realizers, a change in the composition of some realization will suggest a corresponding change in realization. Two realizations that differ in composition, then, will also appear to differ with respect to realization. As the composition of every individual will tend to differ, to some degree, from the composition of very other individual, every physical individual begins to resemble a unique realization. If every physical individual qualifies as a unique realization, of course, every type will be multiply realized in principle and the thesis of multiple realization will be trivially true.

Chapter 6. A Problem for Dimensioned Realization

In this chapter I assess how dimensioned realization fares against the charge that it leads to trivial forms of multiple realization. I evaluate Gillett's response to this worry, and demonstrate how the example of univocal realization offered in that response fails to provide an adequate defense against the triviality worry.

6.1 The Triviality Issue

Top

Trivial accounts of realization are typically characterized by a failure to acknowledge that not all of an individual's properties will be significant from the standpoint of realization. Kinds, after all, are defined by the possession of a particular set of properties. For an individual to realize a kind is for an individual to possess the particular set of properties that defines members of that kind. For two individuals to differ with respect to some kind, then, is for two individuals to differ only in terms of the properties that are relevant to that kind. For this reason, any properties an individual possesses beyond those that qualify it as a member of a certain kind should be understood as inert with respect to the realization of that kind. Therefore, two individuals that differ with respect to some or even many of their properties need not differ with respect to their realization of some kind.

Associating a difference in realization with a difference in kind-relevant properties is necessary in order to avoid trivializing the concept of realization. If any difference between two individuals counts as a difference at the level of realization, differences in realization will be as ubiquitous as differences between individuals. When every kind is constituted by as many realizations as it is individuals, every kind is multiply realizable in principle and the thesis of multiple realization loses much of its significance.

The idea that two individuals can differ without differing with respect to their realization of some kind is intuitively plausible. Shapiro illustrated this plausibility with the example of two corkscrews, identical in all respects save that of color. In that example, Shapiro argued persuasively that two corkscrews that differ only in color should qualify as identical realizations of the kind *corkscrew*. The two corkscrews qualify as the same realization because the property in which they differ; that of color, is inert with respect to removing corks. If color makes no difference to the function of removing corks, two corkscrews that differ only with respect to

color will be the same in terms of their corkscrew-related properties. Corkscrews that differ in color will constitute different corkscrews, but they will not constitute different ways of being a corkscrew.

The flat account effectively resists trivial forms of realization by means of the principles of individualism and causal powers. With the principle of individualism, one property may only realize another where both properties are properties of the same individual. The principle of causal powers augments this restriction on realization by stipulating that one property may only realize another when the causal powers of realizing and realized properties match. The two principles serve as a curb on permissive realization by fixing our attention on the way an individual realizer instantiates the properties of a kind, and assessing the relevance of differences in terms of their effects at this level. Properties that have little or no effect on an individual's ability to qualify as a token of a certain kind will have little or no relevance with respect to realization.

The effectiveness of the principles in limiting differences in realization can be illustrated by considering flat realization's perspective on the relationship between an aluminum atom and the corkscrew that atom may partly compose. According to the principle of individualism, the properties of some aluminum atom should be considered irrelevant to realization because the properties of some aluminum atom and the properties of some corkscrew are properties of different individuals. According to the principle of causal powers, the properties of some aluminum atom should be considered irrelevant to realization because the causal powers of an aluminum atom and the powers of the corkscrew will differ. The influence of a single atom on realization, by this standard, becomes contingent on its ability to affect the properties that define realizations of *corkscrew*.

The principles of individualism and causal powers strongly imply that realizers and realizations will share a common causal mereology. This means that an individual will only tend to qualify as a realizer of some kind, under the flat view, when an individual reflects the causal structure that is appropriate for that kind. If a difference within some realizer fails to make for a difference in terms of this macroscopic causal structure, flat realization is apt to consider that difference irrelevant to realization. If a difference in the properties of a single atom within some realizer are unlikely to affect whether or not that realizer instantiates the causal structure of

corkscrew, a difference in the properties of single atom will be irrelevant to the realization of *corkscrew*.

Taken together, the principles of individualism and causal powers reflect a very literal understanding of what it is for a realizer to 'play the causal role' in the realization of some kind. A realizing property plays a causal role by being an 'instance of' a realized property. If we are assessing potential realizers of *corkscrew*, this will amount to determining whether or not an individual wholly fulfills the specification for *corkscrew*. If they do, that individual qualifies as a realizer of *corkscrew*. As assessing the properties of that same individual at a greater level of detail will not change whether or not the relevant requirement is met, the level of description appropriate to flat realization becomes fixed to the level of realization.

Although the dimensioned view endorses some cases of realization that are consistent with the principles of individualism and causal powers, dimensioned realization also asserts that cases of realization may contravene one or both principles. Allowing that some cases of realization will fail to adhere to one or both principles considerably expands the number of relations that may qualify as realization relations. It is sometimes the case, according to the dimensioned view, that realizing and realized properties are properties of different individuals. The alignment and bonding properties of carbon atoms realize the property of hardness in diamond, even though the properties of alignment and bonding are possessed by some carbon atom while the property of hardness is possessed by the diamond. The dimensioned view also asserts that it is sometimes the case that realizing and realized properties differ in their causal powers. Carbon atoms realize diamond, in the same example, even though some carbon atom possesses the power to maintain the alignment of its neighboring carbon atoms, while the diamond possesses the power to scratch any known surface.

When dimensioned realization rejects the principles of individualism and causal powers, it also abandons the idea of a mereological parallel between the causal properties of a realization and its realizers. Individual realizers, in other words, needn't reflect the causal structure of the kinds they realize. This is because, under the dimensioned view, realizers are identified not by their causal equivalence to some realization but rather by their causal contribution to that realization. With this difference, however, it would appear that many tiny causal forces become

significant to realization. As long as an individual has some sort of causal effect on the ensuing realization, that individual has the potential to qualify as a realizer.

6.2 A Relevance Criterion

Top

An important question, then, is whether or not the dimensioned account can avoid taking every difference between individuals to entail a difference at the level of realization. Gillett's strategy to address the permissiveness worry involves implementing what he calls a 'relevance criterion'. The criterion describes the circumstances under which we may consider two realizations to be the same or different, and does so in a manner compatible with the dimensioned view. The criterion encapsulates the idea that realizations should be individuated in terms of their causal properties:

> (RC) Instances T_1, instantiated in s_1, and T_2, instantiated in s_2, are distinct realizations of a property T only if there is a difference between the properties/relations whose contributions of powers are those in virtue of which s_1 and s_2 have the powers individuative of T.

With this exposition, Gillett considers the realization of a property (T) possessed by two individuals (s_1 and s_1). The claim is that two realizations of that property (T_1 and T_2) should rightfully be considered different realizations of T where there is a difference in the causal properties through which T originates.

The relevance criterion directs our attention to the way in which the causal properties that define a particular realization come about. Suppose we again have a pair of Shapiro's corkscrews. The corkscrews appear identical, aside from the fact that the first is made of steel and the second is made of aluminum. Although compositionally different, the corkscrews are alike with respect to the property of rigidity. Rigidity is causally relevant to realization, in this case, because corkscrews must be rigid in order to remove corks. Gillett's relevance criterion asks that we determine the properties and relations which are causally responsible for rigidity in each corkscrew. For the first corkscrew, we may suppose that rigidity comes about though the collective properties/relations of a population of steel molecules. For the second corkscrew, we

may suppose that rigidity comes about through the collective properties/relations of a population of aluminum atoms.

According to the relevance criterion, we must now ascertain if there a difference between the way in which the properties/relations of steel molecules achieve rigidity and the way in which the properties/relations of aluminum atoms achieve rigidity. Even at somewhat superficial levels of analysis, there does appear to be a significant difference. Steel is a composite material formed when alloys such as carbon are added to iron. As iron atoms tend to form very strong bonds with carbon atoms, a particular quantity of steel is apt to be much more rigid that an equivalent quantity of aluminum. Engineers tend to measure this rigidity according to a parameter called the 'modulus of elasticity'. On average, the modulus of elasticity for steel will be about three times that of aluminum. This means that about three times as much aluminum will be necessary in order to achieve an equivalent rigidity to that of steel. For this reason, an aluminum corkscrew that is actually equal in rigidity to a steel corkscrew is apt to be noticeably larger than its steel counterpart.

If the dimensioned view allows steel and aluminum corkscrews to qualify as different realizations of *corkscrew* based on the fact that steel and aluminum contribute differentially towards the realization of rigidity, the danger of dimensioned realization condoning an overly permissive form of multiple realization begins to look credible. Although the relevance criterion proposes that we should only differentiate realizations where we can discern a difference in the causal properties that produce those realizations, differences of this sort are ubiquitous. In the case of steel and aluminum corkscrews, for instance, the way in which the properties/relations of steel molecules produce rigidity is different than the way in which the property/relations of aluminum atoms produce rigidity. So long as this difference is apparent, the relevance criterion directs us to conclude that steel and aluminum corkscrews will constitute different realizations of *corkscrew*.

The idea that dimensioned realization will judge steel and aluminum corkscrews to be different realizations of *corkscrew* appears consistent with Gillett's own analysis of the case. Gillett notes that the properties/relations of the constituents of the two corkscrews can only be

deemed irrelevant to realization if one assumes the perspective of flat realization.[36] When the principles of individualism and causal powers govern an assessment of realization, the level of description relevant to realization would be the level at which the properties that define *corkscrew* are described. If corkscrews must be rigid in order to qualify as corkscrews, flat realization will be interested in how specific individuals either instantiate or fail to instantiate that rigidity, and thereby succeed or fail in realizing the kind *corkscrew*.

Abandoning the principles of individualism and causal powers, by the same token, removes the expectation that realizers will be assessed at the same level of description at which the properties of the ensuing realization are described. In the absence of this default descriptive level, there is nothing to prevent dimensioned realization from differentiating between the way in which the properties/relations of steel molecules achieve rigidity and the way in which the properties/relations of aluminum atoms achieve rigidity. From the point of view of the relevance criterion, two corkscrews that differ only in composition should indeed qualify as different realizations of *corkscrew*.

In this example, the standard of differentiation set by the relevance criterion is easily met because the individuals that causally contribute to rigidity can be differentiated at relatively low levels of detail. If aluminum requires three times of mass of steel in order to achieve the same modulus of elasticity, there will be an obvious difference in size between steel and aluminum artifacts of similar rigidity. More problematic for the dimensioned view is the idea that much smaller entities than steel molecules and aluminum atoms could also contribute differentially to the realization of rigidity. Two examples of the same aluminum corkscrew, for example, could be differentiated according to the relevance criterion if one discovered that the subatomic components of those corkscrews contributed differentially towards the realization of rigidity. For any numerically distinct realizations of *corkscrew*, in fact, there will be some level of detail at which the causal contribution of the entities composing those realizations will differ. Such a tiny difference in causal properties may not cause two corkscrews to vary with respect to their ability to remove corks, but it may cause two realizations of *corkscrew* to vary from the standpoint of dimensioned realization.

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[36] Gillett 2003, p. 597.

A significant problem for dimensioned realization, then, is how to limit the level of causal detail that is deemed relevant to realization. Although the relevance criterion is intended to specify the circumstances under which we should consider two realizations to be the same or different, there is nothing within that criterion that places any limits on the level of detail at which the causal contribution of realizers is assessed. Once these more detailed levels of causal description become relevant, realizations that differ with respect to this level of detail begin to look like different ways of realizing the causal specification for some kind. As the relevance criterion allows the claim that realizations differ wherever causal differences of this sort are identified, it would seem there must always be some level of detail at which the dimensioned view must consider realizations of some kind to qualify as different realizations of that kind.

A rigorous application of the relevance criterion, then, produces an obvious problem for dimensioned realization. The problem is that realizations of some kind may be differentiated according to the relevance criterion even in cases where our intuition tells us we are dealing with the same realization of some kind. Two corkscrews of the same make and model, for example, will be interchangeable in most everyday contexts. Two such corkscrews are certainly apt to be equivalent in their ability to remove corks. Intuitively, then, two examples of the same make and model of corkscrew will constitute the same way of being a corkscrew. This means that from the point of view of realization, two examples of the same make and model of corkscrew should qualify as the same realization of *corkscrew*. This judgment seems to conflict with the standard set by the relevance criterion, however, where it would seem that every difference between two individuals can potentially amount to a difference in realization.

6.3 The Trace Corkscrew

Top

In order to avoid the charge of triviality, the dimensioned view must demonstrate an ability to classify individuals that lack type-relevant differences as realizations of the same kind. As the micro-causal differences between two aluminum corkscrews are not significant from the standpoint of cork-removal, two aluminum corkscrews that differ in their micro-causal properties should qualify as identical from the standpoint of realization. Since the dimensioned view differs from the flat view in allowing the entities that compose a realization to serve as its

realizers, what the dimensioned view really requires is a demonstration of how two individuals can differ compositionally while remaining identical from the standpoint of realization. Such a demonstration would support the claim that dimensioned realization, like flat realization, recognizes that not every difference between two individuals will be significant from the standpoint of realization.

To this end, Gillett considers the application of the dimensioned view towards a variation of the corkscrew example. In Gillett's example, we have two aluminum corkscrews that are identical in every respect, save for the fact that one corkscrew contains a minute trace of some additional element. This trace element is such that it forms no structural bonds with the other aluminum atoms which compose the corkscrew, although it does lend the corkscrew a yellowish hue.

According to Gillett, an opponent of the dimensioned view may wrongly expect that dimensioned realization must treat trace and non-trace corkscrews as different realizations of *corkscrew*.[37] Dimensioned realization understands realization in causal terms, so determining the status of the two corkscrews involves identifying the properties that causally contribute to the removal of corks. As dimensioned realization allows the constituents of a realization to serve as its realizers, the dimensioned view would appear to be faced with two different realization relations. On the one hand, the non-trace corkscrew is made from constituents than endow the non-trace corkscrew with the power to remove corks. On the other hand, the trace corkscrew is made from different constituents that also endow the trace corkscrew with the power to remove corks. As the constituents of trace and non-trace corkscrews differ, an opponent of the dimensioned view may expect that dimensioned realization will understand the realizing properties of trace and non-trace corkscrews to differ.

If the realizing properties of the trace and non-trace corkscrews differ, of course, dimensioned realization would have to judge trace and non-trace corkscrews as different realizations of *corkscrew*. As a result, the example of trace and non-trace corkscrew would illustrate the multiple realization of *corkscrew*. This result would commit the advocate of the dimensioned to a very trivial form of multiple realization, as a trace element which lends one

[37] *Ibid*, p. 599.

corkscrew a yellow hue is not the sort of difference that is intuitively significant from the standpoint of cork removal. On the contrary, the presence of some trace element is intuitively the sort of inconsequential difference that would warrant classifying trace and non-trace corkscrew as identical realizations of *corkscrew*.

Gillett does not believe, however, that dimensioned realization is forced into the above interpretation and the trivial form of multiple realization that results. On the contrary, Gillett's construal of the trace example ends with the same sort of parsimonious conclusion as might be expected from flat realization. That conclusion is that trace and non-trace corkscrews will constitute identical realizations of the kind *corkscrew*. This conclusion is reached by emphasizing the fact that the trace element is causally inert with respect to the function that defines realizations of *corkscrew*.

Gillett agrees with Shapiro that differences between members of some functional kind should only count as differences for the purposes of realization when those differences are functionally significant with respect to the kind in question. Differences between realizations that lack functional significance, by the same token, illustrate only the univocal realization of that kind. A trace element that is causally inert with respect to cork removal, then, will also be inert with respect to the realization of *corkscrew*. What is significant with respect to the realization of *corkscrew* is the property of rigidity. In the non-trace corkscrew, this rigidity comes about through the collective contributions of a population of aluminum atoms. The dimensioned view will take the properties of aluminum atoms to be the realizing properties of the non-trace corkscrew because the capacity that defines what it is to be a corkscrew is achieved through the causal contribution of these aluminum atoms.

In the corkscrew with the trace element, however, Gillett also concludes that rigidity is achieved entirely through the causal contribution of aluminum atoms. As the trace element does not bond with any of the aluminum atoms that compose the corkscrew, the trace element will be causally inert with respect to rigidity. This means that the trace element will also be inert with respect to the function of removing corks. As a result, the presence of the trace element is not significant with respect to realization of the kind *corkscrew*.

According to Gillett, then, the properties that are relevant to cork-removal in the trace corkscrew are precisely the same properties that are relevant to cork-removal in the non-trace corkscrew. Trace and non-trace corkscrews that are identical in their realizing properties, of course, will qualify as identical realizations of *corkscrew*. If trace and non-trace corkscrews qualify as the same realization of *corkscrew*, they will not illustrate the multiple realization of *corkscrew*. If trace and non-trace corkscrew do not illustrate the multiple realization of the kind corkscrew, it would appear that Gillett would be correct in asserting that trivial differences within tokens of some type need not force the advocate of dimensioned realization to the conclusion that that type is multiply realized.

6.4 How the Flat View Escapes the Triviality Worry

Top

Although Gillett is correct in asserting that the example of trace and non-trace corkscrews should illustrate a case of univocal realization, the example fails to establish that dimensioned realization can avoid taking minor differences between tokens of some type to entail the multiple realization of that type. This is because the triviality worry is not precluded by showing how similar realizers are able to produce identical realizations of some kind, as is the case in the trace example. Instead, the triviality worry is prevented by demonstrating how a difference in realizers may still produce identical realizations of some kind. As the example of trace and non-trace corkscrews associates the same realization of *corkscrew* with equivalent sets of causally efficacious aluminum atoms, it fails to provide an effective defense against the triviality worry.

The trace example is designed to replicate the sort of move that Shapiro employs to forestall the triviality worry for flat realization. When Shapiro first presented the flat view, he argued convincingly that a minor difference in realizing individuals did not warrant the conclusion that a given kind was multiply realizable. The idea was justified by noting that not every difference between realizing individuals was apt to be type-relevant. Although steel and aluminum corkscrews are made from different materials, steel and aluminum corkscrews may be equal from the standpoint of removing corks. If steel and aluminum corkscrews are equal from the standpoint of removing corks, steel and aluminum corkscrews should count as the same

realization of *corkscrew*. A difference in the composition of two corkscrews, in Shapiro's example, fails to produce the multiple realization of *corkscrew*.

The concept of realization becomes more significant to the degree that differences in realizing individuals are associated with sameness at the level of realization. As noted, the triviality worry occurs when minor differences in realizing individuals produces differences in realization. If different individuals too easily qualify as different realizations, attributing a difference in realization becomes much the same as attributing a difference within individuals. If predicating a difference in realization is the same as predicating a difference in individuals, the notion of realization becomes largely redundant. The multiple realization thesis turns out to be trivially true, for every kind constituted by more than one individual will also be constituted by more than one realization.

If different individuals qualify as the same realization, on the other hand, the claim that something constitutes a different realization will have more significance than the mere claim that something constitutes a different individual. After all, physical individuals may be differentiated by any physical property. Where two physical individuals constitute the same realization, realizations will be differentiated by a more rigorous standard than are physical individuals. What is necessary in order to defeat the triviality worry, then, is a demonstration of how a difference in realizing individuals need not entail a difference in realization.

Shapiro's example of steel and aluminum corkscrews is effective at forestalling the triviality worry for this very reason. According to that example, steel and aluminum corkscrews may qualify as the same realization of *corkscrew* so long as steel and aluminum corkscrews are the same with respect to removing corks. Under flat realization, steel and aluminum corkscrews qualify as realizers of *corkscrew* because each corkscrew instantiates the properties that are appropriate for the kind *corkscrew*. Because they instantiate these properties in the same way, however, they also qualify as the same realization of *corkscrew*. The same realization of *corkscrew*, in other words, is correlated with realizers that differ in their physical properties. As a result, a minor difference between realizers is prevented from producing multiple realizations. The example illustrates how flat realization accepts that a difference in realizing individuals; even a substantive differences in composition, need not be significant from the standpoint of realization.

The flat view acquires the ability to classify different realizing individuals as instances of the same realization largely as a consequence of the principles of individualism and causal powers. The principle of individualism requires realizing and realized properties to be properties of the same individual. If some corkscrew must be rigid in order to function as corkscrew, every property that realizes rigidity must be a property of the same corkscrew. The principle of causal powers, on the other hand, requires realizers to exemplify the causal properties of the kinds they realize. If the power to scratch any known surface is one of the causal powers of diamond, the principle of causal powers will require every realizer of diamond to possess the power to scratch any known surface.

The two principles endow flat realization with a very literal understanding of what it is for a realizer to play the causal role in the metaphysics of realization. Realizers play a role by individually and wholly instantiating the causal properties of some realization. For something to realize the properties and powers of the kind *corkscrew* is for something to itself possess the properties and powers of *corkscrew*. Realizers of *corkscrew*, in other words, are themselves corkscrews. One should expect physical diversity in the realizers of a kind, under the flat view, in exactly the same way as one expects diversity in the kind itself.

6.5 The Problem with the Trace Example

Top

Dimensioned realization's rejection of the two principles results in a radically different understanding of what it is for a realizer to 'play the causal role' in the realization of some type. The flat view's conception of role-playing based on the idea of causal equivalence is replaced, under the dimensioned view, with a conception of role-playing based on collective causal effects. Individuals qualify as realizers not by instantiating the causal role of some realization, but merely by contributing causally towards that role. As it is unclear how effective the relevance criterion is in placing a minimum limit on this causal contribution, the dimensioned view has the potential to assess realizing properties at a much more detailed level than will flat realization.

Acknowledging minute causal contributions makes dimensioned realization more vulnerable to the triviality worry, because assessing causal properties at a detailed level may expose differences that are not obviously relevant to an individual's qualification as a member of

a certain kind. A subatomic difference in the causal properties of two corkscrews, for example, is not obviously the sort of difference that is relevant to those corkscrews' qualification as corkscrews. The intention behind the trace example is to illustrate the way in which two nominally different corkscrews may still qualify as the same realization of *corkscrew* by the lights of the dimensioned view. With such a demonstration, the dimensioned view could claim, as did the flat view, that two individuals that differ in minor respects need not entail the multiple realization of that kind.

In this respect, the trace example is not convincing. The trace example does illustrate a case of univocal realization, but the example of univocal realization presented does not constitute a defense against the triviality worry. According to dimensioned realization, individuals realize a kind by contributing causal powers to the properties that define members of that kind. In the non-trace corkscrew, the individuals realizing the properties of *corkscrew* will be a population of aluminum atoms. In the trace corkscrew, however, the situation with respect to realization is very much the same. As the trace element does not bond with any of its neighboring atoms, the trace element fails to make any causal contribution towards the properties that make the trace corkscrew a realization of *corkscrew*. The realizing properties for the trace corkscrew, then, will be identical to the realizing properties of the non-trace corkscrew. The result is a case of univocal realization, as both trace and non-trace corkscrews are realized in the same way.

Importantly, demonstrating the univocal realization of *corkscrew* by trace and non-trace corkscrews will not preclude the triviality worry. As noted at the beginning of this section, the triviality worry is forestalled by demonstrating the way in which a *difference* in realizing individuals may still result in the same realization. If there is no difference between the realizers of the non-trace corkscrew and the realizers of the trace corkscrew, there is no reason to think that a difference in realizing individuals can produce realizations that are the same.

With Shapiro's example of steel and aluminum corkscrews, there is a demonstration of how a difference in realizers can produce realizations that are the same. Although steel and aluminum corkscrews are made of different materials, the flat view does not consider this difference significant to realizations of *corkscrew*. The difference is not significant because corkscrews are defined by properties like rigidity, rather than composition. As steel and aluminum corkscrews individually qualify as realizers of *corkscrew* under the flat view, the

example does show how a difference in realizers can produce realizations that are the same. This precludes the triviality worry, as the flat view can assert that some differences among realizers are simply not significant from the standpoint of realization. A minor difference in the physical properties of realizing individuals, in other words, does not automatically produce the multiple realization of that kind.

The trace and non-trace corkscrew example fails to provide a defense against the prospect of trivial multiple realization because there is no difference in realizing individuals. A certain population of aluminum atoms realizes *corkscrew* in the non-trace corkscrew, while a nearly identical population of aluminum atoms realizes *corkscrew* in the trace corkscrew. As a result, there is no demonstration of how a difference in realizing individuals can result in realizations that are the same. Trivial multiple realization under the dimensioned view remains a possibility, as a minor difference in realizing individuals may still produce a difference at the level of realization.

6.6 Triviality and the Dimensioned View

Top

The inability of the dimensioned view to provide an effective example as to how a difference in realizing individuals may sometimes produce realizations that are the same suggests the vulnerability of that view to the triviality worry. This impression of vulnerability is reinforced when we look in greater detail at the relationship, under the dimensioned view, between realizing and realized properties. In drawing a tight causal connection between realizers and the realizations they form, the dimensioned view allows little leeway for a difference in realizing individuals to produce realizations that are the same.

Flat realization is naturally resistant to the triviality worry because flat realization assumes that realizing individuals that differ in their causal properties may still qualify as the same realization of some kind. The principles of individualism and causal powers entail that realizers, under the flat view, will be physical individuals that wholly instantiate the properties of a realization. A realizer of *corkscrew*, in other words, will be an individual that instantiates the properties that define realizations of *corkscrew*. Steel and aluminum corkscrews may qualify as

realizations of the same kind, under the flat view, because steel and aluminum corkscrews may be alike in terms of the properties that define realizations of *corkscrew*.

Although a difference in the composition of steel and aluminum corkscrews may amount to a minor difference in the causal powers of the two corkscrews, this difference is not apt to be relevant to realization. It will not be relevant because such small causal differences are not apt to be significant relative to the capacity that defines realizations of *corkscrew*. These causal differences nonetheless form part of the realization narrative because, under flat realization, they are part of the individual that qualifies as a realizer. As qualifying as the realizer of some kind does not preclude an individual from possessing other properties unrelated to the realization of that kind, flat realization demonstrates how individuals that differ in their causal properties may still qualify as the same realization of the same kind. The triviality worry is evaded because a trivial difference in realizing individuals fails to produce a difference at the level of realization.

With the dimensioned view, on the other hand, realizations are identified with causal effects. Understanding the realization relation is a process of understanding the way realizing individuals collectively produce these effects. Identifying realizing individuals, then, becomes a process of tracing causal effects to their causal origins. As this process is highly deterministic, there is little opportunity for properties unrelated to realization to enter the realization relation. We might suppose that understanding realization as a sum of causal effects does not preclude the possibility that different physical individuals can produce realizations that are the same. After all, rigidity, in Shapiro's corkscrew example, was realized identically by steel and aluminum corkscrews. Identifying rigidity, in that example, did not commit one to the idea that rigidity was always realized in precisely the same way.

The dimensioned view, however, envisions a very tight connection between a causal effect and its causal origins. Recall that the dimensioned view defined realization as follows:

> (R-D) "Property/relation instance(s) F1-F*n*, realize an instance of property G, in an individual *s*, if and only if *s* has powers that are individuative of an instance of G in virtue of the powers contributed by F1-F*n*, to *s* or *s*'s constituent(s), but not vice versa."

What this formulation makes clear is that the focus of the dimensioned view is not the realization of properties that are, in some sense, shared by all realizations of a certain kind. If there is some

standard of rigidity that is appropriate to all realizations of *corkscrew*, in other words, the realization of this common property is not specifically addressed by dimensioned realization. Instead, the dimensioned view targets the way in which a single occurrence of a property (G) possessed by an individual (s) comes about through the powers contributed by realizers F1-F*n*. The focus of dimensioned realization, as explicitly noted, is the realization of property instances.

If the intention of dimensioned realization is to describe the realization of property instances, the ability of the dimensioned view to countenance trivial changes in realizing individuals without a corresponding change in realization will be severely constrained. This is due to the fact that the causal circumstances that lead to the realization of a single property instance are likely to be similarly constrained. If one also supposes that the causal powers of property instances are realized exclusively through the powers of their causal components, no changes to those causal components will be possible without a corresponding change in the property instance realized. A small difference in the causal properties of realizing individuals, then, would always produce a difference in realization.

We can illustrate the problem by attempting small changes to the realizing properties of G. According to R-D, the causal powers that individuate an instance of G in *s* come about in virtue of the causal powers contributed by F1-F*n*. Suppose the causal properties of a single realizer of G were to change, such that, for example, the causal properties of F1 became the causal properties of F1′. Although this new set of causally efficacious individuals may realize something close to G, they could not realize G. That is because G is individuated by the causal powers of F1-F*n* and not the causal powers of F1′-F*n* . The property G is univocally realized by F1-F*n* by stipulation.

Of course, the aim of the trace example is to predicate a difference in realizers that is devoid of causal significance. The problem is that it is unclear why a trace element devoid of causal properties should have any claim to taking part in the realization relation. Consider the realization of G in *s*: Where G is understood to be a collective property realized by its component parts, we might say that property G of *s* is individuated in virtue of the causal powers contributed by components F1-F*n* of *s*. It is certainly possible that *s* may possess another property, call it H, that is devoid of causal significance. Although we might describe such a property as part of *s*, H plays no part in the realization of G. After all, the property G is individuated solely through the

causal contributions of F1-F*n*. If H is not a realizer of G, it cannot causally affect the realization of G. In the same way, if H has no causal affect on the realization of G, it cannot be a realizer of G. If H is not part of either realizer or realization, H has no claim to being part of the realization relation.

That a causally inefficacious component plays to part in realization under the dimensioned view can be empirically illustrated via the diamond/carbon example. Suppose we consider the way in which the hardness of a particular diamond is realized through the causal contribution of a population of carbon atoms. In such a case, it is certainly also possible for our diamond to possess non-causal properties, such as being beloved by Elizabeth Taylor. Although being beloved by Elizabeth Taylor may be a property of our diamond, it plays no part in the realization of hardness in that diamond. After all, hardness is individuated solely by the properties/relations of our population of carbon atoms. As whether or not the diamond is beloved by Elizabeth Taylor has no effect on the way the properties/relations of carbon atoms produce hardness, being beloved by Elizabeth Taylor is a property that plays no part in the realization of the kind *diamond*.

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In allowing that some individuals may be realized by their causal components, dimensioned realization provides a way of extending the idea of realization to encompass compositional kinds. The dimensioned view runs into problems, however, defending itself against the charge that it leads to very a trivial form of multiple realization. Trivial multiple realization occurs when a very minor difference in realizing kinds leads to the conclusion that the given kind is multiply realized. If any difference amounts to a difference in realization, every type will be multiply realizable in principle. If this is the case, the multiple realization thesis would be trivially true.

The flat view is able to effectively forestall the triviality worry by holding to the principles of individualism and causal powers. Endorsing the principles means that realizers will be individuals that independently and wholly fulfill the causal/functional profile that defines the realization of some kind. As such individuals may also possess properties that are inert with respect to realization, trivial differences between realizing individuals need not amount to

differences in realization. In dispensing with the two principles the dimensioned view abandons this strategy of coping with the triviality worry. Since the dimensioned view allows the components of a realization to serve as its realizers, an effective defense against the triviality worry would show how realizations that differ compositionally may still qualify as the same realization. The example of trace and non-trace corkscrews does not accomplish this goal, however, as the trivial differences proposed have little bearing on realization.

Although both flat and dimensioned views understand realization in causal terms, they differ in terms of what it means for a property to be causally relevant to realization. The flat view understands causal relevance largely in terms of causal equivalence, while the dimensioned view understands causal relevance in terms of causal contribution. For this reason, flat and dimensioned views have different understandings of what it is for something to fulfill a causal role. It is this difference in conceptions of causal role fulfillment that forms the object of chapter 7.

Chapter 7 Top

Realizing Causal Roles

Although flat and dimensioned accounts differ with respect to the way they construe the relation between realizer and realization, both accounts are receptive to understanding realization in terms of the way causal properties fulfill a causal role. The following chapter endorses a causal understanding of the realization relation, such that the question as to what realizes a kind becomes the question of what fulfills the causal role that defines realizations of that kind.

Although flat and dimensioned views seem to agree that realization is properly understood in these terms, flat realization typically understands role-fulfillment in a broader context. This broader context means that flat realization tends to construe role fulfillment in terms of the way an individual affects, and is affected by, their environment. I refer to this understanding as an externalist interpretation of causal roles, insofar as the focus of understanding is a goal or state-of-affairs that is largely external to the individual that partly realizes that role. Dimensioned realization, on the other hand, understands role-fulfillment in a narrower sense, such that fulfilling a causal role is a matter of the way causal forces within an individual produce an object-level capacity. I refer to this understanding as an internalist interpretation of causal roles, as the purpose of the explanation is to describe the internal causal systems through which an individual is able to achieve some capacity.

If a comprehensive understanding of kinds requires both externalist and internalist explanations of causal role fulfillment, a suitable theory of realization may require both flat and dimensioned approaches to realization.

7.1 Realization as Causal Role Fulfillment Top

The idea of identifying a cognitive state in virtue of its causal properties can be counterintuitive, especially in cases where the experience of a cognitive state is closely associated with the phenomenology of that experience. This is particularly true in the case of pain. Although most

would agree that pain is an unpleasant sensation, pain is also an unpleasant sensation of a certain sort. It is the distinctiveness of pain sensation that sets pain apart from other unpleasant sensations such as nausea or dizziness. Pain is a sensation that hurts. Indeed, hurtfulness is so central to the experience of pain that some have theorized that this hurtful aspect is really all there is to pain. Kripke takes this tack when he asserts;

> "Pain… is not picked out by one of its accidental properties; rather it is picked out by its immediate phenomenological quality…. If any phenomenon is picked out in exactly the same way that we pick out pain, then that phenomenon *is* pain."[38]

All there is to being in a state of pain, according to Kripke, is to be experiencing the sensation of pain.

To hold that pain is defined solely by its phenomenological properties is to hold that the physical and functional properties of pain are, in Kripke's words, accidental. Given the success of the physical sciences in explaining the workings of the human body, however, it seems plausible that the physical properties of a state such as pain are, pace Kripke, a necessary condition for that state. As noted, it is less commonsensical to hold that the functional properties of a cognitive state are a necessary condition for pain. Functional properties appear unnecessary because we typically expect the behavior associated with some cognitive state to contain an element of volition. If we are able to choose how we respond to stimuli, in other words, the functional properties of a cognitive state would be contingent, rather than necessary, properties of that state.

Fear, for example, is a cognitive state that is produced by different stimuli, and produces different responses, in different individuals. Some people fear rats, while others fear heights or republicans. Typically, an individual experiencing fear is understood to have a degree of choice in how they respond to that fear. If one fears another person, for example, one could fight that person, hide from them, or simply run away. As a result, we may understand the role fear actually plays to be highly contingent upon the way that other the mental and physical properties are affecting an individual.

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[38] Kripke 1980, p. 152.

Pain is somewhat unusual in this regard as the role-properties of pain are, unlike other cognitive states, strongly associated with the ontology of pain. This is largely due to the fact that our volition when responding to pain is very limited. When a person touches a hot stove, their central nervous system will initiate pain-related withdrawal from the stove even before that person becomes fully aware that they are undergoing a pain experience. Withdrawal from the stove happens *as* one becomes aware of the pain sensation, rather than *because* one becomes aware of the pain sensation. The experience of pain sensation, then, is not a prerequisite to the functional properties of pain. On the contrary, pain appears to be an experience that manifests itself simultaneously in sensation and behavior.

Recognizing the strong connection between pain and the pain-role affords one way of responding to Kripke's suggestion that the only condition necessary and sufficient for pain is the sensation of painfulness. If the sensation of painfulness were sufficient for pain, we would find it unremarkable for pain to occur in the absence of the corresponding pain-role. In other words, we would find it unremarkable for pain to occur that was not caused by damage to the body, or that did not result in withdrawal and protection behaviors.

The idea of pain in the absence of a corresponding pain-role, however, is highly counterintuitive. Suppose a friend, Tara, claims that she is experiencing a pain sensation of the type that typically results from breaking several of one's fingers. Tara claims to be able to describe the precise location and quality of this sensation, which she describes as 'excruciating'. Strangely, Tara also maintains that she is not bothered by this sensation, and continues to use her pained hand in the usual way. For most of us, the idea that Tara is an authentic state of pain will be implausible. Although Tara may claim to feel pain sensation, she does not behave in the way that those who experience pain typically behave. Kripke's idea that we should define pain solely in terms of its phenomenological properties is similarly implausible, as part of our understanding of what pain states are is that they are states with a certain causal properties. Part of what it is to be pain, in other words, is to play the pain-role.

The need to account for the role of cognitive states is what initially motivated Putnam's description of pain in terms of its functional properties.[39] Putnam noted that although we have

[39] Putnam 1967, p. 56.

direct, introspective access to the character of our own cognitive states, we only have access to the states of others via their behavior. It is this behavioral aspect, then, that should be given priority when determining the properties of cognitive states. In Putnam's estimation, there is little reason to suppose that two individuals with similar behavior possess any similarity in their physical properties. There is reason to suppose, however, that two individuals with similar behavior possess a similarity in their functional organization.[40] Fleeing noxious stimuli serves a functional purpose for both human beings and molluscs, for example, despite the fact that there are few physical similarities between human beings and molluscs. As long as this functional organization was construed in a suitably abstract terms, Putnam believed we could describe pain in a way that was independent of the physical properties of pain states.

Understanding the realization of cognitive states in terms of the way physical properties occupy functional roles is rendered problematic, however, by the fact that physical properties are clearly different from cognitive properties. This difference makes it somewhat mysterious as to how physical properties will be able to properly describe cognitive phenomena. We can illustrate the problem by proposing that the cognitive state which is pain be identified with the physical state of C-fibers firing. As someone can know that they are in pain without knowing that their C-fibers are firing, it cannot be a conceptual truth that pain is C-fibers firing. Instead, we may hypothesize that pain should be contingently identified with firing C-fibers, insofar as we expect that identity to be confirmed by empirical research.

The trouble with this idea of contingent identity is that it is not clear how two concepts can be identical without being necessarily, rather than contingently, identical. If we suppose that pain should be identified with firing C-fibers, the concept of pain and the concept of firing C-fibers should share all the same properties. In such a scenario, firing C-fibers would have the property of being necessarily identical to pain, and pain would have the property of being necessarily identical to firing C-fibers. It would hold necessarily if at all, then, that pain was identical with firing C-fibers.

If it is not possible to know *a priori* that pain is firing C-fibers, the concepts of pain and firing C-fibers must not be equivalent. According to the distinct property argument, if terms that

[40] *Ibid*, p. 56.

refer to cognitive concepts are not equivalent to terms that refer to physical objects, the former will only be able to denote the latter by expressing something distinctively cognitive about those concepts.[41] If cognitive concepts possess distinctively cognitive properties, however, those cognitive concepts would not be strictly identical with the physical objects to which they refer. This presents a problem to understanding physical states as occupants of the causal roles that define cognitive states. Although we may wish to assert that the state of firing C-fibers realizes pain in humans, the state of firing C-fibers is a physical state that is defined by its physical properties, while the state of pain is a cognitive state defined by its cognitive properties.

We can largely avoid these metaphysical issues by endorsing a causal interpretation of the realization relation. Such an interpretation would replace the idea that realization is primarily a relation between physical properties and cognitive or functional properties with the idea that realization is primarily a relation between the causal properties of realizers and the causal role that identifies some realization. The distinction between physical descriptions and functional descriptions may still be maintained, so long as that distinction is construed in causal terms. Functional descriptions, under this sort of construal, would simply describe causal properties in broader terms than would physical descriptions. As a result of their more general orientation, functional descriptions of causal role fulfilment will tend to emphasize the causal relationship between an individual and their environment. Physical descriptions, on the other hand, will tend to implicate causal systems or structures within the individual itself.

The idea that realization should be understood in terms of the way causal properties fulfil a causal role is consistent with both flat and dimensioned accounts of realization, as both accounts construe realization in causal terms. Shapiro is explicit in his assertion that the theory of flat realization is to be understood as a theory of causal relations. According to Shapiro, determining the properties that are relevant to realization begins by assessing a kind in terms of its central or defining capacity. Once this capacity is established, the kind may be subject to a functional decomposition in order to reveal the causal processes implicated in the production of that capacity. As this process of decomposition will reveal nothing but further causal processes, we might accurately say that the flat view construes realization as a relation between the causal

[41] J. J. C. Smart responds to this objection, which he attributes to Max Black, in Smart 1959. The argument is also discussed by Stephen White in White 1986 and 2002.

capacity that defines realizations of some kind and the causal properties that produce that capacity.

The idea that the flat view understands realization in causal terms is illustrated via various examples. In the mousetrap example, Shapiro notes that a paper representation of a mousetrap will not qualify as a realization of *mousetrap* because mere representations lack the causal properties essential to realizations of *mousetrap*. Moreover, Shapiro repeatedly emphasizes that the physical properties of an individual are only relevant to the realization of some kind when they are causally efficacious with respect to the properties that define that kind. The difference in composition of steel and aluminium corkscrews, Shapiro notes, is not itself sufficient to determine whether or not two corkscrews qualify as different realizations of *corkscrew*. Instead, two corkscrews made of different materials will only count as different realizations of *corkscrew* if they differ with respect to the causal properties individuative of corkscrews.

The idea that the realization relation should be understood in terms of the way causal properties fulfil a causal role also comports well with Gillett's dimensioned account of realization. According to that view, realizations of some kind are also individuated by their causal powers. The realization of diamond, in Gillett's example, is individuated by the power to scratch any known surface. For something to qualify as a realizer, by the same token, is for an individual to contribute causally towards the properties and powers that define the realization of some kind. The properties of carbon atoms qualify as the realizing properties of diamond, under the dimensioned view, because the properties of carbon atoms are causally responsible for the properties of diamond. Dimensioned realization, like flat realization, construes realization as a relation between the causal properties of a realization and the causal properties that are relevant to producing that realization.

7.2 Internalist and Externalist Approaches to Role-Fulfillment Top

Although both flat and dimensioned views construe realization in causal terms, they differ in their conception of what it means for something to fulfil a causal role. This is due to the fact that flat and dimensioned views understand causal roles to be defined in different ways. The flat

view defines causal roles in terms of the capacity of an individual to achieve a certain sort of goal with respect to their environment, and therefore expect a description of role fulfilment to contextualize the individual that partly fulfils a causal role. Dimensioned views understand causal roles in terms of the causal origins of an ability or capacity, and therefore expect a description of role fulfilment to be largely internal to the individual that realizes a causal role. Although both flat and dimensioned realization may be understood to construe realization in terms of causal role fulfilment, their different understandings as to what role fulfilment entails explains their different conceptions of realization.

These different understandings of role fulfilment may reflect a distinction between internalist and externalist approaches to explanation. According to that distinction, there are different, yet compatible, ways of explaining various phenomena. When we explain an individual from an externalist perspective, we take into account the context in which an individual is situated. Describing an individual from an externalist perspective will frequently take the form of describing the way an individual's behavior has certain characteristic environmental causes, and produces certain characteristic effects. An externalist description of pain, for example, may describe pain as typically caused by a noxious stimulus, and typically productive of withdrawal and protection behaviors. This emphasis on contextual factors means that externalist descriptions of causal role frequently take the form of an aim or purpose. Pain, for example, may be described in terms of pain's ability to ensure survival against threats in the environment.

Explaining an individual from an internalist perspective will tend to assume certain environment factors are already in play, and, as a result, will not cite those environment factors as part of an explanation. The result is a description that focuses more attention on causal properties within the individual itself. For this reason, internalist descriptions do not identify a particular capacity so much as they identify the systems by which a certain capacity is implemented. An internalist description of pain, for example, may describe the way in which a thermal stimulus causes C-fibers to fire, which in turn causes an electrochemical signal to be sent via the spinal column to the brain.

We may apply this idea of externalist and internalist descriptions to an understanding of causal roles. Externalist descriptions of causal roles, for example, will construe a causal role in

broad terms, such that the question of role-fulfilment frequently becomes a question of whether or not an individual interacts with their environment in a particular way. Shapiro adopts this sort of perspective in his discussion of the realization of *mousetrap*. In that example, Shapiro argued against the idea of realization as functional isomorphism by noting that individuals that are functionally isomorphic to a mousetrap may not possess the causal properties that distinguish actual realizations of *mousetrap*. The relevant causal properties, according to Shapiro, were the properties that endow actual mousetraps with the ability to catch and kill mice. As the catching and killing of mice describes a state of affairs between an individual and their environment, supposing that the causal role of mousetraps is given by the catching and killing of mice is to adopt an externalist perspective towards an interpretation of the mousetrap-role.

Adopting an externalist perspective towards causal roles may also minimize the importance of an individual's internal properties towards the fulfilment of that role. This is because understanding role fulfilment in terms of the achievement of an external aim or purpose renders the means through which that aim is achieved largely irrelevant. After all, if the ability to catch and kill mice is the sole criterion defining the mousetrap-role, the internal causal system through which an individual is able to catch and kill mice will be irrelevant. Although standard mousetraps will fulfil the mousetrap-role, so will cats.

Internalist descriptions will construe the idea of causal role more narrowly and, as a result, will tend to describe those roles in terms of the way causal systems function to produce a certain capacity. Descriptions of this sort will tend to ignore the external context in which an individual is situated and, for this reason, will sound more purely mechanistic in character. An internalist description of the mousetrap-role, for example, may describe the way in which a certain mass causes movement of the mousetrap's catch. The movement of the catch causes a holding bar to slip from a notch on the catch, which, in turn, causes a hammer to slip free of the holding bar. The tension of a spring then causes the hammer to close with force on the catch. If mousetraps are defined according to this more specific understanding of the mousetrap-role, only individuals with a catch, holding bar, spring and hammer will have the potential to fulfil the mousetrap-role. Although the internalist may agree with the externalist that mousetraps should be defined by their causal role, the causal properties that define that causal role will tend to be properties that are internal to the individual realizing that role.

As externalist descriptions emphasize an individual's environment in their understanding of causal roles, externalist descriptions will tend to allow more internal flexibility in the way a role is fulfilled. As noted, the more general scope characteristic of externalist descriptions will tend to discount an individual's intrinsic properties in favor of the way an individual affects, and is affected by, their environment. This environmental aspect becomes relevant because understanding causal roles to be defined by their purpose will tend to measure role fulfillment in factors outside the individual. Whether or not an individual fulfills the mousetrap-role, from an externalist perspective, will tend to be measured by an individual's ability to catch and kill mice.

As individuals have the ability to affect and be affected by their environment in different ways, an externalist description will allow the same physical individual to figure in the fulfillment of different causal roles. Suppose we have a physical individual, *s*, with the structural and mechanical properties that endow *s* with the ability to remove corks. According to an externalist understanding of role fulfillment, identifying this ability will mean that *s* fulfills the corkscrew-role. The same materials that give *s* its structural and mechanical properties, however, also possess the sort of mass that endows *s* with the ability to prevent paper from blowing away. According to an externalist understanding of role fulfillment, identifying this latter capacity will also mean that *s* fulfills the paperweight-role.

Whether *s* fulfills the corkscrew-role or the paperweight-role at any given moment is not apt to be determined by any property internal to *s*. As *s* is internally identical with itself, there can be nothing internal to *s* that renders *s* more appropriate for the corkscrew-role than the paperweight-role. If *s* possesses the internal properties that are required to fulfill the corkscrew-role, there will be nothing internal to *s* that prevents *s* from realizing *corkscrew*. If *s* also possesses internal properties that are required to fulfill the paperweight-role, there will be nothing internal to *s* that prevents *s* from realizing *paperweight*. Instead, the determining factor will be found in *s*'s extrinsic properties. In particular, whether *s* fulfills the corkscrew-role or the paperweight-role will be determined by some agent whose interests are served by using *s* for the removal of corks or the weighting of paper.

Where externalist descriptions of causal role implicate the needs and interests of some function-attributor, realization can only be determined contextually. In our example, part of what allows *s* to fulfill the corkscrew-role is the disposition of some agent to use *s* for the

removal of corks. This external, dispositional element places limits on the relevance of intrinsic properties towards causal role fulfillment. As Shapiro notes, corkscrews are made of different materials and operate in accordance with different mechanical principles. As a result, it may appear that the only substantive thing that we can say about the corkscrews is that they represent the achievement of a certain goal. That goal is, of course, the removal of corks.

Shapiro acknowledges that defining mousetraps in terms of the ability to catch and kill mice may not be particularly satisfying. Where externalist descriptions are found to be unacceptably general, we may opt for a more detailed perspective towards the characterization of causal roles. Such a description would look at the causal forces at play within the individual itself, such that that individual is able to carry out the function that it does. This more detailed description of causal properties may be understood as an internalist description of causal roles because the causal properties implicated in the description are those that arise in virtue of an individual's internal structure.

How much detail is picked out by some internalist description will depend on the specificity of the capacity being described. The ability to weight paper, for example, places very few restrictions on the internal causal structure of an individual. So long as that individual possesses sufficient mass to prevent paper from blowing away, any internal structure will do. At other times, a capacity may be so specific as to place very strict limits on the internal structure of the individual possessing that ability. The ability to scratch any known surface is such an example. As the only material able to scratch any known surface is diamond, realizing the ability to scratch any known surface will require an individual to possess the internal structure of diamond.

Importantly, moving to an internalist description of causal roles requires that the question of external role has already been fixed. One cannot determine the internal causal systems through which an individual exemplifies a certain capacity before that capacity is itself determined. In our example, an individual, *s*, may figure in both the capacity to remove corks as well as the capacity to weight paper. The internal causal systems required for the removal of corks, however, are different that those required for the weighting of paper. The capacity to remove corks will require a more extensive causal system capable of gripping and exerting force on a cork, while the capacity to weight paper requires nothing more than sufficient mass. In

other words; an individual does not need a causal system capable of exerting force on a cork in order to qualify as a paperweight, but an individual does need a causal system capable of exerting force on a cork in order to qualify as a corkscrew. Whether or not a causal system able to exert force on a cork is relevant to an internalist description, then, depends upon whether or not we are interested in *s*'s ability to remove corks or its ability to weight paper.

Of course, the recognition of a distinction between externalist and internalist approaches to role fulfilment should not be understood as the claim that externalist and internalist interpretations are mutually exclusive. This is because an externalist description that identifies role fulfilment with certain environment causes and effects may strongly imply something about the internal systems of the individual able to achieve those effects. A description of something as able to scratch any known surface, for example, implies something about the internal systems of the individual able to scratch any known surface. As the only individual able to scratch any known surface is diamond, to describe an individual as able to scratch any known surface is to describe an individual with the internal causal structure of diamond.

The inverse will also be true, in that causal descriptions that are largely internalist in spirit may carry strong implications about the external capacity that corresponds to that internalist description. Describing an individual as having the internal causal structure of diamond, for example, will imply something about the external causal relations that individual is able to enter into. Again, if the only individual able to scratch any known surface is diamond, to describe an individual as possessing the internal causal structure of diamond is to describe an individual that has the external ability to scratch any known surface.

7.3 'Which' and 'How' Explanations

Top

Recognizing that externalist and internalist descriptions pick out causal roles at different levels of abstraction is to recognize that the question of what realizes a causal role may be understood in significantly different ways. One way of realizing a causal role will be addressed by an externalist explanation that describes the sort of causal interaction between an individual and their environment such that we consider that individual to realize one capacity rather than another. For *s* to fulfill the corkscrew-role, in this case, requires *s* to have a distinctive sort of

causal relationship with its environment. It is this object-level causal relationship that instantiates the capacity to be identified with the corkscrew-role. Were *s* to have had a different causal relationship with its environment, *s* may have realized the capacity to weight paper. The question of what realizes a causal role, from an externalist perspective, is more accurately understood as the question of *which* set of object-level causal relations constitutes fulfillment of a causal role.

A different way of fulfilling a causal role will be addressed by an internalist explanation that targets causal systems within the individual itself. Every individual with object-level causal properties will possess an internal causal system through which those object-level properties are produced. A particular corkscrew, for example, will have the compositional and mechanical structure that endows that corkscrew with the ability to remove corks. The analysis required to uncover this internal structure will be largely objective, as it will essentially be a matter of tracing object-level causal effects to their internal origins. The question of what realizes a causal role, in this latter case, is more accurately understood as the question of *how* a certain causal role is fulfilled.

These two ways of fulfilling a causal role will differ significantly in terms of the relative importance attached to an individual's internal character on the one hand, and its external environment on the other. If fulfilling a causal role is understood in its externalist sense; in terms of the causal relations that hold between an individual and their environment, many of the causal properties relevant to realization will be extrinsic to that individual. As previously noted, part of what makes a functional individual into a functional individual of a certain kind may be the disposition of some agent to use that individual in a certain way. The same individual that is used as a corkscrew in one context, for example, may be used as a paperweight in another. If the same individual figures in the fulfillment of different causal roles, the same individual would take part in the realization of different kinds. As nothing internal to such an individual would account for the difference in realization, we would be obliged to conclude that an individual's extrinsic properties are sometimes sufficient for determining its realization.

The second or internalist approach to realizing a causal role is that where the internal causal systems that produce an individual's object-level capacity are described. This latter approach to realization will be considerably less concerned with an individual's extrinsic

properties, as the individual's status with respect to their environment will already have been determined by identifying the capacity being realized. For an individual to realize a diamond, for example, is for an individual to realize something with determinate object-level properties. One of those properties will be the property to scratch any known surface. If the external capacity of a realization is fixed in this way, the internal causal factors that produce that capacity will be largely determinate. It takes a specific population of atoms arranged in a specific way to realize the properties of diamond, as any other population or arrangement would not result in the properties of diamond.

These two ways of realizing a causal role will also differ substantively in terms of their causal mereology. For an individual to realize a causal role in an externalist sense is for an individual to wholly possess the causal properties that define realizations of that kind. This is because to identify something as a realizer, from an externalist perspective, is to identify something in terms of its ability to bring about certain environmental effects rather than others. For an individual to qualify as a realizer of *corkscrew*, from an externalist perspective, is for an individual to possess the ability to remove corks. This means that for an individual to realize a causal role, from an externalist perspective, is for an individual to instantiate the causal properties that define that role.

For an individual to realize a causal role in an internalist sense, on the other hand, is for an individual to contribute only some of the properties that define a causal role. This is because to identify something as a realizer, from an internalist perspective, is to identify something that merely takes part in the implementation of some capacity. For an individual to qualify as a realizer of diamond, from an internalist perspective, is for an individual to take part in producing the properties of diamond. For something to realize a causal role, under this sort of description, is for something to contribute causally towards the properties that define that role.

These different ways of understanding what it is to realize a causal role allow for different, but compatible analyses of the same causal system. We can illustrate the way in which these levels of analysis relate to each other by looking at the example of a portable generator. A portable generator is a type of small appliance where a gasoline engine powers an electrical generator that converts the engine's mechanical energy into electrical energy. Suppose we were to ask the question as to what realizes the generator-role in this system?

One way of interpreting the question is as a request to identify the ability in virtue of which the generator qualifies as a generator. Interpreting the role-question in this fashion is to adopt an externalist perspective towards fulfillment of the generator-role. The question of identifying the generator-role becomes the question of identifying one of several different capacities. These capacities describe the way in which the generator affects, and is affected by, its environment. Generators, of course, can be understood to generate different things. In addition to electricity, a typical generator generates carbon monoxide, vibration, and noise. One way of filling out the idea of the generator-role, then, is given by identifying the capacity through which the generator turns gasoline into electrical energy. Another way of filling out the generator-role is given by the capacity through which the generator turns gasoline into noise. The question as to what fulfills the generator-role is, in this case, is more accurately interpreted as the question of which capacity constitutes the generator-role.

Understanding the role-question from an externalist perspective will also suggest that some realizing properties will be extrinsic properties. As noted, generators have the capacity to generate both electricity and noise. Although we typically understand a generator to be intended for the production of electricity, there is nothing internal to the generator that marks the production of electricity as more appropriate, somehow, than the production of noise. Instead, the capacity that constitutes the generator-role is determined by the generator's extrinsic properties. In particular, the capacity that constitutes the generator-role is determined by the needs and interests of some function-attributor. If that attributor happens to be a building contractor, the capacity that is valued may be the capacity that results in the production of electricity. If that attributor happens to be an industrial musician, the capacity that is valued may be the capacity that results in the production of noise.

Interpreting the role-question from an externalist perspective also suggests a realizer of the generator-role will possess causal properties equivalent to those that define realizations of that kind. If the generator-role designates a certain capacity, whatever occupies the generator-role will be a causal system that wholly instantiates the relevant capacity. A realizer of the generator-role, in other words, will be causally equivalent to a realization of the generator-role. Interpreting the generator-role in terms of the generator's capacity to produce electricity is to understand that the production of electricity wholly realizes the generator-role. Interpreting the

generator-role in terms of the generator's capacity to produce noise is to understand that the production of noise wholly realizes the generator-role. The question as to what fulfills the generator-role in an externalist sense is more accurately interpreted as the question of *which* of these capacities fulfills the generator-role.

A second and very different way of understanding the role-question is to understand the question as a request to identify the particular causal structures through which a certain capacity is achieved. Interpreting the question in this way is to adopt an internalist perspective towards fulfilling the generator-role. When one adopts an internalist perspective towards the generator-role, one assumes the external question as to capacity has already been fixed. When the external capacity of the generator is fixed, understanding the generator-role becomes a question of understanding the means through which that external capacity is achieved. If we assume that the function of a generator is the production of electricity, the generator-role will be described by the causal system that results in the production of electricity. Addressing this understanding of the generator-role may involve a description of the way the combustion of gasoline causes a piston to exert force on a connecting rod, which then causes torque to be exerted on a drive shaft. This torque drives a rotor which spins inside a stator, creating the electrical field necessary for the generation of electricity. As this is the causal system that results in the generators ability to produce electricity, this will be the causal system that fulfills the generator-role. The question as to what fulfills the generator-role in an internalist sense, then, is more accurately interpreted as the question of *how* a certain causal system fulfills the generator-role.

Interpreting the role-question from an internalist standpoint will suggest that realizing properties will be largely properties that are internal to the generator. This is because the causal structures that are understood to produce a certain capacity will tend to be internal structures of that individual. In our example, the production of electricity is explained in terms of pistons, connecting rods, stators and rotors. As these structures are all internal structures of the generator, for these structures to fulfill the generator-role is for the generator-role to be fulfilled by properties that are intrinsic to the generator. Extrinsic properties are not apt to exert much influence on the realization relation because an answer to the external role-question is assumed. If the function of generators is assumed to be the production of electricity, the properties that

realize the generator-role will be those properties of the generator that result in the production of electricity.

Interpreting the generator-role from an internalist standpoint also suggests that realizers and realizations will not be equivalent in their causal properties. This is because understanding how a capacity is produced involves understanding that capacity in terms of the structures that are collectively responsible for that capacity. Where a causal role is realized through individuals working collectively, however, no single individual will possess causal properties equivalent to that of the resulting collectivity. If the generator-role is realized by a causal system that includes both pistons and rotors, for example, no individual piston or rotor will possess causal properties equivalent to that of the generator-role. A realizer of the generator-role, from this point of view, exemplifies only a portion of the causal properties specified by the generator-role. Consequently, fulfilling the generator-role in an internalist sense is to identify individuals that causally contribute towards fulfillment of the generator-role.

In the generator example, then, the question as to what realizes the generator-role may be interpreted in two significantly different ways. The first interpretation understands the generator to embody several different object-level capacities, and interprets the role-question as a request to isolate the particular capacity most relevant to the realization of *generator*. The second interpretation assumes the relevance of a particular capacity, and interprets the role-question as a request to identify the causal sub-systems within the generator that figure in the production of that capacity. Responses to these two understandings of the role-question will clearly differ in their explanatory scope.

The example poses the question:

q. What fulfills the generator-role in a generator?

Two different interpretations of this question are possible:

q_1. Which causal process fulfills the generator-role?

q_2. How does a certain causal process fulfill the generator role?

These different interpretations will be addressed by different responses:

r_1. The generator-role is fulfilled by one of several possible object-level capacities. For example, the generator-role may be fulfilled by the process that turns gasoline into electricity, or by the process that turns gasoline into noise.

r_2. The generator-role is fulfilled by the internal causal systems through which the generator achieves some capacity. For example, the generator-role may be fulfilled by the system of pistons, driveshaft, rotors and stators that figure in the production of electricity.

What we are left with is an understanding that what fulfills the *m*-role in an individual with the capacity to *m* can be unpacked in different ways. As long as different object-level capacities are considered viable alternatives, we are apt to interpret the role-question as a 'which' question along the lines of q_1. If a certain capacity has been assumed and alternative capacities ruled out, we are apt to interpret the role-question as a 'how' question along the lines of q_2. Whether one interpretation can be considered superior to the other is a matter of context, viz., the context in which alternative capacities have (or have not) been ruled out.

The distinction between these different understandings of the role-question echoes a similar distinction noted by U.T Place in his discussion of consciousness[42]. According to Place, responding to questions such as 'What is consciousness?' is complicated by that fact that we recognize different senses of 'is'. On the one hand, we have the 'is' of definition, on the other, the 'is' of composition. One can tell the former from the latter by appending the qualification '..and nothing else'. The 'is' of definition supports the addition, such that one might properly assert 'the generator role is explained by the production of electricity and nothing else'. The 'is' of composition fails to support the qualification, such that the assertion 'the generator role is explained by pistons and nothing else' sounds manifestly false.

According to Place, the difference between the two understandings is a difference between understanding an identity statement as necessary and understanding an identity statement as contingent. Statements such as 'red is a color' or 'the generation of electricity fulfills the generator-role' are true by definition. Part of what it is to be red is to be a color, while part of what it is to generate electricity is to fulfill the generator-role. Statements such as 'his table is an old packing case' and 'a system of pistons, connecting rods, rotors and stators

[42] Place 1956.

fulfills the generator-role' are contingent. These latter identity statements must be investigated and verified by observation.

These two understandings of what it is to realize a causal role map nicely onto our contending theories of realization. Understanding the question 'what realizes the *m*-role' in its externalist sense is to adopt the flat theory of realization. This is because understanding the 'what' question in its externalist sense is to understand role-fulfillment in terms of instantiation. The individual that fulfils the *m*-role in an externalist sense individually and wholly fulfils the *m*-role, in the same way as the production of electricity individually and wholly fulfils the generator-role. The realization relation is correspondingly given a sense of analyticity because the identity relation between realizer and realization is a relation of definition. The realizing predicate defines the realized subject, such that we would say the production of electricity defines the generator-role.

Construing the question as to what realizes a causal role in its internalist sense, by the same token, is to adopt a dimensioned approach to realization. The internalist interpretation is conducive to the dimensioned view because understanding the 'what' question in its internalist sense is to understand realization in terms of causal contribution. An individual fulfils the *m*-role, in other words, by being part of a causal system that collectively produces the causal powers specified by the *m*-role. Realization is given a greater sense of contingency, in this case, because the relation between a realization and its realizers is typically discovered empirically. We discover, for example, that the causal powers of diamond originate in the bonding and alignment properties of carbon atoms.

A properly inclusive theory should accommodate the various explanatory tasks to which the concept of realization is applied. If realization is understood in terms of causal role fulfillment, this will mean a properly inclusive theory of realization will have to address different senses of causal role fulfillment. One of those senses may involve understanding which of several different capacities is properly associated with a certain individual. In other instances, the capacity associated with a particular individual may be a foregone conclusion. In this latter case, it may be more explanatorily useful to understand role fulfillment in terms of the causal processes through which a certain capacity is achieved.

As these alternatives represent different approaches to realization, we should not expect that every case of realization will conform to either internalist or externalist interpretations of role fulfillment. A better idea, then, may be look to the sort of theory that permits different approaches to the realization relation based on the explanatory task at hand.

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One of the standard ways of construing the realization relation is in terms of the way physical states fulfill cognitive roles. This idea may be problematic however, as it is not clear that physical properties are metaphysically sufficient to account for cognitive phenomena. A better idea may be to understand realization in causal terms, such that realization is understood to describe the way in which causal properties fulfill causal roles.

Although flat and dimensioned accounts of realization are amenable to a causal interpretation, they are apt to understand causal role fulfillment in different ways. The flat view understands role fulfillment in a largely externalist sense, such that the fulfillment of some causal roles will tend to describe the way an individual exemplifies a certain capacity. As the ability of an individual to exemplify a certain capacity is often measured in the way an individual interacts with their environment, flat views will tend to interpret role-fulfillment in an environmental context.

The dimensioned view of realization, on the other hand, will tend to interpret role fulfillment in an internalist sense. Under an internalist interpretation, a description of role fulfillment will be a description of the causal structures that typically produce a certain capacity. As this understanding of role fulfillment will focus attention on causal structures within the individual, the properties that qualify as realizing properties will tend to be intrinsic properties of that individual.

These different understandings of role-fulfillment suggest that the bare question as to what fulfills a certain causal role may be ambiguous. One way of interpreting the question is as a 'which' question that is addressed by identifying the capacity that corresponds to a certain causal role. The flat view excels at addressing this sort of 'which' question because the flat view

understands realization in terms of instantiation. The other way of interpreting the role-question is as a 'how' question that is addressed by identifying the causal systems that produce a certain capacity. The dimensioned view of realization excels at describing this aspect of realization because the dimensioned view conceives realization in terms of causal contribution.

If some phenomena are best described by 'which' interpretations of causal role fulfillment, and other phenomena are best described by 'how' interpretations of causal role fulfillment, a comprehensive theory of realization may require both internalist and externalist approaches to realization. Combining these two approaches within the same theory of realization is the goal of chapter 8.

Chapter 8

Top

A Two-Level Conception of Realization

The thesis of multiple realization was initially introduced in order to describe the way in which cognitive properties could be instantiated by different kinds of physical properties. The thesis, then, was originally intended as a way of describing the identity conditions of cognitive individuals. If realization is intended as a thesis about cognitive individuals, however, the foregoing discussion of realization as it pertains to artifacts, or biological and chemical kinds, would be of limited relevance. After all, minds are very unlike diamonds and corkscrews, and a critic may be skeptical as to how the realization of diamonds and corkscrews can offer any insight into the realization of mind. The motivation behind this inclusive approach to realization is naturalistic. By situating our discussion of cognitive types within a more general understanding of the relationship between physical and conceptual kinds, we position our theory of realization within a broader and more cohesive metaphysical framework. Issues that arise when considering the realization of mental states, then, can be informed by a more general view of the way in which physical individuals can be understood as realizations of a particular kind.

What I propose to do now is focus the discussion of realization a little more closely on the realization of cognitive phenomena, in a way that reflects the preceding discussion of realization as it pertains to kinds more generally. In particular, I wish to focus on the means by which we may account for the realization of pain. In the philosophy of mind, accounting for the realization of pain is typically complicated by the element of contingency that exists between the physical and functional properties of pain. Describing pain in terms of its physical properties leads to problem cases where the physical properties of pain do not produce the functional properties of typical pain, while describing pain in terms of its functional properties leads to problem cases where the functional properties of pain do not originate in the physical properties of typical pain.

David Lewis offered a model for resolving this sort of contingency problem in ‘Mad Pain and Martian Pain’. According to Lewis, some state occupies the pain-role for a particular population if, when a member of that population is in that state, their being in that state typically

has the causes and effects that are appropriate to the pain-role. A theory of realization modeled on Lewis' two-level approach to pain suggests a way of combining 'which' and 'how' senses of causal role fulfillment by indexing our description of realization to the context in which that description occurs. Where the descriptive situation allows for populations with unusual physical properties to instantiate pain, we adopt a 'which' approach to pain's realization and identifies pain in terms of the functional properties that typically accompany pain. Where the descriptive situation allows for populations with unusual behavioral manifestations to instantiate pain, we adopt a 'how' approach to pain's realization and identify pain in terms of the physical properties that typically produce pain.

Adopting this sort of two-pronged approach suggests that both the physical properties of pain as well as its functional properties can be contingent to pain's realization. Where we adopt a 'how' approach that identifies pain in terms of the internal physical systems that typically produce pain, we allow for the possibility that those internal systems may produce unusual functional results. Where we adopt a 'which' approach that identifies pain in terms of its functional properties, we allow for the possibility that those functional properties originate in unusual internal systems.

Broadening this approach to realization more generally suggests a way to resolve the more serious problem cases confronting flat and dimensioned views. Flat realization asserted that, if realizations are defined by their functional properties, individuals that perform the same function in different ways will realize different kinds. As a result, individuals that perform the same function in different ways cannot represent different realizations of the same function. Adopting a 'which' approach to realization disputes this line of thought, as a 'which' approach to realization classifies realizations only in terms of their external function. From this perspective, the internal physical systems that produce that function will be largely irrelevant to realization.

Flat realization also suggested that defining realizations in terms of their external causal relations would produce a triviality issue. Where too much emphasis is placed on the external relations that characterize realizations of a certain kind, interpretative or metaphorical examples of that kind will qualify as full-fledged realizations. Under a 'how' approach to realization, however, realizations are identified by the internal causal systems that tend to produce external

relations of a certain sort. As a result, a 'how' approach to realization will effectively screen out interpretative or metaphorical examples of some kind as realizations of that kind.

Dimensioned realization encountered a problem in drawing a very tight connection between the causal properties of component realizers and the properties of an ensuing realization. As every individual is apt to internally differ, to some small degree, from every other individual, understanding individuals to be realized by their causal components will suggest that every individual constitutes a unique realization. Again, adopting a 'which' approach to realization negates this worry, as realizations are only classified as the same or different with respect to their external function. Whether or not realizations are different internally, from this perspective, will be irrelevant to realization.

8.1 Physical Descriptions or Functional Descriptions? Top

What are the identity conditions for the realization of a cognitive state? Or better yet, what does it mean for two different physical states to qualify as the same realization of a cognitive state? When it comes to identifying subjective pain experiences, the issue does not seem to arise. It would appear that I can identify my own state of pain simply in virtue of experiencing that state. Saul Kripke noted that the subjective experience of pain seems to collapse any distinction between appearance and reality.[43] To become aware that you are experiencing pain, in other words, is simply to experience pain. In subjective pain experience, there seems to be no difference between the ontological question as to what pain is and the epistemic question as to how pain is identified. According to Kripke, the only condition that is both necessary and sufficient for pain is the sensation of painfulness.

Properly identifying the criteria that pertain to the more general, intersubjective concept of pain is more difficult. This broader question as to what pain is necessarily transcends my personal experience of pain. To understand this wider conception, I must distinguish between my subjective pain experiences and the circumstances under which I correctly attribute pain to others. Although the more general concept of pain must presumably share some aspects of

[43] Kripke 1980, p. 153.

subjective pain in order for subjective pain to qualify as pain, objective pain will also lack the idiosyncratic features that make the subjective experience of pain into a subjective experience.

It is difficult, however, to understand precisely what these idiosyncratic features will be. As there is no way of experiencing another's pain, we attribute pain on the basis of inference from observed similarities. If the circumstances that surround another's experience are similar to the circumstances under which I experience pain, I will tend to attribute pain to that person. If inadvertently touching a hot stove causes me pain, for example, I will tend to attribute pain to others who inadvertently touch the same stove. Moreover, the greater the similarity between the properties of another's experience and the properties of subjective pain, the more likely one is to attribute sameness in pain experience. If my twin brother and I both get sunburn on the same beach on the same day, for example, I will suppose that he is experiencing pain in much the same way that I am.

The epistemic situation becomes more complicated, however, when the physical and behavioral differences between myself and the object of my pain attribution grow more pronounced. What justifies the inference, for example, that the distinctive pain I experience when a needle pierces my fingertip is the same as a potential pain state in a mollusc that possesses no such digit? In such cases, we may be tempted to say that although the mollusc experiences pain, the character of mollusc pain will differ from the character of my pain. The mollusc and I both experience pain, in other words, but I experience my-pain and the mollusc experiences mollusc-pain. Although the mollusc and I may differ in experience if pain is narrowly defined, we share the same experience when pain is more broadly defined.

This same-but-different response is not particularly satisfying, however, as it sidesteps the important question as to whether or not we should emphasize the experiential similarities between my-pain and mollusc-pain or the experiential differences. Understanding mollusc-pain to be both similar and different from my-pain does not tell me what it is about those experiences such that they qualify as experiences of pain. A better explanation would give some indication as to why the concept of pain that I attribute self-referentially should be considered the same or different from that of the mollusc.

One potential way of addressing the similarity question would be to catalog the properties that characterize the subjective experience of pain, and then ascertain whether or not those properties are attributable to the mollusc. The historical problem with this sort of approach is that pain experiences can be characterized according to two very different sorts of criteria. On the one hand, we are inclined to think that pain experiences may be identified in terms of their physical properties. It is an article of scientific orthodoxy that everything is constituted by physical properties. If everything is constituted by physical properties, it will be trivially true that pain experiences are also constituted by physical properties. In this sense, then, pain experiences must be experiences that are defined by their physical properties.

On the other hand, we are also inclined to think that pain experiences may be identified by their functional properties. This functional understanding may be identified with the stimuli which typically lead to the experience of pain, as well as the behaviors that typically follow from that experience.[44] The conceptual connection between pain and its functional properties is so strong that we typically attribute pain experiences based on the behaviors they cause, and typically explain pain experiences in terms of the stimuli that caused them. If someone asks "Why are you in pain?", for example, the answer is apt to be something like "because I touched the stove". Indeed, it is difficult for most people to imagine a pain experience that was not brought about by some sort of noxious stimulus. It is even more difficult to imagine a pain experience that does not result in an aversive behavioral disposition. In some sense, then, pain experiences are experiences that are defined by their functional properties.

Attributing pain states to others requires confronting the tension between understanding pain in terms of its physical properties and understanding pain in terms of its functional properties. In the case of a mollusc, the distinction between the physical and functional properties of pain may produce different conclusions as to whether or not the experience of the mollusc qualifies as pain. On the one hand, an assessment of the mollusc's experience may be guided by an understanding that pain is properly identified with the functional properties of typical human pain. Those functional properties indicate that pain is, first and foremost, a way that creatures respond to noxious stimuli with withdrawal and protection behaviors. This way of

[44] Functionalism, of course, defines cognitive states in terms of their effects in both behavior and other mental states. This paragraph, however, is intended to address the circumstances of attribution. As an attributor has no access to the cognitive states of another, those states would play no part in the act of attribution.

understanding pain has intuitive appeal, as subjective pain experiences are also defined by a response to noxious stimuli with withdrawal and protection behaviors.

From this functionalist perspective, the experience of a mollusc may indeed qualify as pain. Molluscs react to noxious stimuli with a range of sophisticated behavior patterns, including some that accurately replicate human behavior patterns. The most celebrated of these may be the 'flight and ink' maneuver demonstrated by several species of octopi. This maneuver parallels the two primary roles of human pain; pain as an alarm system and pain as a protection system. When an octopus is subject to a noxious stimulus, it flees the source of that stimulus (alarm) while simultaneously discharging a melanin-loaded ink (protection). As the functional properties of octopi behavior are, in this case, equivalent to the functional properties of human pain behavior, one might reasonably conclude that octopi experience pain.

On the other hand, an assessment of the mollusc's experience may be guided by an understanding that pain is properly identified with the physical properties of typical human pain. As mollusc physiology differs radically from human physiology, understanding pain in terms of the physical properties of human pain may indicate that molluscs are incapable of pain. It is true that both molluscs and human beings detect noxious stimuli through electrically excitable cells called nociceptors. In molluscs, these nociceptors transmit information to nerve cords running the length of the organism, terminating in cerebral ganglia which coordinate movement. Although these physical characteristics allow molluscs to replicate pain behavior, molluscs lack the sophisticated cognitive apparatus that, in humans, produces emotional responses to nociceptive stimulation. If these sorts of emotional responses are necessary in order for experiences to qualify as pain experiences, molluscs would be physically incapable of pain.[45]

The end result is that the identification of pain in others is impeded by the element of contingency that exists between the physical and functional properties of pain. If functional properties other than those that typify human pain experiences sometimes accompany the experience of pain, one cannot indefeasibly infer what pain is from the functional properties of typical human pain. Individuals with erythropoietic protoporphyria, for example, suffer from a deficiency in the enzyme ferrochelatase that causes sufferers to experience pain when exposed to

[45] Crook and Walters 2011, p. 187.

moderate amounts of sunlight.[46] As typical human pain is not produced by exposure to moderate amounts of sunlight, the functional properties of erythropoietic protoporphyria-pain will be different than the functional properties of typical human pain. If the functional properties of some pain experiences can be different than the functional properties of typical pain experiences, the identification of pain will involve the tacit assumption that not all of the functional properties that accompany typical pain experiences may be necessary or sufficient for pain.

By the same token, if physical properties other than those that typify human pain experiences may be identified with pain, one cannot indefeasibly infer what pain is from the physical properties of typical human pain. The condition known as polydactylism, for example, refers to individuals that possess supernumerary fingers or toes. If a needle were applied to the sixth finger of a polydactytite, it seems plausible that they would experience finger-pain. As that pain originates in a body part that typical human beings do not possess, the physical properties of sixth-finger pain may be different than the physical properties of typical human pain. If the physical properties of pain can be different than the physical properties of typical human pain, the identification of pain will involve the tacit assumption that not all of the physical properties of typical pain experiences may be necessary or sufficient for pain.

One of the ways of accounting for the contingency between the physical and functional properties of a cognitive state is to draw a distinction between the functional role of a state and the physical state that occupies that functional role. The role of a cognitive state may be specified in terms of the factors that typically bring about that state, as well as the effects that typically follow from that state. The role of pain states in human beings, for example, may be defined in terms of the way pain is typically brought about by damage to the body and typically results in withdrawal and protection behaviors. This is the sequence of causal relations, then, that defines what it is for a state to play the pain-role.

The occupant of a functional role describes the physical state that embodies that functional role for a given population. Suppose that the pain-role in the human population is defined in terms of damage to the body that results in withdrawal and protection behaviors. If the physical state brought about by damage to the body and resulting in withdrawal and

[46] Bloomer, Wang, Singhal, and Risheg 2006.

protection behaviors is the state of having one's C-fibers fire, the state of having one's C-fibers fire will occupy the pain-role for the human population. The idea behind this role/occupant distinction is that, in using a two-level approach to describe cognitive states, we can account for the contingency between the physical and functional properties of those states.

8.2 Mad Pain and Martian Pain

Top

David Lewis proposed this sort of hybrid theory in 1980 with 'Mad Pain and Martian Pain'. Lewis' idea is that mental states should be identified with the physical state that occupies a certain functional role relative to a particular population. The identification of a state such as pain, then, requires that one draw a distinction between the functional role of pain and the physical state that happens to realize or occupy the pain-role for some population.

The idea that a cognitive state may be defined by both its physical properties as well as its functional properties will entail that every state will be describable in two ways. In the first place, cognitive states may be characterized physically in the sense that some physical state possesses the causal properties that account for a certain causal role. Lewis refers to these first-order states as realizer states. Realizer states will differ from population to population, as the physical properties of individuals exemplifying a given causal role will also differ from population to population. In the second place, cognitive states may be characterized functionally, in the sense that functional properties pick out the physical state that happens to realize a causal role relative to some population. Referred to as role states, these functional states are second-order states in that they consist in having some first-order, physical state that realizes an appropriate functional role. As role states are not defined by their physical properties, they serve to identify cognitive phenomena across, rather than within, populations.

According to Lewis, the concept of pain, or the concept of any mental state, is the concept of a state that stands in certain causal relations to other states. For pain, those causal relations are described by the idea that pain will typically be caused by noxious stimuli, and typically results in withdrawal and protection behaviors. If these are the causal relations that define the pain-role, any physical state that is caused by noxious stimuli and causes withdrawal and protection behaviors will qualify as realizing the pain-role for that individual.

As the population to which an individual belongs may possess distinctive physical properties, the physical state that actually plays the pain-role is apt to vary. For human beings, the physical state that is caused by noxious stimuli and tends to cause withdrawal and protection behavior may be the state of firing C-fibers. Consequently, we may say that firing C-fibers realizes the pain-role for the population of humans. For molluscs, on the other hand, the physical state caused by noxious stimuli that tends to cause withdrawal and protection behaviors may be state *m*. State *m* would qualify as the state that realizes pain for the population of molluscs because state *m* possesses the causal relations that identify physical states as states of pain. If that causal specification mandates that pain is typically caused by noxious stimuli and typically causes withdrawal and protection behaviors, and state *m* fulfils this role for the population of molluscs, state *m* would qualify as pain for molluscs.

Lewis' idea is that, although pain should be identified with a physical state, it is a contingent matter as to which physical state the pain-role identifies. Pain for human beings may be the physical state of C-fibers firing. However, the only reason that C-fibers constitute pain for human beings is because, in human beings, C-fibers possess the causal relations that identify a state as a state of pain. Lewis' specification allows us to say that what makes the state of having one's C-fibers fire a state of pain is the role the state plays in mediating stimuli, mental states, and behavior. At the same time, we can maintain that what makes a human state of pain uniquely human is that this mediating role is played by the physical state of having one's C-fibers fire.

The idea that pain states are picked out by their causal relations to stimuli, behavior, and other cognitive states allows one to identify pain states in any individual that possesses the appropriate causal relations. A Martian, according to Lewis, may also experience pain when their body is damaged. This pain causes the Martian to behave in much the same way as you or I do when we experience pain; the Martian groans and writhes, and attempts to avoid that which is causing them pain. The Martian, however, has no C-fibers to fire. Instead, Lewis states, a Martian is in pain when cavities in their feet fill with fluid. Fluid-filled foot cavities qualify as pain for Martians because, relative to the population of Martians, fluid-filled foot cavities possess the causal relations that identify a physical state as a state of pain. What makes the

Martian state of pain uniquely Martian, however, is that this mediating role is played by the physical state of having fluid-filled foot cavities.

The problem of Martian pain is the problem of identifying pain in terms of the internal, physical properties of typical human pain. Although some version of the identity theory will suggest that we identify pain in terms of the physical properties of human pain, that same theory will be unable to describe pain as it occurs in a Martian. That is because the Martian does not possess the physical properties that occupy the pain-role in human beings. Lewis' two-level account allows us to account for the exceptional nature of Martian pain by identifying pain only contingently with the physical properties of typical pain experiences.

Although pain should be identified only contingently with its physical properties, pain should also be identified only contingently with its functional properties. This is because, in unusual situations, the physical state identified with pain may play an unusual functional role. As Lewis asserts that the physical properties identified with a cognitive state will not always have the causal relations to stimuli, behavior and other states that we expect them to, we cannot simply identify a physical state with a certain causal role. Instead, we should characterize physical states in terms of how apt they are to fulfil a certain causal role.

A madman, for example, may experience pain that is brought about in a different way, and produces different behavior, than that of typical human pain. According to Lewis, mad pain is the outcome of moderate exercise on an empty stomach, and tends to result in thoughts of mathematics. As our madman is a member of the human population, pain in the madman still corresponds to the physical state of firing C-fibers. The difference between the madman and a typical human is that, in the words of Lewis, the madman is "...hooked up wrong".[47] When our madman is in pain, he is in the physical state that occupies the pain-role for the population of typical human beings. At the same time, that physical state occupies a causal role that is different than it is for typical members of the human population. One of the reasons, we might say, that we consider the madman to be mad is in virtue of the atypical causal role played by the madman's physical realization of pain.

[47] Lewis 1980, p. 219.

The problem of mad pain is the problem of identifying the pain in terms of the functional properties of typical human pain. Although some version of functionalism will suggest that we identify pain in terms of these functional properties, functionalism will be unable to describe mad pain as pain. This is because the physical state that constitutes mad pain is not picked out by the causal relations that typically identify some physical state as a state of pain. Lewis' two-level account also allows for the exceptional nature of mad pain by identifying pain only contingently with the functional properties of typical pain experiences.

One of the primary ideas motivating Lewis' hybrid approach to pain is the idea that folk psychological concepts are not analyzable in purely physical terms. Instead, concepts such as pain are analytic in the sense that they can only be defined in terms of other concepts in the psychology of a cognitive population. It is this understanding of pain that motivates the assertion that, relative to a population, whatever physical state typically plays the pain-role is pain. This interpretation does not dispute the idea that pain may strongly correlate with a certain physical state of that population. What it does mean is that the physical state that is picked out by a psychological concept will vary in accordance with the physical properties of a population. Although pain may refer to the psychological state that results from exposure to a noxious stimulus and results in withdrawal and protection behaviors, the physical state that fulfils this description will be different for human beings and Martians. The physical state will be different because the physical properties of human and Martian populations will differ.

By emphasizing the distinction between physical realization and causal role, Lewis offers a means by which our contending physical and functional intuitions can be reconciled. According to Lewis;

> "..a state occupies a causal role for a population , and the concept of occupant of that role applies to it, if and only if, with few exceptions, whenever a member of that population is in that state, his being in that state has the sort of causes and effects given by that role.[48]

By focusing on the causal role of pain, we satisfy our intuition as to the purpose of pain states. Focusing on the physical states which realize those roles, on the other hand, satisfies our intuition as to how those roles are fulfilled.

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[48] *Ibid*, p. 219.

8.3 Explaining the Problem Cases

Top

Lewis' two-level approach to the description of cognitive states suggests two corresponding explanations as to what it is for an individual to fulfil a causal role. On the one hand, an individual's internal causal systems fulfil a causal role in the sense in which an individual's internal, physical properties are understood to produce personal-level behavior. An individual with firing C-fibers, for example, will exhibit certain behavioral effects as a result of those firing C-fibers. In normal human beings who are 'conventionally wired', the firing of C-fibers results in an individual that responds to a noxious stimulus with withdrawal and protection behaviors. In mad human beings who are 'incorrectly wired', the firing of C-fibers results in an individual that responds to moderate exercise with thoughts of mathematics. In both cases, the causal behavior an individual exhibits at the personal level is explained by citing systems and structures internal to the individual displaying that behavior

The second sense of role fulfilment found in Lewis' theory is the sense in which personal-level behavior is understood to fulfil the role that identifies a certain psychological state. For both human beings and Martians, the ability to respond to noxious stimuli with withdrawal and protection behaviors is understood to identify pain. These personal-level behaviors do not qualify as psychological states in virtue of their physical properties. After all, the human pain state is identified with firing C-fibers firing, while the Martian pain state is identified with fluid-filled foot cavities. Instead, these behaviors qualify as pain in virtue of their causal connections to other behavioral and psychological states.

By allowing that there are different senses in which individuals can fulfil causal roles, Lewis' theory provides a means of explaining problem cases. The problem of mad pain is the problem of explaining pain in individuals who are conventional in their internal causal systems, but atypical in their external causal relations. The madman is a human being, and, as such, possesses the sort of internal causal systems that are conventional for human beings. The problem is that the madman's internal systems do not produce the sort of behavior they do in typical human beings. When the madman is in the internal state typically identified with pain, he behaves in an atypical way. Understanding the realization of pain in terms of an individual's

external causal relations will have difficulty with mad pain, because mad pain lacks the external causal relations that typically identify pain. The lesson of mad pain, therefore, is that the realization of pain should not be identified solely in terms of the external relations of typical pain.

The problem of Martian pain, on the other hand, is the problem of explaining pain in individuals who are conventional in their external causal relations but atypical in terms of the internal systems that produce those relations. As with human pain, Martian pain is caused by noxious stimuli, and results in withdrawal and protection behaviors. In the Martian, however, these behaviors do not result from the sort of internal causal systems that produce withdrawal and protection behavior in humans. When the Martian exhibits the external causal relations typically identified with pain, he is in an atypical internal state. Understanding the realization of pain in terms of an individual's internal casual systems will have difficulty with Martian pain, because Martian pain lacks the internal causal systems of typical pain. The lesson of Martian pain, then, is that the realization of pain should not be defined solely in terms of the internal causal systems that typically produce pain.

Lewis' theory suggests a way of resolving the problem cases by allowing that both the internal properties of a cognitive state as well as its external causal role are contingent. Although pain should be identified with internal properties that play a certain external role, the internal properties that actually play that role are contingent upon the internal properties of the population to which that external role is applied. In human beings and Martians, the external role of typical pain is defined by aversive reactions to noxious stimuli. The internal properties that play this external role will be different for humans and Martians, however, because the internal properties of human and Martian populations differ.

In much the same way, the internal causal properties identified with pain have typical causes and effects, but these causes and effects are not strictly necessary. In human beings, firing C-fibers is caused by noxious stimuli, and, in turn, causes withdrawal and protection behaviors. In the madman, however, the same internal system is triggered by moderate exercise and leads to thoughts of mathematics. Although the internal systems typically identified with some cognitive state will be identified via their external relations, in exceptional cases those same internal systems will produce an atypical external role.

Lewis' theory of mind offers an instructive model for a theory of realization because it suggests a way of resolving similar sorts of problem cases that occur in realization. In typical cases, realizations of some kind will achieve the external role identified with that kind through some sort of characteristic internal system. A realization of *corkscrew*, for example, may be described in terms of the internal causal properties that realizations of that type typically possess. These properties may include the property of having a screw and one or more levers. These internal causal systems typically result in the corkscrew's ability to achieve a certain external role, viz., the removal of corks.

In problem cases, the internal causal system that typifies the realization of some kind fails to line up with the external role that is typical for realizations of that kind. As in Lewis' theory, these problem cases take two forms. The first problem case occurs when we have an internal causal system that is typical for realizations of some kind, without the external role typically identified with that kind. These cases present a 'mad pain' sort of problem because our realization is internally conventional, despite the fact that its internal systems result in an unconventional external role.

Suppose we have an artifact that happens to be employed as a paperweight. Upon inspection, we find this paperweight possesses a screw operated by two levers that are braced within a rigid frame. What we find, in other words, is that our artifact possesses internal causal systems that are associated with realizations of *corkscrew*. However, our individual is not employed in the removal of corks, so it does not fulfil the external role identified with realizations of *corkscrew*. On the contrary, it fulfils the external role identified with realizations of *paperweight*.

Taking a cue from Lewis' theory, we can interpret this 'mad-corkscrew' sort of problem by noting that not all realizations of *corkscrew* will be identified by the external role that typically identifies realizations of that kind. As with the madman, this is due to the fact that the external properties that identify an individual as an individual of a certain kind are contingent properties of that kind. Although the madman possesses the internal systems that identify a state as a state of pain, those internal systems do not produce the external relations they typically produce. In the same fashion, we may assert that although our artifact possesses the internal

systems of a corkscrew, those internal systems do not produce the external relations typically identified with realizations of *corkscrew*.

The second sort of problem case arises where an individual does exemplify the external relations identified with realizations of some kind, without the internal systems typically identified with that kind. Realizations of *corkscrew*, for example, are typically identified with an external role that involves exerting force in order to remove a cork. In a typical corkscrew, that external role is achieved through an internal system that involves a screw and one or more levers. The problem is that identifying realizations of *corkscrew* in terms of this internal system does not prevent individuals with very different internal systems from replicating the external role of corkscrews. A cork can be removed from a bottle, for example, by bracing the bottle in a vice and drawing the cork with a forklift. Vice/forklift combinations, however, do not possess the internal properties that typify realizations of *corkscrew*. Such cases represent a 'Martian-corkscrew' sort of problem because the external role that identifies a realization as a realization of a certain kind is produced through an internal system that is atypical for that kind.

Again, we can allow for the 'Martian-corkscrew' scenario by adopting a more flexible understanding of what it is to realize a causal role. Adopting such a view would permit the claim that realizations of *corkscrew* are not always identified by the internal causal system typically identified with realizations of that kind. As with the Martian, the internal properties that identify an individual as a member of a certain kind will be contingent properties of that kind. Although the internal systems of the Martian result in the external role identified with pain, those internal systems are different than the internal systems that typically produce pain. This parallels the situation with respect to our vice/forklift combination, where we may assert that although our vice/forklift combination fulfils the external role that identifies realizations of the kind *corkscrew*, vice/forklift combinations do not possess the internal causal system that realizations of *corkscrew* typically possess.

Recognizing that there are internal and external senses in which individuals fulfil causal roles provides a way of explaining problem cases in realization. The problem of explaining why an artifact with the internal structure of a corkscrew sometimes qualifies as a paperweight is the problem of explaining realization in individuals who are conventional in their internal causal systems, but atypical in the external role those systems fulfil. Correspondingly, the lesson of the

'mad-corkscrew' problem is that realizations should not be identified solely in terms of *which* external role they fulfil. On the other hand, the problem with explaining why a system that fulfils the external role of a corkscrew with the internal systems of a vice/forklift combination is the problem of explaining realization in individuals who are conventional in their external role, but atypical in terms of the internal systems that fulfil that role. Consequently, the lesson of the 'Martian-corkscrew' problem is that realizations should not be defined solely in terms of *how* internal causal systems fulfil an external role.

8.4 An Appropriate Population

Top

As noted, in many cases realizations of some kind will achieve the external role identified with that kind via some sort of characteristic internal system. Corkscrews, in our example, may be described in terms of the internal causal systems that realizations of *corkscrew* typically possess. That internal system may be described by the possession of a central screw and one or more levers. In typical cases, these internal systems will result in a certain external ability. In the case of corkscrews, that ability is the ability to remove corks.

Where an individual possesses both the internal systems as well as the external role identified with some kind, the population to which that individual properly belongs is usually fairly obvious. This is because, in exemplifying both the internal systems and external relations of some kind, an individual will satisfy both internalist and externalist explanations of the realization of that kind. If we have an individual with the internal systems that are typical for corkscrews, and our individual is engaged in the business of removing corks, our individual will satisfy both internalist and externalist descriptions of the corkscrew-role. As a result, we may be confident that our artifact is, in fact, a realization of *corkscrew*.

Of course, asserting that many kinds will possess some sort of characteristic internal causal system is not to say that every kind will possess some sort of characteristic internal system. As Shapiro points out, some kinds are so general that there appears nothing one can say about the kind save for the fact that all members of that kind conform to the criterion that defines the kind. This can be unsatisfying, as it sounds analytic and uninformative to define corkscrews merely in terms of the ability to remove corks. In typical cases, however, we do think that there

is more to corkscrews that merely the ability to remove corks. This is why, in point of fact, corkscrews are rarely identified with vice/forklift combinations. Recognizing that there is more to corkscrews than merely their external role is to associate realizations of corkscrew with some sort of characteristic internal structure.

Again, this is not to assert that the realization of every kind must implicate some sort of characteristic internal structure. The kind paperweight, as noted, places very few limitations on the internal structure of the individual realizing *paperweight*. For this reason, examining only the internal structure of some corkscrew may not reveal whether that individual is fulfilling the external role identified with realizations of *corkscrew* or the external role identified with realizations of *paperweight*. From the point of view of internal structure, there may be no fact of the matter that determines which external role is fulfilled. Instead, the kind ultimately realized is determined by context. Where our artifact is used to remove corks, our artifact will qualify as a realization of *corkscrew*. Where our artifact is used to weight paper, it will qualify as a realization of *paperweight*.

This sort of indeterminacy is consistent with Lewis' discussion of what he terms mad Martian pain. A mad Martian possesses the physical properties of a member of the Martian population, but, because he is mad, those physical properties do not occupy the external role for the mad Martian that they do for members of the typical Martian population. Presumably, this means that when the mad Martian exercises on an empty stomach, cavities in his feet fill with fluid and his thoughts turn to mathematics. From the point of view either the population of Martians or the population of madmen, the mad Martian exhibits some of the properties identified with pain. From the point of view of the normal human population, however, the mad Martian exhibits none of the properties identified with pain. Whether or not mad Martian pain exemplifies the properties of pain, then, is a factor of the population alongside which it is judged.

Lewis offers four criteria to determine whether or not some population constitutes an appropriate standpoint from which to assess an individual. He apparently intends these criteria as measures of plausibility; such that the more criteria apply to some population, the more plausible it becomes to judge an individual alongside that population. The suggestion is that, for any individual *s*, an appropriate population:

(1) should be human

(2) should be a population to which *s* belongs

(3) should be one in which *s* is not exceptional

(4) should be a natural kind

These criteria are then applied to the sample cases, in order to test how the conclusions they render square with our intuitions.

A Martian, although not human, is presumably an unexceptional member of the Martian population. Judging Martian pain in the context of the population of Martians will tell us that Martian pain qualifies as pain, providing that criterion (1) is outweighed by the other three criteria. The madman, on the other hand, is human, but is also an exceptional human. Judging mad pain alongside the population of human beings will tell us that mad pain qualifies as pain, providing that criterion (3) is outweighed by criteria (1), (2), and (4). The situation grows problematic in the case of mad Martian pain, however. Judging mad Martian pain alongside the normal Martian population will tell us that mad Martian pain qualifies as pain only if criteria (2) and (4) collectively outweigh criteria (1) or (3).

The ability of the four criteria to clearly identify an appropriate population is called into question if we examine the application of the criteria in more detail. Peter Alward has pointed out inconsistencies in way Lewis assigns the criteria to subjects in the sample cases.[49] In the case involving the Martian, for example, Lewis suggests that the appropriate population is the population of Martians. The rationale for this choice, according to Lewis, is that criteria (2), (3), and (4) collectively outweigh criterion (1). However, if the population of Martians qualifies as a natural kind, the population of humans would presumably also qualify as a natural kind. Criterion (4), then, would apply to the human population as well as the Martian population. If the Martian is to be evaluated alongside the Martian population rather than the human population, then, it must be because criteria (2), (3), and (4) outweigh (1) and (4) together.

In a similar vein, Lewis suggests that the case involving the madman should be evaluated alongside the human population. The ostensible reason for this is that criteria (1), (2), and (4)

[49] Alward 2004.

collectively outweigh criterion (3) by itself. However, a mad human presumably qualifies for membership in the population of madmen as well as the population of humans. Therefore, we may expect that criterion (2) applies to the population of madmen. If the madman is to be evaluated alongside the human population rather than the population of madmen, it must be because criteria (1), (2), and (4) outweigh (2) and (3) together.

The calculus becomes even more confused in the case of the mad Martian. Lewis suggests that we may judge the mad Martian alongside the Martian population, because criteria (2) and (4) would favor this choice. Judging the mad Martian alongside the human or mad population, on the other hand, would fulfill only fulfill criterion (1) or criterion (3) respectively. Contrary to Lewis' suggestion, however, the human population would actually fulfill criterion (4) as well as criterion (1). The mad Martian population, on the other hand, presumably satisfies (2) as well as (3). If we judge the mad Martian alongside the Martian population rather than the human or mad populations, then, it can only be because criteria (2) and (4) outweigh either criteria (1) and (4) or criteria (2) and (3).

These observations suggest that Lewis' criteria may not be especially helpful in determining an appropriate population from which to assess the realization of pain. This lack of helpfulness is particularly apparent when we consider the relative merit of criteria (2) and (3). Criterion (2) suggests that an appropriate population from which to evaluate *s* should be a population to which *s* belongs. Such a suggestion seems largely redundant. The whole point of determining an appropriate population from which to evaluate an individual is to determine the population to which that individual properly belongs. Although it is true that madmen should be evaluated alongside the population of madmen because madmen belong to the population of madmen, it is equally true that any individual *s* should be evaluated alongside a population of other *s*'s because that is the population to which they belong. For this reason, it is difficult to imagine an appropriate population to which criterion (2) did not apply.[50]

Criterion (3) also appears largely redundant. To assert that some individual is unexceptional relative to some population is to strongly imply that that individual is appropriately considered part of that population. A normal human is appropriately judged

[50] Note, for example, that criterion (2) does apply to every population in our revised version of Lewis' population calculus.

alongside the normal human population, for that is the population alongside which a normal human is unexceptional. Pain in a normal human will then qualify as pain, as normal human pain will exemplify the properties of pain as defined by the normal human population. In the same way, a madman will be appropriately judged alongside the population of madmen, for that is the population alongside which a madman is unexceptional. Mad pain will then also qualify as pain, as mad pain will exemplify the properties of pain as defined by the population of madmen.

Criterion (1) is not redundant, as criterion (1) suggests that we identify pain in terms of the physical properties that are typical within the population of humans. In terms of realization, this amounts to the suggestion that we identify the realization of some kind with the internal systems typically identified with that kind. Of course, the usefulness of this criterion will be justified by those cases where pain is properly identified with the internal causal systems of typical human pain, and opposed by those cases where it is not. The value of the criterion, in other words, will be borne out empirically. If it is not yet known what empirical evidence will oppose the criterion, it cannot be known of what value the criterion is.

Criterion (4) is perhaps the most interesting of the four criteria. Criterion (4) suggests that whether or not an individual realizes some kind should be assessed from the standpoint of whether or not that individual is part of a natural kind. This means that an individual's ability to realize a certain kind will be related to their possession of a feature or property that conforms to some sort of natural grouping. In the case of pain, it suggests the realization of pain will be dependent upon the possession of properties that are characteristic of some natural (and presumably pain-capable) kind.

Criterion (4) may have some usefulness when it comes to the realization of pain, but is clearly of little help when considering the realization of non-natural kinds such as corkscrews, paperweights, and the like. Although the eventual goal of any theory of realization may be to explain the realization of cognitive properties, the applicability of a theory of realization to non-natural kinds will tend to augment a theory's plausibility. Of course, one of Shapiro's central issues with functional kinds such as *corkscrew* is that the manifest variety in the class of corkscrews suggests that there is no significant property intrinsic to corkscrews in virtue of which an individual qualifies as a corkscrew. Consequently, Shapiro is unwilling to consider the realization of functional kinds such as *corkscrew* as the realization of a valid kind.

Despite Shapiro's concerns, there does appear to be some property in virtue of which we are able to recognize certain artifacts as artifacts of a certain kind. Such a property would presumably explain why a waiter's corkscrew appears more similar to a winged corkscrew than it does to a diamond. Whatever that property is, it will presumably not be a property that unites the class of corkscrews as a natural kind. If realization is a relation that can be applied to artifactual kinds, the natural kind criterion will have limited applicability to realization.

Moreover, the discussion of scientific kinds offered in Chapter 3 casts doubt on the strict delineation of kinds into natural and non-natural varieties. Intuitively, an individual would qualify as a member of a natural kind in virtue of some intrinsic property. In sciences like biology, however, individuals are not grouped by their intrinsic properties. Instead, biological individuals are grouped by their extrinsic relations to a common ancestor. What makes an individual a member of the kind *Elephas maximus* is not the possession of a tusk or trunk, but rather having descended from other members of the kind *Elephas maximus*.

If Lewis' population criteria (2) and (3) are not helpful, and criteria (1) and (4) are contentious, the best course of action may be to abandon the criteria in favor of some alternative way of calculating what constitutes an appropriate population for the purposes of realization. Ideally, that alternative would not discriminate between realizations defined by their biological, chemical, functional, or cognitive properties. The same theory that would explain the realization of *corkscrew*, then, could also be used to explain the realization of *mind*.

I propose to define populations rather narrowly; in particular, I propose to define a population in terms of the conversational context that is implicit within some act of attribution. For subject *s* to realize the kind *m* relative to population *p*, by this standard, is for *s* to realize *m* relative to the standard that defines *p* within some act of attribution *a*. After all, when one attributes pain to another, the type of pain intuitively attributed is the type of pain the attributor is familiar with. For a typical human attributor, that type of pain may be caused by a noxious stimulus and identified with the firing of C-fibers. For a Martian attributor, that type of pain may also be caused by a noxious stimulus, but identified with fluid-filled foot cavities. For an individual to be a typical member of a population, by this standard, is for an individual to represent an archetype with respect to the context of attribution.

Understanding a population to be defined by the context of attribution is to understand that what is meant by the term 'realize' will vary. As a result, the claim that '*s* realizes *m*' may express different propositions (and have different truth-values) based upon the context in which that assertion occurs. Relative to population p_1 implicitly defined by some act of attribution a_1, it may be true that *s* realizes *m*, while relative to population p_2 implicitly defined by attribution a_2, it may be false that *s* realizes *m*. The status of realization, under this analysis, is determined locally.

This context-sensitivity adds strength to a theory of realization because it allows for flexibility in the way kinds are determined. This flexibility is necessary because the question as to whether or not a physical individual realizes a particular kind often does depend upon the conversational context in which that question is considered. A vice/forklift combination, for example, is not intuitively understood to be a realization of the kind *corkscrew*. If someone were to present you with a vice and forklift and ask whether it constituted a corkscrew, the answer would likely be 'no'. When the context changes, however, that conclusion may also change.

Suppose you are in a warehouse late at night for a celebration with a few friends and a bottle of wine. A corkscrew quickly becomes necessary, but there is none to be found. In a moment of ingenuity, the wine bottle is braced in a vice and the cork drawn with a forklift.[51] What would we be apt to say in such a situation regarding whether or not a vice/forklift combination realizes the kind *corkscrew*? One obvious response would be to continue to deny that the vice/forklift combination realizes the kind *corkscrew*. This response is unappealing. If realizations of *corkscrew* are at least partly defined by the ability to remove corks, it would appear that a vice/forklift combination must realize some kind of corkscrew. A more conciliatory response might maintain that the vice/forklift combination is not a corkscrew, although it functions 'as if' it were. This response is similarly unappealing. If functional kinds are defined by their functional properties, something that functions 'as if' it were a corkscrew should itself qualify as a corkscrew.

[51] In the interests of science, the hypothesis a vice/forklift combination could actually function as a corkscrew was tested by the author and four volunteers using a machinist's vice and a Bobcat T-190. The hypothesis was confirmed.

A more attractive response would affirm that the vice/forklift combination realizes the kind *corkscrew*, while simultaneously acknowledging the context-sensitivity of that conclusion. This means that the question "Is the vice/forklift a corkscrew?" would be best answered with a response such as "In this situation it is." The response is justified by the idea that, in normal circumstances, a vice/forklift is not considered to qualify as a realization of *corkscrew*. The atypical situation under consideration, however, has prompted a reappraisal of the properties by which the population of corkscrews is defined. Under the more permissive interpretation that results, the vice/forklift may indeed be counted as a member of the population of corkscrews.

Of course, it remains counterintuitive to suppose that a vice/forklift combination could, even in rare circumstances, qualify as a realization of *corkscrew*. Common sense would dictate that standard corkscrews realize *corkscrew* while vice/forklift combinations do not. The point of the contextualist move, however, is to emphasize the idea that some contexts invoke standards of attribution that are different from those of common sense. After all, it is also a matter of commonsense that 'water' refers to uniform molecules of H_2O. As we noted in Section 3.4, however, 'water' may not refer to uniform H_2O molecules in some scientific contexts. Chemists may use the term 'water' to pick out a single isomer or a combination of isomers. At other times, 'water' may refer to the most dominant isomer within a given sample. Although in commonsense contexts we will identify *water* with specific physical properties, this does not prevent water possessing different properties in alternative contexts. In the same fashion, we may assert that although commonsensical contexts will identify realizations of *corkscrew* with a characteristic internal structure, this does not prevent realizations of *corkscrew* from possessing a different internal structure in unusual contexts.

Although I have presented this method of determining population as an alternative to that of Lewis, there is much affinity between the context-sensitivity proposed here and the sort of ideas that Lewis endorses elsewhere. In particular, Lewis is known as an early proponent of contextual approaches to epistemology. Epistemic contextualism holds that key epistemic contexts, such as knowledge and justification, are context-sensitive. This means that a sentence such as "S knows that p" will express different propositions (and have different truth-values) based on the context in which that sentence occurs. Lewis endorses epistemic contextualism,

and affirms that what is meant by knowledge attributions is indeed indexed to the conversational context in which that attribution occurs.[52]

In the paper *Elusive Knowledge*, however, Lewis' contextualism appears to extend beyond epistemological concerns to questions of ontology. This ontological contextualism is most apparent in Lewis' discussion of flatness. Lewis notes that in order to describe a surface as flat there can be no bumps in that surface. As every surface contains some sort of imperfection, describing a surface as flat requires that one ignore imperfections of some sort. Without this willful ignorance, we would have to conclude, absurdly, that nothing is flat. Whether or not something qualifies as flat, in other words, depends on the type of imperfections that one is willing to ignore.[53] However, Lewis' discussion of flatness makes no distinction between what may constitute actual flatness, on the one hand, and the context-sensitive way we might describe actual flatness, on the other. Instead, Lewis asserts that whether or not something really is flat is a context-sensitive matter. In a parallel fashion, a contextual understanding of realization would assert that whether or not something really is a corkscrew will also be context-sensitive matter.

This is not to deny that there are, of course, substantive differences between the realization of flatness and the realization of corkscrews. 'Flatness' is an adjective, whereas 'corkscrew' is a noun. As such, a word such as 'corkscrew' denotes an individual, while 'flatness' will not. It is, therefore, a different thing to talk about a population of individuals that are corkscrews than it is to talk about a population of individuals that are flat.

Nevertheless, there is reason to believe that, population criteria notwithstanding, Lewis is sympathetic towards a contextualist account of realization. This conjecture is supported by Lewis' discussion of domain-specific reductions. In his review of *Art, Mind and Religion* by W.H. Capitan and D.D. Merrill, Lewis notes that there is an apparent contradiction between asserting that (1) there is only one winning lottery number, (2) the winning number is 17, and (3) the winning number is 137. This apparent contradiction is easily resolved, however, by simply appending 'per week' to statement (1), 'this week' to statement (2), and 'next week' to statement (3). In much the same way, Lewis continues, there is an apparent contradiction between asserting that (1) there is a single physical state which realizes pain, (2) pain is physical state *c*,

[52] Lewis 1996.
[53] *Ibid*, p. 554.

and (3) pain is physical state *m*. Again, this apparent contradiction can be dispelled by appending 'for every population' to statement (1), 'in human beings' to statement (2), and 'in Martians' to statement (3).

There is no mention, in this discussion, of any criteria beyond that of context to determine the concept of pain. On the contrary, the concept of pain is explicitly compared to the concept of a winning number. As a winning number is an abstract entity, there can be no non-contextual factors that determine what constitutes a winning number. Lewis asserts that this makes the concept of a winning number comparable to the concept of pain, as "[i]t is the fixed concept expressed by 'pain' that determines how the denotation of 'pain' varies with the nature of the organism in question."[54] The concept of pain, in other words, determines its own extension. If the determination relation Lewis has in mind is some sort of causal relation, Lewis would appear to endorse a contextual understanding of realization.

8.5 Identifying the Pain-Role

Top

What 'Mad Pain' does offer to a theory of realization is a way of connecting the two senses of causal role fulfilment discussed in section 7.3. If we suppose that pain is typically identified by the way in which noxious stimuli produce aversive reactions, we address our expectation as to *which* system of causal relations typically explains the realization of the pain-role. If we suppose that firing C-fibers is the state that occupies this role for the population of humans, we address our expectation as to *how* a system of causal relations explains the realization of the pain-role.

The virtue of this two-level approach is that by allowing that there are different ways in which one individual can realize another, we allow for both *which* and *how* explanations of causal role fulfilment. Allowing for two levels of explanation permits our theory to account for the contingency in the internal and external properties of realization. In the case of pain, accounting for this contingency will permit a theory of realization to accommodate the various explanatory contexts in which the concept of pain is employed. Some of those contexts may raise the possibility that atypical external relations can characterize the experience of pain. In

[54] Lewis 1969, p. 25.

such situations, we might expect an explanation of pain to identify the particular external relations intended to qualify as pain. Other contexts may not allow for the possibility that alternative external relations will characterize the experience of pain. In these latter situations, we might expect an explanation of pain to isolate the particular internal systems that produce pain's external role.

The resulting context-sensitivity implicitly recognizes that the answer as to whether or not a particular individual realizes some kind may not always be the same. A madman qualifies as realizing pain when moderate exercise results in thoughts of mathematics, but only relative to the population of madmen. Relative to the population of Martians, the experience of the madman will not qualify as pain. A human qualifies as realizing pain when their C-fibers fire, but only relative to the population of humans. Relative to the population of Martians, the experience of the human will not qualify as pain. An assessment of realization becomes an assessment that takes place in the context of a certain population, whether or not that population is explicitly acknowledged.

It is this contextual aspect that makes an unqualified appeal as to what realizes a certain causal role ambiguous. In section 7.3, the question was posed as to what realizes the generator-role in a generator. As noted in that section, the question admits of different but equally valid responses. In one sense, we could understand that the generator has the potential to embody several different object-level capacities. After all, generators have the capacity to generate electricity, carbon monoxide, and noise. Although we typically use generators for the production of electricity, there is nothing internal to the generator that designates the production of electricity as more appropriate than the production of noise. Instead, the capacity identified with the generator-role will be determined by some function-attributor. If that attributor happens to be a contractor, the capacity that is valued may indeed be the capacity that results in the production of electricity. If that attributor is an industrial musician, the capacity that is valued may be the capacity that results in the production of noise. To understand one of these capacities as fulfilling the generator-role is adopt a 'which' perspective on the fulfilment of the generator-role.

The second way of fulfilling the generator-role assumes that the capacity identified with the generator is already determined, and interprets the question as a request for the internal

causal systems that figure in the production of that capacity. If we assume that the function of generators is the production of electricity, the request as to what fulfils the generator-role will be interpreted as a request to identify the internal causal systems that figure in the production of electricity. As a typical generator produces electricity though an internal system that involves pistons, drive shaft, rotors and stators, these structures will constitute the system that fulfils the generator-role. Understanding the realization of the generator-role in this way is to adopt a 'how' perspective towards fulfilment of the generator-role.

Adopting a certain perspective towards role fulfilment is necessary because an unqualified appeal as to what fulfils the generator-role is ambiguous. In the generator example, the role-question may be phrased in terms of a 'what'-question, such as:

q. What fulfills the generator-role in a generator?

This 'what' question, however, may be taken in two different ways. On the one hand, we can interpret the question as a request to isolate the capacity in virtue of which the generator qualifies as a generator. In such a case, the question as to what fulfills the generator-role is more accurately interpreted as a 'which' question, such as:

q_1. Which causal process fulfills the generator-role?

On the other hand, we could assume that a certain capacity already defines the generator, whereupon the role-question becomes a question of isolating the internal systems figure in the production of that capacity. In this latter case, the question as to what fulfills the generator-role is more accurately interpreted as a 'how' question, such as:

q_2. How does a certain causal process fulfill the generator role?

In the case of the generator, the two-level approach permits an attributor to describe the realization of the generator-role in a way that is explanatorily relevant to a particular audience. An audience that includes both contractors and industrial musicians, for example, may assume that different capacities define the generator-role. For this reason, an explanation of the generator-role that identifies the generator-role with the production of electricity or the production of noise is apt to be significant. For such an audience, an explanation of the generator-role in terms of pistons, drive shaft, rotors and stators may appear irrelevant. As these

internal structures figure in both the production of electricity as well as the production of noise, explaining the generator-role in terms of pistons, drive shaft, rotors and stators does not settle the question as to the capacity that is properly identified with the generator-role. The explanation that is significant, in this case, is a 'which' explanation.

The same explanation may not be appropriate when the context changes. An audience of only contractors and homeowners, for example, may already assume that the capacity properly identified with the generator is the production of electricity. In such circumstances, explaining the generator-role in terms of the production of electricity is apt to appear uninformative. Consequently, an account of the realization of the generator-role from the standpoint of contractors and homeowners is apt to be a 'how' explanation that identifies the internal systems involved in the production of electricity. If pistons, drive shaft, rotors and stators are the internal systems that figure in the production of the electricity, these will be the structures that are significant to an understanding of the generator-role.

The same contextual aspect that makes an unqualified appeal as to what realizes the generator-role ambiguous may also render an unqualified appeal as to what realizes a particular cognitive state ambiguous. As with the generator, the question as to what realizes a cognitive state can be interpreted in terms of the entity or entities that fulfil(s) a certain causal role. If different understandings of causal role fulfilment are appropriate to different explanatory contexts, however, the question as to what realizes a cognitive state will be determined contextually.

Suppose we are interested in the realization of a cognitive state such as pain. One way of understanding pain-role will be in terms of what pain typically does. From this point of view, pain is a capacity of a certain sort. In typical human beings, what pain does is protect the body from noxious stimuli by initiating withdrawal and protection behaviors. In madmen, of course, pain does something entirely different. In a madman, pain is caused by moderate exercise and produces thoughts of mathematics. Which set of external relations, that of human or madman, constitutes the set of external relations that should be identified with pain is a matter of context. In the context of a typical human, the set of external relations that constitute mad pain is unorthodox. In the context of the madman, the set of external relations that constitute typical human pain is unorthodox. As different understandings of the external relations that identify

pain amounts to different ways of identifying pain, the question of fulfilling the pain-role becomes the question of determining *which* set of external relations are properly identified with pain.

Characterizing pain in terms of what pain is supposed to do also entails that whatever realizes the pain-role will possess causal properties equivalent to that of the pain-role itself. If pain is understood to designate a certain capacity, the only thing that can occupy the pain-role will be something that instantiates the relevant capacity. This means that any realizer of the pain-role will have the same causal properties as a realization of the pain-role. To understand that the pain-role is fulfilled in terms of the way noxious stimuli produce aversive behaviors is to understand that the way noxious stimuli produce aversive behaviors wholly realizes the pain-role. To understand that the pain-role is fulfilled in terms of the way moderate exercise produces thoughts of mathematics is to under that the way moderate exercise produces thoughts of mathematics wholly realizes the pain-role. To understand the realization of pain in terms of which capacity should be identified with the pain-role, in other words, is to understand realization in terms of instantiation.

Alternatively, we could choose to characterize the pain-role in terms of the internal structures through which the capacity identified with pain is achieved. Where the capacity identified with pain is assumed, an explanation of the pain-role becomes an exploration of the internal mechanisms that figure in the production of that capacity. If pain is identified with the way noxious stimuli produce withdrawal and protection behaviors, an explanation of the pain-role will be an explanation of the way internal causal mechanisms are triggered by noxious stimuli in a way that produces withdrawal and protection behaviors. In typical human beings, this may involve a description of the way in which a strong tactile stimulus causes C-fibers to synapse to second-order neurons in the spinal column. These neurons pass an electrochemical signal to the brain, which produces efferent responses that activate certain muscle groups. As this is the causal system by which a noxious stimulus produces withdrawal and protection behaviors, this will be the causal system that fulfils the pain-role. The question as to what fulfills the pain-role, in this latter sense, is more accurately interpreted as the question of *how* a certain causal system fulfills the pain-role.

If we adopt this latter understanding as to what it is to fulfill the pain-role, our description of realization will emphasize the intrinsic properties of realizing individuals. As C-fibers, muscles, and the brain are structures that are internal to human beings, for these structures to fulfill the pain-role if for the pain-role to be fulfilled by properties that are intrinsic to the realizing individual. The relevance of extrinsic properties to realization will be limited because most extrinsic properties will have been become fixed by assuming the external capacity being realized. If the purpose of our explanation is to understand why exposure to a noxious stimulus produces withdrawal and protection behaviors, the extrinsic properties of those withdrawal and protection behaviors will be part of our explanandum rather than its explanans.

Describing the pain-role in terms of the internal structures that produce the capacity identified with pain will also suggest that realizers of the pain-role will not be causally equivalent to realizations of the pain-role. Where pain is explained in terms of several structures working collectively, the pain-role will only be fulfilled in virtue of that collectivity. If C-fibers, muscles and the brain are jointly responsible for fulfilling the pain-role, neither C-fibers, muscles nor the brain will individually possess causal properties equivalent to realizations of the pain-role. To understand the realization of pain in terms of how the pain-role is produced, then, is to understand realization in terms of causal contribution.

Although both ‘which’ and ‘how’ explanations will constitute valid ways of fulfilling the pain-role, the validity of either response derives from the explanatory context in which it figures. Where a particular context allows the possibility that an alternative set of causal relations might play the pain-role, an attributor is apt to interpret the question; “What state plays the pain-role?” in terms of the question “Which causal process plays the pain-role?” Where the context assumes that a particular capacity identifies the pain-role, however, an attributor is apt to interpret the question “What state plays the pain-role?” in terms of the question “How does a certain causal process play the pain-role?” As these different questions mandate entirely different responses, the propriety of any response to the question as to what realizes the pain-role will be determined contextually.

The ambiguity as to what fulfills the generator-role in the realization of a generator, then, reflects a similarly ambiguity as to what fulfills the pain-role in the realization of pain. The question of realization as it pertained to the generator was posed in terms of:

What fulfills the generator-role in a generator?

If we suppose that the realization of cognitive states is also best accounted for in terms of causal role fulfillment, the question as to what realizes pain will take a similar form:

q. What fulfills the pain-role for pain?

As with generator example, two different interpretations of this question are possible:

q_1. Which causal process fulfills the pain-role?

q_2. How does a certain causal process fulfill the pain-role?

The interpretation that constitutes an appropriate interpretation will be a factor of the circumstances surrounding a particular attribution of pain. Where pain may be identified with different capacities, we are apt to interpret the role-question as a request to isolate the particular capacity to be identified with pain. If the identification of pain with a particular capacity is assumed, we are apt to interpret the role-question as a request to isolate the internal causal systems that produce the capacity identified with pain. These different interpretations of the role-question will, in turn, suggest different responses as to what fulfills the pain-role:

r_1. The pain-role is fulfilled by causal role *w* (and not by some other causal role {x, y,..})

r_2. The pain-role is fulfilled by subsystems F1-F*n* of *w* (and not by some other subsystems {G1-G*n,* H1-H*n*, ..} of *w*)

The suitability of either of these responses mirrors the contingency between the physical and functional properties of pain. If pain can be identified with physical properties other than those typically identified with pain, fulfilling the pain-role in the manner suggested by r_2 will require a qualification. The qualification is that identifying pain with the physical properties of pain is contingent upon those physical properties playing the appropriate functional role relative to some population. The same sort of contingency will hold between internalist and externalist interpretations of role-fulfillment. That is to say; identifying pain with the internal causal systems that typically characterize realizations of pain will be contingent upon those internal systems producing the external relations that are typical for pain.

In much the same way, if pain can be identified with functional properties other than those typically identified with pain, fulfilling the pain-role in the manner suggested by r_1 will also require a qualification. In this case, the qualification will be that identifying pain with the functional properties of pain is contingent upon the individual exemplifying those properties being a typical member of an appropriate population. In terms of role-fulfillment, we could correspondingly assert that identifying pain with some external capacity is contingent upon the individual exemplifying that capacity being a typical member of an appropriate population.

8.6 Two-Level Realization

Top

In order to properly account for the realization of cognitive phenomena, then, we require a theory of realization that allows for, and responds to, both 'which' and 'how' interpretations of causal role fulfillment. Only a theory that permits different understandings of role fulfillment will be able to address the contingency between the external capacity typically identified with some realization and the internal systems that typically produce that capacity.

As previously noted, the 'which' aspect of the realization relation will describe the way an individual's external causal behavior may be understood as the instantiation of a particular capacity. Although the internal properties of an individual may be taken to suggest or imply a particular capacity, the capacity an individual ultimately exemplifies will be determined by that individual's extrinsic properties. In particular, it will be determined by the way that individual impacts, and is impacted by, their environment. The second, or 'how' aspect of realization will describe the way an individual's internal causal structures may be understood to produce some external capacity. In situations where a realization is already identified with a particular capacity, accounting for realization by identifying that capacity will not be informative. In such cases, accounting for realization becomes a matter of identifying the internal systems implicated in producing the relevant capacity.

Shapiro's flat theory of realization emphasizes the 'which' aspect of realization. According to flat realization:

(R-S) A physical individual F realizes a function G if the causal properties which individuate G are possessed by F.

Under R-S, individuals realize a kind by possessing the properties that are individuative of that kind. In other words, realizers qualify as realizers by possessing the properties of a realization. This means that realizations and their realizers will be equivalent in causal properties. Realization, under the flat view, becomes a form of instantiation.

One of the chief benefits to understanding realization as a form of instantiation is that the sorts of differences that are understood as relevant to realization are minimized. Shapiro is right to claim that steel and aluminium corkscrews should not count as different realizations of *corkscrew* if steel and aluminium corkscrews are the same with respect to the removal of corks. As the removal of corks is the capacity that defines realizations of *corkscrew*, any differences between steel and aluminium corkscrews that does not impact their ability to remove corks will be differences that are irrelevant to realization.

One of the chief problems with understanding realization in terms of instantiation, however, is that it becomes difficult to account for cases of role fulfilment where many individuals produce the properties of a realization collectively. The causal powers of diamond, for example, are best explained in terms of the causal properties of a population of carbon atoms. If the realization relation is intended to provide explanations of causal role fulfilment, it should explain the way the causal powers of diamond originate in the causal powers of a collection of carbon atoms. As the flat view only allows cases of realization where a realizer instantiates the properties and powers of a realization, however, the flat view would be unable to describe the relation between some carbon atom and diamond as a realization relation.

Understanding realization in terms of the way many individuals produce the powers of a realization collectively is to understand realization in terms of 'how' causal roles are fulfilled. Describing this sort of causal relation is where the dimensioned view of realization excels. According to dimensioned realization:

(R-D) "Property/relation instance(s) F1-F*n*, realize an instance of property G, in an individual *s*, if and only if *s* has powers that are individuative of an instance of G in virtue of the powers contributed by F1-F*n*, to *s* or *s*'s constituent(s), but not vice versa

With R-D, individuals realize a kind by contributing causally to the properties and powers that define realizations of that kind. Where more than one realizer is required to account for the properties and powers of a realization, however, realizers and realizations will not be causally equivalent. Realization, under the dimensioned view, becomes a form of causal contribution.

The chief advantage to understanding realization in terms of causal contribution is that the dimensioned view is well suited to describe the cases of scientific composition that proved problematic for the flat view. As noted, chemists explain the properties of diamond in terms of the properties of a population of carbon atoms. If we identify the diamond as the fulfilment of a certain causal role, and the carbon atoms in terms of the properties they contribute towards that role, the relation between the diamond and carbon atoms should count as a form of realization. As the dimensioned view is able to describe this sort of role fulfilment as a form of realization, the dimensioned view is able to properly account for the realization of compositional kinds.

The chief problem with the dimensioned approach to realization is that allowing the components of a realization to sometimes count as its realizers threatens a triviality problem. If realized individuals are nothing over and above the causal contribution of their component realizers, no change to those component realizers will be possible without the suggestion of a corresponding change in realization. If every individual with a distinct composition is understood as a distinct realization, every kind constituted by more than one individual will be constituted by more than one realization. If every kind is constituted by more than one realization, every kind becomes multiply realizable in principle. Where every kind is multiply realized, the thesis of multiple realization becomes largely trivial.

The motivation for adopting a two-level theory of realization is that such a theory would allow us to exploit the strengths of flat and dimensioned approaches to realization while mitigating their weaknesses. In particular, a two-level theory of realization will offer the opportunity to switch between ‘which’ and ‘how’ senses of causal role fulfilment as the descriptive situation warrants. Lewis’ achieved this flexibility in ‘Mad Pain’ by means of two conjoined principles. Firstly, Lewis asserts that the concepts that correspond to kind-terms are not rigid designators. Instead, concepts pick out first-order states that occupy an external role for some population. Pain, for example, identifies the state of having fluid-filled foot cavities for the population of Martians, while identifying the state of firing C-fibers for the population of

humans. Secondly, Lewis asserts that although these first-order states will typically have certain causes and effects, they will not always have those causes and effects. Pain, for example, is typically caused by noxious stimuli, and typically produces withdrawal and protection behaviors. In the madman, however, pain is caused by moderate exercise on an empty stomach and results in thoughts of mathematics.

The resulting hybrid formulation allows for differences in both the physical and functional properties of a cognitive state. According to Lewis:

> (R-L) "A state occupies a causal role for a population, and the concept of occupant of that role applies to it, if and only if, with few exceptions, whenever a member of that population is in that state, his being in that state has the sort of causes and effects given by the role."

For the realization of pain, the hybrid approach will allow for differences in both the physical and functional properties of pain. For human beings we might assert:

> (R-L_{HP}) Firing C-fibers occupy the pain-role [relative to the population of humans], if and only if, with few exceptions, whenever a human possesses firing C-fibers, their possessing those properties is caused by a noxious stimulus and results in an aversive reaction.

Martian pain would be realized by a different physical state, as we have allowed that the physical properties of pain are contingent. For Martian pain, we might assert:

> (R-L_{MP}) Fluid-filled foot cavities occupy the pain-role [relative to the population of Martians], if and only if, with few exceptions, whenever a Martian possesses fluid-filled foot cavities, their possessing those properties is caused by a noxious stimulus and results in an aversive reaction.

Mad pain could be handled by the exception clause to human pain, as we may choose to view the madman as an exceptional member of the human population. Consequently, firing C-fibers in the madman need not be caused by a noxious stimulus, and need not result in withdrawal and protection behaviors.

The given formulations encapsulate the idea that the proper identification of pain rests upon two variables. In the first place, the external relations that are typically identified with the

pain-role are not the external relations that will always be identified with the pain-role. As a result, the external relations that identify the pain-role must allow for exceptions. Secondly, the internal causal system picked out by pain's external role will not always be the internal causal system that is typically picked out by that role. As it is possible for different sorts of internal systems to produce the same external role, the occupant of the pain-role will be indexed to the intrinsic properties of the relevant pain-capable population.

For this latter reason, any conception of pain that is intended to be equally applicable to either human or Martian individuals will not be able to account for the realization of pain in terms of causal systems within the experiencing individual. This is because, as noted, the internal causal systems associated with human and Martian pain differ. Human pain is associated with the firing of C-fibers, while Martian pain is associated with fluid-filled foot cavities. Instead, a conception of pain appropriate to a mixed population of both humans and Martians should account for the realization of pain in terms of the stimuli that produce firing C-fibers and fluid-filled foot cavities, as well as the behaviors that follow from firing C-fibers and fluid-filled foot cavities:

> (R-L_{HMP}) Bodily damage leading to withdrawal and protection behaviors occupies the pain-role [relative to the population of humans and Martians], if and only if, with few exceptions, whenever a human or Martian exhibits this model, the exhibition of this model constitutes an aversive reaction to noxious stimuli.

Broadening Lewis' approach to pain to realization more generally produces the following formulation of hybrid realization:

> (R-H) Causal properties F1-F*n* realize causal role G, in an individual *s* [, relative to population p], if and only if, with few exceptions, whenever *s* possesses F1-F*n,* the possession of F1-F*n* results in the external causal relations that are individuative of G.

According to this formulation, a causal role (G) is identified in terms of the external relations that individuate that role. The realization of that causal role (G) is then explained by identifying the causal properties that typically individuate G within some population (p). Whether these individuating causal properties are largely intrinsic properties of *s* or largely extrinsic properties

of *s* will be determined by the nature of population p. Therefore, we should amend our formulation with a caveat:

(R-H) Causal properties F1-F*n* realize causal role G, in an individual *s* [, relative to population p,] if and only if, with few exceptions, whenever *s* possesses F1-F*n,* the possession of F1-F*n* results in the external causal relations that are individuative of G.

* Whether causal properties F1-F*n* are intrinsic properties of *s* or extrinsic properties of *s* will be determined by the properties define population *p*.

This hybrid understanding of realization allows us to explain the realization of scientific kinds, insofar as it supports a conception of realization as a form of causal contribution. The realization of hardness in a diamond, for example, may be explained in terms of the causal contribution of a population of carbon atoms:

($R\text{-}H_{DH}$) The orientation and bonding properties of a population of carbon atoms realize the hardness of a diamond [, relative to the population of diamonds], if and only if, with few exceptions, whenever a diamond possesses those properties, the possession of those properties results in the external causal relations that are individuative of hardness.

* As the population of diamonds is defined by individuals with characteristic internal properties, the realizing properties of hardness in a diamond will be intrinsic properties of that diamond.

The same hybrid formulation also allows us to explain realization in cases where realization is understood as a form of instantiation. An artifact *s* that possesses two levers that exert force on a screw, for example, may be understood to instantiate the properties that define realizations of *corkscrew*:

($R\text{-}H_{CS}$) The causal properties possessed by an artifact with two levers that exert force on a screw realize the corkscrew-role for a corkscrew [, relative to the population of corkscrews], if and only if, with few exceptions, whenever a corkscrew possesses two levers that exert force on a screw, the possession of those properties results in the external causal relations that are individuative of corkscrews.

* As the population of corkscrews is defined by individuals with characteristic external effects, the realizing properties of corkscrew-ness in a corkscrew will be extrinsic properties of that corkscrew.

Under this hybrid conception of realization, all realizing properties will ultimately be contingent. The external causal relations of some realization will be contingent because the realization of some kind may not always possess the external causal relations that are typical for realizations of that kind. Although an artifact with two levers that exert force on a screw will typically possess the external causal relations of a corkscrew, in exceptional cases that same artifact may possess the external relations that are individuative of paperweights.

Internal causal properties will also be contingent to realization because the properties that are relevant to the realization of some external role will be the properties that typically realize that role in the population to which an individual belongs. Where an individual is a member of a different population, the internal causal properties that produce that role may also be different. Conceiving of realization in this manner allows us to account for the way in which a vice/forklift combination might realize the external role of a corkscrew:

($R\text{-}H_{VF}$) The causal properties possessed by an ad-hoc mechanical apparatus incorporating a vice to hold a bottle and a forklift to draw the cork realize the corkscrew-role [, relative to the population of corkscrews], if and only if, with few exceptions, whenever a vice/forklift combination possesses those properties, the possession of those properties results in the external causal relations that are individuative of corkscrews.

* As the population of corkscrews is defined by individuals with characteristic external effects, the realizing properties of corkscrew-ness in a vice/forklift apparatus will be extrinsic properties of that apparatus.

8.7 Overcoming Objections

Top

The hybrid theory of realization is effective because it appeals to two intuitions that govern our understanding as to the identity of realized kinds. The first intuition is that realizations should be identified in terms of that which typically fulfils a causal role, rather than by the causal role

itself. Identifying realizations in terms of the typical occupant of a causal role addresses our intuition that the identity of an individual as a token of a certain kind derives from that individual's intrinsic properties. Typical realizations of *corkscrew,* for example, have an internal structure that involves one or more levers and a screw. To define realizations of *corkscrew* merely in terms of the external ability to remove corks, of course, would be to ignore this typical internal structure. Identifying realizations of *corkscrew* solely in terms of the external cork-removing role would also equate individuals that are cork-removers by design and those that are not from the standpoint of realization. If we wish to assert that some ways of realizing a kind are more conventional than others, we must acknowledge that realizations are defined by more than merely their ability to fulfil some external role.

The second intuition that governs our understanding of realized kinds is that the identity of an individual as a token of a certain kind derives from the way in which that individual affects, and is affected by, their environment. Identifying an individual by their relationship to their environment suggests that realizations should be identified by their extrinsic properties. In typical cases, for example, an artifact that possesses an internal structure with two levers and a worm gear will be an artifact that is used to remove corks. As a result, we may suppose that that individual properly qualifies as a realization of the kind *corkscrew*. Where an agent chooses to use the same artifact to weight paper, however, the properties of having two levers and a worm gear will be possessed by an artifact that realizes the kind *paperweight*. Whether or not our artifact possesses two levers and a worm gear, in this case, is irrelevant with respect to the kind it realizes. Instead, the identity of the artifact as a realization of a certain kind derives completely from its extrinsic properties.

By appealing to both of these intuitions, the hybrid account is better positioned to respond to some of the objections confronting flat and dimensioned realization. We noted in section 6.7, for example, that accepting the dimensioned view of realization seems to lead to a triviality problem. The problem comes about because the dimensioned view draws a very tight connection between the causal properties of component realizers and the properties of the ensuing realization. As a result, differences in realizing individuals will suggest a corresponding difference in realization. As every individual stands to differ, in some small way, from every other individual, every individual begins to resemble a unique realization. Where every

individual qualifies as a unique realization, every kind becomes multiply realizable in principle and the thesis of multiple realization loses much of its significance.

The hybrid view largely sidesteps the triviality issue because hybrid realization identifies realizers of some kind with whatever happens to fulfil the external role that identifies realizations of that kind. This external role is given by the way an individual affects, and is affected by, their environment. As internally diverse individuals can potentially affect, and be affected by, their environment in the same way, a difference in realizing individuals may still lead to sameness at the level of realization. Steel and aluminium corkscrews, for example, may differ in terms of their rigidity. For this reason, we may consider steel and aluminium corkscrews to embody a difference in their causal properties. As long as both individuals remove corks, however, steel and aluminium corkscrews will qualify as identical ways of fulfilling the corkscrew-role under hybrid realization. A difference in the realizing properties of steel and aluminium corkscrews, in other words, does not produce a difference at the level of realization.

It is this same emphasis on external role fulfilment that makes the hybrid view largely impervious to Shapiro's dilemma for standard accounts of multiple realization. The first horn of the dilemma notes that where realizing kinds do not differ in terms of the properties that are causally relevant to realization, they will qualify as the same realization of the same kind. Steel and aluminium corkscrews will qualify as the same realization of *corkscrew*, for example, if steel and aluminium corkscrews are the same with respect to their corkscrew-related properties.

The second horn of the dilemma asserts that, when realizations are defined by their functional properties, individuals that perform the same function in different ways will be individuals that differ in their causally relevant properties. As the properties that are relevant to cork removal in a winged corkscrew differ from those that are relevant to cork removal in a waiter's corkscrew, we should consider winged and waiter's corkscrews to differ in terms of the properties that are causally relevant to being a corkscrew. If functional kinds are defined by their causal properties, however, individuals that differ in their causally relevant properties will also be individuals that realize different kinds. As in neither the first case nor the second will we have a situation where the same kind has different realizations, the dilemma represents a challenge to the possibility of multiple realization.

Hybrid realization escapes the dilemma for much the same reason that the hybrid view was able to sidestep the triviality problem. As long as realizations of some kind are defined in terms of that which fulfils a certain causal role, the importance of an individual's internal properties to realization will be limited. Again, this will be because individuals that are internally diverse may still affect, and be affected by, their environment in the same way. If internally diverse individuals affect their environment in the same way, those individuals may qualify as the same realization. Although winged and waiter's corkscrews may differ in their internal properties, they are identical with respect to their ability to remove corks. If this external role is the fundamental factor that defines realizations of *corkscrew*, winged and waiter's corkscrews would qualify as the same realization of *corkscrew*. For this reason, hybrid realization will not accept the claim that individuals that differ in their causally relevant properties will always be individuals that realize different kinds. As denying this assertion amounts to a denial of the second horn of the purported dilemma, the dilemma is invalidated.

Under a hybrid conception of realization, individuals that differ in their causally relevant properties may qualify as realizations of the same kind if they instantiate the same external role. Shapiro is unlikely to condone this idea due to his conviction that any theory that individuates kinds so broadly is not actually claiming anything very interesting. According to Shapiro's taxonomic standard, grouping individuals as members of the same kind should tell us something interesting about those individuals when they are classified in that way. Shapiro's understanding of kinds implies the invalidity of functional kinds, as a wide variety of different individuals may perform the same function in causally different ways. As a result, there may be little to unite the class of individuals that purports to be a functional kind save their performance of the function that defines the kind.

We could specify this sort of trivial definition for pain, for example, by identifying pain with a very general understanding of the external causal relations that typify pain. Such a specification might identify pain as nothing more than an aversive reaction to noxious stimuli. If this were all there were to pain, however, many phenomena that are not intuitively classified as pain would qualify as pain. Certain human and mollusc experiences would qualify as pain, as would the experience of any plant or mechanical device that recoiled from a noxious stimulus. Even a wind-blown newspaper could qualify as experiencing pain, providing we interpreted the

wind as a noxious stimulus and the movement of the newspaper as an aversive reaction. Without some sort of constraint on the internal structure of pain, it would seem that almost anything could qualify as pain. Although identifying pain by its external role will accommodate legitimate pain experiences, it will also allow wildly interpretative or metaphorical examples of pain to qualify as pain.

Hybrid realization responds to this permissiveness worry by emphasizing that realizations of the same kind will often demonstrate internal similarity. This is due to the fact that the external causal relations that identify the realization of some kind are most often a product of the same internal systems. Within the population of humans, for example, realizations of pain are identified with firing C-fibers. This will be because, relative to the population of humans, firing C-fibers is the internal state most often produced by exposure to a noxious stimulus, and most often productive of aversive behavior. The caveat is that the hybrid view understands that the internal systems that produce an external role are a factor of the population to which an individual belongs, such that what constitutes the typical realizer for an external role will also be a factor of the population to which an individual belongs.

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Accounting for the realization of a cognitive state such as pain is complicated by the fact that our understanding of what pain is appeals to different intuitions. One intuition tells us that pain is a physical thing that should be defined in terms of its physical properties, while the other tells us that pain is a functional thing that should be defined in terms of its functional properties.

One way of resolving this tension was suggested by David Lewis in the paper ‘Mad Pain and Martian Pain’. According to Lewis, pain may be defined in terms of the physical state that typically occupies a certain causal role for some population, where that role is specified in terms of the factors that typically cause pain, as well as its typical results. As different populations are apt to have different physical properties, the physical state that actually occupies the pain-role will be contingent. As not every pain experience will have the causes and effects of typical pain, the functional properties of pain will also be contingent. Lewis’ formulation suggests two different ways in which a causal role may be fulfilled. Firstly, a causal role may be fulfilled in

terms of the way the internal properties of an individual result in a certain external capacity. Secondly, a causal role may be fulfilled in terms of the way some external capacity may be understood as the instantiation of a psychological state. If realization is to be understood in terms of the way causal properties fulfil a causal role, this means that there will be two ways of realizing a causal role.

A hybrid theory of realization that incorporates this two-level approach suggests an effective way of dealing with some of the problem cases that occur in realization. The first type of problem case occurs when an individual has the internal systems that correspond to some kind without the external role that is typical for that kind. As the hybrid view allows that realizations of some kind may not always possess the external causal relations that will be typical for that kind, the hybrid view is able to accommodate this first type of problem case. The second type of problem case occurs when an individual does possess the external role that is typical for some kind, without the internal systems that typically produce that external role. As the hybrid view also allows that the internal properties that realize an external role will be the properties that typically realize that role in the population to which an individual belongs, the hybrid view is able to accommodate this second type of problem case.

Acknowledging that both the internal and external properties of a realization are contingent also allows the hybrid view to explain the objections faced by flat and dimensioned accounts of realization. As the hybrid view identifies realizations in terms of their external role, the hybrid view accepts that realizations with internal causal differences may sometimes qualify as realizations of the same kind. This obviates the second horn of Shapiro's dilemma and, as a result, the dilemma itself. The same principle also neutralizes the triviality worry confronting the dimensioned view. That worry suggested that by identifying realizations with the effects of an individual's causal components, the dimensioned view may be committed to the claim that every compositionally unique individual can qualify as a unique realization. Again, by identifying realizations of some kind in terms of their external role, the hybrid view accepts that realizations with internal causal differences may qualify as realizations of the same kind.

Demonstrating the way in which the hybrid view effectively describes the realization of actual pain is the topic of chapter 9.

Chapter 9

Top

Applying the Two-Level View

In philosophy, we frequently use examples designed to promote a particular point of view by focusing the reader's attention on important facets of features of an issue. Daniel Dennett has aptly termed these types of examples 'intuition pumps'.[55] Mad pain may be described as an intuition pump because it focuses attention on the idea that pain is only contingently related to the functional role typically identified with pain. If pain is only contingently identified with its typical functional role, we cannot account for the realization of pain in terms of some theory that identifies pain with the functional role of typical pain. Martian pain also serves as an intuition pump because it focuses attention on the idea that pain is only contingently related to the physical properties of typical human pain. If pain is only contingently identified with the physical properties of typical pain, we cannot account for the realization of pain in terms of some theory that identifies pain with the physical properties of typical pain.

As intuitions pumps, mad pain and Martian pain may not be as persuasive as were when Lewis wrote his original paper. Supposing that some pain will have the functional role of typical pain even though that pain is realized in a physically anomalous manner is to posit a disconnection between the subpersonal properties of pain and its personal-level manifestation. Supposing that other pain will be characterized by an unusual functional role even though it is realized in a physically conventional manner is to affirm a similar disconnection. Positing this sort of disconnection, however, runs counter to the trend amongst some philosophers to understand cognition as embedded within its social and physical context. Where the cognitive properties of a state are embedded in this way, disconnections of the sort envisioned by either mad pain or Martian pain would be implausible.

In section 1.1, we noted that a plausible theory of realization should be subject to nomological constraints. This means that even if we acknowledge that functions may be brought about in different ways, the mere characterization of some kind in functional terms will not warrant the conclusion that that kind is multiply realizable. The realization of pain may be

[55] Dennett, 1984.

constrained in this way. If the realization of pain requires certain functional relations that fluid-filled foot cavities are nomologically incapable of producing, for example, Martian pain will be nomologically impossible. This represents a concern for hybrid realization, insofar as the hybrid view was developed against the background that a comprehensive theory of realization needed to account for the contingency between the physical and functional properties of pain.

My intention in this final chapter is to illustrate the way in which the hybrid account may be used to describe the realization of actual, rather than merely hypothetical, phenomena. In particular, my intention is to describe the way in which the hybrid account may be employed to describe the realization of actual pain. With this goal in mind, the first two sections of the chapter demonstrate how adopting the hybrid account is necessary in order to fully account for the variety of pain phenomena. Where the physical and functional properties of actual pain can be contingent, accounting for the realization of pain will require a theory that allows for contingency in the physical and functional properties of realization. The final section of the thesis offers one possible way in which pain might be multiply realized, within the context of a hybrid approach to realization. As the hybrid approach envisions two different levels at which causal roles are fulfilled, the hybrid approach will allow two levels at which multiple realization may occur.

9.1 Phantom Limb Pain as Martian Pain

Top

Intuitively, the physical properties identified with some cognitive state involve a degree of contingency. Although a physicalist may identify the realization of pain with the firing of C-fibers, for example, they will usually allow that pain in me should be identified with the firing of my C-fibers, while pain in you should be identified with the firing of your C-fibers. Even though the physical properties of my firing C-fibers may be different from the physical properties of your firing C-fibers, in other words, this difference is not significant with respect to the realization of pain. The claim that pain should be identified with firing C-fibers, in this case, is more precisely described as the claim that pain should be identified with the causal properties that are distinctive of firing C-fibers. As a result, a physicalist may stipulate that as long as an

individual possesses physical properties that are causally equivalent to the properties of typical pain, that individual would be capable of pain.

Physicalists may also allow novel or unique structures to be identified with pain, providing those structures are comparable in some way to those of typical pain. The polydactite discussed in section 8.1, for example, possesses a sixth-finger that is comparable to the digits possessed by typical humans. For that reason, it is plausible that an unpleasant stimulus applied to the sixth-finger of a polydactite would result in the experience of pain. Although sixth-finger pain implicates a physical structure few human beings possess, that structure is intuitively compatible with the experience of pain. Presumably, this is because the physical properties of sixth-finger pain are comparable to the physical properties of typical pain. As a result, a physicalist may also grant that as long as an individual possesses physical properties that are causally comparable to the properties of typical pain, the physical properties of typical pain will be unnecessary for pain.

The idea of Martian pain asserts much more than this, however, in that Martian pain contends that there need be little or no similarity between the physical properties of pain and the physical properties of typical pain. The Martian does not possess C-fibers, nor does the Martian possess any internal structure causally comparable to C-fibers. As a result, the possibility of Martian pain requires accepting the contention that the physical properties of typical pain, or something comparable to the physical properties of typical pain, are not necessary for pain.

There is empirical evidence to support this sort of contention, however, in the phenomenon known as phantom limb pain. In phantom limb syndrome, individuals experience sensation in limbs that are absent due to amputation or congenital deficiency. With phantom limb pain, these sensations are experienced as pain. These pain sensations range in intensity from minor irritants to experiences of extreme agony, and are experienced, to a greater or lesser degree, by the majority of amputees.[56] Those who suffer from phantom pain manifest most of the functional properties of typical limb pain. Sufferers are able to make verbal reports on the quality and intensity of their phantom pains, react to the perception of further damage to their

[56] Sherman, Sherman, and Parker report the results of a survey of 5000 American amputees. Of the 55% that responded to a mailed questionnaire, 78% reported phantom limb pain. Sherman, Sherman, and Parker 1984

phantom limbs, and sometimes alleviate phantom pain by imagined movements of their phantom limbs.[57]

Initially, it was believed that the physical properties of phantom pain would be related to the physical properties of typical pain. In particular, it was believed that the physical properties of phantom pain were the result of traumatic damage to the peripheral nervous system incurred during amputation. Neuromas, or stunted growths of nerve tissue, are known to form at the point of amputation. The nerves within these neuromas possess action potentials that differ from those of healthy nerve tissue, and, as a result, may be engaged in sending false or confused information to the brain. If the brain is unable to properly decipher this information, the nerve signal may take the form of pain. If this were the case, we might explain phantom pain in terms of a malfunction of the nervous system, and plausibly assert that the physical properties of phantom pain remain much as they are for typical pain. Although the physical system underlying phantom pain has malfunctioned, the physical properties of typical pain and the physical properties of phantom pain would remain, in some sense, comparable.

The accuracy of this explanation as to the origin of phantom pain has been called into question, however, by the fact that phantom limb pain also occurs in individuals that are missing limbs do to a congenital deficiency. As neuromas tend to be produced by amputation, individuals with congenital limb deficiency do not develop neuromas. If individuals with congenital limb deficiency experience phantom pain, then, an explanation of phantom pain cannot rely on the idea that neuromas cause phantom pain. Furthermore, experiments to relieve phantom pain by blocking the sympathetic nervous system have been unsuccessful or inconclusive. In one such study, recent amputees given epidural injections of bupivacaine and morphine recorded a reduction in phantom pain of only 4% over that of the control group.[58] Partly as a result of these factors, the peripheral nervous system is now believed to be only one of several factors that figure into an explanation of phantom pain.

If the physical object of phantom pain is ephemeral, and the physical mechanism of phantom pain is only partly related to that of typical pain, the claim that the physical properties of phantom pain are comparable to that of typical pain begins to look dubious. Indeed, some

[57] Ramachandran and Ramachandran 1996.
[58] Nikolajsen and Jensen 2001.

studies suggest there is actually very little connection between the non-cranial physical properties of phantom limb sensations and those of actual limbs. Peter Brugger and G. Lorimer Moseley have demonstrated that individuals with phantom limb syndrome are able to contort their phantom limbs in ways that are not physically possible for actual limbs.[59] Brugger and Moseley take this to indicate that the functional properties of phantom limbs may be entirely independent of the physical properties of typical limbs.

McGeoch and Ramachandran report an even more remarkable case involving a patient born with only three fingers on her right hand. The patient in question underwent amputation of this deformed hand following a car accident, and consequently experienced phantom limb syndrome in the absent hand. Strangely, the phantom hand was not experienced as having three fingers. Instead, the phantom hand was experienced as having five fingers, despite the fact that the patient had never actually possessed a five-fingered right hand.[60] McGeoch and Ramachandran explain this phenomenon by hypothesizing that the brain may contain an innate representation of a five-fingered right hand. Although the influence of this representation may have been suppressed so long as the patient possessed a hand with three fingers, the amputation of the three-fingered hand allowed the innate representation of a five-fingered hand to become psychologically dominant. This may be further evidence that the functional properties of phantom limbs are independent of the physical properties of those limbs.

If the functional properties of phantom limbs are independent of the physical properties of typical limbs, we should allow that the functional properties of pain sometimes originate in physical properties that may be unrelated to the physical properties of typical pain. Pain is typically the result of damage to the body. In typical cases, information about this damage is relayed to the brain via the peripheral nervous system. With phantom pain, however, bodily damage is illusory. Moreover, the peripheral nervous system appears to play a very limited role in an explanation of phantom pain. As a result, we may claim that the physical properties of phantom pain are notably different from the physical properties of typical pain. If this is case, the physical properties of typical pain will be a contingent, rather than necessary, component of pain.

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[59] Moseley and Brugger 2009.
[60] McGeoch and Ramachandran 2012.

One of the two principles of the hybrid approach to realization is that the internal causal systems identified with the realization of some kind do not have to produce the capacity identified with that kind, even if they typically will. The idea of Martian pain was used to motivate this principle, as Martian pain does not have the internal causal structures typically identified with the realization of pain. The plausibility of Martian pain is not a prerequisite to the plausibility of hybrid realization, however, as the phenomena of phantom pain offers an empirical parallel to Martian pain.

With both Martian pain and phantom pain, individuals manifest the external causal properties that typically characterize the pain-role. This means that an individual experiencing Martian pain or phantom pain may groan and writhe, issue verbal reports that they are in pain, and generally seek out ways of stopping or reducing that pain. With both Martian pain and phantom pain, these functional properties do not arise in virtue of the physical properties that typically produce pain. In the Martian, the functional properties of pain arise in virtue of fluid-filled foot cavities, while in phantom pain, they arise in virtue some other atypical physical properties. In order for phantom pain to qualify as pain, then, the physical properties of typical pain must be properties that are contingent to pain.

The hybrid view allows for phantom pain by identifying some realizations of pain in terms of the external role pain typically plays. If that role requires those that suffer from pain to make verbal reports on the quality and intensity of their pains, react to the perception of further damage, and sometimes alleviate their pain through limb movements, the hybrid view will identify phantom pain as a realization of pain. As the hybrid view also allows that the physical properties of a realization are contingent, the fact that phantom pain does not share the physical properties of typical pain is unproblematic.

9.2 Pain Asymbolia as Mad Pain

Top

Phantom limb pain is remarkable because, in phantom limb pain, pain occurs without the physical properties that are typically identified with pain. A different sort of pain, pain asymbolia, is remarkable because, in pain asymbolia, pain occurs without the functional properties that are typically identified with pain. In this respect, pain asymbolia is comparable to

Lewis' idea of mad pain. Mad pain was intended to demonstrate that there need be no similarity between the functional properties of pain and the functional properties of typical pain. After all, pain in the madman is caused by moderate exercise on an empty stomach, and results in thoughts of mathematics. In order for mad pain to qualify as pain, then, we must accept the contention that the functional properties of pain, like the physical properties of pain, are contingent.

As noted in section 7.1, there is a sense in which it is taken for granted that the functional properties of pain are contingent. This sense of contingency in the functional properties of pain is represented by the element of volition. If someone spills hot tea on my hand, for example, I may exclaim "that's hot!" and quickly withdraw that hand. If the Queen spills hot tea on my hand at a royal reception, however, I may choose not to behave in the way a burn usually causes me to behave. This is because, in the latter case, my behavior is overruled by a sense of etiquette. Although volition has the potential to mitigate the pain-role when that role is construed only in terms of behavior, volition is less apt to influence the pain-role when that role is construed in terms of dispositions. Although I may not exclaim loudly when the Queen spills tea on my hand, for example, I may still be disposed to exclaim loudly. As this is the same disposition that arises when someone other than the Queen spills hot tea on my hand, the pain-role in both situations would be the same.

When we construe the pain-role in dispositional terms, however, there is still reason to doubt that the functional properties of pain are a necessary component of pain. This is because some pain phenomena are characterized by causal-roles that seem inappropriate to the sensation experienced. Paradoxical cold, for example, occurs when extremely hot temperatures are perceived for a short period of time as being extremely cold. Thermal perception of either hot or cold occurs when sensory receptors in the skin, known as thermoreceptors, respond to thermal stimuli. Hot stimuli are perceived through the stimulation of hot thermoreceptors, while cold stimuli are perceived through the stimulation of cold thermoreceptors. In some cases, an unusually strong hot stimulus can overload the peripheral nervous system, producing a systemic malfunction where both hot and cold thermoreceptors fire. The result can sometimes be the misperception of a very hot stimulus, for a brief period of time, as a cold stimulus. Hot tea spilled on one's hand, under these circumstances, could cause an individual to incongruously exclaim "that's cold!"

Although paradoxical cold does call into question whether pain must always be accompanied by the typical pain-role, the phenomenon does not demonstrate that the role-properties of pain are entirely contingent. This is because, with paradoxical cold, the functional properties of thermal pain are still present. With paradoxical cold, an unpleasant thermal stimulus still produces the withdrawal and protection behaviors identified with pain. Moreover, the hot thermoreceptors that properly respond to hot stimuli still function in the appropriate way, although their effect is temporarily blocked by the influence of firing cold thermoreceptors. The result is a situation where the functional properties of thermal pain are largely intact, although the stimulus causing pain is misperceived.

A much more persuasive example of contingency in the functional properties of pain is illustrated by the phenomenon known as pain asymbolia. Understanding pain asymbolia requires drawing a very counterintuitive distinction between the sensorial aspect of pain and its motivational aspect. This same distinction has been variously described as a distinction between sensations proper and non-sensory affective feelings,[61] as a distinction between the somesthetic quality of pain and its aversiveness,[62] and, more confusingly, as a distinction between pain and painfulness.[63] Regardless of the label attached to the distinction, the purpose of the distinction is to separate the sensory component of pain, on the one hand, from the suffering occasioned by pain, on the other. For the purposes of clarity, the best way of describing the distinction may be in terms of a difference between the way pay feels and the ability of that feeling to cause distress.

This distinction between the sensorial and motivational aspects of pain is highly counterintuitive. Our commonsensical way of describing pain assumes that pain sensations are inherently unpleasant. To explain something as causing pain sensation is understood as an explanation of aversive behavior. If someone asks me why I withdrew my hand from the stove, for example, it will be sufficiently explanatory for me to note that contact with the stove caused a pain sensation in my hand. The sensory and motivational components of pain are assumed to go together because, in the vast majority of cases, they do go together. When I burn my hand, for example, I feel a particular sensation. That sensation is such that I want it to stop. As every pain

[61] Aydede 2000.
[62] Clark 2006.
[63] Hardcastle 2000, also Grahek 2001.

sensation I have heretofore experienced has been accompanied by the same feeling of unpleasantness, I may come to believe that pain sensations are inherently unpleasant.

The idea that pain sensations are inherently unpleasant is reinforced by the difficulties we encounter in trying to describe why pain sensations should qualify as painful without referring to their unpleasantness. Consider the following list of pain descriptors, taken from the McGill Pain Questionnaire:[64]

> nagging, nauseating, agonizing, dreadful, torturing, suffocating, fearful, frightful, terrifying, punishing, grueling, cruel, vicious, killing, wretched, blinding, annoying, troublesome, miserable, intense, unbearable, spreading, radiating, penetrating, piercing, tight, numb, drawing, squeezing, tearing, cool, cold, freezing, pinching, pressing, gnawing, cramping, crushing, tugging, pulling, wrenching, hot, boring, scalding, searing, tingling, itchy, smarting, stinging, dull, sore, hurting, aching, heavy, tender, taut, rasping, splitting, tiring, exhausting, sickening, flickering, quivering, pulsing, throbbing, beating, pounding, jumping, flashing, shooting, pricking, boring, drilling, stabbing, lancinating, sharp, cutting, lacerating

Although the list can be used to describe many sensations which will intuitively qualify as pain sensations, it will be difficult to describe what those sensations have in common aside from their unpleasantness. For this reason, it may seem that when we apprehend a pain sensation we are apprehending something in virtue of its unpleasantness.

The impression that sensations of pain are somehow inherently or intrinsically unpleasant is challenged by empirical pain research. This research suggests that, although in the vast majority of cases the sensory and motivational components of pain will co-occur, in a very few exceptional cases they will not. Those with pain asymbolia, as a case in point, experience the sensation of pain without experiencing that sensation as unpleasant. Pain sensations, for asymbolics, are experienced as having the same qualitative character pain sensations are typically understood to have. Piercing one's finger with a needle still causes a pricking sensation in pain asymbolics, while inadvertently touching a hot stove still causes a burning sensation. Remarkably, however, pain asymbolics do not perceive these sensations as inherently unpleasant. As a result, an asymbolic experiencing even intense pain sensation may give no outward behavioral indication of that experience.

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[64] Melzack 1975.

Pain asymbolia is usefully distinguished from related pain phenomena that approximate its behavioral effects, but do not demonstrate the dissociation of pain from its emotional/motivational component. Congenital analgesia, sometimes referred to as congenital insensitivity to pain, is another rare pain phenomenon that is sometimes confused with pain asymbolia. In congenital analgesia, both the sensory and motivational component of pain are diminished or absent. Congenital analgesia usually comes about as the result of increased endorphin production in the brain. As endorphins have an opiative effect on the central nervous system, an increase in endorphin levels means that the nociceptive neurons that transmit pain information will tend to fire at higher action potentials than they usually do. For this reason, noxious stimuli will fail to elicit the usual nervous system reactions.

In congenital analgesics, then, both sensation and emotional reaction are diminished. If analgesics are insensitive to pain sensation, however, the label 'congenital insensitivity to pain' is misleading. Congenital analgesics are not insensitive to pain per se, they are insensitive to the harmful stimuli that usually cause pain. If harmful stimuli do not cause congenital analgesics pain sensation, they cannot properly be described as indifferent to pain sensation. In other words; if placing your hand on a hot stove does not cause you to feel the sensation of pain, it is not pain that you are insensitive to. Although congenital analgesics do not react to pain in the same way as you or I might, they also do not feel pain sensation in the same way as you or I might.

This is not the case with pain asymbolia, as asymbolics have full and complete discrimination of pain sensation. Pain asymbolia originates when peripheral nociceptors of the somatic sensory system are stimulated in the usual way. However, due to the influence of opioid alkaloids or surgical intervention, transmissions from the somatic system are interrupted before they reach the cerebral cortex. As a result, asymbolics exhibit a disconnection between the information available to the sensory system, on one hand, and the limbic system, on the other. As the flow of information to the sensory system is relatively unimpeded, pain is fully appreciated in regards to its modality, quality, intensity, and location.[65] Due the disconnection between the somatic sensory system and limbic system, however, pain sensations are not assigned their typical emotional status. The result is a highly unusual and counterintuitive

[65] Grahek 2001, p. 52.

situation whereby asymbolics possess full awareness of pain sensation, without attaching emotional significance to that sensation.

Pain asymbolia may serve as an illustration of how pain could possess the physical properties of typical pain, without the functional properties that are typical for pain. In asymbolics, the physical properties of pain are largely intact. Due to the disconnection between sensory and limbic structures, however, pain sensations may not be assigned their typical emotional associations. As a result, asymbolics will not respond to pain sensations with the aversive behaviors that are typical for pain. If this is case, we should allow that the functional properties of typical pain are a contingent, rather than necessary, component of pain.

The second of the two central principles of hybrid realization is that the external role identified with the realization of some kind will not always be possessed by realizations of that kind, although it typically will be. The idea of mad pain was used to motivate this principle, as mad pain does not possess the external role that is typical for pain. The plausibility of mad pain is not a prerequisite to the plausibility of hybrid realization, however, as the phenomena of pain asymbolia offers an empirical parallel to mad pain.

With both mad pain and pain asymbolia, individuals possess many of the physical properties that are typically identified with pain. This means that the experience of either mad pain or pain asymbolia may be characterized by the firing of C-fibers. With mad pain and pain asymbolia, however, these physical properties do not produce the external role that firing C-fibers typically produce. In the madman, firing C-fibers results in thoughts of mathematics, while in pain asymbolia, they result in an equally atypical functional role. In order for pain asymbolia to qualify as pain, then, the functional properties of typical pain must be properties that are contingent to pain.

The hybrid view allows for pain asymbolia by identifying some realizations of pain in terms of the internal causal systems that typically produce pain. If those internal systems mandate that pain arises in virtue of firing C-fibers, the hybrid view will identify pain asymbolia as the realization of pain. As the hybrid view allows that the functional properties of a realization are contingent, the fact that pain asymbolia does not share the functional properties of typical pain is unproblematic.

In light of these unusual pain phenomena, we can again consider the question as to what realizes pain? If we suppose that realization is best understood in causal terms, we can interpret this question in terms of that which realizes the pain-role. As we noted in chapter 8, however, the bare question as to what realizes the pain-role may be ambiguous. One way of fulfilling the pain-role is to adopt a 'which' perspective that targets the external relations that properly identifies pain. The second way of fulfilling the pain-role is to adopt a 'how' perspective that targets the internal causal systems through which the capacity identified with pain is achieved.

Adopting one approach to the exclusion of the other curtails our ability to properly describe pain phenomena. Pain asymbolia possesses many of the physical properties of typical pain, but few of its functional properties. In order for pain asymbolia to qualify as pain, then, we have to adopt a 'how' approach to realization that identifies pain with the internal causal systems that typically produce pain. Phantom pain, on the other hand, possesses many of the functional properties of typical pain, but few of its physical properties. In order for phantom pain to qualify as pain, we have to adopt a 'which' approach to realization that identifies pain with the external relations that are typical for pain. Accommodating both types of pain within the same theory, then, mandates a two-level approach to realization. The two-level view is necessitated by the idea that there is more than one way in which causal individuals may play the pain-role.

9.3 Different Realizations of Pain

Top

The argument that a theory of realization should allow for contingency in the physical and functional properties of pain was introduced by emphasizing the contingency of physical and functional properties in accounting for mad pain and Martian pain. In Lewis' theory, mad pain demonstrates the contingency of functional properties to pain, while Martian pain demonstrates the contingency of physical properties to pain.

The idea of mad pain and Martian pain serve a secondary purpose, however, in that they provide a very intuitive example of multiple realization. One way of realizing pain will be the typical, human way of realizing pain, while other ways of realizing pain will be the mad and Martian ways of realizing pain. As we noted in section 8.5, the hybrid view responds to Lewis'

theory by proposing different levels at which realization may occur. This suggests, in turn, different levels at which multiple realization may occur.

From an externalist perspective, pain may be realized when noxious stimuli produce withdrawal and protection behaviors. As pain may also be realized when exercise on an empty stomach produces thoughts of mathematics, Lewis' theory would support an externalist interpretation as to the multiple realization of pain. From an internalist perspective, pain may be realized by a causal system that involves the firing of C-fibers. As the same internalist perspective will also allow a causal system involving fluid-filled foot cavities to realize pain, Lewis' theory would support an internalist interpretation as to the multiple realization of pain.

Dispensing with the Martian intuition renders Lewis' example of multiple realization less plausible. This implausibility is in line with the suggestion that cognitive properties are actually embedded within their specific physical context. Where cognitive properties are embedded in their physical context, that physical context starts to look like a necessary condition for the manifestation of cognitive properties. If pain is only found in the context of firing of C-fibers, for example, this may constitute evidence that firing C-fibers are a necessary condition for pain. This threatens the multiple realization of pain, of course, in that it suggests the univocal physical realization of cognitive properties.

In response, we may wish to develop a plausible example of multiple realization that does not rely on the Martian intuition, and yet is compatible with hybrid realization. One way of doing so will be to examine the way in which the hybrid view may allow for different realizations of pain.

During the exposition of the hybrid view, the example of a generator was used to demonstrate different senses in which one might fulfil the generator-role. From an externalist point of view, the question of identifying the generator-role became the question of identifying one of several different object-level capacities. As typical generators generate electricity, carbon monoxide, and noise, interpreting the generator-role from an externalist perspective is to understand either the production of electricity, carbon monoxide, or noise to fulfill the generator-role.

Importantly, however, the same event that is responsible for the generation of electricity is simultaneously responsible for the generation of carbon monoxide and noise. We are inclined to understand the generation of electricity and the generation of noise as realizations of the same kind, in other words, because the generation of electricity and the generation of noise are different interpretations of the same event. As a result, we may believe that the generator embodies several different ways of realizing the kind *generator*. If we also believe that these realizations should qualify as different in that they serve different purposes and respond to different contexts, we will have a basis on which to claim that the kind *generator* is a kind that can be multiply realized.

In parallel with the generator example, we can make a stronger case for the multiple realization of pain by demonstrating how different realizations of pain may also arise through the same pain event. It is because these realizations arise in virtue of the same event that we have reason to understand these realizations to be realizations of the same kind. As these realizations also serve different purposes and respond to different contexts, we have reason to understand them as different realizations of that kind.

Pain, as we have already noted, is commonly identified in terms of the way noxious stimuli produce aversive behaviors. These aversive behaviors have different, yet complimentary, functions. In the first place, pain functions as an alarm system that detects urgent threats to the safety and wellbeing of the body. If I carelessly place my hand on a hot stove, the experience of pain serves as a strong and timely reminder to remove that hand before more serious damage occurs. Secondly, pain serves as part of a protection system that provides ongoing feedback on the status of damaged or weakened parts of the body. The pain that arises from contact with the stove, for example, may cause me to seek treatment for the damage that has occurred.

These two different pain functions depend, to a large part, on different physical systems. When a hand comes into contact with a hot stove, cells damaged by contact with the stove activate sensory receptors in that hand. These sensory receptors, known as nociceptors, are typically described in terms of two features. The first is their diameter, where nociceptors that are larger in diameter permit the transmission of a greater volume of information, while those that are smaller in diameter permit the transmission of less. The second characteristic of nociceptive fibers is their mylenation. Myelin is an electrically insulating material that forms

around the axons of neurons, in order to prevent electrical signals from degenerating during the process of transmission. Consequently, nociceptors with a protective myelin sheath function more efficiently than those without.

There are two primary classes of nociceptors that largely correspond to the distinct functions of pain. The alarm function of pain is served by the class of nociceptors known as the A(Δ)-fibers. A(Δ)-fibers will respond immediately and energetically to even weak stimuli, such that effective behavioral responses can be triggered before noxious stimuli have the potential to do more serious damage. A(Δ)-fibers are characterized by a relatively large diameter, which facilitates the swift transmission of detailed information to the rest of the nervous system. A(Δ)-fibers are also protected by an insulating myelin sheath, such that the potentially important and time-sensitive signal they transmit is less prone to distortion.

The other essential function of pain; that of protecting damaged or weakened parts of the body, is identified with the celebrated C-fibers. C-fibers possess a higher firing threshold than do A(Δ)-fibers, and only reach their action potential when affected by a strong stimulus. This means that C-fibers will typically fire in response to actual, and not merely potential, bodily damage. As the purpose of the system is to provide ongoing feedback about extant damage, the system is designed for duration at the expense of speed and refinement. As a result, C-fibers are characterized by their small diameter and lack of mylenation.[66]

The alarm and protection functions of pain are, for the most part, also served by distinct sensory pathways. The alarm function of pain is generally associated with the neospinothalamic tract. Within the neospinothalamic tract, A(Δ)-fibers terminate in an area of the dorsal horn known as the lamina marginalis (lamina I). At the lamina marginalis, A(Δ)-fibers excite second-order neurons which cross the anterior white commissure and terminate in the somatosensory cortex and thalamus. The protection function of pain, on the other hand, is largely associated with the paleospinothalamic tract. Within the paleospinothalamic tract, C-fibers terminate in the substantia gelatinosa (lamina II and III), of the dorsal horn, where they excite second-order

[66] This is not to say that alarm and protection functions are served by physiological systems that are completely distinct. In all pain experiences, at least some C-fibers fire during the alarm stage of pain activation, while at least some A-fibers continue to fire after the alarm role has given way to the protection role of pain. What we do find, however, is that the alarm stage of pain is marked by a preponderance of A(Δ)-fibers firing, while the protection stage of pain is marked by a preponderance of C-fibers firing.

neurons that terminate in lamina V of the dorsal horn. After crossing the anterior white commissure, these second-order neurons transmit their electrochemical signal to the medulla, pons, and other areas of the brain stem.

Remarkably, these two complimentary nociceptive systems strongly correlate with two distinct pain experiences.[67] In our example, we might suppose that initial contact with the stove triggers the physiological system that identifies the alarm role of pain. The A(Δ)-fibers respond immediately, conducting information about the burned hand to the central nervous system at the rate of 6 to 30 meters per second. The result is a rapid withdrawal of the wounded limb, and a feeling of pain that is typically described as sharp, prickling, or stabbing. Shortly after this initial contact, the physiological system that identifies pain's protection role becomes active. The slower C-fibers conduct information at no more than 0.5 to 1.5 meters per second, and tend to result in pain that is typically described as dull or burning. [68] Consequently, burns that may initially be experienced as sharp or stabbing are soon thereafter experienced as dull or throbbing.

Suppose we were to ask what realizes the pain-role within this single pain event? The hybrid view allows that there may be different, yet compatible analyses of the same event. The first way of interpreting the role-question is as a request to identify the capacity in virtue of which this pain event qualifies as a pain event. To interpret the role-question in this way is to adopt an externalist perspective towards the realization of the pain-role. As a result, the question of identifying the pain-role becomes largely a question of identifying a certain set of external causal relations. The pain event, as described, has the capacity to produce two different sets of external relations. One set of external relations will correspond to the withdrawal function of pain, while the other will correspond to the protection function of pain. This difference in external relations will amount to different ways of realizing the pain-role. One way of realizing the pain-role will correspond to the way the event produces withdrawal behaviors, while another way of realizing the pain-role will correspond to the way the event produces protection behaviors.

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[67] Grahek 2001, p. 11.

[68] Even within the respective classes of C- and A-fibers, there appear to be physiological differences that correlate with distinct pain experiences. A-Δ mechano-nociceptive fibers, for example, react to mechano-noxious stimuli, and are associated with headaches and joint pain. C-nociceptive-chemo fibers, on the other hand, respond slowly to slight inflammation in peripheral tissues are associated with feelings of moderate sensitivity and tenderness. See Eilers and Schumacher 2005, also Grahek 2001.

From an externalist perspective, these different ways of realizing the pain-role make a persuasive case for the multiple realization of pain. As both withdrawing pain and protecting pain constitute ways of fulfilling the pain-role, both withdrawal pain and protecting pain should qualify as realizations of pain. As both realizations respond to noxious stimuli with aversive reactions, the realizations should count as realizations of the same kind. As withdrawing pain and protecting pain serve different purposes and respond to different contexts, we have reason to understand withdrawing pain and protecting pain as different realizations of pain. If this is correct, an interpretation of a single pain event from an externalist perspective would illustrate the multiple realization of pain.

A second and different way of responding to the role-question results from interpreting the pain event from an internalist perspective. An internalist understanding of the role-question will typically assume that the capacity that identifies pain has been fixed. Where the capacity that corresponds to pain has been assumed in this way, the question as to what fulfills the pain-role becomes the question of identifying the internal causal structures that figure in the production of that capacity. If we assume that pain should be identified with the way a noxious stimulus triggers the withdrawal function of pain, for example, the properties that fulfill the pain-role will be those that are causally responsible for producing withdrawing pain. As the properties that produce withdrawing pain will be the properties of A(Δ)-fibers, the lamina marginalis, and the thalamus, these will be the properties that fulfill the pain-role. In a different context, however, we might identify pain with the way a noxious stimulus triggers the protection function of pain. Within this latter context, the properties that fulfill the pain-role will be those that are causally responsible for producing protecting pain. As the properties that produce protecting pain will be the properties of C-fibers, the substantia gelatinosa, and the medulla, an alternative context will identify these properties as the properties that fulfill the pain-role.

Again, it is plausible that these different ways of fulfilling the pain-role may be interpreted as an example of the multiple realization of pain. As the causal properties which produce both withdrawing pain and protecting pain constitute ways of fulfilling the pain-role, the properties that produce withdrawing pain and those that produce protecting pain should qualify as realizations of pain. As both ways of realizing pain are picked out by an external capacity that responds to noxious stimuli with aversive reactions, the realizations should count as realizations

of the same kind. As a description of pain in terms of the causal properties that produce withdrawing pain will serve a different purpose, and respond to a different context, than a description of pain in terms of the causal properties that produce protecting pain, we have reason to understand withdrawing pain and protecting pain to be different realizations of pain. Under such circumstances, an interpretation of a single pain event from an internalist perspective could also illustrate the multiple realization of pain.

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Mad pain and Martian pain may be used to motivate a two-level view of realization, where mad pain illustrates that the idea that the functional properties of pain are contingent, while Martian pain illustrates the idea that the physical properties of pain are also contingent. As mad and Martian pain are purely hypothetical examples, however, a theory of realization based on the necessity of accounting for mad and Martian pain may not be particularly persuasive.

Abandoning the Martian intuition, however, does not diminish the explanatory utility of the hybrid view. Instead, pain dissociation syndromes suggest an empirical analogue to both mad and Martian pain. In phantom limb pain, the realization of pain occurs in the absence of the physical properties typically identified with pain. As a result, classifying phantom limb pain as pain will indicate that the physical properties of typical pain are contingent to the realization of pain. In pain asymbolia, on the other hand, pain sensation occurs in the absence of the functional properties typically identified with pain. As a result, classifying pain asymbolia as pain will indicate that the functional properties of typical pain are also contingent to the realization of pain. As only the hybrid view allows for contingency in both the physical and functional properties of pain, only the hybrid view can properly account for the realization of the various pain phenomena.

Abandoning the Martian intuition also does little to diminish the possibility of multiple realization. We can demonstrate the way in which pain might be multiple realized, under the hybrid view, by examining different perspectives under which the pain-role may be fulfilled. A single pain event, for example, may involve different functions that are each composed of largely independent physical systems. From an externalist perspective, these different functions may

illustrate the multiple realization of pain. From an internalist perspective, the physical structures that produce the different functions may also illustrate the multiple realization of pain. There can be little question that our realizations constitute realizations of the same kind, insofar as they derive from the very same pain event.

Conclusion

This thesis has offered an account of how we should conceive of the realization relation. Although realization is associated with the idea that there can be sameness in spite of physical differences, the traditional problem is determining how much sameness should survive what sort of differences. Flat realization, in its expectation of causal equivalence between realizer and realization, emphasizes sameness. The result is the second horn of Shapiro's dilemma, as individuals that do happen to differ are not permitted to differ in terms of the properties that are causally relevant to realization. The dimensioned view, in suggesting that some realizations should be understood as the collective effect of their causal constituents, emphasizes difference. As every individual is unique with respect to their causal components, every individual, under the dimensioned view, begins to look unique with respect to realization. The result is the threat of trivialization of the multiple realization thesis, as every kind begins to look like it may support multiple realizations.

The difference between flat and dimensioned approaches to realization may derive from a difference in perspective as to which aspect of the realization relation, realizer or realization, should be emphasized. There is a sense in which, under flat realization, realizations are emphasized. This sense is given by the fact that the flat view begins by isolating the function that corresponds to some realization, and then inquiring as to the individual(s) that might fulfill that function. The dimensioned approach to realization, on the other hand, suggests an emphasis on realizers. After all, under the dimensioned view, many realizations are properly understood as the causal product, or outcome, of their component realizers. In order to determine whether two individuals that appear the same actually qualify as realizations of the same kind, the dimensioned view deems similarity at the level of realization not as important as similarity in the causal contribution of realizers.

The hybrid view seeks to come to terms with this difference in emphasis by suggesting that there are different levels at which one individual may be understood to realize another. The difference in levels permits an emphasis on either aspect of the realization relation as the situation warrants. At the externalist level, there will be an emphasis on the properties that define realizations. The question of realization, at this level, becomes the question of

determining whether or not some candidate individual instantiates the properties that corresponds to the realization of some kind. At the internalist level, on the other hand, there will be an emphasis on realizers. This is due to the fact that adopting an internalist perspective towards realization assumes that the properties of some realization are largely determined, whereupon out attention is directed to the realizers that are causally responsible for producing that realization.

This contrast between levels allows the hybrid view to respond to different explanations of causal role fulfillment. As noted in chapter 7, it is sometimes possible that different capacities will fulfill a certain causal role. In Lewis' theory, for example, it was understood that either mad pain or Martian pain could fulfill the causal role for pain. In such situations, it would be inaccurate to attempt to explain the causal role of pain in terms of the internal structures that produce pain, as mad pain and Martian pain are produced in different ways. In such cases, pain is properly explained by determining *which* capacity properly fulfills the pain-role.

At other times, however, the capacity identified with pain may be assumed. In this latter situation, it will not be explanatory to account for the causal role of pain in terms of that assumed capacity. If pain is identified by its capacity to produce withdrawal and protection behaviors, in other words, it is not explanatory to account for pain in terms of its ability to produce withdrawal and protection behaviors. Instead, the causal role of pain is explained by identifying *how* certain causal structures produce that capacity. If realization is intended to capture the idea of causal role fulfillment, two ways of fulfilling a causal role will entail that there are two ways in which one individual may realize another.

Failing to adopt a two-level approach to realization may impede our ability to describe certain related phenomena as realizations of the same kind. Pain asymbolia, for example, possesses few of the functional properties typically identified with pain, but many of its physical properties. In order to identify pain asymbolia as pain, we are required to adopt a 'how' explanation that identifies pain with the internal causal systems that typically produce pain. Phantom pain, on the other hand, possesses few of the physical properties of pain, but many of its functional properties. In order to identify phantom pain as pain, then, we are required to adopt a 'which' explanation that identifies pain with the external causal relations that typically identify pain.

Conclusion

The hybrid view also suggests a way of resolving the problem of sameness and difference with respect to the realization of some kind. Under the hybrid view, sameness and difference are determined by the context of attribution. According a prominent role to context allows the hybrid view to deny the claim that realizers of the same kind will always be realizers that are identical in their causally relevant properties. Denying this claim is to deny the second horn of Shapiro's dilemma, and thereby reopen the possibility of multiple realization. Denying the claim also allows the hybrid view to assert that certain differences may not be relevant, within a certain context, to an internalist understanding causal role fulfillment. Where certain causal differences are not relevant, they have no power to affect the realization relation. Where causal components cannot affect the realization relation, they may not serve to differentiate realizations of the same kind. As a result, the threat of minor causal differences leading to trivial multiple realization is minimized.

Although a contextualist interpretation of realization means that the answer to whether one individual realizes another may vary, this variability is intuitive. After all, when an individual is deemed to qualify as the realization of a certain kind, the properties attached to that realization are intuitively those familiar to the relevant attributor. For this reason, the properties of mad pain will exemplify the properties of pain for the population of madmen, but not for the population of Martians. For the same reason, the properties of Martian pain will exemplify the properties of pain for the population of Martians, but not for the population of madmen.

Although the hybrid view understands that standards of sameness and difference in realization derive from standards of sameness and difference in population, the account of how to determine a population for the purposes of realization as given in section 8.4 is rather brief. There are many conversational contexts which may occur, each of which may implicate a certain conception of population. A fuller accounting of the contextualist approach to realization would better illuminate the circumstances under which a certain population is picked out by some act of attribution.

The populations picked out by some act of attribution will also not all be equally robust. Although the idea that some kinds are more 'natural' than others is contentious, it seems right to assert that chemical kinds are somehow more robust than biological kinds, and that biological kinds are more robust than functional kinds. A more detailed approach to the population

question would allow for differences across functional, biological, and chemical kinds, while still recognizing that the status of a realization as a realization of a certain kind depends upon an act of attribution.

Although the concept of realization was original intended to describe only the realization of functional kinds, the opportunity to extend the concept of realization beyond the realization of functional kinds provides some of the incentive for moving towards a two-level view. This is particularly true, as Gillett aptly notes, for those scientific kinds where the properties and powers of the kind are explained in terms of the properties and powers of components of the kind. If we choose to understand realization in terms of the way causal properties fulfill a causal role, there should be no reason that these compositional explanations should not count as a species of realization. A theory of realization that is able to simultaneously account for both functional and scientific kinds would be indicative of a theory that takes a broad approach to the idea of causal efficacy.

As previously noted, the advantage of this broader approach to realization is naturalistic. When the realization of cognitive types is situated within a more general understanding of the relationship between physical and conceptual kinds, our theory of realization is positioned within a broader and more cohesive metaphysical framework. Issues that arise for the realization of cognitive states can then be informed by a more general understanding of the way in which physical individuals can be understood as realizations of a particular kind. The merits of any alternative to the hybrid theory, by the same token, should be judged in light of this advantage.

Appendix

The author’s woodstove.

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