How to Fix Kind Membership: A Problem for HPC Theory and a Solution

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Natural kinds are often contrasted with other kinds of scientific kinds, especially functional kinds, because of a presumed categorical difference in explanatory value: supposedly, natural kinds can ground explanations, while other kinds of kinds cannot. I argue against this view of natural kinds by examining a particular type of explanation—mechanistic explanation—and showing that functional kinds do the same work there as traditionally recognized natural kinds are supposed to do in "standard" scientific explanations. Breaking down this categorical distinction between traditional natural kinds and other kinds of kinds, I argue, delivers two goods: It provides us with a view of natural kindhood that does justice to the epistemic roles of kinds in scientific explanations. And it allows us to solve a problem that HPC theory, currently one of the more popular accounts of natural kindhood, confronts.

1. Introduction. What should any good theory of natural kindhood minimally provide us with? While different philosophers entertain different views of what the natural kinds debate is actually about and what exactly a theory of natural kinds should deliver, two demands seem beyond doubt. First, any philosophical theory of natural kinds should specify what distinguishes natural kinds from other kinds of kinds. Second, any natural kind theory should specify what sorts of factors determine the kind membership of a given entity.

In the context of philosophy of science, these demands take on a specific form. Traditional accounts often contrast natural kinds with other kinds of kinds featuring in science, in particular functional kinds, on the grounds of a presumed categorical difference in explanatory value. Natural kinds

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are epistemologically privileged, the thought is, because reference to them has explanatory force, whereas reference to other kinds of kinds does not. And the underlying reason why natural kinds can ground explanations is that they (in contrast to other kinds of kinds) group things according to metaphysically fundamental properties on which scientific explanations zoom in, such as the "real natures" of things (as typically claimed in essentialist accounts of natural kindhood) or those properties that appear in laws of nature (e.g., Fodor 1974; Churchland 1985). Accordingly, scientific fields that do not focus on natural kinds but classify their subject matter into "mere" functional and other kinds of kinds—that is, virtually all special sciences—are often deemed nonexplanatory (and, as far as their explanatory power is concerned, nonautonomous) sciences.

My aim in the present article is to counter this widespread intuition that traditionally recognized natural kinds are epistemologically "special" in a way that functional kinds and the like are not.[1] In so doing, I aim to show how one of the currently most popular accounts of natural kindhood, Richard Boyd's "homeostatic property cluster" (HPC) theory, can (and should) be modified to accommodate the view of natural kinds that I defend. My strategy will be to focus on the standard contrast class to the category of natural kinds, namely, functional kinds, and to proceed as follows. First, I shall point to a problem that HPC theory confronts (Section 2). I shall continue in Section 3 by examining how functional kinds feature in a particular type of scientific explanation, namely, mechanistic explanation (ME). If functional kinds do the same work in MEs as accepted natural kinds do in "standard" explanations and if MEs can be counted as genuinely explanatory, then functional and natural kinds should be placed on an equal footing with respect to their epistemological importance. I shall argue that the two antecedents of this argument (Sections 3.1 and 3.2, respectively) are indeed the case and that, therefore, traditionally recognized natural kinds and the sciences that focus on them are not epistemologically "special" as compared with functional kinds and the sciences in which these feature. I shall conclude in Section 4 by bringing the two lines of work from Sections 2 and 3 together: the realization that there is no *in principle* difference between functional and natural kinds regarding their epistemic importance for scientific reasoning and explanation provides clues how the problem for HPC theory that I pointed out in Section 2 can be resolved, and HPC theory can be turned into a full-fledged theory of natural kindhood able to cover kinds in the special sciences as well as the less controversial natural kinds.

1. Brigandt (2009) recently reached a similar conclusion on the basis of different considerations.

2. A Problem for HPC Theory. In the philosophical literature on the topic, two distinct ways of thinking about natural kinds can be found. On the one hand, there is the essentialist tradition that, broadly taken, understands natural kinds as groupings of things according to their natures, their intrinsic properties or causal capacities, their microscopic structures, and so on. On the other hand, there is the more recent tradition that understands natural kinds as groupings of things over which we can make reliable inductions. That these lines of work really are quite distinct can be seen from the way in which they conceive of the problem of natural kinds.[2] The former line of work conceives of the problem as a metaphysical problem, that is, as the question, What sorts of things are there in the world? As Brian Ellis put it in a recent defense of essentialism, "membership of a natural kind is decided by nature, not by us" (2001, 19). The latter line of work, in contrast, sees it as foremost a question in epistemology, that is, as the question, Which ways of grouping things are best suited to help us make inferences and to explain phenomena? Boyd, for example, asserted that "it is a truism that the philosophical theory of *natural* kinds is about how classificatory schemes come to contribute to the epistemic reliability of inductive and explanatory practices" (1999a, 146; also 1999b, 69). On this view, kind membership is decided more by us than by nature.

With respect to the explanation-grounding capacity of natural kinds, the two lines of work provide different answers that run into different kinds of problems. From the perspective of the essentialist tradition it should be no miracle that natural kinds ground reliable inferences and explanations. If there is a definitive, objective way in which the world is made up of kinds of things, then clearly any explanation of a given phenomenon should ultimately make reference to some of these objectively existing kinds of things. Once we have achieved an inventory of the various kinds that exist in the world and have an account of their metaphysics, we have a theory of the kinds that can feature in our explanations. The problem, however, is that we do not have any direct access to the world that would allow us to compile the required inventory of the world's furniture. Our best bet at obtaining such an inventory is to consult the various fields of science and to look at the ontologies that these currently adopt. But scientists entertain particular ontologies not because they have in some way directly observed the existence of the kinds that feature in them, but because these make sense in the context of particular theories—more specifically, because the kinds featuring in these ontologies have a

2. The distinction is found (albeit implicitly) in a discussion between Hacking (1991) and Boyd (1991). Neither of these two authors, however, has actually claimed that there *are* two distinct traditions of thinking about natural kinds.

track record of successfully serving as the bases of generalizations, explanations, predictions, and so on *against the background* of the particular theories that are adopted (cf. Quine 1969, 15). And this brings us back full circle to the question that we started with, that is, Wherein lies the explanation-grounding capacity of the kinds that particular fields recognize?

The second, epistemology-oriented tradition of thinking about natural kinds thus seems to be in a better position than the essentialist tradition, as it begins by looking at how reference to kinds is epistemically important in actual scientific practice. Boyd's HPC theory is at present the most prominent exponent of this line of work.[3] It was developed from the 1980s onward as an attempt to take seriously the epistemic roles that kinds play in the special sciences, regardless of whether or not they fit the essentialist picture of natural kinds. HPC theory starts from the recognition that most kinds that feature in science are not groupings of things with exactly the same (microstructural, causal, . . .) properties but groups of things that bear various degrees of causally supported resemblances to each other—that is, they all exhibit largely similar properties due to largely the same causes (Boyd 1999a, 142–144). Accordingly, kinds should not be defined by separately necessary and jointly sufficient essential properties that all and only the members of the kind exhibit without exception but rather by the cluster of properties that are found to regularly, but not exceptionlessly, cluster together in natural entities in combination with the set of causal factors (Boyd speaks of "homeostatic mechanisms") that underlie this clustering of properties:[4]

> (**HPC**). A particular natural kind term is defined by a combination of a particular F and a particular H, where
> F = the set ("property family") of all properties that are found to repeatedly cluster in nature, where this clustering may be imperfect and exception-ridden,
> H = the set of causal factors ("homeostatic mechanisms") that underwrite this clustering.

Because for a given natural kind there is no set of properties unique to and characteristic of all the members of that kind, F cannot exhaustively define the kind (or else a form of traditional kind essentialism would obtain). Accordingly, HPC theory adds H to the definition and assumes the combination of F and H to uniquely define a kind: a kind is defined

3. Primers of HPC theory can be found in Boyd 1999a, 1999b.

4. Boyd also uses 'F' to denote the property family, but the notation in terms of F and H is mine.

by the properties that are found to repeatedly cluster together plus the underlying factors that cause this clustering.

In order to do justice to the messy state of affairs in the world in which entities are hardly ever exactly alike, HPC theory conceives of the *F* and *H* that define a particular natural kind in an *open-ended* manner: no property is necessarily unique to one *F*, no causal factor is necessarily unique to one *H*, the *F* of a kind may come to include new properties and present properties may cease to be members, causal factors may begin or cease to operate, and there are no "core sets" of properties or underlying causal factors that all and only members of the corresponding kind exhibit or are affected by. This yields an account of natural kinds that is sufficiently flexible to accommodate all the various kinds that feature in the various special sciences, as well as more traditional natural kinds.

However, precisely this flexibility causes a problem for HPC theory. Essentialist accounts of natural kinds tell us which factors in nature determine the extensions of kind terms. If for a particular kind a kind essence is identified, we immediately have a criterion for assessing whether or not a given entity is a member of that kind: Does it instantiate the kind's essence? Does it exhibit all the properties deemed necessary and sufficient for membership in the kind? (This may often not be a very operational criterion, but at least it is a criterion that can be used in principle.) HPC theory, however, fails to provide any such criteria. Even if we have fully identified all the members of the property family *F* and of the set of causal factors *H* for a given kind, we still have no criteria for determining the kind term's extension. The reason is that both *F* and *H* are open-ended in the aforementioned sense. Both the *F* and *H* that define a particular kind may in principle change in time to such an extent that at a much later time they no longer contain any of the elements that they contained at an earlier time.

This can be seen particularly clearly for biological species, which Boyd presented as prime examples of HPC-kinds (Boyd 1991, 1999a, 1999b). According to Boyd, biological species are HPC natural kinds defined by the properties that a species' member organisms typically exhibit in combination with the mechanisms that underwrite this clustering (common descent, reproductive cohesion, stabilizing selection, and so on; see Boyd 1999a, 167). But species are subject to open-ended evolution: its organisms can come to exhibit newly evolved properties and old traits can be lost as time goes by, while there is no reason to assume that any particular core set of properties will be conserved. Furthermore, in the case of a speciation event in which a new species branches off from its ancestor species, the member organisms of the two species will typically continue to be characterized by the same family of properties for quite some time. (And often properties that are conserved remain present over long evolutionary time scales and, thus, are not typical for a particular species; see Reydon 2006.) The same holds for H if the relevant causal factors are, for example, environmental: the environment may change heavily during a species' lifetime without speciation occurring or remain the same over the lifetimes of an ancestral species and a series of its descendants. Hence, the combination of F and H is insufficient to determine the boundaries of the species that it is supposed to define.

HPC theory, then, can only account for kinds whose extensions have already been fixed independently by other means. If we have independent criteria by which we can enumerate which entities are to be counted as the members of a given kind and which are to be discounted, HPC theory can tell us which properties and underlying causal factors are characteristic for the kind. (In the case of species, the relevant independent criterion is organisms' locations on particular branches of the Tree of Life.) But a good natural kind theory should do more: it should also provide us with criteria with which kind membership can be determined in the first place—and on this count HPC theory fails. In other words, HPC theory is not a theory of natural kinds—rather, it is a theory of property clustering (as its name indicates).

3. Functional Kinds in Mechanistic Explanations. Clues about how to solve this problem for HPC theory can be obtained from an examination of how kind terms function in actual scientific explanations. In "standard" explanations the names of natural kinds typically appear—if not in statements of laws of nature—in statements of lawlike generalizations of the form "All *K*s have property *p*" that can ground explanations.[5] But at the same time the natural kinds that are being referred to are themselves phenomena in need of an explanation: why do elementary particles, atoms, and so on, come in those kinds that they do, rather than different ones? Reference to natural kinds, then, has a double role in scientific explanation: natural kinds are mentioned as explananda and as explanantia.

In what follows, I shall argue that this double role is not unique for traditionally recognized natural kinds. In some types of explanations, functionally defined kinds play the same epistemic roles as "standard" natural kinds play in "standard" explanations. Clearly, a complete analysis of the explanatory value of reference to kinds cannot be undertaken here, as the variety of classificatory and explanatory strategies used in the various sciences is just too large and thus can only be studied on a case-by-case basis. I shall therefore argue by example and focus on one particular

5. The often assumed connection between laws and kinds is not straightforward, as the paradigmatic laws of nature do not typically mention natural kinds. But this is an issue that I must leave for elsewhere.

type of explanation that is increasingly moving into the focus of philosophy of science, namely, mechanistic explanation.

3.1. Mechanistic Explanation. At present, MEs are increasingly receiving philosophical attention in what has come to be called the "new mechanistic philosophy."[6] Although the various authors in the "new mechanistic philosophy" advocate different accounts of how exactly MEs explain, they share the basic view that MEs explain "by describing how the component entities and activities are organized together such that the phenomenon occurs" (Craver 2006, 374). That is, an ME of a particular property or behavior of a given entity proceeds by (1) decomposing the entity under study into its constituent parts, each of which exhibits a particular behavior when placed in a particular systemic context, and (2) specifying the actual systemic context of the entity under study in which each of the parts is embedded. The explanandum then can be derived from generalizations about the characteristic behavior of the constituent parts combined with specifications of the actual systemic conditions (see also Bechtel 2006, 26–33).

Examples of MEs are found throughout the various special sciences. Let me here consider an ME from the domain of evolutionary-developmental biology in some more detail: the *Drosophila* Segment Polarity Network (SPN; Von Dassow and Munro 1999; Von Dassow et al. 2000). The SPN is a gene regulatory network consisting of several dozens of genes responsible for the occurrence of boundaries between segments in fruit fly embryos.[7] The developmental phenomenon to be explained—the appearance and maintenance of body segments of developing *Drosophila* embryos—is explained by reference to, among other things, the typical behavior of SPNs in the context of a particular stadium of embryo development. The particular behavior of SPNs, in turn, is taken as explanandum and is explained by reference to the typical behavior of the various kinds of entities of which SPNs are composed and the way in which these interact in the context of the SPN. Here, '*engrailed*', '*hedgehog*', and so on appear as functional kind names, as genes are identified primarily (albeit not exclusively) by their functions—that is, causal roles—in molecular biology (e.g., Waters 1994; Griffiths and Stotz 2007).[8] In a next

6. See, e.g., Skipper and Millstein 2005; Bechtel 2006, 19–63; Craver 2006; or Bogen 2008.

7. The SPN genes include *engrailed*, *hedgehog*, *wingless*, *cubitus interruptus*, and *patched*. Models of the SPN typically include only about five genes (e.g., Von Dassow et al. 2000; Ingolia 2004).

8. Elsewhere (Reydon 2009), I have argued that the functions by which genes are individuated are to be conceived of as causal roles.

step, the particular behavior of entities of, say, the *engrailed* kind can be taken as the explanandum and explained by reference to the various kinds of functional parts of which *engrailed* genes are composed (regulatory regions, exons, etc.).

This explanatory strategy is recursive. In each step, part of the explanation is achieved by specifying the typical intrinsic behavior of a system's constituent parts while black-boxing these parts themselves. What matters in MEs is that particular parts perform particular functions under particular circumstances. The detailed ways in which these functions are actually realized are not important in the analysis of the overarching system—this becomes interesting only when the functional part is considered in isolation and the research question becomes which behaviors it exhibits in which circumstances. Functionally defined kinds, then, serve as the "hinges" around which MEs turn in the following sense. Reference to the functional kind to which a particular part of a system belongs is explanatory as the basis of a generalization about the behavior that it is expected to exhibit when placed in a particular environment. In addition, the existence of the various functional kinds is itself a phenomenon in need of an explanation, as it needs to be explained how the black-boxed entities are able to realize the various functions that they realize as parts of systems and how these entities have come into existence in the first place. Thus, functional kinds play a double role in MEs as explanantia and explananda in the same way that commonly accepted natural kinds play a double epistemic role in more "standard" scientific explanations. Just as natural kinds can be said to be the "hinges" around which "standard" scientific explanations turn, functional kinds can be conceived of as the "hinges" of MEs.

3.2. Are MEs Genuinely Explanatory? What I have said, however, does not imply that reference to functional kinds in MEs is actually explanatory in the same sense as referring to traditional natural kinds is usually thought to be. The fact that a system like the *Drosophila* SPN can be hierarchically decomposed into a number of subsystems does not imply that such a decomposition has any explanatory force. After all, any material entity can be decomposed into parts in a plethora of different ways, without all these possible decompositions necessarily picking out kinds with the same degree of—or even any—explanatory import. What makes reference to natural kinds explanatory is that natural kinds are supposed to represent objectively existing features of nature, rather than mere ways of grouping things useful for our particular purposes. Similarly, I want to suggest, MEs can be considered genuinely explanatory when the decomposition of the system under consideration into functional parts can be understood not just as representing a heuristically useful way of analyzing a given system but also as identifying organizational structures that are actually found in nature. For an ME to be explanatory, then, there need to be good reasons to think that the involved decomposition is a decomposition of the mechanism into kinds of components that are actually found in nature.

In the case of systems like the *Drosophila* SPN, this suggestion can be substantiated by taking recourse to the notion of modularity. Roughly, modularly organized systems are systems that are not composed of their basic parts in a simple, aggregative manner (like bricks stacked in a wall) but exhibit a multilevel compositional structure (a system composed of functionally interdependent subsystems, in turn composed of functionally interdependent sub-subsystems, in turn composed of sub-sub-subsystems, and so on, until the level of the basic parts is reached). Each of these units and subunits—the *modules* into which the system can be decomposed—are comparatively well-integrated subsystems of the larger system that are (to a good degree) materially separable from other subsystems of the same system, built of various recognizable components and distinguishable from other modules by the well-defined functions (causal roles) that they perform in the context of the system of which they are parts (Von Dassow and Munro 1999, 307; Bolker 2000). Although modularity has been at the focus of scientific and philosophical attention for some time now, it has turned out to be surprisingly difficult to define precisely what modules are (e.g., Von Dassow and Munro 1999, 312; Bolker 2000, 771; Rieppel 2005, 18). For my purposes, however, it is sufficient to notice that scientists have good reasons to conceive of modules as objective features of natural systems.

Over 40 years ago, Herbert Simon (1962) pointed out that we can expect to find modularly organized systems in the living world, because of two ways in which organizing systems in a modular way can be advantageous. Modular organization can contribute to the efficiency of the assembly processes in which systems come into being and it can contribute to the functional stability of finished systems. That is, modular organization can positively contribute to what is commonly called the "evolvability" of biological systems (their capacity to evolve further) and to their "survivability" (their ability to survive in various environments).[9] At present, it is increasingly becoming clear that modularity is indeed a widely found property of systems in the living world and that various sorts of modules can be identified on many different levels of organization (Bolker 2000, 774; Callebaut 2005).

There is, then, no reason to conceive of the various functional kinds

9. For a discussion of the notion of evolvability in recent biological literature, see Love 2003. 'Survivability' is my own term.

of modules that are featured in MEs of systems like the *Drosophila* SPN as being less representative of objective features of nature than "standard" natural kinds. Therefore, if one is prepared to admit that commonly accepted natural kinds play important epistemic roles in "standard" scientific explanations (something that I want to leave open for the moment, however), then one should also be prepared to admit that some functional kinds play the same roles in MEs.

4. Fixing HPC Theory. If I am correct in my suggestion that there is no in principle difference between functionally defined kinds and traditionally recognized natural kinds regarding their epistemic importance for scientific reasoning and explanation, this could help to remedy the problem for HPC theory pointed out in Section 2. The root of the problem, I believe, is that, even though Boyd repeatedly emphasized that kinds are dependent on the disciplinary context in which they feature, HPC theory still rests on a view of natural kinds according to which similarities between different entities are "found" in nature. Boyd (1991, 141–142) himself pointed to the fact that the HPC definition of a kind often fails to fully specify kind membership but did not consider this a problem for HPC theory. According to Boyd, this indeterminacy is a necessary element of the HPC definition of kinds, as it reflects the actual state of affairs in nature in which many kinds are a bit vague around the edges. Boyd's phrasing often suggests that stable property clustering is the normal case found "out there" in the world, and exceptions, while occurring regularly, still constitute the minority of cases.

But, as the case of MEs shows, there are scientific explanations that derive explanatory force from kinds that are not defined simply by families of properties found to cluster repeatedly in natural entities. MEs use functional kinds in which kind membership is determined by a particular causal role that is realized in the context of a particular system, where the particular properties of the entities that perform these functions are initially disregarded. The particular properties relevant for performing the function under consideration only come into focus when the functional kind itself is taken as explanandum. Taking seriously Boyd's suggestion that "the philosophical theory of *natural* kinds is about how classificatory schemes . . . contribute to . . . inductive and explanatory practices" (1999a, 146; quoted above) implies that we should focus on those criteria that scientists *actually* use when identifying kinds for use in explanations. And when these criteria are not framed in terms of properties that the kind's members exhibit, we should turn to those factors that actually single out kinds of things in explanations (such as functions). This suggests the following modification to (**HPC**) as presented in Section 2:

(**HPC***). A particular natural kind term is defined by a combination of a particular Φ, F^*, and H^*, where

Φ = the factor(s) that individuate(s) things as members of particular kinds in explanations (e.g., the capability to perform a particular causal role function),

F^* = the set of those particular properties that play central roles in the explanation of Φ and are found to repeatedly cluster in nature, where this clustering may be imperfect and exception-ridden,

H^* = the set of causal factors that underwrite this clustering.

The definition of a natural kind that is obtained in this way does justice to the following important motivation behind Boyd's account.[10] Natural kinds do not simply emerge from a direct examination of the state of affairs in nature, nor do they emerge exclusively on the basis of whatever way of classifying things we might find useful in particular contexts. Rather, natural kinds emerge from human interactions with nature in epistemic (typically investigative and explanatory) practices. In many cases, the kinds that emerge there cannot be defined by explanatorily important properties that repeatedly cluster together in natural entities, as these properties are not specified in the explanations under consideration. This was the case in the MEs discussed in Section 3, in which the explanatorily important characteristics were functional and the corresponding explanatory kinds were functional kinds.

Summarizing, my suggestion how to fix HPC theory is as follows. Traditional accounts of natural kinds conceive of kinds as identified by clusters of *metaphysically* singled-out properties that constitute the essences of the kinds' members. HPC theory counters that the relevant properties are not metaphysically but *epistemically* singled out: they are explanatorily important properties and hence crucially depend on the investigative context in which a kind is used. But as there are cases in which the explanatorily important properties are left unspecified in explanatory relevant kinds, defining kinds in terms of property clustering is not always adequate to the investigative or explanatory practice under consideration. This can be remedied by adding the factor that *actually* makes a kind explanatorily interesting to the definition of the kind.

5. Conclusion. I have argued that functionally defined kinds should not be thought of as intrinsically explanatorily unimportant or even less important than traditionally recognized natural kinds. As functional kinds

10. This is a motivation that was also put forward earlier by, e.g., Platts (1983).

do the same work in MEs as accepted natural kinds do in "standard" scientific explanations and MEs are genuinely explanatory, the functional kinds that feature in MEs should not be conceived of as being categorically distinct from natural kinds. But it should be noted that I have not advanced a general argument that functionally defined kinds should without further ado be brought under the natural kind fold, or suggested that modified HPC theory could be used to do this. Many functional kinds (i.e., those that are defined only by a shared function) don't have much explanatory power, but some do and should therefore be thought of as natural kinds. I have suggested a modification to Boyd's account of natural kinds that takes seriously the suggestion that natural kinds are kinds of things that stand at the focal points of scientific explanations as both explananda and explanantia. Focusing on these explanatory roles of kinds in science yields, I believe, an account of natural kinds that is more appropriate to those kinds that are featured in the various special sciences than is the original formulation of HPC theory.

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