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ARTICLE

Natural Kinds: The Expendables

François Papale[1] and David Montminy[2]

[1]Université Laval, Québec, Québec, Canada, Faculty of Philosophy; Université de Sherbrooke, Sherbrooke, Québec, Canada, Department of Microbiology and Infectious Disease, and [2]Université de Montréal, Montréal, Québec, Canada, Department of Philosophy; Cégep Édouard-Montpetit, Longueuil, Québec, Canada, Department of Philosophy
Corresponding author: François Papale; Email: francoisppl@gmail.com

Abstract
Theoreticians that defend a form of realism regarding natural kinds minimally entertain the belief that the world features divisions into kinds and that the natural kind concept is a useful tool for philosophy of science. The objective of this paper is to challenge these assumptions. First, we challenge realism toward natural kinds by showing that the main arguments for their existence, which rely on the epistemic success of natural kinds, are unsatisfactory. Second, we show that, whether they exist or not, natural kinds are expendable when it comes to describing and analyzing scientific explanations accurately.

Keywords: Natural kinds; scientific explanation; classification; induction; epistemic highlighters; eliminativism; realism

1. Introduction

In this paper, we argue that natural kinds (henceforth, NKs) are expendable when it comes to analyzing classificatory practices in science. Our argument stands in two parts. First, we argue that realist arguments for the existence of NKs are unsatisfactory. Second, we show that philosophical analysis of scientific classification can do without the notion of natural kinds.

Skepticism toward NKs is nothing new. Ludwig (2018), for example, follows Hacking (2007) and argues that the diversity of theories of natural kinds is irremediable and questions the usefulness of a general concept of NKs. The plurality of theories should be embraced, as different approaches provide different useful insights regarding scientific classifications that no single and general NK concept could encompass. Brigandt (2020), despite having previously defended the homeostatic property cluster account of NKs (Assis and Brigandt 2009; Brigandt 2009), stresses the analytical and social problems related with the claims of naturality entrenched in the tradition(s) of NKs. Our argument is complementary to these two: first, we show that realism toward NKs is unsatisfactorily defended, strengthening the case made by Brigandt (2020) against the naturality of scientific kinds. Second, we dismiss the usefulness of a general concept of NKs, as Ludwig did, but without relying on the plurality of theories of NKs.

Despite the insightfulness of these two arguments (Brigandt 2020; Ludwig 2018), we believe it remains important to push forward further eliminativist arguments regarding NKs because the notion is still present in philosophy of science. The result is that the NK concept and its usefulness in the context of philosophy of science are mostly taken for granted (Conix and Chi 2021 is a notable exception, as they provide arguments meant to answer Ludwig's eliminativist take). Our two-parts argument, along with the already existing eliminativist approaches (Brigandt 2020; Ludwig 2018), provides solid grounds for an eliminativist posture toward NKs and shifts the burden of proof toward theoreticians claiming that NKs exist and that the concept is an important tool for philosophy of science.

The first part of our argument targets realism toward NKs. In philosophy of science, theories of NKs vary greatly but are meant to offer insights in the role alleged NKs play within scientific explanations and practices. For some authors, this implies providing an ontological description that fits the wide variety of classes of things that stand as NK candidates (e.g., Bird 2018; Boyd 1991; Craver 2009; Khalidi 2013). For others, an approach to NKs should focus on their epistemic specificities and the metaphysical status this confers them (Ereshefsky and Reydon 2015; Slater 2015, 2018). In all cases, theoreticians that defend a form of realism regarding NKs minimally hold the belief that the world features divisions into kinds, a belief usually related to naturalism[1] or the idea that scientific classifications "carve the world at its joints" better than other attempts to do so (Bird 2018; Ereshefsky and Reydon 2015). Our first objective is to challenge these realist intuitions regarding NKs by showing that the main arguments for their existence (i.e., for their reality), which rely on the epistemic successes of NKs, are unsatisfactory. To achieve this, we dissect three recent approaches to NKs: Bird's essentialism, Khalidi's causal node theory and Slater's stable property cluster approach. After presenting the justificatory structure of their approaches in section 2, we rebut them in section 3.

Intimately tied to NK realism is the belief that the NK concept is useful for understanding scientific explanation and is consequently a useful tool for philosophy of science. Our second objective is to show that whether they exist or not, NKs are expendable when it comes to describing and analyzing scientific explanations accurately. In sections 4, we show, with the help of Vermaas and Houkes's work on functions, that predicates traditionally conceived as NK predicates can be treated as epistemic highlighters rather than as ontological categories (i.e., NKs).

We are aware that our argument is not exhaustive. This is to be expected given the scope of the tradition(s) of NKs. Yet we do believe that we cover a lot of ground by rebutting an argument nested in an essentialist view of NKs (Bird's) and two that are meant to focus on the epistemic dimensions of kinds (Slater's and Khalidi's). Indeed, the trend that claims to focus on the epistemic work achieved when using NKs has gained traction in the last decade (Brigandt 2011; Chang 2016, 2017; Ereshefsky 2018; Ereshefsky and Reydon 2015; Franklin-Hall 2015; Griffiths 2007; Kendig 2016; Magnus 2014a, 2015; Martinez 2017; Reydon 2009; Spencer 2016). While we do not claim that our challenge to weak realism applies directly to this whole list, we do believe it is a good starting point for a more generalized argument for the expendability of the NK concept. Indeed, it seems that epistemically minded approaches to NKs, beyond the two we review, share core beliefs that we tackle directly: that NKs play a role in epistemically successful scientific practices and that there exists a hierarchy[2] of categories or kinds.

2. Illustrating the justificatory structure of weak realism

2.a The justificatory structure of Bird's defense of weak realism

In a recent paper, Bird (2018) argues that NKs can be conceptualized as complex universals, the existence of which is established by one of two arguments: the syntactic argument and the essence-implies-existence one (he favors the latter, as he claims it provides more insights into the metaphysics of NKs). Both these arguments concern the existence of NKs *qua* entities, rather than the mere existence of divisions into kinds in the structure of the world.

[1]"More commonly, an argument for weak realism is a corollary of an argument for naturalism. Thus one may argue for the existence of natural divisions by articulating an argument for scientific realism that focuses on the presence of classifications into kinds in science" (Bird 2018, 1399).

[2]We use the term 'hierarchy' to insist on the fact that NKs are considered epistemologically and metaphysically more important than non-natural kinds by many people involved in the debate.

Where strong realism refers to views acknowledging the ontological reality of NKs *qua* entities, weak realism, according to Bird, refers to views acknowledging only the reality of the divisions in the world that our NK terms and concepts capture. Weak realism therefore implies the belief that entities in the world are divided into kinds (classes of objects), without assuming that those classes of objects are ontological entities in and for themselves (Bird 2018; see also Hawley and Bird 2011). According to weak realism, NKs nonetheless translate ontological information about their members: the fact that they belong to a given kind.

In this paper, we are concerned with the minimal form of ontological commitment toward NKs, i.e., weak realism, assuming its rebuttal may potentially scale up to uproot strong realism also. We leave this demonstration for further work, but we do believe such an endeavour is warranted by a successful rebuttal of weak realism. Accordingly, this section reviews solely Bird's argument for weak realism.

Weak realism regarding NKs has traditionally been argued on the basis of induction. Bird links this epistemic argument to both Mill and Quine before highlighting an important distinction between their two milestone theories of NKs: Quine calls NKs any classes in which entities are related by similarity that sustains robust induction (Quine 1969); Mill restricts the use of what he called 'real kinds' to those that can be the ground of an unlimited amount of successful and independent inductive inferences (Magnus 2014b, 2015; Mill 1862). Interestingly enough, Mill's restriction is motivated by normal usage: "But as Mill […] pointed out, over a century before Quine's essay, normal usage is more restrictive than this; we do not normally regard all white things as belonging to a common [natural] kind" (Bird 2018, 1401). In other words, a liberal approach, as the one assigned to Quine in this discussion, obscures the fact that the inductive successes of scientific research are not sufficient to ground a thorough, albeit weak, realist view of NKs. This implies, according to Bird and many others, that *a realist theory of NKs requires a hierarchy of kinds.* In Mill's theory, only the kinds (or categories) that potentially sustain an infinite amount of inductive inferences are Real kinds. Others are artificial or nonreal.

According to Bird, the induction related capacities of NKs fail to establish such a hierarchy and to justify weak essentialism because: "it is not clear that the kinds are essential [to induction]. The reason why is that for kinds to be essential for induction, it must be the case that the induction could not be done without them. And the fact that we do use kinds does not show that we must use kinds" (1402). The criterion that NKs should be essential to inductive inferences is too strong.

Alternatively, Bird suggests that if explanatory power were to be reduced by the "forced elimination" of NKs, the elimination of NKs would be unwarranted.[3] Conversely, this means that the fact that NKs strengthen the explanatory power of sciences should be held as proof that there are divisions in nature and that these are divisions into kinds. They are not essential to explanations, but they are useful parts of them. This argument for weak realism relies first on Bird's capacity to show that eliminating NKs weakens explanations. The details of his attempt to do so are provided in 3.a.

Secondly, the argument appeals to the establishment of a hierarchy of kinds, which serves to restrict the use of the term and to reject promiscuous or liberal realism, as Mill did with his reference to the unlimited inductive power of NKs. Indeed, if any class of objects that strengthens scientific explanations could be considered a NK, then most classes used by scientists would end up filling the bill. In order to avoid this traditionally disdained predicament, Bird introduces a hierarchy of kinds through essentialist considerations (Bird 2018; see also Bird 2009, 2010). In short, essentialism, denoting Locke's legacy more than Mill's, states that the presence of an essence, or lack thereof, tells us whether a kind is natural or not. By providing an essentialist description of the ontology of NKs, Bird *explains* why normal usage usually restricts the predicate of kind to certain divisions in the structure of the world; the hierarchy implicit in normal usage of the NK concept, in Bird's theory, is an explanandum. As such, the argument for the hierarchy is independent from the one Bird uses to

[3]As a reminder, Bird also has an "essence implies existence" argument for the existence of NKs, but it is made in favor of a more committing strong realist take, which is not the target of our argument.

establish weak realism, since the latter avoids reference to essence and focuses on the epistemic usefulness of NKs.

There are two things to be remembered from this presentation of Bird's arguments. First, if a person were sceptical regarding the existence of NKs and the validity of weak realism, the only argument Bird provides to sway this person is based on their epistemic usefulness. Second, Bird's argument for rejecting promiscuous realism (Quine 1969; Dupré 1993) is that this stretches the concept of NK beyond normal usage (essentialism subsequently comes to justify or explain the hierarchy).[4]

A similar rationale transpires in other essentialist approaches to NKs. In an essentialist perspective, the ontology of NKs, namely their essence, is irremediably conceived as an explanation for some of their other characters (their "naturality," their capacity to sustain inferential processes, etc.). Devitt, for example, writes:

> Generalizations of this kind [inductive inferences used by biologists] demand an explanation. *Why are they so?* […] Explanations will make some appeal to the environment, but they cannot appeal only to that. There has to be something about the very nature of the group—a group that appears to be a species or taxon of some other sort—that, given its environment, determines the truth of the generalization. That something is an intrinsic underlying, probably largely genetic, property that is part of the essence of the group. Indeed, what else could it be?" (Devitt 2008, 352; italics from the original).

This entails that realism is advocated for by appealing to inferential usefulness: epistemically successful endeavours must be explained; when NKs terms or concepts are involved, this success is explained by the ontological structure of NKs, their essence; ergo the essence, the related essential kind and the hierarchy of kinds exist.

2.b Epistemically minded theories of NKs and the existence of NKs

2.b.1 Khalidi's approach

How do epistemically minded approaches to NKs contrast with Bird's argument for weak realism? They do not, at least when it comes down to justifying belief in the existence of NKs. According to Khalidi, the rationale we highlighted is the basis for the tradition of natural kinds in general: "[t]his much is common ground among essentialists and nonessentialists. Indeed, nonessentialists philosophers also maintain that natural kinds are discoverable by science and constitute the basis for projection and inductive inference" (Khalidi 2013, 14). More recently, Khalidi has linked this idea explicitly to the matter of realism: "We infer what natural kinds exist and discern their commonalities after determining which categories play a central role in our knowledge-gathering enterprises." (Khalidi 2018, 1385–86.) In other words, NKs are the ontological basis of successful epistemic endeavors, but they are also alleged objects of inquiry made visible by the successes of science.

Beyond this, however, Khalidi's approach differs from Bird's defense of weak realism. The specificity of his theory is best illustrated by its delineation between natural and nonnatural kinds. According to Khalidi (2013, 2018), natural kinds are clusters of properties with a causal structure that features core properties and derivative ones. A cluster's causal dimension refers to the idea that natural processes cause both the clustering of properties and the structure of these clusters (where causality emanates from core properties toward derivative ones).

Khalidi's view differs from essentialism mainly by its characterization of the properties associated to a NK: "on the current proposal, the causal properties associated with natural kinds can be extrinsic or functional, and there may be no set of properties that are singly necessary and jointly

[4]While Bird refers only to Quine when tackling the liberal take on NKs, we thought it might be wise to make the connection with promiscuous realism, a significant milestone for the tradition(s) of NKs.

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sufficient for membership in the kind" (Khalidi 2018, 1385). Furthermore, it differs from Boyd's homeostatic property cluster (HPC) account (Boyd 1991, 1997, 1999), first by defending a stronger realism (this claim's validity depends on how one interprets Boyd's accommodation thesis; see, for examples, the nuances between the following treatments of the said thesis, including Craver [2009], Ereshefsky and Reydon [2015], Magnus [2014a] and Slater [2015]), second by being a general account of NKs (not only focused on a specific kind of NKs; Magnus 2014a) and third by avoiding positing an external homeostatic mechanism as a necessary condition for NKs: "Boyd's account has to be loosened in such a way as to retain the emphasis on causality without the mechanism or the homeostasis" (Khalidi 2018, 1386). Any causally determining process can generate a causal node, i.e., a structure of causal connection between clustering properties, which can be involved in further causal processes. The causality involved explains why NKs are featured in successful epistemic endeavors.

This account is explicitly built to stress the distinction between mere correlations from causation, and concurrently between nonnatural from natural kinds. The problem stated by Khalidi is that one must be careful when giving a term or concept the status of NK on the basis of projectibility, because projectibility can be achieved by linking two distinct effects (without the cause) or by starting with the effect and projecting toward the cause. From this follows two dangers: first, one may miss out on the proper understanding of NKs and their specificities; second, this can lead to false positives in the identification of NKs. Hence, only the identification of an adequate causal structure sustaining projectibility warrants the attribution of the NK status. The hierarchy of kinds is therefore inherent to Khalidi's causal-nodes account of NKs.

2.b.2 Slater's approach

We now turn to Slater's theory as a second example of epistemically minded approaches to NKs. Slater (2013, 2015, 2018) turns the ontological rationale of the NK tradition on its head: the variety of epistemic kinds should not be assumed to have a unifying underlying ontological structure (such as causality); the projectibility of kinds is all it takes to provide them with a privileged ontological status; hence all projectible kind predicates are NK predicates. He suggests that: "Modest realists, for instance, can interpret the 'projectibility' of certain categories as amounting to a metaphysical fact about those categories and an epistemological matter concerning our recognition of this fact (presumably in the context of much background knowledge)" (Slater 2015, 385). The "metaphysical fact" here implies an ontological commitment toward NKs (they are at least metaphysically sound divisions in the world), but the unity of the kind NK is not to be found in a common ontological foundation (mechanism, essence, etc.). It is to be found in an epistemic feature common to all NKs: projectibility.

The NK status[5] is in this case more readily attributed to groupings of entities than it is when using Khalidi's theory. Yet a hierarchy is still at the core of the scheme. His stable property cluster (SPC) theory of NKs uses the notion of cliquish stability as well as pragmatists inclinations related to the explanatory context in which a kind is used to establish a loose epistemic threshold for a kind to obtain the status of NK. The threshold, in a nutshell, corresponds to the degree of stability a cluster of properties must showcase to be held as an epistemically useful tool in the field of inquiry concerned with it.

In other words, the SPC theory claims the distinction between natural and nonnatural kinds is *not* explained or justified by an ontological reality. It is grounded in the epistemic analysis of classificatory practices, but that still leads to an ontological commitments toward kinds: "What the SPC account offers us is a flexible, high-level approach to understanding the various ways in which various categories (scientific or otherwise) can be regarded *as genuine features of the world* in organizing and facilitating our epistemic contact with the world" (Slater 2015, 407; emphasis

[5]"Natural kindness," in Slater's words.

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added). Some categories can be said to pick out genuine features of the world; some cannot. The former showcase natural kindness; the latter do not. If this hierarchy does not translate a privileged ontological commitment toward NKs, it is unclear what is meant by "genuine features" or by "natural."

3. Critical analysis of the justificatory structure of weak realism

The argument for weak realism regarding NKs was shown in section 2 to have a similar structure in at least three different accounts of NKs. This structure features two dimensions interacting differently in each account. The first dimension (D1) refers to the idea that epistemic usefulness of NK terms, concepts, or predicates justifies claims about the structure of reality and divisions into kinds therein. The second (D2) is the establishment of a hierarchy of kinds that marks the distinction between NKs and other kinds of kinds. D1 can be further analyzed. For it to stand, two independent claims must be defended: (D1a) NK terms, predicates or concepts are useful in successful scientific practices; (D1b) we can infer ontology from epistemic successes. In this section, we analyze the arguments for weak realism of Bird, Khalidi, and Slater to show that they fail to justify D1a and D2 (D1b is addressed more thoroughly in section 4 of the paper). In other words, we show that these authors fail to establish that there are such things as NKs in a minimal sense, i.e., that "the world [is] such that there are genuinely natural divisions of things into kinds" (Bird 2018, 1401).

3.a Critical analysis of Bird's argument for weak realism

It was shown in 2.a that Bird's argument for weak realism relies mostly on D1 (D2 is used as a constraint on liberalism in regard to NKs but does not justify realism), about which he is quite explicit: "Natural science does divide things into kinds—kinds of subatomic particle, kinds of chemical element, [etc.]. If such divisions are not natural, then much science has got things massively wrong. Conversely, if science is by and large right, then we can have a high degree of confidence that the divisions science draws are genuinely natural" (Bird 2018, 1399). Both D1a and D1b are well illustrated.

Bird's argument in favor of D1a relies on a formalization of knowledge in regard to specific objects (see Bird 2018, 1403), which can be translated as follows. First, knowledge about an object can be reduced to the relation of co-occurrence that its properties entertain in nature and can be quantified accordingly. Second, knowledge of property correlations can be formulated in terms of properties alone (*P1* and *P2* being correlated with *P3*, for example) or it can be formulated using a kind predicate that ties a set of properties together (*P1*, *P2,* and *P3* form a kind *K*, so that when, for example, *P1* and *P2* are observed, we can infer this to be an occurrence of kind *K* and predict the presence of *P3* [or any other associated property]). Third, the bundling of properties into kind predicates allows (supposedly) for more efficiency by reducing the amount of generalization needed: "In such a case the inductive power provided by use of the [NK predicate] is indicated by fact that our inductive knowledge can be encapsulated in a fraction ($1/n$–2) of the generalizations that would otherwise have been needed" (Bird 2018, 1403). According to Bird, his formalization, along with the claim of inferential efficiency tied to NK predicates, illustrates that eliminating kinds from explanations reduces their strength, such that it can be safely assumed that NKs contribute to the epistemic successes of science (and therefore that they exist).

At least two issues can be found in Bird's formalization of knowledge concerning objects and the relation of such knowledge to kind predicates. First, Bird's rationale rests on the idea that because NK predicates allow us to lower the number of generalizations needed to relate properties of objects together, they represent an epistemic gain. This is what he refers to as the "unification provided by kind predicates" (Bird 2018, 1403). The problem with this is that it fails to acknowledge the loss of information that comes with the said unification. When properties are bundled up together into a

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kind term, inferences according to them are coarse-grained. They involve such and such property and their co-occurrence with the bulk represented by the kind term.

On the contrary, when one unpacks the bundle, fine-grained inferences relating to specific properties and their relations become available, allowing for epistemically rewarding nuances and flexibility. There is a famous and important example of this in the history of science, namely the establishment of the theory of evolution by natural selection through Darwin's argument. An important part of this argument is what Mayr coined population thinking (Mayr 1959, 1994). Population thinking, in this context, refers specifically to the unpacking of biological species.[6] Indeed, Darwin's important "innovation" was to focus on the individual differences that characterize members of a species. Evolution feeds on these individual differences, which lead to differential survival and reproduction of some individuals whose lineages thrive across genealogical times to generate new varieties, species, genera, etc. (Gayon 1998; Lewontin 1970): "This standard way of viewing evolution assigns a causal role to individual idiosyncrasies. Individual difference are [...] the causes of events that are absolutely central to the history of evolution" (Sober 1980, 370–71). While biologists look at species by focusing on their shared properties, the basic fuel of evolution by natural selection remains invisible, neglected because it was considered accidental (O'Hara 1997).

This example shows that the elimination of NKs is not, in principle, epistemically damaging any more than the "forced" belief in the existence of NKs. On the contrary, Bird's argument turns on him if this example is taken seriously (as it should, given the scientific importance of the theory involved). Packing occurrences together into a single bundle leads to information loss (we lose information regarding individual differences), which might very well translate into explanatory losses as well (as in the Darwinian case). This falls short of rejecting NK realism altogether, but it shows that Bird's argument for weak realism is unsatisfactory: we cannot simply assume that generalizations allegedly (see our next argument against Bird's) made possible by NKs are epistemically more rewarding than inferences made without them before thoroughly exploring the benefits and drawbacks of both alternatives. Bird does not give the eliminativist approach a real chance; he claims that the presence of an isolated and alleged epistemic benefit that comes with the use of NKs implies that they exist without weighing this against possible drawbacks.

Our second objection concerns the actual link between NKs and projectibility or inferential power. Consider cases where correlations involve a set of objects that would never be considered a kind, let alone a natural one. An example from phylogenetics illustrates this widely occurring phenomenon very well.[7] The presence of chloroplast acquired through endosymbiosis by a lineage of eukaryotes is (very) highly correlated with the possibility of eukaryotic photosynthesis, yet due to the fact that photosynthesis is a trait that can be found in distinct monophyletic groups (photosynthetic eukaryotes have transferred their photosynthetic ability to other eukaryotic lineages through subsequent endosymbioses usually referred to as secondary endosymbioses), *no phylogenetic systematist would treat all photosynthetic eukaryotes as being part of a single NK* (McFadden 2001).[8]

[6]Mayr argued that population thinking is opposed to typological thinking, which, according to him, refers to the treatment of species as homogeneous categories considered by pre-Darwinian biologists in an essentialist perspective. The claim that all pre-Darwinian biologists were essentialist thinkers has been debunked (Winsor 2006). To our knowledge, the claim that Darwin's focus on individual differences was crucial to the establishment of his theory still stands. Here, we suggest that population thinking is a good example of the epistemic gains that can come from the disunification of kind predicates, which enables one to access otherwise obscured information. This is different from arguing that population thinking, in and by itself, is an instance of NK eliminativism.

[7]Phylogeneticists do not usually use natural kind language, but they do refer to some classification and groupings, such as monophyletic lineages, as being more natural than others (Doolittle 1999; Wiley and Lieberman 2011).

[8]Could all these organisms be tied to a single NK based on theoretical frameworks other than that of phylogenetics? Even if similarity-based groupings were considered NKs by biologists (they are not), genetic, morphologic and physiologic differences would preclude the formation of a NK based on eukaryotic photosynthesis (Kim and Archibald 2009). An ecologically based classification would also require differentiating the various photosynthetic eukaryotes, as their embedment into ecosystems reveals too much functional (*not* in the selected effect sense) heterogeneity to warrant a single grouping.

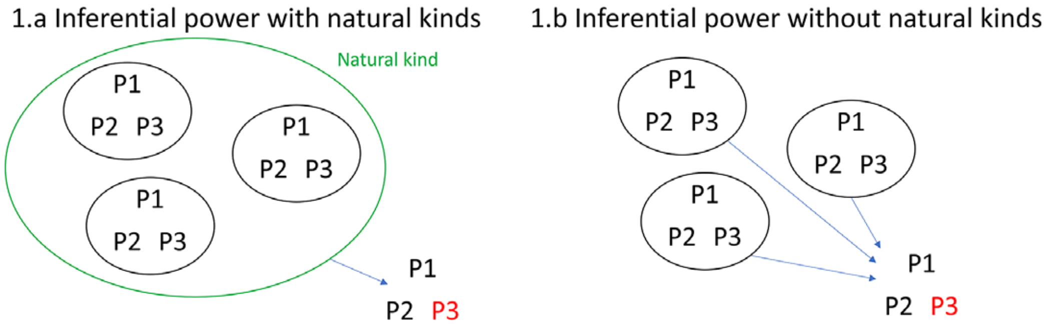

Figure 1. Property clusters, inferential power and natural kinds.
In this figure, we illustrate the inferential power resulting from the observation of property clustering or, more simply, of correlations. In 1.a, the property clusters purport to form a natural kind. The stability of the correlation allows to infer the presence of P3 if we observe P1 and P2 (in cases where P3 has not yet been observed). In 1.b, the property clusters do not form a natural kind, yet the inferential power remains the same. As we detail in the body of the text, this shows that the epistemic successes based on property clustering cannot be used to defend weak realism in regard to natural kinds.

Hence, Bird's scientific realism (see footnote 1) generates a tension. If we hold that science is our best guide to identify natural kinds, then we cannot hold photosynthetic eukaryotes to form one. Yet that set of entities does feature projectability. The two notions (NK and projectability) are therefore independent. Importantly, whether there is a NK ultimately changes nothing to the inferential power associated to the correlation in question: if photosynthesis is observed in eukaryotes, the presence of endosymbiotically acquired chloroplasts can be expected (and vice versa). The existence of a NK would simply be postulated a posteriori, most probably by NK theorists (rather than by practitioners). The inferential power remains intact whether the existence of the NK is confirmed or infirmed, as Figure 1 clearly illustrates, because the correlation between properties is what matters for projectibility and generalizations (we turn back to this issue when analyzing Khalidi's and Slater's arguments, which recognize the importance of the relationship between properties).

In summary, for D1 to be a valid dimension of the justificatory structure of weak realism, it needs to be established that NKs predicates are useful enough to "force" us to believe in the existence of corresponding NKs (in the weak realist sense). Because Bird's formalization faces two strong objections (1: packing occurrences into kinds might be more epistemically damaging than postulating eliminativism; 2: projectability can do without underlying NKs), we claim it fails to warrant weak realism.

3.b Critically analyzing Khalidi's and Slater's arguments for weak realism

While Khalidi and Slater also embrace D1, they use D2 to justify it. The idea is that what distinguishes NKs from other kinds is the same thing that justifies the ontological reification of NK terms, predicates and concepts. These authors, like many others (Ereshefsky and Reydon 2015; Kendig 2016; Magnus 2012; etc.), claim to focus on the epistemic dimensions of the use of NKs in scientific practice, which may make our charge of reification surprising to the reader. Yet, by focusing their work on a hierarchy of kinds featuring *natural* kinds (or kinds that showcase *natural kindness*), weak realists inevitably uphold some of the metaphysical content of the NK tradition(s). Brigandt endorses a similar reading of the two authors reviewed: "some philosophers (e.g., Khalidi 2013; Slater 2015) have recently endorsed quite specific theories of what ontologically counts as a natural kind" (Brigandt 2020, 5).

Khalidi's hierarchy of kinds states that NKs refer to property clusters, which are causally structured due to extrinsic and intrinsic causal processes. The bundling of occurrences is useful in the case of NKs specifically because identifying the underlying causality provides powerful information. Given this reconstruction of Khalidi's theory, it does seem, at first sight, that eliminating NKs would lower explanatory power if it comes down to neglecting the distinction between causality and correlation. Does this establishment of a hierarchy of kinds (D2) also properly support D1a, the belief that NKs predicates are useful to scientific explanations? While we accept the importance of the distinction stated by Khalidi between correlations with causal explanations and those without, we fail to see why this should be translated into a distinction between kinds of kinds. This objection applies *mutatis mutandis* to Slater's theory.

To illustrate the projectibility of NKs, Slater (2015) refers to basic inductive inferences that work as follows: when properties, for example P1, P2, and P3, tend to show up together in nature (featuring 'cliquish stability'), a specific occurrence in which we observe P1 or P1 and P2 is a case in which we can infer the presence of P3. The induction-sustaining capacity of P1, P2, and P3 entails that those properties tend to form a cluster and, allegedly, that all occurrences of this cluster can be lumped together into a NK, given they feature sufficient (in terms of the specific needs of an epistemic community) stability.

Slater's account of basic inductive inferences, just like Khalidi's assessment of those sustained by causal processes, is adequate. Nonetheless, they both fail to notice that kinds play no part in them (this echoes our second objection to Bird). Whenever stability is observed regarding a cluster of properties, inductive inferences are available in relation to those properties; yet *the fact that the said clusters form a NK (or not) changes nothing to the inductive potential of our observations.* It is superfluous; it appears only as a posteriori labeling of an open-ended grouping of occurrences whose scientific use can be tracked down to its underlying properties and the explanatory role they play in a theoretical framework (see Figure 1). This means that even if we agree that some inductive inferences are to be epistemically privileged over others (on the basis of underlying causality or any other pragmatic inclinations), a hierarchy of kinds cannot be deduced from this (a hierarchy of inductive inferences, on the contrary, could be). Weak realism about NKs should *not* be defended on this basis.

Of course, if we hold as an a priori assumption that there is, in fact, a hierarchy of kinds, the story is different. The epistemic successes then appear as an effect of the existence of these divisions into kinds that the world has on offer. This seems to be a generalized posture in the literature, as this introductory comment by Ereshefsky clearly illustrates: "An underlying assumption of this paper is that a proper philosophical account of natural kinds should help us understand the success of natural kind classifications in science" (2018, 845). This belief, however, begs the question. Theories of NKs would gain from justifying this logically first assumption.

At this point, it could be objected that our critique only brings the discussion one level down: instead of having NKs of clusters of properties or of entities, we have NKs of properties that sustain inductive inferences. Our rebuttal of the SPC and the causal node theories of NKs is stronger than that: the similarity between two occurrences, whether they be occurrences of properties or occurrences of property clusters, is relevant to induction whether occurrences are grouped into kinds or not. Consider a case in evolutionary biology.

The unit of selection is a central concept in the theory of evolution by means of natural selection. Units of selection are generally understood as biological individuals forming populations that can evolve by means of natural selection (Godfrey-Smith 2009; Lewontin 1970).[9] As a kind of biological entities, they are usually recognized by fundamental properties. The main ones are their capacity to reproduce and persist. Although there are ongoing debates regarding the relative importance of these two traits, philosophers and biologists agree that if an entity can both persist and reproduce, then it has the potential to sustain evolution by means of natural selection. Hence, the property of evolvability can be inferred from the coexistence of persistence and reproduction.

[9]There are several ongoing debates regarding the nature of units of selection on which we do not wish to focus in this paper. It should also be noted that the expression *unit of selection* is not used by all authors involved in debates concerning evolutionary individuality. Among the variety of terms used, 'unit of selection' is the most general one and that is why we use it.

A traditional take on NKs would explain such inferences by referring to the projectibility of entities belonging to the same kind. The rationale would state that some biological entities can sustain induction regarding their evolutionary potential *because* they are part of the NK *unit of selection*. On the contrary, our view states that induction is only indebted to the properties stated above. This statement is strengthened by the literature, which is not concerned with the natural kind "unit of selection" per se, but rather with the relationship between the relevant properties and the theory of evolution by means of natural selection.[10]

As was said, an objection to our view could be that NKs are not dismissed but simply brought one level down: reproduction, persistence, and evolvability would in fact be NKs of properties. The idea is that to infer evolvability from persistence and reproduction, we need to know that two occurrences feature reproduction *of the same kind* or persistence *of the same kind*. Our answer to this is that reproduction, for instance, just like "being a unit of selection," is understood only by being broken down into its significant components and by being embedded the overarching theory.

Indeed, reproduction is a very loose term that may refer to a great variety of biological phenomena (Bouchard 2008; Godfrey-Smith 2009). The literature is filled with papers exploring this variety in order to identify what about reproduction is so fundamental to the Darwinian processes of evolution (an excellent synthesis can be found in Clarke 2013). Some suggested relevant features of reproduction are: the presence of bottlenecks (Godfrey-Smith 2015), integration of the parts of the reproducing entity (Booth 2014; Godfrey-Smith 2013), material overlap (Griesemer 2000), fitness alignment (O'Malley 2015), its capacity to generate heredity (Dawkins 1976) or to regenerate populations (Charbonneau 2014), etc. Membership for the NK *reproduction*, just like membership for the NK *unit of selection*, can be reduced to the presence of some underlying properties, which are relevant for inductive inferences iff they are related to a theoretical explanation (in this case, how reproduction is related to the theory of evolution by means of natural selection and what about it is necessary for Darwinian evolution to occur).[11]

In other words, we avoid replacing kinds of entities with kinds of properties. We claim that at any level, alleged kind predicates are only relevant to scientific explanation when they stand for a cluster of properties embedded in a theoretical matrix. As such, they are referentially useful but inductively accessory (in contrast to the observation of correlations between theoretically relevant properties).

Before turning to the next part of our argument, a summary of section 3 is required. It must be kept in mind that we challenge specific arguments for weak realism, not the usefulness of kind predicates in scientific practice (as they are at least useful for communicative purposes). To Bird's claim that eliminativism regarding NKs is only warranted if it brings no loss of explanatory power, we answered that the same can be said of NKs. NK realism is warranted only if potential epistemic drawback for their use has been thoroughly weighed with potential benefits. Bird failed to accomplish such an analysis.

Our second argument against Bird's defense of weak realism overlaps with our argument against Khalidi's and Slater's. They claim that successful inferences regarding cluster of properties strengthen the case for weak realism. In short, we argued that we can only postulate the existence of NKs after having observed correlations. This fact alone suggests the observation of correlations and the inferences this allows for are independent from the existence of kinds. In this light, kind predicates can be useful semantic shortcut, but this does not warrant postulating the existence of natural kinds or of categories imbued with the metaphysical aura of natural kindness. In our view, Slater and Khalidi have only successfully established a hierarchy of inferences, but they failed to establish a metaphysically significant hierarchy of kinds. New arguments are needed to defend weak

[10]See, among others, Bouchard 2008; Bouchard and Rosenberg 2004; Bourrat 2014; Charbonneau 2014; Doolittle and Booth 2017; Ereshefsky and Pedroso 2015; Godfrey-Smith 2009; Hull 1980; Matthen and Ariew 2005; Papale 2021; Papale, Saget, and Bapteste 2020; Wilson and Sober 1989.

[11]This view commits us neither to metaphysical nor to causal reductionism. Indeed, in the proposed example, the environment can determine the behavior of a unit of selection and could accordingly be part of its (relational) properties.

realism. In the meantime, we suggest an alternative to NKs and weak realism, where predicates are considered to be epistemic highlighters, i.e., markers of the theoretical role ascribed to phenomena.

4. Naming and explaining

Our paper has two related theses: first (as defended in the previous section), weak realism toward NKs is not warranted and, second, the NK concept is expendable in the context of philosophy of science. The second thesis can still face a solid objection according to which the use of NKs in philosophy of science is warranted by the fact that it provides accurate descriptions of the work of scientists. If it were the case, this would justify using the concept in science studies (and could be used as a basis for weak realism). In 4.a and 4.b, we show that scientific practice is better described by avoiding the ontologically weighty concept of NK.

Section 4 as a whole can be taken as an indirect answer to Conix and Chi (2021) who argue against Ludwig (2018) that, despite the theoretical uselessness of the NK concept (which they acknowledge)[12], the notion should *not* be eliminated. Their argument is twofold. First, they claim that the NK concept plays an investigative role that is valuable. It enables us to compare more specific theories about kinds or categories and to analyze the belief of scientists according to which there are indeed scientific categories that are more real than others. Second, they claim that the NK concept plays an important social role by tying together philosophers interested by classificatory practices in the sciences and by providing an entryway for scientists that want to feed on the related philosophical literature.

As we show, in the following pages, this second role can be met by other concepts, such as 'epistemic highlighter' or 'classificatory practices.' Furthermore, no NK eliminativist theory suggests that the past work on NKs should be rejected altogether. As our discussion of the work of Ereshefsky and Reydon (section 4.a) clearly highlights, useful tools have been developed in the tradition(s) of NKs and should be imported in a post-NK philosophy of classification if it ever came to be. Reference to past publications on NKs would ensure a smooth transition that would leave the social role intact.

As for the investigative role of the NK concept, we hope to convey the possibility to structure research on classificatory practices in the sciences on concepts that are theoretically useful. We show that the notion of epistemic highlighter can tackle a wide range of scientific practices, including some traditionally understood in NK terms. Whether competing approaches were structured around a NK concept or not, they could still be compared. For example, nothing would stop researchers from comparing the work of Ereshefsky and Reydon centered on classificatory programs with our own centered on epistemic highlighters, or even to explore their complementarity. Nothing would stop researchers from philosophically analyzing the belief of scientists according to which some categories are "more real" than others (in a way comparable to what we do in the previous pages of this paper), whether they used NK concepts or not. Hence, we do believe our work answers the arguments of Conix and Chi (2021) against NK eliminativism.

4.a Mechanistic explanations and functions

Although mechanistic explanations are not the only ones relevant in a scientific context, they appear as a good starting point because they are numerically very significant, they have attracted a lot of philosophical attention[13] and some of their features are akin to what is traditionally called a NK.

[12]"It is clear that the role of [a general] NK concept in such research is not theoretical. Clarifying the overlap between different accounts of natural kinds does not require us to define natural kinds or restrict the usage of that concept to a particular subset of scientific kinds" (Conix and Chi 2021, 9007).

[13]Notable contributions are Machamer, Darden, and Craver (2000) and Craver and Darden (2001).

A good contemporary example of this trend is Glennan's 2017 book in which he proposes an account of explanation where functional ascriptions contribute to the identification of mechanisms: "A mechanism for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon" (Glennan 2017, 17). Once identified, these mechanisms and the entities composing them can be used to explain the targeted phenomena. The postulated entities are used in inferences and when a given inferential pattern is successful in explaining the behavior of a system, these putative entities are kept as scientifically useful notions. For example, a protein can be seen as a mechanism composed of peptides (entities) and whose structure is stabilized by hydrogen bonding (activities), among other things.

A proponent of the existence of NKs might claim that this is good ground for believing that such useful notions, as they refer to a set of entities, translate the existence of NKs. As we will show, however, with the help of Vermaas and Houkes (2013), such a commitment toward kinds (and especially *natural* kinds) is superfluous when it comes to explanation. *Specific entities are simply labelled to refer to the role they play in a scientific explanation, not to a NK they belong to.* In other words, the epistemic usefulness of a notion justifies the *use*, but not the ontological reification of theoretical entities (D1b is unwarranted).

We claim this view can be expanded outside the scope of traditional mechanistic explanations (e.g., in the context unificationist, manipulationist and statistical explanations; see Glennan [2017, 216–17] for an ontologically light approach that applies beyond mechanistic explanations). Any given concept—be it a putative entity, an alleged process, a temporarily stable activity, or a class of things—is scientifically relevant if one gains explanatory power over a targeted phenomenon by making room for that given concept within the causal nexus held to be responsible for the targeted phenomenon. Scientific concepts, understood in this fashion, *do not* carve the world at its joints. Hence, although we do not endorse Glennan's (2017) take on NKs, we certainly agree with his claim that the causal powers of given entities and activities are always local and singular.[14] An exploration of the relationship between mechanisms, functions, and explanations should make our case clearer (and further work could illustrate how this claim applies to other types of explanations).

Indeed, some mechanistic accounts of phenomena allow one to ascribe functions solely on the putative causal role of entities or processes composing the mechanism under study. This causal-role approach to functions was inspired by Cummins (1975), who maintained that: "the function of *X* being *Y* explains or contributes to an explanation of the general proper activity of a system which includes *X*" (Huneman 2013, 2). A functional ascription has epistemic payoff when it is the available one that best explains the behavior of a system.

This view of functions, supplemented by the collaborative work of Vermaas and Houkes (2013), sheds light on the use of kinds in scientific practices. The inherent diversity of explanatory-driven functional ascriptions suggests that pragmatic considerations could indeed be considered the unifying force behind the use of function and mechanism in the scientific enterprise. In this regard, we agree with Vermaas and Houkes that functions are best thought of as epistemic highlighters, which describe components to explain the behavior of the system in which they are embedded. Vermaas and Houkes (2013) use Cummins's (1975) account of function to propose a unified account in which biological and technological functions can be conceptualized as mind and community-dependent epistemic highlighters. They also offer a complementary formulation in which functions can be seen as parts of the problem-solving capacities of a system and as communicative tools: "there is, to some extent, a privileged (designer) perspective from which functions are ascribed: a function is a capacity that is selected by someone, presumably for good reason, and that is communicated to others, presumably to aid them in dealing with the thing in question" (Vermaas and Houkes 2013, 218).

[14]See Glennan 2017, 3.

The notion of mind-dependent capacities and the notion of goal-oriented ascriptions should make clear the case that, under the conception of functions put forward by Vermaas and Houkes (2013), functions are epistemically and not ontologically driven. This means that functions are postulated and used not because they are real features of the world, but because acting "as if" they are real features of the world yields epistemic gain.[15] Functions are tags that highlight explanatory capacities.

Our claim, here, is that functions, understood as an epistemic highlighter, could replace alleged NKs and avoid the metaphysical debates tied to weak realism. Consider the notion "unit of selection." In section 3, we said that it is the theoretically determined relationships between properties (reproduction, persistence, and evolvability) of the alleged NK "unit of selection," rather than the lumping of occurrences into a kind, that was responsible for the explanatory power regarding the targeted phenomenon. In the case of units of selection, the targeted phenomenon is the evolution of the populations they form. Glennan (2017) refers to Godfrey-Smith (2009) in recognizing that, in this case, the mere action of labelling something as Darwinian individual (i.e., a unit of selection) requires a broader theoretical framework.

> Godfrey-Smith's analysis of Darwinian individuals starts with the observation that you cannot define a Darwinian individual except in the context of a Darwinian population. This seems to me to be a specific application of the principle of the phenomenon dependence of decomposition. (Glennan 2017, 38)

By translating the evolutionary scenario into functional terms, we see that the alleged NK can also be described as a function and hence as an epistemic highlighter. The fact that an entity plays the role of a unit of selection means that it holds a specific place in the mechanism postulated in Darwinian explanations. Is an entity relevant for understanding evolutionary dynamics? One way to know this is to look at the properties of the individual to see if it matches those that warrant the ascription of the label "unit of selection," which are determined theoretically (as described in section 3.b). Furthermore, different units of selection feature different properties and accordingly fit differently in evolutionary dynamics, such that bundling them into a coarse-grained kind would obfuscate information important for evolutionary inquiries (Godfrey-Smith 2009, 2013). Epistemic highlighters thereby also account for multiple realizability.

In functional terms, the properties of units of selection (reproduction, persistence, and evolvability) would be subfunctions—lower-level or constitutive functions—of the putative function (unit of selection) that would be ascribed to explain the larger system in which it is embedded (evolutionary population). Echoing Vermass's and Houkes's claim that functional ascription is not about the world but about human cognition, we can see that the alleged NK predicate, even though it is useful to epistemic endeavors (assuming for the sake of argumentation that D1a holds), it still leaves D1b unwarranted. Ascriptions of labels are pragmatic things, not ontological ones.

The same intuitions seem to be present in Ereshefsky and Reydon (2015) when they recognize that kinds are not ontological categories, but only useful posits of successful theories. They maintain that "[n]atural kinds on our account are not necessarily eternal ontological categories; they are foremost groupings picked out by our best scientific theories and classificatory programs" (984). Our position differs, however, in that they seem to think that the best theories are the best place to learn about NKs, taking for granted that NKs are things to learn about or to discover.

It should also be noted that the analytic work done in their paper is achieved mostly without the notion of NK. Instead, they focus on classificatory programs, whose successes can be tracked and analyzed by looking at their constitutive elements (e.g., motivating or sorting principles). These insights are extremely powerful, as they avoid a narrow focus on the end products of classificatory practices (i.e., the alleged NKs) and stand as the type of analysis that our eliminativist view condones (see Chang

[15]This insistence on the epistemic rather than ontological nature of functional ascription is akin to Knuutila's strategy regarding the epistemic aspect of models (see Knuuttila 2011, 263). Glennan (2017) also uses the "as if," or more precisely, the "treated as" analogy in his account of mechanisms.

[2016] for another analysis of classificatory endeavors in which the notion of NK is superfluous to the analysis despite appearing in the paper).

This roundabout to discuss the work of Ereshefsky and Reydon reiterates a crucial philosophical matter. Even if inductive inferences cannot justify the ontological status of NKs, one must still make sense of the fact that kind terms are used in scientific practice. It was shown that an adequate understanding of scientific explanations can refer to suggested NKs predicates as being merely epistemic highlighters of a role played by some entities within a system to be explained. It is not the grouping of entities into a kind itself that makes the inferences possible, but the observation of similarities deemed relevant in a given theoretical framework. Hence, not only is weak realism regarding NKs unwarranted, but a sound description of scientific (mechanistic) explanations is more *accurate* if it refers to epistemic highlighters rather than kinds, at least because such modesty precludes potential reification fallacies (James 1975; Whitehead 1997) and insists on what descriptive labels actually do for us.

In short, we suggest structuring further work in the philosophy of classification around the notion of epistemic highlighters for at least two reasons: first, in the absence of satisfying arguments for weak realism regarding NKs, a more ontologically prudent approach is warranted; second, epistemic highlighters account for the epistemic usefulness traditionally associated to kind predicates by insisting on the fact that this usefulness is theoretically and contextually dependent.

4.b More reasons to avoid ontological commitments

Beyond functions, there is another epistemological notion that strengthens our ontologically dry take. When underlying properties cannot be relied upon to ascribe an entity its role in a theory or mechanism because theoretical considerations are scarce or because the complexity of a given phenomenon does not allow one to specify relevant properties, the use of black boxing strategies makes even more salient the fact that the explanatory capacity of an epistemic highlighter does *not* entail any ontological commitment toward a class of things. By “black boxing strategy” we refer to the action of “cutting” through phenomena to delineate a “space” (in which there is very little or no knowledge at all of the internal workings) in order to control only the inputs and outputs of the delineated “space” that was just created for modelling purposes.

It was shown in section 4.a that functions and NKs predicates are not to be ontologically reified. Indeed, function ascriptions are relative to specific research interests, such that conceiving them as epistemic labels stems from an accurate description of scientific practice that avoids overstepping this descriptive role. Where black boxing is concerned, the issue is the same such that we end up with a form of *promiscuous black boxing*.

The promiscuousness comes from the fact that black boxes can be assembled, decomposed, and expanded at will, according to the task at hand and the success rate of a given concept use. O’Malley (2016) gives the example of the epistemic gain that ecologists reach when they attribute agency to viruses. Whether viruses form a NK or not has no impact on their epistemic usefulness. What matters is their suggested role as a node in the causal nexus of functional structures of ecosystems. Black boxing viruses, in this case, allows researchers to concentrate on the inputs and outputs that are relevant to the: “[…] flows of chemistry and energy in the oceans […]” (O’Malley 2016, 77). A black box is either discarded when it is not useful to explain the behavior of the system in which it is embedded or opened when new knowledge is gained about its internal workings.

If a given black box is associated with enough data, Baetu’s notion of parameter sufficiency, for example, can then be used to determine whether the explanatory model is accurate enough to explain the phenomenon of interest. The use of parameter sufficiency, which is a method to “determine whether it is safe to bottom out at the level of composition at which the mechanism is described” (Baetu 2015, 783), gives indications on the appropriateness of the chosen level of description and it also determines the level of independence of the selected mechanism within a larger system. This shows that despite the goal-oriented use of black boxing, anything does *not*

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go. Epistemic goals are used as benchmark of success; theoretical inputs serve as conceptual constraints while data and experimental results serve as empirical constraints.

The fact that certain classes of things are used in scientific explanations although they are not explained by underlying mechanisms or properties could suggest, in accordance with D1, that those classes of things are proper NK candidates. We propose, on the contrary, that because these unexplained nodes in causal structures are black boxes, they cannot be NKs in a weak realist sense. *By definition, they are fictions warranted only by the epistemic gain they provide.* Their ontological value is thus minimal and in no way comparable to what is argued for by weak realism. In the case of the viruses, epistemic gain comes not from their belonging to a class that would be eligible to kindhood (viruses are too diverse in too many ways to be considered a NK by ecologists or biologists; see Jansson and Wu [2022] or Summers [2014]), but from the fact that supressing their complexity contributes to better models of the larger systems in which they are embedded. These black boxes end up playing roles in scientific explanations that are similar to the ones played by traditional NK candidates. The fact that the ontological reification of the former is not warranted by their epistemic use gives further reasons to think that it is not warranted for the kind terms either. Most importantly, this challenges the validity of D1b because it would be a mistake to reify black boxes.

5. Conclusion

The tradition(s) of natural kinds stand(s) on two pillars: the belief that NKs exist, somehow, in the world, independently of our scientific practice and the belief that the notion of NK is (therefore) useful to understand how sciences work. In this paper, we evaluated the solidity of these two pillars and challenged their robustness. We are aware that we only chipped at a vast and well-built epistemological structure, but we hope that our argument will either foster debates that could strengthen the tradition(s) of natural kinds or favor the development of other approaches for describing classificatory practices.

In section 2, we provided a description of three arguments for weak realism—those of Bird, Khalidi, and Slater. This description allowed us to identify two claims present in each of them, although articulated somewhat differently in each case: first, the epistemic usefulness of NKs justifies claims according to which the world features division into kinds (D1); second, there is a hierarchy of kinds used by scientists (and other epistemic agents) such that only some of these kinds are said to be natural (D2). D1 features two components: NKs are epistemically useful (D1a) and ontology (or metaphysics) can be inferred based on this epistemic claim (D1b).

We argued that D1a, which plays a central role in all three weak realists approaches reviewed, is unsatisfactory for at least two reasons (our arguments formulated explicitly against Bird): bundling occurrences of an alleged kind may lead to a loss of information; when it does not, the epistemic gain comes from the observation of stable co-occurrences of properties taken to be relevant in a given framework rather than from the fact that these co-occurrences form a kind. This second objection applies also to the work of Khalidi and Slater because they claim we can infer a hierarchy of kinds (D2) based on the fact that some inferences (inferences that rely on causality in Khalidi's account and stable enough inferences in Slater's) are sounder than others. While we agree that some inferences are epistemically sounder than others, we argue that this is insufficient to defend a realist take, albeit weak, toward NKs. These critiques apply, *mutatis mutandis*, to any realist account of NKs mobilizing D1 and D2. *Ipso facto*, it should be noted that our eliminativist take relies neither on pluralism about NK theories (Ludwig 2018) nor on the analysis of the aims they are meant to fulfill (Brigandt 2020). We believe all three approaches are complementary.

Finally, the use of the NK concept for adequately describing scientific practices is also doubtful. Section 4 underscores that predicates traditionally considered to be NK predicates can be described as epistemic highlighters (mind and community-dependent theoretical notions that ascribe a problem-solving capacity to a given phenomenon or to one of its constitutive elements). This notion is more suited to accommodate the pragmatic dimension of scientific explanations, to avoid reification fallacies (thereby challenging the validity of D1b), and to account for theoretical concepts that are explicitly meant to be fictions (e.g., black boxes or models). Hence, implicit to our argument is the idea that the NK concept is more harmful than helpful for investigating classificatory practices (*contra* Conix and Chi 2021).

While there is still much work to be done to make the eliminativist posture the go-to viewpoint on NKs (by, for example, tackling stronger realist approaches or more of the epistemically minded approaches to NKs), our argument gives good incentives for pursuing such work. Furthermore, our work shifts the burden of proof: eliminativist arguments are often asked to show that NKs are inexistent or that their "forced elimination" leaves the strength of scientific explanations or of philosophical analysis intact. Given our argument, we claim that NK theoreticians should be the ones justifying the existence of NKs (without relying on the tradition(s) of NKs, a strategy that simply begs the question) and justifying their usefulness for the philosophical analysis of scientific practices.

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François Papale is currently a postdoctoral fellow at Université Laval (Faculty of Philosophy) and Université de Sherbrooke (Department of Microbiology and Infectious Disease). His work in philosophy of science is focused on classificatory practices and on reductionism, while his work in philosophy of biology is centered on evolutionary theories.

David Montminy is a PhD candidate in the Department of Philosophy and a research ethics expert at University of Montreal. His philosophical work revolves around epistemological and methodological issues in large-scale scientific projects. He also teaches philosophy at Cégep Édouard-Montpetit.

References

Assis, Leandro C. S., and Ingo Brigandt. 2009. "Homology: Homeostatic Property Cluster Kinds in Systematics and Evolution." *Evolutionary Biology* 36 (2): 248–55. https://doi.org/10.1007/s11692-009-9054-y.

Baetu, Tudor M. 2015. "The Completeness of Mechanistic Explanations." *Philosophy of Science* 82 (5): 775–86. https://doi.org/10.1086/683279.

Bird, Alexander. 2009. "Essences and Natural Kinds." In *The Routledge Companion to Metaphysics*, edited by Robin Le Poidevin, 497–506. Routledge.

Bird, Alexander. 2010. "Discovering the Essences of Natural Kinds." In *The Semantics and Metaphysics of Natural Kinds*, edited by Helen Beebee and Nigel Sabbarton-Leary, 125–36. Abingdon: Routledge.

Bird, Alexander. 2018. "The Metaphysics of Natural Kinds." *Synthese*, 1397–426. https://doi.org/10.1007/s11229-015-0833-y.

Booth, Austin. 2014. "Symbiosis, Selection, and Individuality." *Biology & Philosophy* 29 (5): 657–73.

Bouchard, Frédéric. 2008. "Causal Processes, Fitness, and the Differential Persistence of Lineages." *Philosophy of Science* 75 (5): 560–70.

Bouchard, Frédéric, and Alex Rosenberg. 2004. "Fitness, Probability and the Principles of Natural Selection." *The British Journal for the Philosophy of Science* 55 (4): 693–712.

Bourrat, Pierrick. 2014. "From Survivors to Replicators: Evolution by Natural Selection Revisited." *Biology & Philosophy* 29 (4): 517–38. https://doi.org/10.1007/s10539-013-9383-1.

Boyd, Richard. 1991. "Realism, Anti-Foundationalism and the Enthusiasm for Natural Kinds." *Philosophical Studies* 61 (1): 127–48.

Boyd, Richard. 1997. "Kinds as the 'Workmanship of Men': Realism, Constructivism, and Natural Kinds." In *Rationality, Realism, Revision: Proceedings of the 3rd International Congress of the Society for Analytical Philosophy*, edited by J. Nida-Rumelin, 52–89. New York: de Gruyter.

Boyd, Richard. 1999. "Homeostasis, Species, and Higher Taxa." In *Species: New Interdisciplinary Essays*, edited by Robert A. Wilson, 141–85. Cambridge, MA: MIT Press. http://philpapers.org/rec/BOYHSA.

Brigandt, Ingo. 2009. "Natural Kinds in Evolution and Systematics: Metaphysical and Epistemological Considerations." *Acta Biotheoretica* 57 (1–2): 77–97. https://doi.org/10.1007/s10441-008-9056-7.

Brigandt, Ingo. 2011. "Natural Kinds and Concepts: A Pragmatist and Methodologically Naturalistic Account." In *Pragmatism, Science and Naturalism*, edited by J. Knowles and H. Rydenfelt, 171–96. Frankfurt am Main: Peter Lang.

Brigandt, Ingo. 2020. "How to Philosophically Tackle Kinds without Talking About 'Natural Kinds.'" *Canadian Journal of Philosophy* 52 (3): 1–24.

Chang, Hasok. 2016. "The Rising of Chemical Natural Kinds through Epistemic Iteration." In *Natural Kinds and Classification in Scientific Practice*, edited by Catherine Kendig, 53–66. Abingdon, UK: Routledge.

Chang, Hasok. 2017. "Epistemic Iteration and Natural Kinds: Realism and Pluralism in Taxonomy." In *Philosophical Issues in Psychiatry IV: Psychiatric Nosology*, edited by Kenneth S. Kendler and Josef Parnas, 29. Oxford: Oxford University Press.

Charbonneau, Mathieu. 2014. "Populations without Reproduction." *Philosophy of Science* 81 (5): 727–40.

Clarke, Ellen. 2013. "The Multiple Realizability of Biological Individuals." *The Journal of Philosophy* 110 (8): 413–35.

Conix, Stijn, and Pei-Shan Chi. 2021. "Against Natural Kind Eliminativism." *Synthese*, 8999–9020. https://doi.org/10.1007/s11229-020-02614-2.

Craver, Carl F. 2009. "Mechanisms and Natural Kinds." *Philosophical Psychology* 22 (5): 575–94.

Craver, Carl F., and Lindley Darden. 2001. "Discovering Mechanisms in Neurobiology: The Case of Spatial Memory." In *Theory and Method in Neuroscience*, edited by Peter K. Machamer, Rick Grush, and Peter McLaughlin, 112–37. Pittsburgh, PA: University of Pittsburgh Press.

Cummins, Robert. 1975. "Functional Analysis." *The Journal of Philosophy* 72 (20): 741–65. https://doi.org/10.2307/2024640.

Dawkins, Richard. 1976. *Le Gène Égoïste*. Paris: Odile Jacob.

Devitt, Michael. 2008. "Resurrecting Biological Essentialism." *Philosophy of Science* 75 (3): 344–82.

Doolittle, W. Ford. 1999. "Phylogenetic Classification and the Universal Tree." *Science* 284 (5423): 2124–29.

Doolittle, W. Ford, and Austin Booth. 2017. "It's the Song, Not the Singer: An Exploration of Holobiosis and Evolutionary Theory." *Biology & Philosophy* 32 (1): 5–24. https://doi.org/10.1007/s10539-016-9542-2.

Dupré, John. 1993. *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*. Cambridge, MA: Harvard University Press.

Ereshefsky, Marc. 2018. "Natural Kinds, Mind Independence, and Defeasibility." *Philosophy of Science* 85 (5): 845–56. https://doi.org/10.1086/699676.

Ereshefsky, Marc, and Makmiller Pedroso. 2015. "Rethinking Evolutionary Individuality." *Proceedings of the National Academy of Sciences* 112 (33): 10126–32.

Ereshefsky, Marc, and Thomas A. C. Reydon. 2015. "Scientific Kinds." *Philosophical Studies* 172 (4): 969–86. https://doi.org/10.1077/s11098-014-0301-4.

Franklin-Hall, L. R. 2015. "Natural Kinds as Categorical Bottlenecks." *Philosophical Studies* 172 (4): 925–48. https://doi.org/10.1007/s11098-014-0326-8.

Gayon, Jean. *Darwinism's Struggle for Survival: Heredity and the Hypothesis of Natural Selection*. Cambridge: Cambridge University Press, 1998.

Glennan, Stuart. 2017. *The New Mechanical Philosophy*. First edition. Oxford: Oxford University Press.

Godfrey-Smith, Peter. 2009. *Darwinian Populations and Natural Selection*. New York: Oxford University Press.

Godfrey-Smith, Peter. 2013. "Darwinian Individuals." In *From Groups to Individuals: Evolution and Emerging Individuality*, edited by Frédéric Bouchard and Philippe Huneman, 17–36. Cambridge, MA: MIT Press.

Godfrey-Smith, Peter. 2015. "Individuality and Life Cycles." In *Individuals across the Sciences*, edited by Alexandre Guay and Thomas Pradeu. Oxford: Oxford University Press.

Griesemer, James R. 2000. "Development, Culture and the Units of Inheritance." *Philosophy of Science*, 67: S348–68.

Griffiths, Paul E. 2007. "The Phenomena of Homology." *Biology & Philosophy* 22 (5): 643–58. https://doi.org/10.1007/s10539-007-9090-x.

Hacking, Ian. 2007. "Natural Kinds: Rosy Dawn, Scholastic Twilight." *Royal Institute of Philosophy Supplement* 61: 203–39.

Hawley, Katherine, and Alexander Bird. 2011. "What Are Natural Kinds?" *Philosophical Perspectives* 25 (1): 205–21. https://doi.org/10.1111/j.1520-8583.2011.00212.x.

Hull, David L. 1980. "Individuality and Selection." *Annual Review of Ecology and Systematics* 11: 311–32.

Huneman, Philippe. 2013. "Introduction." In *Functions: Selection and Mechanism*, edited by Philippe Huneman, 1–18. Dordrecht, Nether.: Springer.

James, William. 1975. *Pragmatism & The Meaning of Truth*. Cambridge, MA: Harvard University Press.

Jansson, Janet K., and Ruonan Wu. 2022. "Soil Viral Diversity, Ecology and Climate Change." *Nature Reviews Microbiology*, November. https://doi.org/10.1038/s41579-022-00811-z.

Kendig, Catherine E. 2016. "Homologizing as Kinding." In *Natural Kinds and Classification in Scientific Practice*, 106–25. Abington, UK: Routledge.

Khalidi, Muhammad Ali. 2013. *Natural Categories and Human Kinds: Classification in the Natural and Social Sciences*. Cambridge: Cambridge University Press.

Khalidi, Muhammad Ali. 2018. "Natural Kinds as Nodes in Causal Networks." *Synthese*, 1379–96. https://doi.org/10.1007/s11229-015-0841-y.

Kim, Eunsoo, and John M. Archibald. 2009. "Diversity and Evolution of Plastids and Their Genomes." In *The Chloroplast*, edited by Anna Stina Sandelius and Henrik Aronsson, 13: 1–39. Berlin: Springer. https://doi.org/10.1007/978-3-540-68696-5_1.

Knuuttila, Tarja. 2011. "Modelling and Representing: An Artefactual Approach to Model-Based Representation." *Studies in History and Philosophy of Science Part A* 42 (2): 262–71. https://doi.org/10.1016/j.shpsa.2010.11.034.

Lewontin, Richard C. 1970. "The Units of Selection." *Annual Review of Ecology and Systematics* 1: 1–18.

Ludwig, David. 2018. "Letting Go of 'Natural Kind': Toward a Multidimensional Framework of Nonarbitrary Classification." *Philosophy of Science* 85 (1): 31–52. https://doi.org/10.1086/694835.
Machamer, Peter K., Lindley Darden, and Carl F. Craver. 2000. "Thinking about Mechanisms." *Philosophy of Science* 67 (1): 1–25.
Magnus, Paul D. 2012. *Scientific Enquiry and Natural Kinds: From Planets to Mallards*. Houndmills: Palgrave Macmillan.
Magnus, Paul D. 2014a. "NK≠HPC." *The Philosophical Quarterly* 64 (256): 471–77.
Magnus, Paul D. 2014b. "No Grist for Mill on Natural Kinds." *Journal for the History of Analytical Philosophy* 2 (4): 1–15.
Magnus, Paul D. 2015. "John Stuart Mill on Taxonomy and Natural Kinds." *HOPOS: The Journal of the International Society for the History of Philosophy of Science* 5 (2): 269–80. https://doi.org/10.1086/682373.
Martinez, Eduardo J. 2017. "Stable Property Clusters and Their Grounds."
Matthen, Mohan, and André Ariew. 2005. "How to Understand Casual Relations in Natural Selection: Reply to Rosenberg and Bouchard." *Biology and Philosophy* 20 (2): 355–64.
Mayr, Ernst. 1959. "Darwin and the Evolutionary Theory in Biology." In *Evolution and Anthropology: A Centennial Appraisal*, edited by Betty J. Meggers, 1–10.
Mayr, Ernst. 1994. "Typological versus Population Thinking." In *Conceptual Issues in Evolutionary Biology*, edited by Elliott Sober, 157–60. Cambridge, MA: MIT Press.
McFadden, Geoffrey Ian. 2001. "Primary and Secondary Endosymbiosis and the Origin of Plastids." *Journal of Psychology* 37 (6): 951–59. https://doi.org/10.1046/j.1529-8817.2001.01126.x.
Mill, John Stuart. 1862. *A System of Logic, Ratiocinative and Inductive Being a Connected View of the Principles of Evidence, and the Methods of Scientific Investigation*. 4th ed. London: Parker. http://books.google.com/books?id=jB3kAAAAMAAJ.
O'Hara, Robert J. 1997. "Population Thinking and Tree Thinking in Systematics." *Zoologica Scripta* 26 (4): 323–29.
O'Malley, Maureen A. 2015. "Reproduction Expanded: Multigenerational and Multilineal Units of Evolution." *Philosophy of Science* 83 (5): 835–47.
O'Malley, Maureen A. 2016. "The Ecological Virus." *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 59 (October): 71–79. https://doi.org/10.1016/j.shpsc.2016.02.012.
Papale, François. 2021. "Evolution by Means of Natural Selection without Reproduction: Revamping Lewontin's Account." *Synthese* 198; 10429–55. https://doi.org/10.1007/s11229-020-02729-6.
Papale, François, Jordane Saget, and Éric Bapteste. 2020. "Networks Consolidate the Core Concepts of Evolution by Natural Selection." *Trends in Microbiology* 28 (4): 254–65. https://doi.org/10.1016/j.tim.2019.11.006.
Quine, Willard Van Orman. 1969. *Ontological Relativity and Other Essays*. New York: Columbia University Press.
Reydon, Thomas A. C. 2009. "How to Fix Kind Membership: A Problem for HPC Theory and a Solution." *Philosophy of Science* 76 (5): 724–36.
Slater, Matthew H. 2013. "Cell Types as Natural Kinds." *Biological Theory* 7 (2): 170–79.
Slater, Matthew H. 2015. "Natural Kindness." *The British Journal for the Philosophy of Science* 66 (2): 375–411. https://doi.org/10.1093/bjps/axt033.
Slater, Matthew H. 2018. "Anchoring in Ecosystemic Kinds." *Synthese* 195 (4): 1487–508. https://doi.org/10.1007/s11229-016-1302-y.
Sober, Elliott. 1980. "Evolution, Population Thinking, and Essentialism." *Philosophy of Science* 47 (3): 350–83.
Spencer, Quayshawn. 2016. "Genuine Kinds and Scientific Reality." In *Natural Kinds and Classification in Scientific Practice*, edited by Catherine Kendig, 157–72. New York: Routledge.
Summers, William C. 2014. "Inventing Viruses." *Annual Review of Virology* 1 (1): 25–35. https://doi.org/10.1146/annurev-virology-031413-085432.
Vermaas, Pieter E., and Wybo Houkes. 2013. "Functions as Epistemic Highlighters: An Engineering Account of Technical, Biological and Other Functions." In *Functions: Selection and Mechanisms*, edited by Philippe Huneman, 213–31. Dordrecht, Nether.: Springer. https://doi.org/10.1007/978-94-007-5304-4_11.
Whitehead, Alfred North. 1997. *Science and the Modern World*. New York: Free Press.
Wiley, Edward O., and Bruce S. Lieberman. 2011. *Phylogenetics: Theory and Practice of Phylogenetic Systematics*. Hoboken, NJ: Wiley. https://doi.org/10.1002/9781118017883.
Wilson, David Sloan, and Elliott Sober. 1989. "Reviving the Superorganism." *Journal of Theoretical Biology* 136 (3): 337–56.

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