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Why Use Generic Language in Science?

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Scientists often communicate using generic generalizations, which are unquantified generalizations such as 'Americans overestimate social class mobility' or 'sound waves carry gravitational mass'. In this paper, I explain the role of such generic generalizations in science, based on a novel theory about their characteristic meaning. According to this theory, a scientific generalization of the form '*Ks* are *F*' says that *F* is one property based on which category *K* qualifies as a scientific kind. Because what it takes to qualify as a scientific kind varies depending on the discipline, what a generic sentence entails also varies. Based on this semantic theory, I discuss the benefits and drawbacks of using generic language in science.

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1. Introduction

Sometimes, science trades in universally quantified generalizations, such as the statement that 'every photon has energy equal to its oscillation frequency times Planck's constant'. Other times, a scientific generalization is universally quantified but hedged by a *ceteris paribus* clause, as in '*ceteris paribus*, whenever the demand for a good increases, the price of that good increases as well'. More surprising, however, is that many scientific generalizations do not contain any type of quantification at all. Here are several examples of such unquantified scientific generalizations:

(1) Americans overestimate social class mobility. (Kraus et al., [2015])

(2) Sound waves carry gravitational mass. (Esposito et al., [2019])

(3) Infants distinguish between leaders and bullies. (Margoni et al. [2018]).

(4) Individuals with autism spectrum disorder have difficulty relating new stimuli to past experiences. (de Marchena et al. [2015])

(5) Toddlers draw broad negative inferences from wrongdoers' moral violations. (Ting et al. [2021])

Each of these sentences ascribes a property to the members of a scientific kind, without the use of a determiner quantifier (e.g., 'all *K*s are *F*', 'most *K*s are *F*') or of an adverbial quantifier (e.g., '*K*s are always *F*', '*K*s are generally *F*'). These unquantified generalizations of the form '*K*s are *F*' are known as 'generic generalizations', or just 'generics' for short.

Generics are common in everyday conversations but as the list above illustrates, they are also frequently found in a scientific context. Several of the sentences in the list were used as the title of a research article, to communicate its main result to other experts in the field. It would not take too long to find many other examples either (Bowker [2022]). One study that measured the prevalence of generic language in the titles, highlights, and abstracts of a sample of journal articles in psychology, found that 89% of them contained at least one generic statement (DeJesus et al. [2019]). In experimental philosophy, around 70% of a sample of 170 papers contained at least one generic statement about the study's findings (Peters & Lemeire, [2023]).

This common use of generic language in science is puzzling. Generics have at least two features that appear to make them unfit for scientific communication. First, their quantificational strength is often vague. Consider 'infants distinguish between leaders and bullies' from the list above (i.e., 3). It is unclear precisely how many infants would have to make the distinction for this sentence to be true. The sentence rather appears to convey a vague range in which this prevalence falls. In contrast, a quantified generalization such as '80% of infants distinguish between leaders and bullies' conveys a precise prevalence level. If the main purpose of generalizing statements in science is to communicate the regularity with which a property occurs within a category, then generic generalizations appear to be problematically vague.

Second, generics can convey widely varying prevalence levels, depending on the kind and property involved (Tessler & Goodman [2019]). For instance, the sentence 'sound waves carry gravitational mass' (i.e., 1) has universal strength, even without an explicit universal quantifier. It says something about all sound waves. In contrast, a generic such as 'Americans overestimate social class mobility' (i.e., 2) has weaker quantificational strength; it doesn't say that all Americans overestimate social class mobility. Interpreting the prevalence level implied by a generic sentence thus requires some background knowledge about the kind and property at issue. Compared to sentences that do contain explicit quantifiers such as 'all', 'most', or '80%', this need to rely on background knowledge to determine the prevalence implications of a generic sentence increases the risk of miscommunication. An author may be mistaken about the presumed background knowledge of their audience.

Given these issues of quantificational vagueness and variation, the common use of generic language in science is puzzling. It also appears that the resulting risk of miscommunication could easily be avoided if authors were to just use the appropriate quantifiers. Even in cases where the precise prevalence of a property is unknown, authors could minimize the risk of miscommunication by using vague quantifiers (e.g., 'most', 'around 80%') or by employing the appropriate specification or hedging (e.g., 'in condition Y, all *Ks* are *F*', '*ceteris paribus*, all *K*s are *F*'). Yet even though natural languages like English provide scientists with ample tools to quantify, specify and hedge, they often choose not to, simply stating that '*K*s are *F*'. Of course, generics are shorter than explicitly quantified generalizations because they lack a quantifier, but why are they not widely regarded as too short for communicating scientific results, leaving out crucial bits of quantifying and specifying information?

In this article, I explain the prevalence of generic generalizations in science, based on a novel theory about their characteristic meaning. I will argue that generics express kind-qualifying generalizations, succinctly conveying complex information that facilitates kind-based reasoning. According to the theory I propose, a scientific generalization of the form '*K*s are *F*' says that *F* is one property based on which category *K* qualifies as a scientific kind. Since what qualifies a category as a scientific kind varies across disciplines, this semantic theory implies that what a generic sentence entails also varies.

In the following section, I first introduce some desiderata for an adequate semantic theory of scientific generics. I then evaluate two existing theories—Cohen's ([1996]) probabilistic theory and Nickel's ([2016]) mechanistic theory—to demonstrate why they fail to meet these desiderata (Sections 3 and 4). In Section 5, I present my alternative theory, arguing that generics express kind-qualifying generalizations. Finally, in Section 6, I use the semantic theory I have developed to assess the benefits and drawbacks of using generic language in science.

2. Desiderata and scope

Barring some notable exceptions, philosophers of science have rarely theorized about generic generalizations, at least compared to the voluminous literature on quantified (universal and probabilistic) generalizations, law statements, and the phrase '*ceteris paribus'* (for some notable exceptions, see Bowker [2022], Claveau & Girard [2018], Nickel [2014], Schiller [2023], Visser [2023]). This relative lack of attention is, in part, due to the common assumption that sentences of the form '*K*s are *F*' are essentially just convenient abbreviations of familiar quantified generalizations. According to this assumption, we already have theories about the role of generic generalizations in science and scientists' reasoning with them, since generic generalizations would simply be short forms of well-studied generalizations, such as ‘it is a law of nature that all *K*s are *F*’ and ‘*ceteris paribus,* all *K*s are *F*’.[1]

To be sure, for certain projects in philosophy of science, the assumption that generics are abbreviations of familiar quantified generalizations can be a justified simplification. If one is interested in understanding the modal scope of lawlike generalizations in physics, it may be irrelevant whether that generalization is explicitly quantified (e.g., ‘all sound waves carry gravitational mass’) or generic (e.g., ‘sound waves carry gravitational mass’), because both appear to have the same modal scope (Armstrong [1983], p. 6).

Nevertheless, despite sometimes making for a useful simplification, the assumption that scientific generics are shorthand for well-studied quantified generalizations is inaccurate. To illustrate this point, consider that even though the generic ‘sound waves carry gravitational mass’ may have the same modal scope as the universally quantified ‘all sound waves carry gravitational mass’, the two sentences are not exactly synonymous. One could not appropriately answer the question ‘how many sound waves carry gravitational mass?’ with the generic sentence, whereas one could with the quantified sentence. Unlike quantified generalizations, the generic ‘*K*s are *F*’ does not provide a suitable response to a ‘how many’ question (Leslie [2007]). Furthermore, generics in the special sciences are sometimes assumed to be synonymous with *ceteris paribus* generalizations, but consider that ‘Americans overestimate social class mobility’ is not synonymous with the quantified ‘*ceteris paribus,* all Americans overestimate social class mobility’. While the generic generalization may be true, the second generalization is almost certainly too strong.

These considerations concern only two specific examples, but they should suffice to give us pause and reconsider what scientific generics say. In answering this question, I have two desiderata. The first desideratum is to provide a semantic theory for scientific generics. That is, the goal is to analyze the standing meaning that is linguistically encoded by scientific generalizations of the form ‘*K*s are *F*’, which all of them therefore share. While scientific generics about different kinds and properties can be interpreted somewhat differently—for

[1] This assumption is sometimes stated explicitly, like when Kistler ([2007]) writes about law statements that ‘The universal scope of the statement need not be made explicit by a quantifier expression such as “all”, as can be seen from this example: “Beavers build dams”. We shall take it for granted that the generic form […] “As are Bs” is logically and semantically equivalent to the explicitly universal form […]’ (Kistler [2007], p. 76). More often, however, the assumption is implicit in philosophers’ concern for the underlying logical form of lawlike generalizations, which is typically taken to be universally quantified irrespective of the surface form of the generalization.

example, concerning their prevalence implications or modal scope—the first desideratum is to disregard this variation and to analyze the meaning that is shared by all scientific generics.[2]

The second desideratum is to also explain the further variation in meaning between scientific generics. While a semantic theory for scientific generics should account for the standing meaning they all share, it should also explain why the meaning of generic sentences varies, depending on the kind and property at issue. Why do the five examples of scientific generics in the list above have such different truth-conditions? What is it about the standing meaning of '*K*s are *F*' that makes us interpret 'sound waves carry gravitational mass' as saying something about all sound waves, while we do not interpret 'Americans overestimate social class mobility' as saying something about all Americans? There must be something about the standing meaning of '*K*s are *F*' that guides us in interpreting a generic sentence based on certain aspects of our background knowledge and of the context. Of course, some of the details about how we coordinate on the meaning of scientific generics will be of interest only to linguists, but this paper aims to demonstrate that a semantic theory for scientific generics does hold promise for philosophers of science as well.

Despite the goal of providing a semantic theory that accounts both for the standing meaning shared by all scientific generics and for the meaning that varies between them, the scope of the theory will also be restricted in several ways. First, the theory only concerns generics with a bare plural noun phrase, which are of this form '*K*s are *F*'. While it is also possible to formulate a generic generalization using an indefinite singular or a definite singular noun phrase (e.g., 'a tiger is striped', 'the tiger is striped'), there are subtle differences in meaning between these formulations (Krifka et al. [1995]). Only bare plural generics are considered here. Furthermore, the formulation '*K*s are *F*' can also be used to define a kind (e.g., 'bachelors are unmarried men'), but the theory does not aim to account for this definitional use.

Second, the focus lies on scientific generics, which are generics used in a scientific context to communicate about one's theoretical domain with other experts in the field. Hence if someone states that 'ravens are black' while bird-watching with a friend, this does not qualify

2 In adopting this desideratum, I am assuming that a semantic theory for (scientific) generics is possible. There are several ways of disputing this assumption: one may hold that generics are semantically ambiguous and hence require multiple semantic theories (Cohen [1996]), or one may hold that generics are semantically primitive, rather requiring a psychological (Leslie [2007]) or metaphysical (Liebesman [2011]) account of their truth-conditions. I cannot here defend my position against each of these challenges (for an argument against the ambiguity of generics, see Sterken [2015]), but I take it that my view that (scientific) generics express kind-qualifying generalizations will also be of interest to those who believe this tells us something about the cognition or metaphysics of scientific generics, rather than about their semantics.

as a scientific generic. Yet, despite this focus on scientific generics, the semantic theory I defend will also have to apply to everyday generics, since the linguistically encoded meaning of a generic sentence remains the same regardless of whether the generic is uttered in a scientific context. Section 5.3 discusses how the semantic theory initially developed for scientific generics can be extended to everyday generics as well.

Finally, I focus on simple scientific generics that do not contain any comparatives, negations, complex predicates, or modal expressions. This excludes many otherwise interesting scientific generics, such as the following:

(6) Students eat less meat after studying meat ethics. (Schwitzgebel et al. [2023])

(7) Retinas from albino rats are more susceptible to ischaemic damage than age-matched pigmented animals. (Safa & Osborne [2000])

Ultimately, a semantic theory for scientific generics should be integrated with further theories about the semantics of other phrases. The goal here is to lay the groundwork first. The next two sections introduce two existing theories that initially look promising.

3. Probabilistic Semantics

The linguist Ariel Cohen ([1996]) argues that generics express probabilistic generalizations. The simplest version of such a probabilistic theory would have it that '*K*s are *F*' says that for any member of *K*, the probability that it is *F* is greater than 50%. However, this very simple version of a probabilistic theory would fail to explain the truth of so-called 'minority generics', such as 'birds lay eggs'. This sentence is true, despite any particular bird having a less than even chance of laying eggs, given that only adult female birds do so. The generalization expressed by a generic sentence must be more complex than the simplest version of a probabilistic theory has it.

Cohen therefore proposes that generics are restricted in scope to those members of *K* that either possess *F* or an alternative to *F*. The sentence 'birds lay eggs' does not concern all birds, but only those birds that either lay eggs or have some other way of extruding offspring. The sentence would then say that for any bird with some way of extruding offspring, the probability that it lays eggs is greater than 50%. This analysis explains why the generic is true, even if less than half of all birds lay eggs. Cohen defends the following semantic theory:

Probabilistic Truth-Condition: '*K*s are *F*' is true iff for any member of *K* that instantiates *F* or an alternative to *F*, the probability that it instantiates *F* is greater than 0.5.[3]

This theory, originally proposed for everyday generics, also suggests an interesting explanation for the prevalence of generic language in science: scientific generics could serve as default reasoning rules. The probabilistic content of 'ravens are black,' for example, would license the default inference that any encountered raven (that is black or has an alternative color) will be black (Cohen [1996]; Krifka [1995]).[4] While this inference may sometimes prove to be incorrect—given the existence of leucistic white ravens—it is still a reasonable one to make in the absence of defeating information. Default reasoning like this is useful in everyday contexts but may also be the reason why generics are used in science (Schiller [2022]), namely to facilitate default reasoning in cases where one has incomplete knowledge about the target of one's inference or about the conditions it would have to satisfy for the inference to be deductively valid. Scientific generics of the form '*K*s are *F*' could be used to succinctly communicate to other experts that there is a robust probability, greater than 50%, for any member of *K* to be *F*, thereby licensing a default inference about any individual *K*.

Given this perspective on what generics say and why one would want to say it in science, let us put the theory to the test. Does Cohen's probabilistic theory successfully account for the meaning of scientific generics? The analysis does appear to capture part of what some scientific generics say. For example, part of what the generic 'infants distinguish between leaders and bullies' (i.e., 3) conveys, does seem to be that any infant probably distinguishes between leaders and bullies, licensing the corresponding default inference.

However, Cohen's probabilistic analysis fails to account for the meaning of many other scientific generics, like examples 1 and 2. According to Cohen's theory, these sentences would express the following contents:

(8) The probability that any American (with some estimation of social class mobility) overestimates social class mobility, is greater than 0.5.

[3] I am ignoring many subtleties of Cohen's account. One notable feature is that Cohen also argues that probability is itself best interpreted as a relative frequency in the limit, which would explain the nomic flavour of generic sentences (Cohen [1996]).

[4] To clarify, the following argument type is defeasibly valid, on Cohen's view: (1) *K*s are *F*, (2) *k* is a *K* that instantiates *F* or one of its alternatives, (3) hence, *k* is *F*. Note that Cohen (1996) also argues that generics have multiple readings. The type of defeasible reasoning outlined here only applies to the (absolute) probabilistic reading I have described.

(9) The probability that any sound wave (with either some or no gravitational mass) carries gravitational mass, is greater than 0.5.

This analysis is incorrect. The scientific generics ‘Americans overestimate social class mobility’ and ‘Sound waves carry gravitational mass’ do not express the probabilistic generalizations 8 and 9, respectively. To illustrate, consider the context in which these generics were uttered. ‘Americans overestimate social class mobility’ serves as the title of an article that presents several studies that compare the average estimation of social class mobility among a sample of Americans to the actual level. Such a study of averages is standard social science methodology. Importantly, the authors of the paper did not examine the individual probability of any particular American to overestimate social class mobility. Instead, the generic title—to be explained by a semantic theory—conveys the key finding that the average estimation of social class mobility among Americans exceeds the actual level.

In response to this objection, one might argue that it still feels quite natural to interpret the generic as saying that any American probably overestimates social class mobility. However, I contend that this interpretation results from not reading the generic sentence in its proper scientific context. When this generic sentence is uttered in an everyday conversation among friends, it may indeed convey such a vague probability. Section 5.3 elaborates on why a generic sentence can convey something quite different when used as an everyday generic compared to when it is used as a scientific generic. Importantly, however, as a scientific generic, the sentence does not express this vague probabilistic generalization. This is evident when we make the scientific context in which the sentence was stated more explicit:

Scientific Context: In this study, we hypothesized that among the population of Americans, the average estimation of social class mobility exceeds the actual level. Based on our results, we conclude that this hypothesis is confirmed: Americans overestimate social class mobility.

With the scientific context made explicit, it is clear that the generic ‘Americans overestimate social class mobility’ does not communicate that any American probably overestimates social class mobility, but rather conveys an entirely different message about a population average. Cohen’s theory fails to account for the meaning of this generic generalization, in its scientific context.

The same argument applies to the second example in our list, namely ‘sound waves carry gravitational mass’. This generic reports a surprising result obtained in theoretical physics. As it turns out, the application of field theory techniques to the behavior of sound waves leads to the prediction that all sound waves will interact with a gravitational field in such a way that they carry a tiny negative mass as they travel through a medium, effectively 'floating' upwards. In this research context, the probabilistic analysis underestimates the strength of the generic. The generic sentence does not say that any sound wave will probably carry gravitational mass. If generic sentences encoded such vague probabilistic claims, it would be surprising to see a generic sentence used as the title of a research article in theoretical physics instead of a more precisely quantified sentence. Imagine how surprising it would be if the title of this article had actually been 'any sound wave probably carries gravitational mass', yet this is precisely what Cohen's view entails.

Hence, even within our limited list of five scientific generics, there are at least two examples that do not express the type of vague probabilistic generalization proposed by Cohen. Importantly, this is not to deny that some scientific generics convey information about the probability for a member to instantiate the property at issue and that some of these generics also license default inferences. However, the probabilistic analysis proposed by Cohen cannot be the standing meaning shared by all generic sentences and consequently, one should not expect all scientific generics to fulfill the role of licensing default inferences. Perhaps an alternative analysis can reveal what it is that, most fundamentally, scientific generics say.

4. Mechanistic-Explanatory Semantics

According to Bernhard Nickel ([2014], [2016]), generics should rather be understood as mechanistic-explanatory statements (also see Strevens [2012a]). In his view, the generic '*K*s are *F*' says that there is a contextually relevant explanatory mechanism that operates in at least some Ks and that leads to these Ks being F. While Nickel acknowledges that stating such a mechanistic-explanatory claim may often be taken to imply that the property at issue is also prevalent among members of the kind, this is not really what the sentence says. The sentence itself only says that there is a contextually relevant causal mechanism that explains why at least some members of *K* are *F*.

In a discussion among evolutionary biologists, for instance, the generic 'ravens are black' would say that there is a mechanism that satisfies the explanatory strategies of evolutionary biology and that operates in at least some ravens, leading these ravens to be black. Based on one's further biological knowledge, one may take this to imply that most ravens are black, but this is not what the sentence says. The mechanistic content of the sentence would be true even if only a small minority of ravens were black, as long as this was due to an evolutionary mechanism. Remarkably, according to Nickel, the sentences ‘ravens are black’ and ‘ravens are brown’ could both be true, namely if it were the case that both black and brown are naturally evolved colors for ravens (and one is talking in a context where evolutionary explanations are relevant). Nickel proposes the following truth-conditional analysis for generics:

Mechanistic-Explanatory Truth-Condition: Let a ‘suitable mechanism’ satisfy the contextually operative explanatory strategies. Then, the generic sentence ‘*K*s are *F*’ is true iff there is a suitable mechanism *m* that operates in at least some *K*s and that leads to a *K* being *F*. (Adapted from Nickel [2016])

Similar to Cohen’s theory, Nickel’s semantic theory was intended to describe the meaning of everyday generics, but it also suggests an intriguing explanation for the prevalence of generic language in science.[5] According to Nickel’s analysis, a generic sentence is used to concisely state that there is a mechanism that (a) satisfies the contextually relevant explanatory strategies and that (b) causes the members of *K* in which it operates (without interference) to possess F. When using a generic sentence to assert the existence of such a mechanism, the speaker may not be able to specify what that mechanism is like or in which individuals it operates. It follows that the scope of *K*s that are said to be *F* by a generic of the form ‘*K*s are *F*’ may be opaque to the very author of that sentence.

One could then hypothesize that it can be useful in science to state such partially opaque mechanistic-explanatory claims (Bowker [2022], Strevens [2012a]). Taking our earlier example, Nickel holds that ‘ravens are black’ uttered in the context of evolutionary biology says that there is a mechanism *m* that satisfies the explanatory strategies of evolutionary biology and that operates in at least some ravens, leading these ravens to be black. Even if the precise nature of this mechanism is not fully understood, it can still be useful to state the existence of this mechanism and describe its consequences. The opacity of the generic’s scope would reflect the incompleteness of one’s knowledge about the posited mechanism. As one’s understanding of the mechanism increases, so would one’s understanding of what the generic generalization entails.

[5] Here, I focus Nickel’s ([2016]) theory. Nickel’s ([2014]) theory is more closely aligned with my own, since there he argues that one condition for a mechanism being ‘suitable’ is whether it underlies a kind. My own proposal makes this notion of ‘kinds’ a crucial component of the meaning of generics, rather than merely one condition on the suitability of mechanisms (see Section 5).

Having explained Nickel's analysis of scientific generics, let us then also evaluate it. Like Cohen's theory, Nickel's semantic theory does seem to capture part of what some scientific generics convey. The generic 'sound waves carry gravitational mass' (i.e., 2) may very well convey that there is a physical mechanism that causes some sound waves to have this property, entailing that every sound wave in which this mechanism operates will carry gravitational mass.

However, several other scientific generics cannot be analyzed as purely mechanistic-explanatory claims, like examples 1 and 3, which would be analyzed as follows:

(10) There is a mechanism *m* that satisfies the contextually operative explanatory strategies and that operates in at least some Americans, leading these Americans to overestimate social class mobility.

(11) There is a mechanism *m* that satisfies the contextually operative explanatory strategies and that operates in at least some infants, leading these infants to distinguish between a leader and a bully.

This analysis does not accurately capture what the scientific generics convey. The first mechanistic-explanatory analysis, for instance, does not capture the main message of the generic 'Americans overestimate social class mobility', even if this generic sentence may also convey something about the type of causal factors (e.g., American culture) that are responsible for the property at issue (see section 5.2).[6] According to Nickel's analysis, the generic expresses only mechanistic-explanatory information and no statistical information. However, as we have seen, this generic was in the first place used to convey a population average. Nickel could, of course, argue that this statistical information is implied and not expressed, but consider how unlikely it is that the authors would have opted for a purely mechanistic-explanatory claim as the title of their article to imply a population-level average, given that their paper focused primarily on determining this population-level average.

Furthermore, since it says nothing about the statistics involved, the mechanistic-explanatory analysis proposed by Nickel (i.e., 10) could be true even if, on average, Americans under-estimated social class mobility. However, if, on average, Americans underestimated social class

[6] That 'Americans overestimate social class mobility' also says something about the type of causal factors that are responsible (e.g., American culture), explains why the generic would be false if the population-level average it expresses is inflated by the extreme values of a small group of individuals (e.g., the extreme overestimation of social mobility by Californians). Although there are other ways of explaining this too; one could also argue that generics semantically presuppose that the kind is homogenous with respect to the property at issue (Cohen [1996]).

mobility, the generic ‘Americans overestimate social class mobility’, as used in its scientific context, would be false. Therefore, Nickel’s analysis does not adequately capture the truth-conditional content of this scientific generic.

The same criticism applies to Nickel’s analysis of ‘infants distinguish between leaders and bullies’, the third example in the list. According to Nickel’s mechanistic analysis, this sentence would be true even if it were the case that only very few infants distinguish between leaders and bullies, as long as those who do make such a distinction, do so in virtue of a mechanism that satisfies the explanatory practices of developmental social psychology. However, if distinguishing between leaders and bullies would indeed be rare among infants, then ‘infants distinguish between leaders and bullies’ would be false, given the scientific context in which this sentence was used.

In conclusion, while both Cohen’s probabilistic theory and Nickel’s mechanistic-explanatory theory capture part of what some scientific generics convey, they fail to account for the full spectrum of what scientific generics can be used to communicate. It appears that scientific generics express a type of generalization that can have probabilistic or mechanistic-explanatory implications in some contexts but is not universally confined to either. In the remainder of the paper, I argue that scientific generics express kind-qualifying generalizations, making their truth-conditions as varied as the criteria for scientific kinds themselves.

5. The Meaning of Scientific Generics

In this section, I first aim to establish a—not too controversial—definition of ‘scientific kinds’, since in what follows, I will then argue that scientific generics express kind-qualifying generalizations, making crucial use of this notion of scientific kinds. To arrive at this definition, I will argue that the two dominant metaphysical theories of scientific kinds face a dilemma. When these theories are interpreted strongly, they fall short of accounting for all types of scientific kinds. When interpreted weakly, they underdetermine what makes a category qualify as a scientific kind. In response to this dilemma, I advocate for a relativist notion of scientific kinds (Conix [2019], Ereshefsky & Reydon [2023]).

5.1 Qualifying as a scientific kind

Philosophers of science have long been concerned with understanding the role of categorization in successful scientific inquiry. While some categories (e.g., electrons, metals, democracies) support successful scientific predictions, explanations, and interventions, other ways of categorizing the world (e.g., weeds, large white objects, abnormal people) do not in this same way support our scientific goals. Wherein lies the difference? What makes some categories qualify as scientific kinds?

Although a complex debate, there are currently two main theories about the nature of scientific kinds: the probabilistic and the causal theory. The probabilistic theory posits that a category qualifies as a scientific kind when it corresponds to a probabilistic cluster of properties (Häggqvist [2005], Slater [2015]). When interpreted strongly, this theory holds that a scientific kind corresponds to a set of properties that *mostly* co-occur, where this clustering is also counterfactually robust. Slater ([2013], [2015]) explains his version of this view by likening such clusters of properties to cliques of friends hanging out at the mall together; when some of them are around, you can bet that the others will be around as well. That is, "while some of the clustered properties might go missing from time to time, they will be *mostly* or *typically* found together" (Slater [2013], p. 134).

Interpreted this strongly, however, a probabilistic cluster theory fails to account for many scientific kinds, since many kinds do not correspond to clusters of properties that mostly co-occur. For example, several biological species exhibit significant polymorphism between sexes or developmental life stages, so that they do not correspond to a single cluster of co-occurring properties (Ereshefsky & Matthen [2005], Magnus [2011]). There are also cases where members of a scientific kind behave in similar ways under similar circumstances, yet their properties do not typically co-occur. Take gold as an example; it melts when heated above 1064°C and vaporizes when heated above 2970°C. These behavioral properties never co-occur. Nevertheless, the fact that all members of the category behave in the same way in the same circumstances, is a crucial part of what makes the category *gold* qualify as a scientific kind (Khalidi [2013]).

To address these counterexamples, one could opt for a weaker interpretation of a probabilistic cluster theory, which states that scientific kinds correspond to clusters of properties that co-occur with the required probability and under the conditions necessary to accommodate the epistemic goals and practices of a given discipline and research program. While this weak interpretation offers flexibility, it also underdetermines the specific relation between a set of properties that is required for a category to qualify as a scientific kind. Nevertheless, this weak interpretation does provide a helpful framework. According to this framework, a discipline-specific account of scientific kinds must analyze the discipline-specific criteria related to the probability and conditions under which properties co-occur (Slater [2015]).

A similar argument applies to the second major theory about scientific kinds, namely the causal theory. In one strong version of it, this theory holds that a category qualifies as a scientific kind when its members share one defining property that is causally responsible for many other 'secondary' properties (Ellis [2001]). Although these secondary properties need not co-occur, they must all share the same cause, making the corresponding category support many scientific explanations. For instance, while many of the behavioral properties of gold may not co-occur, each of them is explained by the defining microstructural composition of gold.

However, this strong, essentialist, version of a causal theory does not apply to many scientific kinds. Again, biological species present a problem, since organisms that belong to a single species do not share a single causal essence (Slater [2015]). This is true of many other special science kinds too, like 'autism-spectrum disorder' (Cooper [2005]) or 'innate cognitive capacities' (Khalidi [2016]). In response to such counter-examples, the causal theory can also be interpreted weakly, holding that scientific kinds correspond to sets of properties that are causally related in a manner conducive to the epistemic goals and practices of a given discipline and research program (Lemeire [2021]). This view, akin to Khalidi's ([2016]) Simple Causal Theory, provides a framework for understanding the discipline-specific causal criteria for scientific kinds, rather than being a determinate criterion. According to this framework, understanding what it takes to qualify as a scientific kind requires that one analyze the type of causal relations between properties that would accommodate a given discipline's epistemic goals and practices. Some fields may require that one defining property is causally responsible for many others, while others perhaps require homeostatic mechanisms (Boyd [1999]) or shared causal histories (Godman [2020]).

When interpreted as two frameworks for analyzing the discipline-specific criteria for scientific kinds, there is no need to choose between a probabilistic and a causal framework. Given the variety of scientific goals and practices across scientific research programs, we should rather expect a wide array of both probabilistic and causal criteria that determine whether a set of properties corresponds to a scientific kind. In fact, there are likely other types of relations too that can determine whether a category qualifies as a scientific kind, such as a functional relation (Reydon [2009]) or an entanglement relation (Strevens [2012b]).

If scientific kinds can be realized in different ways, the most general criterion that applies to all of them is their ability to accommodate the epistemic goals and practices of a given discipline/research program (Ereshefsky and Reydon [2023]). We can then propose the following relativist definition of scientific kinds:

Definition Scientific Kind: A category *K* qualifies as a scientific kind for a given discipline *D* iff the category corresponds to a set of properties between which that probabilistic, causal, or other relation *R* exists, that is required for the category to accommodate the epistemic goals and practices of *D*.

5.2 Kind-qualifying Generalizations

With this definition of scientific kinds in place, we can now make progress in analyzing the meaning of scientific generics. Rather than that they express probabilistic generalizations or mechanistic-explanatory generalizations, I propose that scientific generics express a type of generalization in which the notion of a 'scientific kind' plays a crucial role. Scientific generics say of some property that it contributes to a category qualifying as a scientific kind, whatever that entails in the scientific context at hand (Ritchie & Knobe [2020]). Here is an initial formulation of this theory:

Kind-Qualifying Generalization: A scientific generic of the form '*K*s are *F*' is true iff *F* is one of the properties based upon which *K* qualifies as a scientific kind.

This is the linguistically encoded meaning shared by all scientific generics, irrespective of the context and the category under consideration. To be clear, the proposal is *not* that scientific generics say of some property that it is a defining or essential property of a kind. Rather, scientific generics such as examples 1-5 concern 'secondary' properties of kinds, saying of those properties that they are related to other (perhaps defining) properties of the kind in such a way that the category qualifies as a scientific kind. Following this analysis, the first two scientific generics in our list express the following generalizations:

(12) *Overestimating social class mobility* is one of the properties based upon which *American* qualifies as a scientific kind.

(13) *Carrying gravitational mass* is one of the properties based upon which *sound wave* qualifies as a scientific kind.

According to this analysis, scientific generics are not always used to license default inferences, nor are they always used to facilitate mechanistic reasoning. Instead, scientific generics primarily facilitate kind-reasoning. Whatever criteria exist in a particular scientific context for a category to qualify as a scientific kind, a generic sentence says of some property that it contributes to a category meeting those criteria. Depending on the criteria at play, saying as much may license a default probabilistic inference or may facilitate mechanistic reasoning, but that need not be the case. In fact, given our earlier (relativist) definition of 'scientific kinds', we can analyze what scientific generics say in some more detail, by combining both theories like so:[7]

Kind-Qualifying Generalization (Combined Version): A scientific generic of the form '*K*s are *F*' is true iff *F* belongs to the set of properties between which that probabilistic, causal, or other relation *R* exists, based upon which *K* accommodates the epistemic goals and practices of the contextually operative discipline *D*.[8]

For example, the scientific generics 1 and 2 in our list above express the following generalizations:

(14) *Overestimating social class mobility* belongs to the set of properties between which that probabilistic, causal, or other relation *R* exists, based upon which *American* accommodates the epistemic goals and practices of [insert contextually operative discipline *D*].

(15) *Carrying gravitational mass* belongs to the set of properties between which that probabilistic, causal, or other relation *R* exists, based upon which *sound wave* accommodates the epistemic goals and practices of [insert contextually operative discipline *D*].

What these generalizations further entail (e.g., about the prevalence of the property, the type of factors that cause it, or its counterfactual robustness) depends on what type of relation between properties would accommodate the contextually operative epistemic goals and practices. For example, perhaps the content of 14 was uttered relative to a research program in

[7] Note that my semantic analysis of generics as expressing kind-qualifying generalizations and my relativist definition of 'scientific kinds' are independent (though reinforcing) theories. Hence readers who prefer an alternative analysis of 'scientific kinds' can still adopt my analysis of scientific generics, testing for themselves whether their alternative notion of scientific kinds can explain the truth-conditional meaning of scientific generics.

[8] This basic idea can be developed in different ways. As I have developed it, the notion of qualifying as a kind is a component of the encoded content of generic sentences. But one may alternatively argue that this notion is rather a component of their (Kaplanian) character, selecting as the content of the sentence that type of relation *R* (e.g., probabilistic, causal, etc.) that accommodates the contextually operative epistemic goals and practices. There are further theoretical options too. I do not intend to take a firm stance on these issues here, but rather develop the idea in the most straightforward way. The goal here is not to provide a full-fletched compositional semantic theory (which would most likely need to be quantificational as well). Rather, the goal is to explain that aspect of the meaning of generics that is relevant for understanding their prevalence in science.

social psychology that aims to discover interesting averages among the psychological traits of groups of people, which can be causally explained by further social-cultural factors affecting these groups. If this were the research program relative to which the generic was uttered, then the generic entails both a statistical average and something about the type of factors responsible for this population average. Of course, this would be only a very vague description of the potential research program relative to which this generic was uttered. Understanding what 'Americans overestimate social class mobility' actually entails requires proper background knowledge of the research program relative to which it was uttered.

5.3 Supporting the analysis

Several observations support this analysis of scientific generics as kind-qualifying generalizations. Firstly, generic language can be found across scientific fields. Therefore, generics must express a type of generalization that makes sense in each of these fields. Unlike concepts such as 'probability' and 'explanatory mechanism', which may not universally apply to all scientific fields, the concept 'scientific kind' is universally applicable. Hence, that generics express kind-qualifying generalizations would explain why they are used and are interpretable in every scientific discipline, ranging from theoretical physics to social psychology.[9]

Secondly, there is a striking similarity between the literature on generic language and that on scientific kinds. Notably, there are remarkable parallels between the probabilistic and causal theories explaining the meaning of generic sentences and the theories regarding the probabilistic and causal criteria for scientific kinds. These parallels are to be expected if generic sentences express kind-qualifying generalizations. Just as linguists studying the meaning of modal expressions and metaphysicians exploring modality are likely to develop somewhat similar theories, researchers studying generic language (i.e., language that describes properties that stand in a kind-making relation to each other) and metaphysicians exploring "how to make kinds with properties" (Chakravartty [2007], p. 168) are also expected to yield similar theories (Liebesman & Sterken [2021]).

Thirdly, the theory that scientific generics express kind-qualifying generalizations explains why various scientific generics are also interpreted differently, depending on the kind and

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[9] That generics can be found in all scientific fields does not mean they are equally prevalent in all scientific disciplines. In fact, a testable predication of my account is that generics will be less prevalent in disciplines where kind-reasoning is less prevalent.

property at issue. In the introduction, I noted that the interpretation of scientific generics can vary, for example with respect to their prevalence implications or modal scope. Why is that? The answer is two-fold: (a) scientific generics say that a property contributes to a category's qualification as a scientific kind, and (b) what relation R is required for a set of properties to correspond to a scientific kind depends on the contextually operative discipline and research program.

The crux of the idea, then, is that the notion of a scientific kind—which is a component of the standing meaning of a generic sentence—is incomplete, since it can only be interpreted relative to the epistemic goals and practices of a particular discipline/research program. Relative to particular epistemic goals and practices, the notion *scientific kind* refers to a set of properties between which that probabilistic, causal, or other relation exists, that is required for the corresponding category to accommodate these goals and practices. A generic sentence '*K*s are *F*' says that a property *F* belongs to that set for a category *K*.

Finally, the semantic theory I have proposed can also explain the difference in meaning between scientific and everyday generics, since the theory can be extended to everyday generics as well. Here is a more generalized version of the semantic theory, which no longer refers to 'scientific' kinds in particular:

Kind-Qualifying Generalization (Universal Version):
A generic of the form '*K*s are *F*' is true iff *F* belongs to the set of properties between which that probabilistic, causal, or other relation *R* exists, based upon which *K* accommodates the contextually operative epistemic goals and practices.

According to this view, the generic formulation '*K*s are *F*' encodes that *F* is one property based upon which *K* qualifies as a kind, and a kind, furthermore, is a category that corresponds to a set of properties that accommodate the contextually operative epistemic goals and practices. What is distinct of the meaning of scientific generics, on this perspective, is only that they are stated relative to scientific epistemic goals and practices. As a result, a generic sentence such as 'Americans overestimate social class mobility'—which encodes a kind-qualifying generalization—may be interpreted quite differently when used as the title of a research article in social psychology, compared to when it is used in a conversation among friends about national stereotypes. Uttered in a context with more everyday epistemic concerns, this generalization may imply that any American probably overestimates social class mobility. Used in a scientific context, however, with the epistemic concerns of social scientists at play, this same sentence may rather imply a statistical message about a population average.

In this way, the semantic theory that generics linguistically encode kind-qualifying generalizations, explains not only what meaning all generics share, but also explains why this shared meaning can lead to such different interpretations of particular generic sentences. Not only will generics uttered relative to different scientific fields and research programs (e.g., 1-5) be interpreted differently, but the same generic sentence may also be interpreted differently depending on whether it is uttered in a scientific context or an everyday context, given the different requirements for a category to qualify as a scientific kind versus an everyday kind.

6. Why Use Generic Language in Science?

The semantic theory developed in the previous sections can now be used to evaluate the potential benefits and drawbacks of using generic language in scientific communication. There are several potential benefits to consider.

Firstly, generic language can facilitate scientists' coordination about the categories that are kinds for their field. Every generic that is used in a scientific context presupposes that the subject category is a scientific kind (Noyes & Keil [2019]). For example, the generic 'sound waves carry gravitational mass' presupposes that *sound wave* is a scientific kind for physicists. Similarly, the other scientific generics in our list presuppose that—perhaps surprisingly—*American*, *infant*, *individual with autism spectrum disorder* and *toddler* qualify as scientific kinds for the related disciplines.[10] As such, scientists can use generic language to communicate to others that a category satisfies the epistemic goals and practices operative in their field.

Secondly, generic language offers a way to convey highly complex information in a concise manner (Bowker [2022]). I have argued that what a generic entails is determined by the set of epistemic goals and practices relative to which it is stated, making the full message it conveys as intricate as these goals and practices themselves. For instance, physicists may require all the members of a scientific kind to behave in the same way in the same circumstances, due to the same physical forces, and to do so under all physically possible suppositions (i.e., be maximally counterfactually stable). If this is the case, then the scientific generic 'sound waves carry

[10] One interesting upshot of the view that scientific generics presuppose that the category at issue is a scientific kind, is that there are many more scientific kinds than are typically theorized about by philosophers. For example, in biology, much of the literature on scientific kinds focuses on (evolutionary) taxonomy, but there are many other types of categories as well. To give one example; the generic "retinas from albino rates are more susceptible to ischaemic damage than age-matched pigmented animals" (Safa & Osborne [2000]) presupposes that the category 'retina from an albino rat' is a scientific kind.

gravitational mass' entails something about each of these different aspects, conveying this complex information in a concise manner to those experts who understand the operative epistemic goals and practices.

Thirdly, generic language allows researchers to describe relations between properties directly. Scientific generics do not primarily concern how many members of a particular group feature a given property. Rather, scientific generics concern the relation between a property and a set of other—perhaps defining—properties. By allowing researchers to discuss the relation between a set of properties based upon which a category qualifies as a scientific kind, generics facilitate the type of kind-based reasoning that several philosophers have now argued is crucial in science (Khalidi [2013]; Slater[2015]).

Finally, generic language allows researchers to be appropriately non-specific. 'Sound waves carry gravitational mass' does not specify in which conditions they do so. Similarly, 'infants distinguish between bullies and leaders' does not specify to what extent infants do so or how prevalent exactly this property is among them. There may of course be contexts in which being more specific about these features can be important, requiring more specified or quantified generalizations. Nevertheless, non-specificity can also be useful to establish agreement on certain broad features of the world, while still allowing disagreement on the specifics. For example, since the precise conditions under which sound waves carry gravitational mass are still unknown, it is useful to be able to express a generalization that leaves these conditions unspecified, to establish agreement on the broader fact that they do so in some conditions.

However, the use of generic language in science is not without its potential costs either. For one, generics convey by way of presupposition that the category at issue is a scientific kind. However, thinking about a category as a scientific kind can also lead to reasoning mistakes, which could then be facilitated by the use of generic language. In psychology, for example, a recent study showed that 94% of a set of papers only sampled WEIRD populations (i.e., Western, Educated, Industrialized, Rich, Democratic populations; Rad et al. [2018]). Yet despite the fact that WEIRD populations are psychological outliers in several respects (Henrich et al. [2010]), many papers in psychology still generalized their findings to people or the folk as such, without justifying this very broad scope (Thalmayer [2021]). Potentially, one factor that leads to such overgeneralizations is the common use of generic language in psychology about categories like *people* and *the folk* (DeJesus et al. [2010]), conveying that these are the appropriate kinds to generalize over in psychology. In these cases, the use of quantified, specified, or hedged generalizations to communicate one's results could encourage researchers to take a more reflective attitude toward the target populations for their inferences (Peters & Lemeire [2023]).

Furthermore, as mentioned before, to determine everything that a scientific generic implies, requires that one knows the epistemic goals and practices relative to which the generic was stated. While experts in a given field may therefore be able to communicate successfully using generic language, novices may be prone to misunderstand them, given their limited knowledge of the relevant practices. For example, a novice who reads the title 'Americans overestimate social class mobility' may take this to imply that most of them do, mistakenly interpreting the scientific generic based on a more everyday understanding of social kinds. In fact, although this is a more tentative point, this problem may not be restricted to novices' interpretation of scientific generics. Even experts may sometimes interpret a scientific generic based on their pre-theoretical folk understanding of kinds.

Hence using generic language in science is somewhat of a double-edged sword; because they express kind-qualifying generalizations, they can be used to coordinate on the categories that are scientific kinds and can be used to concisely convey complex information that is appropriately non-specific and facilitates kind-based reasoning. On the other hand, scientific generics may also encourage overgeneralizations and are prone to be misunderstood by those who lack the required context.

7. Conclusion

In the introduction, I stated that the goal of this paper was to show why a semantic theory for scientific generics also holds promise for philosophers of science. To achieve this goal, I have argued that generics express kind-qualifying generalizations, rather than that they always express the probabilistic generalization proposed by Cohen, or always express the mechanistic-explanatory generalization proposed by Nickel. Building on this semantic theory, I argued that generics are not always used in science to license default inferences, as Cohen's theory would suggest, nor to facilitate mechanistic reasoning, as Nickel's theory would suggest. Instead, generics are used to convey kind-qualifying generalizations, with their distinct benefits and potential drawbacks.

Let me conclude by highlighting one more way in which a semantic theory for scientific generics holds promise for philosophers of science. As mentioned before, many philosophers have sought to describe the criteria that a category must meet to qualify as a scientific kind, often through in-depth analyses of specific cases (Kendig [2016]; Khalidi [2023]). Given the semantic theory I have defended, however, there may also be an alternative way of studying these criteria. Since the type of probabilistic, causal, or other relation that is posited by a generic sentence is determined by the contextually operative criteria for scientific kinds, what information scientists take a generic to imply will also reflect how they understand these criteria. As such, one alternative way for philosophers to study the criteria for scientific kinds within a particular discipline or research program, is to study how experts actually reason with generics pertaining to their discipline. What information do they consider as confirming or falsifying a scientific generic? What information do they take to be implied by a scientific generic?

Hence, while the common assumption that scientific generics merely serve as shorthand for various well-studied quantified generalizations may be a useful simplification for some projects in philosophy of science, it also precludes other interesting questions to arise. Generics, as I have argued, express kind-qualification generalizations, which should lead us to ask what function such generalizations have in science, and what further insights their use may hold for philosophers studying the nature of scientific kinds.

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