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The neutral theory of conceptual complexity

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Abstract

Philosophical studies of complex scientific concepts are predominantly "adaptationist," arguing that conceptual complexity serves important purposes. This is a historical artifact. Having had to defend their views against a monist presumption favoring simpler concepts, pluralists and patchwork theorists felt compelled to show that complexity can be beneficial. This neglects an alternative possibility: Conceptual complexity is largely neutral, persisting simply because it does little harm. This article defends the neutral theory of conceptual complexity in two forms: (a) as a plausible theory in its own right and (b) as a useful foil for adaptationist arguments.

1. The onion test

Consider the onion. Not merely the edible bulb, but the entire plant: *Allium cepa.* The onion possesses a great deal of DNA: Its haploid genome size is 15.9 gb (Ricroch et al. 2005). Humans, by contrast, have a piddling 3.1 gb haploid genome size (Genome Reference Consortium 2022)—roughly one-fifth as much as *A. cepa*. This disparity motivates Ryan Gregory's onion test (Palazzo and Gregory 2014). The test is simple: Those who deny the existence of nonfunctional, "junk" DNA (e.g., Pennisi 2012) must explain what, exactly, the onion is doing (and the human is not) that requires five times as much of the stuff. Failing this, we should acknowledge that a great deal of DNA is—from the host organism's perspective (cf. Doolittle and Sapienza 1980)—junk, in onions and humans alike.

Recent work highlights the complexity of important scientific concepts (Brigandt 2003a, 2003b; Jamniczky 2005; Griffiths and Stotz 2013; Bursten 2018; Haueis 2018, 2021a; Novick 2018). Some regard conceptual complexity as a problem to be resolved by conceptual fragmentation (Ereshefsky 1992, 2010; Machery 2009; Taylor and Vickers 2017); others defend it as valuable for scientific reasoning and communication (Wilson 2006, 2018; Neto 2020; De Benedetto 2021; Haueis 2021b). But, whether friend or foe to conceptual complexity, all share a basic "adaptationist" presupposition: Conceptual complexity should be tolerated, if at all, only if it serves some valuable function. The disagreement largely concerns whether or not it does.

Complex scientific concepts may, however, be like onions: bloated with junk that neither serves much of a purpose nor does much harm. Just as much of molecular evolution is neutral (Kimura 1983) or nearly neutral (Ohta 1992), the same may be true of conceptual complexity: It may arise independent of its value and it may (justifiably) persist simply because getting rid of it is more trouble than it's worth. Call this *the neutral theory of conceptual complexity*. This article defends that theory.

2. Monist hangover

That ordinary language concepts are messy is uncontroversial. That the same is true of core scientific concepts, as they appear in practice, is foundational to philosophy of science: It justifies the practice of explication, both historically (Carnap 1962) and presently (Justus 2012). In speaking of conceptual "complexity," I mean to include a range of phenomena, including vagueness, polysemy, imprecision, and anything else that prevents a concept from admitting of a single, relatively simple definition that lays down definite criteria of application. I shall refer to all views that favor replacing complex concepts with one or more simpler, more definite, disambiguated concepts as "monist." In this sense, self-styled eliminative pluralists are a type of monist (cf. Ereshefsky 1992, 688).

Monists can point to several advantages of such conceptual clean-up work. Carnap's (1962, ch. 1) classic defense of explication identifies two: (a) bringing the concept into a well-connected conceptual system and (b) allowing for the statement of (a greater number of) universal laws.

Explication also allows one to disentangle distinct but related uses of the same term. Wherever such uses coexist, there is risk of conflation. For instance, Ereshefsky (1992, 680) argues that

> The term "species" is superfluous beyond the reference to a segmentation criterion; and when the term is used alone it leads to confusion. The term "species" . . . should be replaced by terms that more accurately describe the different types of lineages that biologists refer to as "species."

Likewise, Machery (2009, 220) argues that

> The notion of concept ought to be eliminated from the theoretical vocabulary of psychology because it might prevent psychologists from correctly characterizing the nature of the knowledge in long-term memory and its use in cognitive processes.

Carnap, Ereshefsky, and Machery are all alike concerned that inexact and polysemous concepts hinder clear communication and fruitful theoretical development.

Pluralists (e.g., Brigandt 2003b; Jamniczky 2005; Currie 2016; Neto 2019) and patchwork theorists (e.g., Wilson 2006; De Benedetto 2021; Haueis 2021b) show greater appreciation for messiness. This appreciation, however, rests on the belief that there is greater order within the mess than meets the eye. The gambit is that messiness and polysemy can be functional in ways that monists have failed to appreciate.

The proposed functions of complexity are various. Jamniczky (2005, 694; cf. Brigandt 2010) views the plurality of "homology" concepts as an array of "investigative tools" for the study of biological similarity; the messiness allows each

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discipline to use the specific tool best suited to its purposes. Neto (2020, 57) argues that the imprecision of "lineage" "helps biologists integrate theoretical principles and methodologies into different areas of biology." Novick and Doolittle (2021, 75, 72) contend that the patchwork structure of "species" facilitates "the transfer of reasoning patterns" developed for macrobes to the study of microbes (and vice versa), and so helps "manage inquiry into processes of speciation."

This emphasis on the functionality of complexity is meant as a defense against monist critiques. Neto (2020, 57–58), for instance, writes:

> Imprecision typically leads to miscommunication, reasoning errors, and similar problems in science. For these reasons, imprecise concepts seem to be obstacles to scientific knowledge, and thus scientists should avoid them.

There should thus be a prima facie presumption against tolerating imprecision. Neto's defends the imprecision of "lineage" on the grounds that the ways it facilitates important forms of integration is sufficient to overcome this presumption. Novick and Doolittle (2021, Section 7) likewise take the transfer of reasoning patterns between patches of "species" to impose a cost on eliminativist views.

Examples might be multiplied, but the point is clear: Monists and pluralists share the adaptationist presumption that complexity is prima facie undesirable, that it should be tolerated only if it can be shown to serve some valuable function. This, I suggest, is a historical artifact, a hangover from the period of monist dominance, a side effect of having had to make the case for complexity against a backdrop of suspicion.

This monist hangover has led to the neglect of the view that conceptual complexity is predominantly *not* problematic, *not* functional, but rather *benign*. Or, to continue the analogy with evolutionary theory, that conceptual complexity is by and large *neutral*.

3. Conceptual adaptationism: A critique

The adaptationist presupposition, shared by monists and critics alike, might seem unobjectionable. Imprecision and polysemy inherently create at least the possibility of confusion. This provides prima facie reason to distrust them. However, uncritical acceptance of this presupposition disposes us to accept weak arguments for the functional value of conceptual complexity, much as Gould and Lewontin (1979) worried that defaulting to evolutionary adaptationism led to the too easy acceptance of particular adaptationist hypotheses.

Before defending the neutral theory directly, therefore, I will raise general concerns about arguments that purport to show that conceptual complexity is functional. Such arguments may concern either or both the *origin* and the *present value* of conceptual complexity. About the present value of some instance of conceptual complexity, they claim, first, that this complexity serves some function and, second, that serving that function provides a net benefit. One may also go further and claim, third, that this complexity arose *for the sake of* serving that function. Accepting the first two claims while rejecting the third leaves the present function an *exaptation* (Gould and Vrba 1982).

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Adaptationist arguments defending conceptual complexity generally successfully establish only the first claim. They fail to successfully establish the second claim because they are *selective*. They fail to successfully establish the third claim because they are *insufficient* to eliminate neutralist interpretations.

Arguments defending the present value of conceptual complexity tend to be selective. They do not provide anything like a global cost-benefit analysis of the trade-offs involved in managing complex concepts. Rather, they focus on establishing that conceptual complexity serves some particular function (first claim). Even if the case for functionality is compelling, however, such an argument will not show that it is adaptive on the whole because it will not show that the benefits of serving that function outweigh the costs imposed by complexity.

Consider Novick and Doolittle's (2021) arguments concerning "species." Their target is Ereshefsky's view that different species concepts—because they pick out different biological properties—are distinct concepts. Granting Ereshefsky's (1992, 2010) claims about the relationship between species concepts and real-world properties, they reject the inference to conceptual distinctness.

Instead, they argue, the species concept has a patchwork structure (Wilson 2006; Haueis 2021b) and that this structure allows it to serve the function of managing inquiry into speciation (clustering) processes. Because evolutionary processes work differently in different domains of life (Novick and Doolittle 2019), the resulting clusters can vary: "Species" in macrobes need not be the same kind of cluster as "species" in microbes. However, reasoning strategies concerning the role of gene flow in macrobes have been successfully applied to microbes, and reasoning strategies about species pangenomes developed in studies of microbes have been successfully applied to macrobes. Thus, even though "species" does not display a neat one-predicate-meets-one-property alignment (Wilson 1982), it facilitates transfer of reasoning patterns between domains, and so helps manage inquiry into speciation.

Suppose that Novick and Doolittle are correct that "species" serves this function. This is still insufficient to establish that the benefits of serving this function outweigh complexity's costs, for two reasons. First, they do not consider the direct costs of complexity. Referring to both macrobial and microbial clusters as "species," for instance, risks encouraging meaningless comparisons (e.g., "are there more macrobial or microbial species in the world?"). How we use species concepts also matters for conservation purposes (Frankham et al. 2012)—this is not considered at all. Without considering these costs, Novick and Doolittle fail to provide a compelling defense of the overall value of the concept's complexity.

Second, they do not consider whether the complexity serves this function *comparatively well*. It is one thing to show that the complexity of "species" facilitates transfer of reasoning patterns between different regions of inquiry into speciation. It is another to show that this function could not be served equally well or better using multiple simpler concepts. In the case of "species," some of the transfer of reasoning patterns between domains does occur in the course of asking questions about the extent to which macrobial and microbial species are similar (Bobay and Ochman 2017). However, what is crucial to this transfer is that similar reasoning strategies work in both domains. This does not require that we regard both macrobial and microbial clusters as "species."

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These weaknesses are not limited to Novick and Doolittle. A global assessment of the value of using any given complex concept requires considering and weighting a wide range of factors—no mean task. Note that eliminativists and other proponents of fragmentation do not escape this charge: Emphasizing the potential for confusion—even pointing to actual confusion—is insufficient to establish that complexity is harmful overall. While much valuable work has been done by friends and foes alike, establishing the overall value of any given instance of complexity is more difficult than either side has appreciated.

Arguments about the value of conceptual complexity are also generally insufficient to support adaptationist accounts of the *origin* of that value over neutralist alternatives. Even if it is established that a complex concept serves some function, it is rarely satisfactorily demonstrated that the function could not be served with multiple simpler concepts. Further, it is rarely shown that the complexity exists for the sake of serving the function, in the sense that serving the function plays a role in its origin or even its maintenance.

There is a difference between conceptual complexity *serving* some function and its existing *for the sake of serving* that function. Where functional roles for conceptual complexity exist (regardless of whether or not they outweigh complexity's costs), they may be *exaptations* at best. On this view, conceptual complexity may be latently present for nonfunctional reasons and may be called on to serve some function simply because it is available, not because it is especially well suited for that purpose. On this view, reasoning transfer about speciation processes occurs under the aegis of a complex species concept merely because biologists happen to refer to both macrobial and microbial clusters as "species." This alternative is compatible with Novick and Doolittle's arguments showing that "species" plays a role in facilitating this transfer. As with the worry about selectivity, this concern is general. While adaptationist explanations of the origin of conceptual complexity are not *essential* to taking an adaptationist view of the present value of complexity, rejecting such claims will be an important aspect of the neutral theory.

In raising these critiques, my aim has been neither to show that all arguments for the functional value of conceptual complexity fail, nor to argue that conceptual complexity is never functional. Rather, I have sought to illustrate the difficulty of assessing the functional value of conceptual complexity *at all*. That this difficulty has hitherto been insufficiently appreciated is at least partially due to the general neglect of the neutralist alternative, for it is precisely this alternative that throws the relevant standards into sharp relief.

4. The neutral theory of conceptual complexity

The neutral theory of conceptual complexity has both descriptive and normative elements. The descriptive element is a neutralist account of the *origin* of conceptual complexity. The normative element is a neutralist account of the *present value* of conceptual complexity, which should in most instances be tolerated rather than eliminated.

There is reason to believe that complex scientific concepts arise through largely neutral processes. For instance, there are two basic ways in which patchwork concepts form—both plausibly neutral. The first way involves a concept that is initially applied

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in a loose way across a range of domains, then is rendered more precisely measurable (e.g., "temperature," Chang 2004; "hardness," Wilson 2006, ch. 6). If the worldly supports of the initial uses vary across domain, the term can naturally settle into local patches of use that behave in importantly different ways (e.g., "hardness" picks out different physical properties when applied to different classes of materials). The second way involves the precisification of a concept within one domain, followed by an extension to new domains (e.g., "cortical column," Haueis 2016; "homology," Novick 2018). In these cases, what seems like a conceptually straightforward extension may prove in retrospect to have substantially increased the complexity of the concept.

Both processes involve ignorance of complexity on the part of concept users. Both involve the application of a concept to a domain before it is known exactly how the concept will behave in that domain. "Hardness" was applied to various materials well before people had any deep understanding of its physical underpinnings (let alone reason to suspect that these differ by material). "Homology"—initially a morphological concept—was applied to genes well before the discovery of the nature of DNA replication. In hindsight, however, these details cause gene homology to work in importantly different ways from morphological homology.

When conceptual extension proceed in advance of detailed knowledge about how the concept will adapt to new domains, concept users have little ability to consider the potential costs and benefits of rendering the concept more complex through such extension. Such extensions often seem straightforward when they occur, precisely because the complexifying factors are unknown (Wilson 1982). Only after struggling to accommodate the concept to the new domain does the complexity reveal itself, at which time the complexity may be entrenched and difficult to eliminate.

Consideration of these processes of complexification provides prima facie reason to accept a neutralist account of the origin of conceptual complexity. Complexity arises, not because it is advantageous as such, but rather because, once the extension has happened, it is required to make the concept function at all in the new domain. Some nuance is required here. In speaking of conceptual extensions "adapting" or being "accommodated" to a new domain, this model may seem adaptationist after all. I am not denying that language users in these scientific communities consciously try to make their *local* uses of a concept fit the domain. My point is that the complexity plays no role in this process; it is a by-product, not a cause.

Transposable elements furnish an evolutionary analogy. The processes by which transposable elements spread are adaptive *for the transposable element*. This generates genomic complexity *for the organism* as a by-product. From the organism's perspective, most transposable element insertions are neutral. Likewise, complexity-increasing conceptual extensions may be adaptive at the level of the local use, but this does not mean that the complexity is adaptive. Indeed, this should be expected, for most of the pressures driving such conceptual adaptations function within the local communities. A global linguistic regulatory structure that spans subcommunities of researchers is rare.

But, if complex concepts arise using neutral processes, why tolerate them? If they offered an especially good way of dealing with a complex world, that would be one thing. But if they are the unforeseen consequence of deceptively simple-seeming extensions, why not replace them with an array of more cleanly defined concepts (as eliminativists favor)?

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Enter the normative element of the neutral theory of conceptual complexity: Conceptual complexity is probably net neutral or, more precisely, nearly neutral, and is therefore not worth eliminating. In evolutionary biology, the neutral theory predicts that most mutations are selectively neutral, and so spread (or not) through genetic drift. The nearly neutral theory extends the neutral theory, recognizing that, as effective population size decreases, genetic drift becomes more powerful. For any given effective population size, then, there is a range of selective values (positive and negative) where selection is weaker than drift. Mutations in that range—nearly neutral mutations—will evolve *as if* they are neutral (Ohta 1992).

The neutral theory of conceptual complexity suggests that most conceptual complexity is nearly neutral in an analogous sense. Using complex concepts may be slightly beneficial or slightly deleterious, compared with other ways of conceptualizing a domain, but these (dis)advantages are not so large as to occasion much worry. It just doesn't really matter which we use, so we can follow whatever the contingent historical development of our conceptual toolkit has left us. Conceptual housekeeping (Haueis and Novick forthcoming) is rarely worth the effort.

There are a few reasons to think this. Some follow from what has already been discussed. The weakness of adaptationist arguments provides reason to be sympathetic to the neutralist view. Likewise, the account just given of how conceptual complexity arises is readily compatible with the normative aspect of the neutral theory. Both of these reasons, however, cut only against the idea that conceptual complexity is beneficial, without addressing its costs. Thus, they might equally be taken to support eliminativism.

There is, however, reason to think that conceptual complexity is not especially harmful. Humans are competent navigators of polysemy, they are able to determine relevant uses from context (Falkum 2015). Biologists researching speciation, for instance, recognize the differences between macrobes and microbes. While conceptual complexity may pose greater difficulty for nonspecialists (who are more susceptible to problematic conflations of distinct uses), there are at least two reasons not to worry overly much about this. First, the obvious alternative (replacing a complex concept with multiple simpler concepts) comes with challenges of its own. Second, the differences between specialized uses are often not relevant. Outside of engineering contexts, the differences between the hardness of plastic and of metal are of limited importance, and even biologists can often skate over the fine differences between species concepts (Currie 2016).

Furthermore, while conceptual complexity may not be of much value, what *is* valuable is familiarity. By the time the complexities introduced by a given conceptual extension reveal themselves, the new use may be entrenched: The relevant speakers will have habituated to it (and to switching between uses). Changing the linguistic behavior of an entire community is difficult, and is worth the effort only where complexity is causing significant, demonstrable confusion (Haueis and Novick forthcoming). In other words, by the time the value of a particular instance of conceptual complexity can be explicitly assessed, it may be too late to change by deliberate effort. This may be understood as a conceptual analog of constructive neutral evolution (Stoltzfus 1999; Wideman et al. 2019; Muñoz-Gómez et al. 2021), in which complexity increases using neutral processes such that later changes "lock in" earlier ones by rendering reversion to the former, simpler state deleterious.

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If the preceding reasoning is cogent, then the neutral theory of conceptual complexity is at worst plausible. There is good reason to suspect that conceptual complexity emerges, not because it is beneficial, but rather as the by-product of neutral processes. Furthermore, once it has emerged, there is good reason to think that it is neither advantageous enough to celebrate nor deleterious enough to eliminate.

5. Conclusion: Using the neutral theory

This article is short and polemical. Its arguments are intended to motivate the plausibility of the neutral theory of conceptual complexity; I harbor no delusions that they definitively establish it. For my purposes, plausibility suffices: The neutralist perspective has been unduly neglected. It deserves more, and more serious, consideration. I would like to conclude by discussing two roles for the neutral theory going forward.

As with neutralism-selectionism debates in evolutionary theory, discussion of the respective roles of neutral and adaptive processes in generating and sustaining conceptual complexity will take the form of a relative frequency debate (Beatty 1997). Almost certainly, some conceptual complexity is adaptive, some is harmful, and some is neutral. I have provided reason to think that more of it falls into the last category than has generally been recognized. The first role for the neutral theory is thus as a viable candidate explanation for particular interesting cases of conceptual complexity.

The second role for the neutral theory of conceptual complexity is methodological. While the neutral theory of molecular evolution is still the subject of intense debate (Kern and Hahn 2018; Jensen et al. 2019), its value is partially independent of its truth. By establishing on theoretical grounds the potential power of genetic drift, the neutral theory raised the standards for attributing evolutionary change to selection (Dietrich 2006). The neutral theory of conceptual complexity can play a comparable role. We have already seen that adaptationist arguments about the value of conceptual complexity are generally insufficient to rule out neutralist alternatives. This is, in part, due to the fact that the neutralist view has simply not been considered. Even if, on further study, the neutral theory proves to fit only a limited range of cases, explicitly including it as a possibility can force adaptationist arguments (monist and pluralist alike) to greater sophistication, and so can yield a clearer picture of the conditions under which complexity of all three kinds arises (Kovaka 2021).

Is this enough? Does this secure the importance of the neutral theory of conceptual complexity? Or is conceptual complexity an interesting topic for philosophical reflection only when it is either especially valuable or especially harmful? My own view is that what is important is to find the truth, and that if the neutral theory is a valid investigative hypothesis, then to establish the theory, test it against particular cases, and defend it is a worthwhile philosophical exercise.

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