

categorization involves a computation of similarity, the two classes of models are different in one respect. Prototype-based models usually employ a *linear* similarity measure, while exemplar-based models usually employ a *nonlinear* similarity measure. This may suggest that prototypes are processed following an algorithm that uses a *linear* similarity measure, while exemplars are processed following an algorithm that uses a *nonlinear* similarity measure.

But as Machery also points out, linear measures of similarity are not required for prototype-based models (2009, p. 90), and nonlinear measures of similarity are not required for exemplar-based models (2009, p. 98). Thus, the use of linear versus nonlinear measures does not determine whether an algorithm is prototype-based or exemplar-based. Therefore, there is no clear evidence that prototypes and exemplars are used in processes that follow different algorithms.

In conclusion, Machery has provided no convincing evidence that prototypes and exemplars are typically used in distinct cognitive processes. This lack of evidence is enough to at least partly undermine the fourth tenet of HH. The considerations we have presented are part of a larger set of doubts on Machery's way of splitting concepts into prototypes, exemplars, and theories. Machery may yet be right that there are different kinds of concept, but there might be a more fruitful way to split concepts into kinds than that postulated by HH.

Specifically, one of us (Piccinini) has argued that the two main kinds of concept are implicit concepts and explicit concepts. Implicit concepts encode information about a category in an implicit form that cannot be accessed directly by the language faculty, whereas explicit concepts encode information in an explicit form that can be manipulated by the language faculty (Piccinini, forthcoming; Piccinini & Scott 2006). This proposal fits with and may contribute to explain a wide range of evidence about implicit versus explicit cognition (Evans & Frankish 2009).

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Doing with development: Moving toward a complete theory of concepts

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Abstract: Machery proposes that the construct of "concept" detracts from research progress. However, ignoring development also detracts from research progress. Developmental research has advanced our understanding of how concepts are acquired and thus is essential to a complete theory. We propose a framework that both accounts for development and holds great promise as a new direction for thinking about concepts.

In *Doing without Concepts*, Machery (2009) provides a solid argument for how the current construct of "concept" has led to useless controversies. While agreeing that research on concepts needs to be refocused, we contend that Machery's proposal is only a small step towards a new framework for thinking about concepts. We suggest that a promising direction for concepts

exists in research that is too often ignored – the acquisition, formation, and development of concepts.

Unfortunately, like many theories in cognitive science and philosophy, Machery's proposal largely ignores development. *Doing without Concepts* avoids issues that are central to a theory of concepts: how concepts are acquired, how conceptual structures change across development, and how concepts that are coordinated early in development become uncoordinated over time. In fact, Machery's proposal acknowledges the sentiment that development is less important than other areas of research on concepts (2009, p. 18). This blanket rejection of development is erroneous and dangerous – identifying the mechanisms by which concepts are acquired, how knowledge changes over time, and how cognitive processes give rise to such changes is essential to our understanding of how concepts operate and are organized. Because of the focus on such issues, many developmental researchers have taken a step back from the assumption that concepts originate from existing mental structures or representations.

One way that developmental research has advanced our understanding of concepts is by introducing the idea that concepts are formed in the moment (e.g., Gibson 1969; Samuelson et al. 2009; Smith et al. 1999; Spencer & Schöner 2003; Thelen & Smith 1994). By this account, performance on tasks is a reflection of the dynamic interaction between the learner and the learning environment – prior experiences recalled from long-term memory act together with task dynamics, perception, and action, to generate behavior. For example, one study (Samuelson et al. 2009) had children generalize novel nouns for rigid and deformable objects in two different tasks: a forced-choice task, in which children had to choose one of three objects that shared the same name with an exemplar, and a yes/no task, in which children had to respond whether each of the three objects shared the same name with an exemplar. Children's performance in the two tasks suggested conflicting conclusions about how children organized categories. Performance on the forced-choice task suggested that children treat rigid and deformable things differently when assigning labels: Rigid things are named by similarity in shape, whereas deformable things are named by similarity in material substance. However, performance on the yes/no task suggested that children did not distinguish between rigid and deformable things in naming and generalized names for both kinds by shape similarity. Given that children were all at the same developmental level and were presented with the exact same stimuli, differences in performance between the two tasks were likely not attributable to possessing different object concepts. Instead, children's object concepts were formed in the moment given the demands of the different tasks.

Machery notes that the feasibility of concepts being formed in the moment fails because there is not a significant body of research suggesting a "variability across contexts of the knowledge brought to bear on tasks" (2009, p. 22). However, Machery ignores countless examples of developmental research demonstrating great variability in the knowledge that is brought to bear in a particular task (e.g., Plumert 2008; Samuelson et al. 2009; Sandhofer & Doumas 2008; Siegler 1994; Smith et al. 1999; Thelen & Smith 1994; van Geert & van Dijk 2002; Vlach et al. 2008). This literature has demonstrated that performance on tasks is flexible (e.g., Sloutsky & Fisher 2008), context dependent (e.g., Samuelson & Smith 1998), and altered by seemingly minor changes in the conditions of the task (e.g., Sandhofer & Doumas 2008; Sandhofer & Thom 2006; Vlach et al. 2008). For example, altering the timing of exemplar presentation by a matter of seconds can lead to marked differences in children's performance on a generalization task (e.g., Vlach et al. 2008).

Machery also rejects the idea that concepts are formed in the moment, too quickly dismissing the proposal that there are not enduring mental structures for prototypes, exemplars, and theories. The book refers to this perspective as the "anti-representationalist argument" (2009, p. 222). However, developmental

research has provided substantial evidence suggesting that variability and behavior can be explained without the presence of a mental structure or representation (e.g., Samuelson et al. 2009; Smith et al. 1999; Spencer & Schöner 2003; Thelen & Smith 1994). For example, Piaget (1954) originally attributed errors in the A-not-B task to infants' lack of an "object concept" (i.e., an enduring mental structure about the spatial and temporal consistencies of objects). Over the last few decades, research has demonstrated that errors on this task result from factors other than a lack of an object concept (e.g., Smith et al. 1999), such as visual input (e.g., Butterworth et al. 1982), direction of gaze (e.g., Horobin & Acredolo 1986), and memory (e.g., Diamond 1985). Moreover, performance on this task can be explained by the interaction of these processes alone (e.g., Smith et al. 1999). Altogether, this work has provided a compelling argument for how concepts and performance are shaped in the moment from a confluence of factors, rather than being accessed from an enduring mental structure.

To conclude, thinking about concepts needs a better direction. However, any theory of concepts would be remiss if it did not account for development. We propose that thinking about concepts should be situated within a dynamic framework that includes the learner and learning environment. Future research should explore the mechanisms by which concepts emerge in the moment – perception, action, and memory, interacting with properties of the environment, will reveal how this process works. This framework accounts for how concepts arise and change over time and thus holds great promise as the new direction for thinking about concepts.

Constituency also plays a role in psychological explanation. Not everything about a category in long-term memory is or can be accessed in a single task; only some packets are extracted and used at once. Tokening a complex representation makes its constituents available to working memory for processing. And complex representations may make greater processing demands than simpler ones. The notion of a representational constituent is needed in describing what packets are retrieved from the vast reserves of long-term memory, and how these copies in working memory affect task performance.

So we can safely embrace the notion that concepts are constituents of thoughts. But I agree with Machery that these constituents are heterogeneous (*non-uniform*, in my terms). My own provisional list of types of concepts includes prototypes, exemplars, causal models, ideals and norms, and some perceptual and linguistic representations. This is central to the pluralist view of concepts I defend (Weiskopf 2009a; 2009b). While Machery and I agree on much of the empirical data, we disagree on its import. Where I see evidence for pluralism, he favors eliminativism. I suggest that we should be optimistic about the study of concepts as such.

Concepts are a functional kind, like most in psychology and neuroscience (Weiskopf, forthcoming). Consider how functional explanation proceeds. We decompose cognitive systems into a host of nested and interconnected subsystems, and populate them with representations, processes, and resources such as memory stores. This is obviously true in explaining competencies such as visual perception and numerical cognition, and it is no less true for concepts. Inductive and deductive reasoning, decision making, long-term planning, theory construction and testing, language use, and a host of "higher" capacities require explanation, and concepts are the representations, whatever they may be, that are proprietary to the system that underlies these capacities.

Machery argues that concepts have nothing in common beyond this functional description, and hence are not a "natural kind" in his sense (2009, pp. 243–44). But functional kinds are empirically discovered, and are posited in order to explain a (possibly open-ended) range of capacities that creatures possess. And concept possessors are strikingly different from creatures lacking concepts. They have a cognitive repertoire that is flexible – that is, sensitive to, but substantially independent of, ongoing perceptual input in terms of both content and processing – and that displays integration of information freely across domains (Weiskopf 2010). Concepts also explain the productive character of human thought in virtue of being able to combine open-endedly; Machery does not discuss productivity, but it is widely taken to be a central property of conceptual thought, and one that separates concepts from other types of representation.

The fact that a separate cognitive system is needed to explain these capacities is a discovery, not an a priori deliverance. Otherwise we could have predicted from the armchair that Skinnerian behaviorism and its modern descendants (e.g., Brooksian robotics) were doomed to fail. Instead, the limits of these models are demonstrated by their failure to capture the relevant phenomena. Concepts constitute a kind because positing them gives us the needed explanatory leverage over a wide range of creatures and their capacities. If we posit them, we simultaneously gain the ability to account for phenomena that would otherwise have been inexplicable, and to capture similarities among otherwise dissimilar creatures. This is how the functional kinds posited in models of cognitive systems typically earn their distinctive status. If a model containing a functional category *F* has greater explanatory and unifying power than ones that lack it, then *F* is *prima facie* a kind. The failure of models of human cognition that lack anything corresponding to concepts shows that they satisfy this condition.

But suppose we followed Machery's lead and eliminated the term "concept," talking only of prototypes, exemplars, and so

The theoretical indispensability of concepts

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Abstract: Machery denies the traditional view that concepts are constituents of thoughts, and he more provocatively argues that concepts should be eliminated from our best psychological taxonomy. I argue that the constituency view has much to recommend it (and is presupposed by much of his own theory), and that the evidence gives us grounds for pluralism, rather than eliminativism, about concepts.

What are concepts? A long tradition in philosophy and psychology takes them to be the constituents of thoughts. In *Doing without Concepts*, Machery rejects this, defining them instead as bodies of knowledge stored in long-term memory and used by default in a range of higher cognitive processes (Machery 2009, p. 12).

Machery's arguments against the constituency view, however, are not compelling. He suggests that the notion of a constituent is ill-understood (2009, p. 26). But he also notes that the language of thought (LOT) hypothesis (Fodor 1975; 2008) gives us one fairly clear sense of what this might mean (Machery 2009, p. 27). So why *shouldn't* we adopt precisely this sense? Moreover, it is hard to understand many of his own claims about conceptual processing without appealing to constituency. Prototypes, exemplars, and theories are all complex representations that bear structural relations to their parts, over which inferences, similarity computations, and the like, might operate. He may wish to remain neutral on issues of what the vehicles of thought are, but connectionist and dynamical systems models of these phenomena are notably unpromising. The best candidates for bodies of knowledge that can fill the role he posits are ones organized, *inter alia*, by relations of constituency.