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Developing without concepts

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Abstract

We evaluate the heterogeneity hypothesis by considering the developmental time course and the mechanism of acquisition of exemplars, prototypes, and theories. We argue that behavioral and modeling data point to a sequential emergence of these three types of concepts within a single system. This suggests that similar or identical underlying cognitive processes – rather than separate ones – underpin representation acquisition.

Doing without Concepts proposes an interesting solution to the problem of applying the term "concept" to prototypes, exemplars, and theories, which according to the Machery, are unrelated. Each type of concept engages a distinct cognitive process – such as similarity comparison or causal inference – so that a unified label is inappropriate. The book synthesizes an impressive amount of literature in psychology and philosophy to provide evidence for this heterogeneity hypothesis. From the point of view of developmental psychology, however, two key questions remain unanswered. First, what is the time course for the emergence of prototypes, exemplars, and theories? Second, and more importantly, what is the mechanism behind their formation? Specifically, does each require a dedicated mechanism, or is a single system sufficient? In our view, an answer to the second question is particularly important for our ability to evaluate the proposal that distinct cognitive processes underlie the use of prototypes, exemplars, and theories.

Answering the first question is an important component to answering the second question. If exemplars, prototypes, and theories emerge in succession and not simultaneously, then it is possible that they build upon each other. This could suggest the development of a single mechanism or, at the very least, the development of three related mechanisms. While no single study provides definitive evidence, a pattern of successive emergence can be observed across studies. As an example, we can examine infants' knowledge about individuals. Three-month-old infants can discriminate an image of their mother's face from that of a stranger (Barrera & Maurer 1981), which suggests that they have stored an exemplar of their mother's appearance. By 6 months of age, infants can extract a prototype from a series of faces and display a preference for a novel face when it is presented with either a familiar face or the previously unseen prototype (Rubenstein et al. 1999). By 10 months, infants display more theory-like knowledge about individuals in that they do not generalize goal-directed actions, such as reaching for an object, from one individual to another (Buresh & Woodward 2007). This task requires not only theoretical knowledge about the properties of goals but also the ability to store exemplars of the individuals so that goals may be matched correctly. Taken together, these studies provide some support for the sequential emergence of exemplars, prototypes, and theories.

In addition to determining the time course for these processes, the most important developmental question with respect to the heterogeneity hypothesis relates to the mechanism of acquisition. Do dedicated mechanisms exist for of prototypes, exemplars, and theories, or are all three acquired within the same system? In our view, the literature points to the latter. We suggest that if the underlying mechanism of acquisition is shared, then entirely distinct cognitive processes do not underlie different types of concepts.

According to Machery, prototypes and theories have little in common: The former involves extraction of the statistics of a category, while the latter involves causal inference. However, as has been suggested by Sobel and Kirkham (2007), statistical learning is involved in the emergence of causal reasoning. In the backwards blocking paradigm, children's and adults' judgments about an object's causal effectiveness are influenced by prior knowledge about frequencies with which causal and noncausal objects are present in the environment. Sobel and Kirkham argued that causal knowledge involves probability distributions and likelihoods of particular hypotheses – to reason causally, children must have the ability to extract statistical regularities from the environment. The formation of prototypes and theories, then, relies on processing of statistical information.

Work in computational modeling provides additional evidence for a shared mechanism by demonstrating that reasoning based on similarities (using exemplars or prototypes) and reasoning based on theories does not require separate architectures. Chaput and Cohen (2001) used hierarchical self-organizing maps to model changes in infants' perception of simple collision events in which one ball causes another to move. Studies have shown that younger infants respond to such events based on temporal or spatial similarity. Older infants respond based on causal features of events: Noncausal events with a temporal gap in the sequence are perceived to be the same as those with a spatial gap, and different from continuous causal events. Chaput and Cohen (2001) produced a model in which the intermediate layers responded based on temporal and spatial components early in training, much like younger infants. As training progressed, the top layer integrated these components and began to respond based on causal information.

Similarly, Verguts and Fias (2009) used modeling to demonstrate that similarity and rule-based responding can be thought of as lying on the same continuum. Similarity judgments are made based on many readily perceivable features; rule judgments are made based on fewer internally generated features. The model replicated human performance on a prediction task in which participants who received little training used similarity to observed cases to make predictions, and those who received more training used rules. With an increased number of training trials, the model progressed from making similarity judgments using the components of the input to making rule judgments by extracting regularities among components. Taken together with the Chaput and Cohen (2001) work, these findings suggest that separate mechanisms are not necessary for the emergence of prototypes, exemplars, and theories, and that theories can emerge through the reorganization of similarity information within the same system.

The proposal that exemplars, prototypes, and theories are underwritten by distinct processes is a convenient way to account for the conflicting psychological data on concepts. However, an examination of the developmental literature is necessary for the evaluation of this proposal. Behavioral and modeling studies suggest that exemplars, prototypes, and theories develop sequentially and can do so within the same system without the need for three dedicated mechanisms. In our view, if the mechanism of acquisition is shared, then the cognitive processes underlying prototypes, exemplars, and theories must be partially, if not completely, overlapping, casting doubt on the heterogeneity hypothesis. From the developmental perspective, the three are not so distinct, and “doing without concepts” may be unnecessary.

References

Barrera ME, Maurer D. Recognition of mother's photographed face by the three-month-old infant. Child Development. 1981; 52:714–16.

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Buresh JS, Woodward AL. Infants track action goals within and across agents. Cognition. 2007; 104:287–314. [PubMed: 16930577]

Chaput, HH.; Cohen, LB. Proceedings of the Twenty-Third Annual Conference of the Cognitive Science Society. Erlbaum; 2001. A model of infant causal perception and its development; p. 182-87.

Rubenstein AJ, Kalakanis L, Langlois JH. Infant preferences for attractive faces: A cognitive explanation. Developmental Psychology. 1999; 35:848–55. [PubMed: 10380874]

Sobel, DM.; Kirkham, NZ. Interactions between causal and statistical learning. In: Gopnik, A.; Schulz, LE., editors. Causal learning: Psychology, philosophy, and computation. Oxford University Press; 2007. p. 139-153.

Verguts T, Fias W. Similarity and rules united: Similarity- and rule-based processing in a single neural network. Cognitive Science. 2009; 33:243–59.