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Discussion

Can a perceptual task be used to infer conceptual representations?: A reply to Glorioso, Kuznar, Pavlic, & Povinelli

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Walker and Gopnik (2017) consider the role of low-level perceptual cues in children's previously reported success on a novel causal version of the relational match-to-sample (RMTS) task (Walker et al., 2016; Walker & Gopnik, 2014). While Glorioso et al. (2020) agree that developing an unambiguous measure of relational reasoning is important, they disagree that it is possible, even in principle, to do so using any variety of RMTS. Their paper provides two related arguments, both based on a conservative interpretation of the perceptual hypothesis. We believe this interpretation precludes making any conceivable claims about the existence of higher-order relations from behavior that is elicited from perceptual input. If so, these arguments are not relevant to the empirical project of discriminating *particular* perceptual and conceptual hypotheses.

First, Glorioso et al. highlight the fundamentally asymmetrical relationship between the perceptual and conceptual processes at work in Walker & Gopnik's *same-different* reasoning task. Specifically, while detecting perceptual differences does not require the use of higher-order relations, detecting higher-order relations *does* require detecting perceptual differences (pg. 2). The latter point is trivially true—after all, without perceptual input, there would be no basis for generating *same-different* concepts. However, to disprove this characterization of the perceptual hypothesis, children would have to distinguish between relational concepts in the absence of *any* perceptual differences at all. Some comparative psychologists' have made similar general arguments against attributing rich conceptual capacities to non-verbal animals (e.g., see research on "theory of mind," Heyes, 1998; Povinelli & Vonk, 2003; Penn & Povinelli, 2007). Although the authors suggest that it is possible to develop an alternative non-verbal, perceptual task that would provide empirical evidence for abstract relational concepts, they provide no examples of such a task, and it is not clear that their argument actually supports this possibility.

Walker and Gopnik's paradigm was not intended to address this strong claim. Although a similar approach has been used to critique research in infant cognition (e.g., Heyes, 2014; see also Chandler et al., 1989), a more moderate formulation of the perceptual account has typically been applied in the developmental literature. Specifically, in order to provide evidence for an abstract concept that goes beyond a low-level perceptual response, researchers will run a series of controls that retain most of the perceptual features of the main task, but fail to elicit the same behavior (e.g., Baillargeon et al., 1985; Kibbe & Leslie, 2019; Spelke, 1990; Woodward, 1998).

Taking a similar approach, we developed a single control task (the *fused condition*) to test a wide range of alternative low-level perceptual explanations (e.g., variability, symmetry, oddity, contrast) that might underlie toddlers' previously reported success on the causal RMTS task. Since the *fused condition* involves a single object rather than two objects, but is otherwise perceptually identical to the *unfused condition*, we clearly show that these specific alternatives do not explain the phenomenon, and can be reasonably ruled out. These findings represent a significant theoretical advance in our understanding of the development of relational reasoning in human learners, and consider whether and to what extent prior effects have been confounded by a variety of plausible perceptual issues. That said, we were, of course, unable to remove *all* perceptual disparities between conditions, since otherwise we would not expect to observe a behavioral difference. Our task, like all non-verbal tasks, and arguably verbal ones as well, *must* be rooted in a perceptual process. The sensible approach is surely to try to eliminate likely perceptual alternatives using the methodological technique we outline above, and to argue that this process makes the conceptual hypothesis more likely. Of course, there might always be some other alternative that could explain the data, given that (as noted above) there will have to be some perceptual differences in the stimuli. However, to show that an alternative perceptual hypothesis is more likely than the proposed conceptual one, critics would have to formulate this hypothesis precisely and design a viable empirical approach to test it.

This relates to the authors' second major argument, which is

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embedded in the first, emphasizing the difference between *same-different* concepts and entropy, and the difference between entropy and other types of perceptual variability. Although informational entropy is one way of describing the low-level account, it has long been unclear how to best use this metric to interpret relational reasoning data. The central difficulty is that defining variability itself depends on defining the units across which variability is measured. If you can specify those units, whether they are defined as objects, properties or dimensions, then you can specify the variability of those units fairly precisely. For instance, you could claim that perceptual entropy must be calculated between separate objects, i.e., using the amount of inter-item variability in an array of two or more entities. But, if you cannot consider the amount of perceptual variance *within* a single object, then this definition of entropy is itself relational. Our experiment shows that children behave differently in the within-object (*fused*) condition and the between-object (*unfused*) condition, though the low-level perceptual variability remains the same. This addresses at least one straightforward interpretation of an alternative hypothesis based on entropy. Of course, if you now define the units of variability differently in the within- and between-object cases, then there will (trivially) be a difference in entropy between them. Critically, we aimed to make a *different* distinction: between low-level perceptual variation and relations between objects. Although we acknowledge that relying on the variability of elements within a single object (e.g., colors, edges, angles) differs from previously used methods for assessing entropy, we argue that perceptual variability need not be subject to differences in object identity.

In sum, we agree with the authors that there is a need for more precise definitions in the literature regarding what "counts" as relational information. Although it is intuitively understood, it is not precisely defined. Perceptual entropy has the opposite problem. It is precisely defined, but it is so widely applicable, that it is not clear how it relates to the project of understanding the early expression of relational reasoning. Walker & Gopnik provide a positive empirical approach to answering these questions, eliminating some alternatives and so supporting others, and we welcome similar empirical investigations from other researchers.

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