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Categorization of two-dimensional and three-dimensional stimuli by 18-month-old infants

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ABSTRACT

In two experiments, 18-month-old infants' categorization of 3D replicas and 2D photographs of the same animals and vehicles were compared to explore infants' flexibility in categorization across different object representations. Using a sequential touching procedure, infants completed one superordinate and two basic-level categorization tasks with 3D replicas, 2D cut out photographs, or 2D images on photo cubes ("2D cubes"). For superordinate sets, 3D replicas elicited longer mean run lengths than 2D cut outs, and 3D replicas elicited equivalent mean run lengths as 2D cubes. For basic-level sets, infants categorized high-contrast animal sets when presented with 3D replicas, but they failed to categorize any of the 2D photograph sets. Categorization processes appear to differ for 3D and 2D stimuli, and infants' discovery of object properties over time while manipulating objects may facilitate categorization, as least at the superordinate level. These findings are discussed in the context of infants' representation abilities and the integration of perception and action.

Categories structure and clarify cognition, and they allow us to respond to novel entities as if they were familiar (Bornstein, 1984; Harnad, 1987). Categorizing is thus an essential cognitive and developmental achievement, and humans categorize early in life (Bornstein & Arterberry, 2003; see Rakison & Oakes, 2003, for a review). A common method for assessing older infants' categorization abilities is the sequential touching procedure (Mandler, Fivush, & Resnick, 1987). This procedure involves presenting infants with objects from two categories (e.g., four animals and four vehicles), and observing, recording, and analyzing their patterns of touching. The empirical observation is that, if children recognize a categorical distinction amongst the objects, they touch those from within a category in succession more than would be expected by chance (Mandler et al., 1987).

The objects used in the sequential touching procedure are typically 3D replicas of real-world objects, such as realistic toy animals and cars (see Fig. 1A). The use of 3D replicas most likely facilitates categorization as they are highly realistic exemplars of their real object referents, and infants show equivalent categorization of real object referents and their replicas, whether tools (phones, brushes) or fruit (lemons, pears) (Arterberry & Bornstein, 2012). 3D replicas provide a rich source of information regarding object features, information infants may use to access existing object representations or to create new categories (e.g., Arterberry & Bornstein, 2012; Horst et al., 2009; Mareschal & Tan, 2007; Rakison & Butterworth, 1998).

Not all information about objects comes from objects themselves or 3D replicas. From early life, infants have experience with two-dimensional representations of objects in picture books, on TV, and so forth. High-quality photographs of replicas

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Fig. 1. Top view of cows and frogs that comprised the basic high-contrast animal set in (A) 3D replica, (B) 2D cut out, and (C) 2D cube conditions.

also contain information in terms of object features (Fisher, Ferdinandsen, & Bornstein, 1981; Kuchuk, Vibbert, & Bornstein, 1986), although this information is only available visually (Fig. 1B), rather than multimodally as with 3D objects (Fig. 1A). Moreover, processing 3D stimuli involves only a one-step inference from symbol to referent. When viewing a 2D photograph of a replica, however, infants might need to perceive the image as a replica first and then make the link between the replica and its real-world referent. In other words, 2D stimuli might involve two steps of inference from symbol to referent. Both 3D and 2D stimuli require forms of mediated perception (Gibson, 1966), but 2D images of replicas likely require more mediation than 3D replicas. Of interest here was how different levels of mediation impact infant categorization. Thus, in the present study we compared infants' categorization of the same 2D and 3D stimuli in 2 experiments.

To categorize 2D images of objects, infants need some rudimentary pictorial competence (see Beilin, 1999, for a review); and it appears that this foundation may be present in the first year or two. Infants as young as 5 months of age reportedly perceive correspondences between 2D and 3D stimuli (DeLoache, Strauss, & Maynard, 1979; Dirks & Gibson, 1977), and at 18 months they can learn labels for novel objects using photographs (Ganea, Pickard, & DeLoache, 2008). By 2–3 years, representations (in the form of pictures or objects-on-display) encourage young children (and parents) to think about categories (Gelman, Chesnick, & Waxman, 2005). At the same time, infants do not equate pictures and referents; 9-month-old infants show different manual actions to 2D and 3D stimuli (Yonas, Granrud, Chov, & Alexander, 2005), suggesting at the very least that 2D and 3D stimuli of the same objects afford different actions.

Research on categorization in the first half year of life has relied exclusively on 2D depicted images in looking time paradigms, and researchers have concluded from these studies that infants' categorization ability is advanced. For example, using 2D color photographs Quinn and Eimas (1996) found that 3-month-old infants categorized animals, such as dogs and cats, a basic-level comparison; Arterberry and Bornstein (2001) found that this same age group also categorized animals and vehicles, a superordinate comparison; and Quinn, Doran, Reiss, and Hoffman (2010) found that by 7 months infants categorized different breeds of cats, a subordinate-level comparison. In fact, these examples depict a competency that appears to be more advanced than the developmental story that emerges when infants' categorization is assessed using the