



Original Articles

Naming influences 9-month-olds' identification of discrete categories along a perceptual continuum



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ABSTRACT

A growing body of evidence documents that naming guides 9-month-old infants as they organize their visual experiences into categories. In particular, this evidence reveals that naming highlights categories when these are visually distinct. Here we advance this work in by introducing an anticipatory looking design to assess how naming influences infants' categorization of objects that vary along a perceptual continuum. We introduced 9-month-old infants ($n = 48$) to continua of novel creature-like objects. During the learning phase, infants had an opportunity to observe that objects from one end of the perceptual continuum moved to the left and objects from the other end moved to the right. What varied was how the objects were named. Infants in the *one-name* condition heard the same novel noun applied to all objects along the continuum; those in the *two-name* condition heard one name for objects from one end of the continuum and a second name for objects at the other end. At test, all infants viewed new objects from the same continuum. At issue was whether infants would anticipate the side to which the test objects would move and whether their expectations varied as a function of naming condition. Infants in the *one-name* condition formed a single overarching category and therefore searched for new test objects at either location; those in the *two-name* condition discerned two categories and therefore correctly anticipated the likely location of the test objects, whether these were close to the poles or to the center of the continuum. This provides the first evidence that by 9 months, naming supports both the number of categories infants impose along a perceptual continuum and the clarity of the category boundaries.

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1. Introduction

Although there is lively debate as to *how* and *how deeply* language exerts its influence, there is little doubt that the language (s) we speak shape our experience of the world. Perhaps the most dramatic evidence comes from cross-linguistic differences in our perception of color. Across the world's communities, sighted people experience the very same spectrum of visible light and impose discrete categories along this perceptual continuum. But the particular categories we impose bear the imprint of the language we speak. For example, speakers of English categorize wavelengths ranging from 455 to 492 nm as *blue* and wavelengths from 492 to 577 nm as *green*. But for speakers of Berinmo, an indigenous language of Papua New Guinea, *blues* and *greens* are marked with a single color term, *nol*. This cross-linguistic difference in the

number of color categories we form and the boundaries we place between them influences not only the color lexicon but also our memory: Berinmo speakers are less likely to remember distinctions between wavelengths that English speakers describe as *blue* versus *green* (Kay & Regier, 2006; Roberson, Davidoff, Davies, & Shapiro, 2004, 2005; Roberson, Davies, & Davidoff, 2000; but also see Regier & Kay, 2009; Lindsey & Brown, 2006). But what remains unanswered is how early in development naming begins to shape the categories we impose along a perceptual continuum. Here, we consider this question by focusing on the effects of naming on 9-month-old infants' categorization of novel objects along a perceptual continuum.

There is now considerable evidence that infants successfully form object categories within the first months of life (Gliga, Mareschal, & Johnson, 2008; Mandler, 2000, 2004; Pauen, 2002; Plunkett, Hu, & Cohen, 2008; Quinn, 2006; Quinn & Bhatt, 2009; Quinn, Schyns, & Goldstone, 2006; Rakison & Oakes, 2003; Rakison & Yermolayeva, 2010; Westermann & Mareschal, 2013). Moreover, recent evidence reveals that by well before they begin

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to speak, infants' categorization is affected by language. By 3 months of age, simply listening to language supports infants' ability to form object categories (Ferry, Hespos, & Waxman, 2010); within the next several months, infants begin to trace whether the *same* or *different* names are applied to a set of objects. For example, using a novelty preference paradigm, Waxman and Braun (2005) familiarized 13-month-old infants to four distinctly different objects from a single category (either animals or tools). What varied across conditions was whether infants heard the same word applied consistently to all of the familiarization objects (e.g., *Look at the keeto! Look at the keeto!*...) or a different word applied to each (e.g., *Look at the keeto! Look at the bookoo!*...). At test, two novel objects were presented simultaneously in silence – one belonged to the now-familiar category (e.g., another animal) and one to a novel category (e.g., a tool). Infants who heard the same word applied consistently to all familiarization objects categorized successfully, but infants who heard a distinct word applied to each familiarization object performed at chance levels (Waxman & Braun, 2005; Ferguson, Havy, & Waxman, 2015). Consistently applying the same name to a set of distinct objects highlights commonalities among them and facilitates categorization; conversely, applying distinct names to each distinct object highlights differences among them and facilitates the process of object individuation (Dewar & Xu, 2007; Ferguson et al., 2015; Ferry et al., 2010; Fulkerson & Waxman, 2007; Gelman & Waxman, 2009; Graham, Keates, Vukatana, & Khu, 2012b; Plunkett et al., 2008; Song, Baillargeon, & Fisher, 2014; Vales & Smith, 2015; Waxman & Booth, 2001, 2003; Waxman & Braun, 2005; Xu, 2002; Xu, Carey, & Quint, 2004; Xu, Cote, & Baker, 2005).

Thus, by 9 months, infants track not only *which* objects they see (Quinn, 2006) and *which* words they hear (Byrd & Mintz, 2010), but also *how* each object is named (Ferguson et al., 2015; Waxman & Braun, 2005; see also Smith & Yu, 2008).

This link, impressive in itself, sheds light on the effect of naming on categorization. But it also raises a question: In the work described thus far, infants viewed objects from perceptually distinct categories (e.g., distinct object kinds or distinct shapes). But not all categories have such perceptually distinct boundaries. For example, there is no hint of a perceptual “break” between the adjacent wavelengths considered as *blue* versus *green* in English; nonetheless, speakers of different linguistic communities impose boundaries and treat them as categorical (Kay & Regier, 2006; Roberson et al., 2000, 2004, 2005). At issue, hence, is whether and how naming sculpts the categories infants impose along a perceptual continuum.

Landau and Shiple (2001) were the first to address this question. They created two distinctly different novel objects (Standard A and Standard B) and then morphed them successively to obtain a set of intermediate objects along the perceptual continuum bounded by the two standards. Their design was straightforward: An experimenter introduced 2- and 3-year-old children to the two standards, and asked children about the intermediate (morphed) test objects. When Standards A and B were each introduced with its own distinct name, children formed two distinct categories along the perceptual continuum (e.g., Standard A: *This is a dax*; Standard B: *This is a blicket*; Test object: *Is this a blicket?*). But when both standards received the same name, children formed a single category (e.g., Standard A: *This is a blicket*; Standard B: *This is a blicket*; Test object: *Is this a blicket?*). This documented that by two years of age, naming shapes the categories children impose along a perceptual continuum.

More recently, Althaus and Westermann (in press) sought to examine this naming effect in younger infants. Like Landau and Shiple, the authors morphed two distinctly different novel objects (Standard A and Standard B) to create a continuum. During a familiarization phase, 10-month-old infants viewed eight different

objects from the continuum, selected to represent a distribution that was slightly bimodal (that is, with a gap at the center of an otherwise uniform distribution). What varied was whether the familiarization objects were presented in silence, with a single name applied to all eight objects, with two distinct names (one applied to the four objects from each end of the continuum) or with two tones (one applied to the four objects from each end of the continuum). At issue was whether infants in each condition would form a single inclusive category or two distinct ‘subcategories’, one at each end of the continuum. To test this issue, the experiments presented infants in all conditions with several different test trials, all comprised of two objects each. These trials were not counterbalanced.

In the first two test trials, infants viewed (a) a new object from the center of distribution (the average of the ‘inclusive category’) and (b) a new object that was the average of one of the two ‘subcategories’. Infants performed at chance on these trials; there were no reliable differences among conditions. Notice that this outcome is consistent with two possibilities: infants in all conditions either failed to form any category (inclusive or subcategory) or formed both the inclusive category and the subcategories.

In the next four test trials, infants viewed a new novel object drawn from an entirely different continuum. This same object was presented repeatedly, pitted each time against one of the objects infants had seen on the first two test trials: the average of the ‘inclusive category’ vs the average of one of the two ‘subcategories’. The authors conducted a series of comparisons within each condition. These suggested that in the *single name* condition, the *two-tone* condition and the *silent* condition, infants may have formed a single inclusive category; in these conditions, infants preferred the object from outside the original distribution over the average of the ‘inclusive category’. But in the *two-name* condition, infants may have formed two subcategories; they preferred the object from outside the distribution over the subcategory average.

Although this pattern is consistent with prior evidence documenting that hearing two distinct names guides infants to form two categories, but that hearing a single name guides them to form a single inclusive category (Ferguson et al., 2015; Ferry et al., 2010; Fulkerson & Waxman, 2007; Graham et al., 2012a; Landau & Shiple, 2001; Plunkett et al., 2008; Waxman & Braun, 2005), there are several reasons to interpret this with caution. First, there was no evidence to this effect on the first two test trials. Infants in all conditions performed at chance levels, with no differences between them. Second, because test trial order was not counterbalanced, the latter test trials all included at least one, and often two, objects that infants had already seen. This makes it difficult to interpret analyses based on infants' ‘novelty’ preferences. Third, these latter trials were analyzed using within condition comparisons to chance, leaving it unclear whether there were any reliable differences across the conditions (see Gelman & Stern, 2006 for a discussion of why a difference between ‘significant’ and ‘not significant’ condition does not mean that the difference between the conditions itself is statistically different). Finally, it is uncertain about whether infants formed strong category-based expectations about the location of category boundaries or whether category judgment was more continuous. Together, then, these results, although suggestive, do not provide sufficiently clear answers to whether and how naming influences infants' categorization of objects along a continuum.

In the current experiments, we address this question directly. To do so, we move beyond the novelty preference design to trace the role of naming on infants' categorization of objects along a perceptual continuum. We focus on 9-month-old infants because although they do not yet produce category names on their own, there is evidence that they are sensitive to the distinct conceptual consequences of naming objects with the same vs different names

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