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What The Shape and Material Biases Can Tell Us About Object Recognition

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Motivation and Background

Imagine a child who is just beginning to produce words. To figure out what a word like CUP means, she has to not only identify the individual cup, but also understand what properties are relevant for belonging to the category of cups in order to remember the word later and apply it to new cups she encounters (e.g., its abstract shape rather than its purple plastic material).

At the same time this child is learning all about cups, she is also learning other words, many of which also name categories of objects similar in shape (e.g., BALL and CAR), from which she will learn a bias to attend to shape when generalizing novel names to novel objects (i.e., shape bias). A child's prior knowledge and experiences help her to not only learn individual words and categories, but also, more importantly, to learn how to learn words, making subsequent word learning easier.

In this talk I will discuss my research on children's word learning biases and the consequences these biases have on their future learning and generalization. Additionally, I will discuss how our understanding of the development of these biases can inform our understanding of children and adults' visual recognition abilities.

Attention to Shape

At first glance, the "shape bias" may seem like an artificial laboratory phenomenon. Children are presented with three novel objects: an exemplar, one object that matches the exemplar in shape but differs in material and color, and one object that matches the exemplar in material but differs in shape and color. When the experimenter names the exemplar and asks the child to generalize it to one of the other two saying, by the time children are about 2-years-old they systematically select the object mapping in shape (Landau, Smith, & Jones, 1988). Although this phenomenon may seem simple, it has been shown to have consequences for children's future word learning (e.g., Perry et al., 2010) and is window into children's developing object recognition (Yee, Jones, & Smith, 2012) and memory (Vlach, 2016).

Additionally, evidence from atypical populations further suggests that the shape bias can tell us about developmental process. For example, children with autism (Tek, Jaffery, Fein, & Naigles, 2008), children who are late talkers (Jones & Smith, 2005), and children who are deaf or hard of hearing and wear cochlear implants (Quittner, Cejas, Wang, Niparko, & Barker, 2016) all show delayed or atypical biases when generalizing novel nouns.

My own work reveals interesting individual differences even within typically developing populations. Children whose vocabularies differ from the norm show generalization biases that differ from the norm (Perry & Samuelson, 2011). The more words a child knew naming solid objects in categories organized by similarity in shape (e.g., CUP), the more likely she was to generalize novel names by similarity in shape. However, the more words she knew naming solid objects in categories organized by similarity in *material* (e.g., CHALK), the more likely she was to generalize novel names by similarity in material.

I have extended this line of research to examine how vocabulary differences lead to differences in memory for objects' features (Perry, Axelsson, & Horst, 2015) and recognition of familiar objects (Perry & Saffran, 2016). For example, regardless of vocabulary size, children who knew relatively few names for categories organized by shape had more trouble recognizing objects in the wrong colors (e.g., pink cow) than children who know more categories organized by shape. The particular words children already know, bias their future word learning and recognition.

Importantly, longitudinal training studies suggest vocabulary regularities play a *causal* role in shape bias development. Teaching young children categories organized by similarity in shape leads them to develop a precocious shape bias and learn new words at an increased rate (e.g., Perry et al., 2010). Together, this work on the shape bias offers insights about developmental process: 1) the process of learning words has cascading consequences for future word learning; and 2) the structure of a child's vocabulary influences what information they attend to and remember.

Attention to Material

In addition to learning about solid objects like CUP, children also learn about nonsolid substances like APPLESAUCE and JUICE, for which material is important. When generalizing the names of novel nonsolids, older children and adults attend to similarity in material ("material bias"). Compared to the shape bias, the material bias is later acquired (Samuelson & Smith, 1999) and is sensitive to stimuli and task changes (Samuelson & Horst, 2007).

One reason for this difference in development is that children learn about nonsolids in a relatively constrained context—all early-learned nonsolids are foods seen at mealtimes, while solids are seen across a variety of contexts. I found that putting children in a highchair allows them to explore stimuli as they would at mealtimes and led them to show a material bias several years earlier than they do in a standard lab context (Perry, Samuelson, & Burdinie, 2014).

An additional difference is that materials might be difficult to recognize from static visual information and may

require tactile information. Indeed, it was the children who touched stimuli the most who showed the strongest material bias in my study (Perry et al., 2014). And those in the highchair were messiest because that setting increased context-dependent action patterns that proved necessary for recognizing similarity between materials (cf Perry, 2015). Children's developing attention to material similarity builds on what we already know about attention to shape, and also provides new insight into the importance of context and exploration in recognition and generalization.

How do children eventually learn to pay attention to substances' materials outside of this specific context? Adults don't need to sit in a highchair to distinguish whiskey from juice. How do children learn to visually recognize materials? What do adults even know about substances? These questions have important applications beyond understanding word learning: although we can teach artificial intelligence systems to recognize solid objects, it is nearly impossible to teach them to recognize nonsolid substances (Adelson, 2001). To begin answering these questions, I conducted a study in which adults and children drew familiar objects and substances from memory.

New Insights From Drawing

In my recent work, I assessed children and adults' drawings of familiar objects and substances from memory. Examining these drawings allows us to assess what visual information is relevant to representations of different kinds of things and how this information changes over development. As such, this study is an important first step in understanding how we recognize objects and substances.

Amazon Mechanical Turk participants identified drawings. Critically, they were more accurate in identifying drawings of solid objects than nonsolid substances. Both children and adults tended to include container information for nonsolids rather than draw the substance itself. Drawings of nonsolids that depicted distinct, prototypical containers (e.g., milk carton, coffee mug) aided recognition.

Additionally, adult were quite consistent in color use—e.g., all adults drew brown (i.e., chocolate) pudding and purple grapes, while children used a variety of colors. These results suggest 1) color might be more important to object representations than previously believed and 2) that as children develop, they become more systematic and prototypical in the colors they associate with objects.

Overall, these new findings build on my previous work examining children's attention to shape and material by demonstrating what information we use to remember and recognize solids and nonsolids. These results demonstrate that visual recognition of *both* solids and nonsolids—is aided by shape, suggesting we may conceptualize nonsolids as more object-like than was thought.

Relevant publications

My publications most relevant to this presentation are: Perry et al., 2010; Perry & Samuelson, 2011; Perry et al., 2014; Perry, 2015; Perry et al., 2015; and Perry & Saffran, 2016.

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