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How do biases in spatial memory change as children and adults are learning locations?

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Abstract

This investigation tracked changes in categorical bias (i.e., placing objects belonging to the same spatial group closer together than they really are) while 7-, 9-, and 11-year-olds and adults were learning a set of locations. Participants learned the locations of 20 objects marked by dots on the floor of an open square box divided into quadrants. At test, participants attempted to place the objects in the correct locations without the dots and boundaries. In Experiment 1, we probed categorical bias during learning by alternating learning and test trials. Categorical bias was high during the first test trial and decreased over the second and third test trials. In Experiment 2, we manipulated opportunities for learning by providing participants with either one, two, three, or four learning trials prior to test. Participants who experienced one or two learning trials exhibited more bias at test than did those who experienced four learning trials. The discussion focuses on how categorical bias emerges through interactions between the cognitive system and task structure.

Keywords: Spatial memory; Cognitive development; Spatial cognition; Category learning

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Introduction

The idea that people (and animals) create and store "cognitive maps" of their environments has a long and venerable history (Tolman, 1948). Many studies conducted over the past 50 years have focused on the nature of these spatial representations. For example, there is considerable controversy over whether people's spatial representations are viewpoint dependent or independent (e.g., Diwadkar & McNamara, 1997; Epstein & Kanwisher, 1998; King, Burgess, Hartley, Vargha-Khadem, & O'Keefe, 2002). Largely, these studies focus on what spatial memory looks like after people have learned a set of locations in an environment. As a consequence, relatively little is known about how spatial memory changes while people are learning a set of locations (for an exception, see Hund & Spencer, 2003). The goal of our investigation was to track changes in memory for location while children and adults were learning a set of locations in a small-scale environment.

Systematic bias in memory for location is an important signature of the underlying processes involved in reproducing previously seen locations. Recent work has shown that both children and adults exhibit systematic bias toward the centers of geometric regions and spatial groups (Huttenlocher, Newcombe, & Sandberg, 1994; Plumert & Hund, 2001; Spencer & Hund, 2002). A key question is where this bias comes from. According to the category adjustment model originally proposed by Huttenlocher, Hedges, and Duncan (1991), retrieval of locations from memory involves the use of both fine-grained and categorical information. When trying to remember a location, people make estimates based on their memory of fine-grained metric information such as distance and direction from an edge. However, because memory for fine-grained information is inexact, people adjust these estimates based on categorical information about the location. This categorical information can be represented by a prototype located at the center of the spatial region (Huttenlocher et al., 1991) or by the associations among locations in a spatial group (Plumert & Hund, 2001). In both cases, adjustments based on categorical information lead to systematic distortions toward the centers of spatial categories. That is, spatial prototypes and spatial groups exert "pull" on estimates of location. More recent work suggests that the magnitude of the pull toward category centers depends on the interaction of memory for fine-grained and categorical information (Plumert, Hund, & Recker, 2007). When memory for the individual locations is strong relative to memory for the spatial categories, people exhibit little or no categorical bias in their placements. Conversely, when memory for the individual locations is weak relative to memory for the spatial categories, people place objects closer to the centers of spatial categories than they really are.

Recent studies have examined how the strength of memory for fine-grained and categorical information influences bias in estimates of location by manipulating the salience of one type of information relative to the other (Hund & Plumert, 2002, 2003, 2005; Hund, Plumert, & Benney, 2002; Hund & Spencer, 2003; Plumert & Hund, 2001). A claim that has been widely supported is that increasing the uncertainty of memory for fine-grained information leads to greater categorical bias (Engebretson & Huttenlocher, 1996; Herman, Cachuela, & Heins, 1987; Hund & Plumert, 2002; Hund & Spencer, 2003). One way to manipulate fine-grained certainty is to impose a delay between learning and reproducing locations. The rationale behind this approach is that memory for fine-grained information should decay with delays between learning and test, leading to increased weighting of categorical information in estimates of location. Consistent with this proposal, Hund and