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## Implicit memory of locations and identities: A developmental study



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### ABSTRACT

Objects in the environment have both location and identity properties. However, it is unclear how these independent properties are processed and combined in the implicit domain. The current study investigated the development of the implicit memory of object locations and object identities, both independently and combined, and the relation between implicit memory and working memory (WM) for these properties. Three age groups participated: 6- and 7-year-old children, 9- and 10-year-old children, and adults. Children and adults completed a repeated search paradigm. In the learning phase, targets' locations were consistently predicted by both the identities and locations of the distracters. In the test phase, either both remained predictive or just the identities or just the locations of the distracters predicted the location of the target. All groups showed significant implicit learning when both the identities and locations of the distracters remained predictive. When only the locations but not the identities of the distracters were predictive, adults and 9- and 10-year-olds showed significant learning, whereas 6- and 7-year-olds did not. When only the identities but not the locations of the distracters were predictive, none of the groups showed significant learning effects. In evaluating the contributions of either visual or spatial WM to implicit learning and memory, we found that children with smaller visual WM exhibited larger implicit memory effects for object identities than

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did children with larger visual WM. Taken together, the results indicate that children's ability to differentiate identity and location undergoes development even in the implicit domain.

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## Introduction

All objects in the environment afford at least two kinds of information for processing: information about their identity, such as shape and color, and information about their spatial location. The human brain seems to be able to integrate identity and location information rather seamlessly. However, object information and location information are generally mapped onto different neural pathways in the visual system (Haxby, Horwitz, Ungerleider, & Maisog, 1994; Pihlajamäki et al., 2005; Zachariou, Klatzky, & Behrmann, 2014). The identity information or object properties (e.g., shape, color) correspond to the “what” or ventral stream (occipitotemporal lobes). The spatial information (e.g., location, size) corresponds to the “where” or dorsal stream (occipitoparietal lobes). Research has demonstrated that these two systems are anatomically and functionally distinct for healthy young adults, young adults with intellectual disabilities, and healthy infants (Chinello, Cattani, Bonfiglioli, Dehaene, & Piazza, 2013; Haxby et al., 1994; Mareschal & Johnson, 2003; Paul, Stiles, Passarotti, Bavar, & Bellugi, 2002; Pihlajamäki et al., 2005; Woodcock, Humphreys, & Oliver, 2009). Whereas the majority of previous studies have focused on differences in explicit memory processing of identity versus location information, the goal of the current study was to investigate the development of implicit memory for object identities and object locations. Our study may help to illustrate whether the dissociation between object location and object identity memory is also present during implicit information processing activities and whether the ability to separate these two dimensions undergoes developmental change.

### *Identity and location memory*

Generally speaking, research suggests that remembering object location information is more incidental and less effortful than remembering object identity information. Early theoretical perspectives actually proposed that location information may be encoded automatically (Ellis, Katz, & Williams, 1987; Hasher & Zacks, 1979, 1984). This relatively extreme position has not received much support in the literature in that location memory is influenced by several properties that affect effortful processing such as intention, competing tasks, and practice (Cestari, Lucidi, Pieroni, & Rossi-Arnaud, 2007; Naveh-Benjamin, 1987; Puglisi, Cortis Park, Smith, & Hill, 1985; Siemens, Guttentag, & McIntyre, 1989). However, it does seem that locations may be easier to remember than identities. A brief snapshot of a display may be enough for adult participants to register location memories of the items in the display, which can be viewed as one holistic visual pattern (Haladjian & Mathy, 2015). By contrast, identity memories of heterogeneous items in the display would require a series of eye movements examining each item in detail (Beck, Peterson, & Vomela, 2006; Hollingworth, 2007; Huang & Grossberg, 2010).

The difference between explicit object identity and object location memories is also evident in their developmental trajectories. In a typical study, researchers present child participants with objects in identifiable locations and then instruct them to explicitly recall identity information, location information, or both. Throughout childhood, although age differences always seem to be found for object identity memory, it is common to find similarities across age or smaller age differences for object location memory (e.g., Cestari et al., 2007; Heil & Jansen, 2008; Jansen-Osmann & Heil, 2007; Lange-Küttner, 2010; Pentland, Anderson, Dye, & Wood, 2003; Van Leijenhorst, Crone, & van der Molen, 2007). In addition, researchers generally agree that the ability to recall both location and identity information develops more slowly than the ability to recall either dimension separately for children

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