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# Exploring age differences in visual working memory capacity: Is there a contribution of memory for configuration?

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ABSTRACT

Recent research has shown marked developmental increases in the apparent capacity of working memory. This recent research is based largely on performance on tasks in which a visual array is to be retained briefly for comparison with a subsequent probe display. Here we examined a possible theoretical alternative (or supplement) to a developmental increase in working memory in which children could improve in the ability to combine items in an array to form a coherent configuration. Elementary school children and adults received, on each trial, an array of colored spots to be remembered. On some trials, we provided structure in the probe display to facilitate the formation of a mental representation in which a coherent configuration is encoded. This stimulus structure in the probe display helped younger children, and thus reduced the developmental trend, but only on trials in which the participants were held responsible for the locations of items in the array. We conclude that, in addition to the development of the ability to form precise spatial configurations from items, the evidence is consistent with the existence of an actual developmental increase in working memory capacity for objects in an array.


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## Introduction

The current work focuses on the developmental role of one potential factor that might influence working memory ability for a visual array of simple objects: the ability to combine multiple items in a display to form an overall mental configuration. This configuration would be one form of grouping items to form a new larger unit in memory, reducing the load on working memory similar to what one can do by chunking together items based on prior knowledge (Miller, 1956).

Children from the late preschool years through adulthood can carry out some of the same sorts of tasks designed to examine working memory, which is essentially the small amount of information that can be held in mind at once. Clearly, working memory ability increases steadily during this age range (e.g., Gathercole, Pickering, Ambridge, & Wearing, 2004). Working memory is of special importance because its capacity limits are thought to constrain the kinds of concepts that individuals can understand or problems that they can solve (e.g., Halford, Cowan, & Andrews, 2007). If we understood the reasons for working memory capacity development, that understanding could in turn shed light on the nature of capacity limits in adults, the mechanisms of cognition in children, and the best course for improving educational practices (e.g., Cowan, 2014).

There is a growing body of evidence on the development of working memory in change detection tasks (after Luck & Vogel, 1997), in which a briefly presented array of objects to be remembered is followed by a probe to be judged present or absent from the array (Cowan et al., 2005; Cowan, Fristoe, Elliott, Brunner, & Saults, 2006; Cowan, Morey, AuBuchon, Zwilling, & Gilchrist, 2010; Riggs, McTaggart, Simpson, & Freeman, 2006; cf. Shore, Burack, Miller, Joseph, & Enns, 2006). Items in an array, however, sometimes can be combined to form a configuration, at least by adults (e.g., Brady & Tenenbaum, 2013; Chong & Treisman, 2003, 2005; Jiang, Olsun, & Chun, 2000; Woodman, Vecera, & Luck, 2003; Xu & Chun, 2007). If older participants use a multi-item configuration more readily than young children do, we might expect stimulus cues that encourage a configuration to help children use them, thereby reducing age differences in working memory. Alternatively, if no age groups are ordinarily using a configuration in a particular situation, cues encouraging a configuration might be used only by more mature participants, thereby increasing age effects in working memory.

There is some evidence suggesting that it is possible to dissociate effects of configuration from other aspects of working memory load. Jiang, Capistrano, and Palm (2014) recently found that array configuration knowledge did not differ between children with and without autistic spectrum disorders even though capacity was impaired in those with autistic spectrum disorders. We sought to use a similar research strategy, applied to a paradigm that we used previously (Cowan et al., 2010), to determine whether cues to the configuration would similarly help participants of all ages or would help one age group more than another. The latter outcome would indicate a developmental change in the use of configuration to assist in memory span. In principle, it would even be possible that age differences in span might come largely or entirely from age differences in the ability to use knowledge of the configuration.

## The current experiment

Consider a stimulus setup like the one that we used in the current study (modified from Cowan et al., 2010, to study context effects; see Fig. 1). Each trial included an array to be studied containing four differently colored objects: in particular, two circles and two triangles. This array was followed by a probe display that included a single colored object or probe item. The probe item always matched one array item in both location and shape, but the nature of the color of the probe varied depending on the condition. Judgments were to be made about where, if anywhere, the probe item appeared in the prior array. The answer was to be given with a mouse click.

An individual might notice things about the configuration of stimuli in the initial array. On some trials, for example, the individual might notice that the circles both have light colors (red and yellow), whereas the triangles both have dark colors (blue and green). Alternatively, the individual might encode the overall configuration formed by the constellation of colors and then use a memory of this