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When this means that: The role of working memory and inhibitory control in children's understanding of representations

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ABSTRACT

We investigated cognitive skills that contribute to 4-year-olds' understanding of representations. In our main task, children used representations on a perspective line drawing to find stickers hidden in a model room. To compare the contributions made by various cognitive skills with children's understanding of different types of representations, we manipulated the resemblance between the representations and their referents. Our results indicate that when representations are iconic (i.e., look like their referents), children have very little difficulty with the task. Controlling for performance on this baseline version of the task, we found that specific cognitive skills are differentially predictive of performance when using arbitrary and conflicting representations (i.e., symbols). When the representation was arbitrarily linked to the sticker, performance was related to phonological and visuospatial working memory. When the representation matched the color of an alternate sticker (thereby conflicting with the desired sticker), performance was related to phonological working memory and inhibitory control. We discuss the role that different cognitive skills play in representational understanding as a function of the nature of the representation–referent relation.

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Introduction

Representational understanding is a fundamental aspect of human cognition (Schwartz, 1995). Therefore, it is of great interest how children learn to deal with many different types of representations. Previous research has investigated children's ability to deal with written words (e.g., Bialystok & Martin, 2003), numbers (e.g., Bialystok & Codd, 2000), musical notations (e.g., Reybrouck, Verschaffel, & Lauwerier, 2009), scale models (e.g., DeLoache, 2000; DeLoache, Miller, & Rosengren, 1997), maps (e.g., Liben & Yekel, 1996; Myers & Liben, 2008; Uttal & Wellman, 1989), and photographs (e.g., Beilin & Pearlman, 1991; Zaitchik, 1990). From this work, we know that children understand many aspects of representations. For example, we know that 3-year-olds can use a scale model to represent a larger room (e.g., DeLoache, 2000) and that 5- and 6-year-olds can identify the symbolic intention of a map creator (Myers & Liben, 2008). However, we also know that young children have not yet mastered representational understanding; they often expect representations to resemble their referents in some way. For example, Bialystok, Shenfield, and Codd (2000) found that 4- and 5-year-olds often expect the names of large objects to be longer in their written forms relative to the names of smaller objects (e.g., cf. *train* and *caterpillar*).

Although the work done to date has been informative, we still know fairly little about the way in which cognitive skills contribute to children's emerging ability to use representations (Myers & Liben, 2012). For example, we know very little about which skills account for individual differences found on tasks of a representational nature or whether these skills vary across different types of representations. Knowing more about the contributing cognitive skills is of value because it will add to existing explanations of what accounts for children's representational errors and may help to account for some of the variability in children's performance. Thus, the main goal of the current work was to investigate the contribution of specific cognitive skills to children's (4-year-olds') performance on measures of representational understanding.

Representations vary in terms of how they stand for their referents; some do so by virtue of resemblance, whereas others share no physical similarities. The former type is known as *iconic* (Peirce, 1868), an example of which is a wavy blue line on a map indicating where a wavy blue river (the referent) is located. Alternatively, a representation may have an arbitrary, but socially agreed on, relation to its referent. For example, a red line on a map typically stands for an international border or a route to follow. There is no corresponding red line in the real world (Boston's Freedom Trail aside). This type of representation is known as *symbolic* (Peirce, 1868). With symbols, anything can be used to stand for anything else as long as the representation–referent relation has been conveyed (e.g., as done in a map's legend). Although we have adopted Peirce's terminology for labeling these different types of representations, there is some discrepancy with the labels as they are used in the existing literature (e.g., Piaget's use of *sign* and *symbol* differ notably from Peirce's; see Piaget, 1952). For the current study, the labels themselves are of importance only for distinguishing between what characterizes the representations (i.e., resembling vs. arbitrary).

We did not want to limit our investigation to only one particular type of representation, such as symbolic or iconic, because we predicted that different types of representation–referent relations would draw on different cognitive skills. We did, however, want to select a method that would enable us to use a common task structure so that we could make straightforward comparisons. We decided to use a perspective line drawing of a model room to present both symbolic and iconic representations. Our main task was based largely on a task developed by Myers and Liben (2008). A review of their task makes clear why we selected these types of representations and why we considered the cognitive skills that we did.

Myers and Liben (2008) investigated whether 5- and 6-year-olds were able to use representations that did not resemble their referents (symbols). To conduct their investigation, they designed the *use-a-map* task in which children looked for stickers in a room based on information provided by a map of that room (an overhead view with colored shapes depicting the colored furnishings in the room). Children had the option of searching for either red fruit stickers or green vegetable stickers (which were hidden in the room) using maps that indicated the hiding locations with dots of the *alternate* color; in other words, the red fruit stickers were represented by green dots and the green vegetable stickers