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Analysis of attention and analogical reasoning in children of poverty

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Abstract

This study examined the relationship between specific attentional aspects of processing capacity and analogical reasoning in children from low-income families. 77 children aged 48–77 (M = 56.7) months were assessed on an analogical reasoning task (matrices subtest of the Kaufman Brief Intelligence Test) and on computerized attention tasks designed to assess orienting, vigilance, and executive attention abilities [Posner, M.I., and Petersen, S.E. (1990). The attention system of the human brain. Annual Review of Neuroscience, 13, 25–42]. Results showed that analogical reasoning abilities were associated with the executive attention network abilities, suggesting that skills associated with this network, such as the resolution of conflicts between competing demands on attention, may be particularly important for relational mapping. This was evident in girls only. Implications for understanding how attentional components of processing capacity can affect children's academic success in impoverished environments are discussed.

Keywords: Analogical reasoning; Attention networks; Orienting; Vigilance; Executive attention; Relational mapping; Children; Poverty; Sex differences

1. Introduction

Analogical reasoning is an important cognitive skill involved in abstract mental processes such as creating metaphors, constructing explanations, and solving complex problems (Goswami, 2001). Researchers describe analogical reasoning as achieved when similarity judgments shift from simple perceptual feature comparisons to more complex reasoning based on common relational structures (Gentner, 1989; Goswami & Brown, 1990).

Researchers have begun to study the mechanisms underlying the development of analogical reasoning and the age at which the shift from similarity judgments based on perceptual similarity to relational mapping appears (Goswami & Brown, 1990; Halford, 1989; Kotovsky & Gentner, 1996; Markman & Gentner, 1993). Research shows that infants as young as eleven months old make inferences between objects based on perceptual similarity.

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For example, an infant might manipulate a red apple in a manner similar to a previously encountered red ball because they share similar features like color and roundness (Baldwin, Markman, & Melartin, 1993). Additionally, Brown (1989) found that one- and two-year olds could solve a transfer problem that required them to obtain an out of reach toy by recognizing that perceptually different tools such as a cane and rake could be used to achieve the same outcome because of their similar enabling qualities. It is believed that the major accomplishment of relational mapping between different structures arises from such early inferences based on similarity while irrelevant object features are ignored (Gentner, 1989).

While evidence has shown that infants can make similarity judgments and 2 year olds are capable of recognizing functional relational similarities, full comprehension of more sophisticated abstract relational mapping is not achieved until the preschool years. For example, Holyoak and Thagard (1995) concluded that a "mental leap" occurs between the ages of 3 and 5 years as reasoning formerly based on object similarity shifts to more advanced processes using relational mapping.

To make successful relational mappings, children must selectively pay attention to the relevant relations between objects while ignoring distracting mappings that may be perceptually similar (Goswami & Brown, 1990; Ratterman & Gentner, 1998). That is, the child must sort through possible matches between a source and a target, many of which may involve irrelevant perceptual similarities, before finding a match based on relational similarity. For example, a relational mapping question might present a child with pictures of a loaf of bread (A) paired with a slice of bread (B); then a picture of a whole lemon (C) is presented. The child's task is to select the correct picture (D) from an array to pair with (C) that corresponds to the first A:B relationship, which in this case would be a slice of lemon (Goswami & Brown, 1990). In the problem the child must ignore distracting (D) choices that are perceptually similar, such as a lemon cut in half or another whole lemon. According to Gentner (1989), younger children must overcome a preference for the concrete similarities of objects to be mapped. Several studies indicate that success at ignoring the concrete similarities and at finding the relational similarities increases significantly in the preschool years (Gentner & Rattermann, 1991; Kotovsky & Gentner, 1996; Ratterman & Gentner, 1998).

Theoretical accounts that explain the underlying mechanisms and variability in the age of children's shift to relational mapping strategies generally represent two positions. First, there are theoretical approaches that stress the importance of domain knowledge to the ability to make relational mappings in a particular domain (Brown, 1989; Crisafi & Brown, 1986; Gentner, 1989; Gentner & Rattermann, 1991; Kotovsky & Gentner, 1996; Vosniadou, 1989). Other theoretical accounts argue for the contribution of maturation and a global change in children's cognitive processing capacity (Halford, Wilson, & Phillips, 1998). For example, Halford and colleagues state that higher order relational mappings, such as those used in analogies, require a high number of propositional arguments, placing processing demands on working memory. Halford and colleagues argue that analogical reasoning develops with changes in strategies and individuals' capacity for parallel processing of complex relations with multiple arguments (e.g., Halford & McCredden, 1998; Halford et al., 1998).

1.1. Analogical reasoning and attention skills

The present study explored an aspect of processing capacity in the development of analogical mapping that had not been previously examined. Specific attentional requirements of analogical mapping were explored. Particular components of attention may be differentially important for relational mapping. Recently attentional processes have been examined in terms of three networks of attention: the orienting, alerting, and executive networks (Posner & Petersen, 1990). The orienting network is involved in focusing, disengaging, and shifting spatial attention. The alerting network is related to the maintenance of an alert state and sustaining attention. The executive network controls executive functions, such as goal-directed behavior, target detection, error detection, resolving conflict among responses, and inhibition of an automatic response. The executive network also appears to be required during tasks that require mental effort (Jones, Rothbart, & Posner, 2003; Posner & Rothbart, 1998).

All three components are assumed to play a role in an analogy task but the executive network is expected to be especially important. The orienting network may help direct attention to, and shift attention within, task relevant information (at least with spatial problems). The alerting network may help maintain focus on the task over time. But the executive network is expected to be particularly relevant because analogical reasoning requires the inhibition of attention to irrelevant perceptual features of stimuli and the direction of attention to relational information. This conflict between salient perceptual features and more hidden relational matches is precisely what makes analogical reasoning