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Progression paths in children's problem solving: The influence of dynamic testing, initial variability, and working memory

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ABSTRACT

The current study investigated developmental trajectories of analogical reasoning performance of 104 7- and 8-year-old children. We employed a microgenetic research method and multilevel analysis to examine the influence of several background variables and experimental treatment on the children's developmental trajectories. Our participants were divided into two treatment groups: repeated practice alone and repeated practice with training. Each child received an initial working memory assessment and was subsequently asked to solve figural analogies on each of several sessions. We examined children's analogical problem-solving behavior and their subsequent verbal accounts of their employed solving processes. We also investigated the influence of verbal and visual–spatial working memory capacity and initial variability in strategy use on analogical reasoning development. Results indicated that children in both treatment groups improved but that gains were greater for those who had received training. Training also reduced the influence of children's initial variability in the use of analogical strategies with the degree of improvement in reasoning largely unrelated to working memory capacity. Findings from this study demonstrate the value of a microgenetic research method and the use of multilevel analysis to examine inter- and intra-individual change in problem-solving processes.

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Introduction

Fine-grained investigation of children's cognitive abilities, including the influence of training, is complex, and children's performance on reasoning and problem-solving tasks has proven significantly more variable over time than many researchers and practitioners had assumed (Bjorklund & Rosenblum, 2001; Siegler, 2007). Substantial variability in solving cognitive tasks, between and within participants, has been demonstrated in a variety of domains such as math, spelling, and problem solving (Siegler, 1996). Studying this variability could provide us with more insights into how children determine the best ways of solving tasks. This approach may also help us to gain a greater understanding of individual differences in the development of strategy use over time and with increasing experience (Siegler, 2006).

Our study sought to examine variability in children's strategic behavior in analogy solving when receiving either a series of unguided practice sessions alone or this in combination with a training procedure derived from dynamic testing. We also studied the possible influence of working memory differences on analogy performance because a differential relationship between working memory and analogical reasoning has been found for children trained in dynamic testing settings (e.g., Stevenson, Bergwerff, Heiser, & Resing, 2014; Swanson, 1994, 2011). The main focus of our study, therefore, was on "the rate of change" and "variability" dimensions of Siegler's (1996) "overlapping waves" theory.

Inductive reasoning tasks, such as classification, analogies, and series completion, all require comparable underlying problem-solving processes; starting with specific observations of the task details under consideration and identification of a rule that leads to the solution must be detected and formulated. This rule-finding process can be reached by means of systematic comparison processes, which involve finding similarities and/or differences between task attributes and/or relations among attributes (Holyoak & Nisbett, 1988; Klauer & Phye, 2008; Perret, 2015). Analogical reasoning involves a basic inductive process that plays an important role in a number of higher cognitive processes (Halford, 1993; Morrison et al., 2004; Richland & Simms, 2015). In analogical studies, base item domains (e.g., white:black) and target domains (e.g., snow:?) need to be compared in order to find and formulate a relational correspondence existing between them (e.g., Holyoak, 2012; Thibaut & French, 2016).

The development of analogical reasoning in children and its role in instruction and classroom learning have been the focus of much research (Csapó, 1997; Goswami, 2002; Klauer & Phye, 2008; Kolodner, 1997; Richland, Morrison, & Holyoak, 2006; Richland & Simms, 2015; Singer-Freeman, 2005; Vosniadou, 1989). The development and training of children's ability to reason by analogy have also been studied extensively (Alexander, Willson, White, & Fuqua, 1987; Alexander et al., 1989; Goswami, 2013). In most studies, children older than 6 years have displayed clear improvements in analogical reasoning after receiving a (brief) period of training or, alternatively, after having been given extensive instructions or training for, for example, verbal analogies (Resing, 2000), physical problem analogies (Tunteler & Resing, 2007), concrete pictorial analogies (Hessels-Schlatter, 2002; Stevenson, Resing, & Froma, 2009), and classic geometric analogies (Hosenfeld, Van der Maas, & Van den Boom, 1997; Tunteler, Pronk, & Resing, 2008). In contrast, younger children have tended to show such gains only when they had received extensive training (Alexander et al., 1989; Tunteler & Resing, 2007).

Studies focusing on the development of inductive (analogical) reasoning have often used cross-sectional designs (e.g., Chen, 1996; Chen & Daehler, 1989; Richland et al., 2006; Singer-Freeman, 2005; Thibaut, French, & Vezneva, 2010). However, these are likely to provide an incomplete picture of the dynamics of variability and change (e.g., Granott, 2002; Kuhn, 1995; Siegler, 2006). Very few studies have compared changes in analogical reasoning over time that have been induced by repeated practice and/or training (e.g., Alexander et al., 1989; Hosenfeld et al., 1997), a shortfall that the current study sought to address.

One valuable approach to investigating learning trajectories is that which employs a microgenetic research design (Siegler, 2006; Winne & Nesbit, 2010). Such designs are characterized by frequently repeated (trial-by-trial) assessment sessions given within a relatively short period of time. They typically use somewhat basic instructions or unguided practice sessions, and they typically yield

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