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Building a knowledge base: Predicting self-derivation through integration in 6- to 10-year-olds

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ABSTRACT

Self-derivation of new factual knowledge through integration of separate episodes of learning is one means by which children build knowledge. Content generated in this manner becomes incorporated into the knowledge base and is retained over time; successful self-derivation predicts academic achievement. Yet the component processes on which self-derivation through integration depends are as yet unknown. In parallel studies with 6- and 8-year-olds ($N = 41$; Experiment 1) and 8- and 10-year-olds ($N = 40$; Experiment 2), we tested a number of predictors related to other productive processes and learning (reasoning, executive functions, verbal comprehension, and long-term retrieval). Across studies, with different methods, only verbal comprehension, a measure of accumulated semantic knowledge, accounted for unique variance in self-derivation through integration performance. The results indicate that self-derivation through integration of separate episodes relates to accumulation of knowledge and the ability to recruit the knowledge in the service of specific task demands. Implications for cognitive training and transfer are discussed.

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Introduction

Constructing a knowledge base is one of the most important tasks in development. Knowledge lays a foundation for language and thought, and knowledge supports the acquisition of more knowledge (Goswami, 2011). Children build knowledge through direct tuition and experiences. Because learning experiences are distributed over time and modalities, for knowledge to accumulate, separate but related episodes must be integrated with one another. Importantly, elaborating the knowledge base also depends on productive processes that permit self-derivation of new semantic content based on integrated representations (see Bauer, 2009, 2012). Research has revealed that new facts resulting from integration and self-derivation become incorporated into the knowledge base (Bauer & Jackson, 2015) and are retained over time (Varga & Bauer, 2013; Varga, Stewart, & Bauer, 2016). Critically, performance on tasks that test self-derivation of new factual knowledge through integration predicts academic achievement in both reading and math (Esposito & Bauer, 2017). Currently unknown are the component cognitive abilities on which self-derivation through integration depends. In the current research, in separate studies with 6- and 8-year-olds (Experiment 1) and 8- and 10-year-olds (Experiment 2), we tested candidate predictors suggested by research on other productive processes, specifically reasoning, executive functions, verbal comprehension, and long-term retrieval.

Productive processes and component cognitive abilities

Productive processes such as analogy, deduction, and induction allow learning to proceed efficiently because learners can extend beyond information explicitly provided in a lesson to derive novel understandings (e.g., Goswami, 1992, 2011; Perret, 2015). Productive processes have been observed across the lifespan (see Mandler & McDonough, 1996, for examples even during infancy) and are assumed to be a major mechanism of cognitive development (Bauer & Varga, 2017; Bauer, 2012; Brown, Bransford, Ferrara, & Campione, 1982; Goswami, 2011; Siegler, 1989).

The current literature on the component cognitive abilities on which productive processes depend has examined only a limited number of candidates, with particular emphasis on inhibitory control and working memory. The number of direct tests of these candidate processes is small, yet there is consensus that both inhibitory control and working memory play a role (see Goswami, 2011, for discussion). In terms of direct tests, Moutier (2000b) studied inhibitory control, training in logic, and deductive reasoning in 10- and 11-year-old children. In one condition children were trained to inhibit a common perceptual matching error, and in another condition they received logical training. At posttest, only the children with the training in inhibitory control showed improvement in the deductive reasoning task. In a related study, Moutier (2000a) tested 10- and 11-year-olds' deductive reasoning and performance on a number of inhibitory control tasks (Stroop Task, Trail Making, and Wisconsin Card Sort). Higher performance on the deductive reasoning task was related to higher inhibitory performance (see also Moutier, Plagne-Cayeux, Melot, and Houdé, 2006, for additional, indirect evidence of relations between cognitive inhibition and 8- to 10-year-olds' performance on deductive reasoning problems).

Other studies have not measured inhibitory control directly but have implicated it, working memory, or both based on patterns of task performance. For example, Richland, Morrison, and Holyoak (2006) investigated analogical problem solving in children aged 3–14 years. They found that younger children were more susceptible to the presence of feature-level distractors, relative to older children, and had lower levels of performance. They interpreted the pattern to indicate that younger children did not yet have sufficient inhibitory control to ignore the distractors and maintain the task-relevant information in working memory.

In addition to inhibitory control and working memory, accumulation and use of prior knowledge has been implicated as a factor accounting for age-related changes in inductive and deductive reasoning (e.g., Goswami, 2011). Yet this conjecture has not been subjected to strong empirical testing because there are few studies that have included a measure of verbal comprehension or other measures of acquired knowledge among the candidate predictor variables. An exception is Fisher, Godwin, and Matlen (2015), in which measures of verbal comprehension and reasoning were exam-