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Cognitive flexibility in young children: General or task-specific capacity?

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ABSTRACT

Cognitive flexibility is the ability to adapt to changing tasks or problems. To test whether cognitive flexibility is a coherent cognitive capacity in young children, we tested 3- to 5-year-olds' performance on two forms of task switching, rule-based (Three Dimension Changes Card Sorting, 3DCCS) and inductive (Flexible Induction of Meaning–Animates and Objects, FIM-Ob and FIM-An), as well as tests of response speed, verbal working memory, inhibition, and reasoning. Results suggest that cognitive flexibility is not a globally coherent trait; only the two inductive word-meaning (FIM) tests showed high inter-test coherence. Task- and knowledge-specific factors also determine children's flexibility in a given test. Response speed, vocabulary size, and causal reasoning skills further predicted individual and age differences in flexibility, although they did not have the same predictive relation with all three flexibility tests.

Introduction

Cognitive flexibility is the capacity to modify working memory, attention, and response selection in response to changing endogenous and exogenous task demands. Cognitive flexibility has been the focus of behavioral and neuropsychological studies (e.g., Eslinger & Grattan, 1993; Kramer, Cepeda, & Cepeda, 2001; Smith & Blankenship, 1991) using a variety of tasks and contexts and wide age ranges

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(Ionescu, 2012). Age-related changes in cognitive flexibility have been reported in tests of rule switching (Zelazo, Frye, & Rapus, 1996), word learning (Deák, 2003), spatial reasoning (Hermer-Vazquez, Moffet, & Munkholm, 2001), categorization (Blaye & Bonthoux, 2001), and problem solving (Chen, 1999). Many studies and paradigms suggest that flexibility improves significantly from 3 to 6 years of age. If flexibility develops similarly across multiple tasks, it might mean that flexibility is a generalized cognitive capacity—an "executive" control process that operates over a wide range of task contexts (e.g., Martin & Rubin, 1995; Zelazo & Frye, 1998).

The idea of general cognitive capacities has a long history in psychology (e.g., Ackerman, 1988; Engle & Kane, 2004; Humphreys, 1979). Many researchers have argued that a few general *executive functions* (EFs) control cognition in a variety of tasks and contexts (but see Barkley, 2012; Jurado & Rosselli, 2007). Many proposed EF frameworks incorporate a function of cognitive flexibility or "set shifting" (e.g., Miyake et al., 2000). A related hypothesis is that EFs are stable endogenous traits of individuals (Friedman et al., 2008). This implies that individual differences in cognitive flexibility should be constant across tasks, times, and content. Some authors have suggested that these general EFs, including flexibility, mature and stabilize during early childhood (Carlson, Moses, & Breton, 2002; Davidson, Amso, Anderson, & Diamond, 2006).

That hypothesis is controversial; an alternative is that flexibility develops in a domain-specific fashion as children gain task-specific skills and knowledge (Luwel, Verschaffel, Onghena, & De Corte, 2003; Ravizza & Carter, 2008). By this view, flexibility might improve in many tasks between 3 and 5 years of age simply because children acquire a great deal of varied knowledge and skills during that time. That is, flexibility might improve due to parallel gains in knowledge and skills across domains, not to the development of a generalized EF. If this is true, older children's flexibility should relate to individual domain-specific skills. For example, it has been shown that school-aged children's flexibility in reading-related tasks is partly predicted by their reading skill (Cartwright, Marshall, Dandy, & Isaac, 2010).

It is also possible that children's flexibility is determined by both a general EF and task- or domain-specific skills and knowledge. Another related possibility is that there are several dissociable, moderately general flexibility capacities, and each is more relevant to (or more heavily recruited for) some tasks than others (Kim, Johnson, Cilles, & Gold, 2011). Both of these alternatives would predict limited between-test intra-individual coherence of flexibility.

Determining whether children's cognitive flexibility depends on general capacities, on task-specific knowledge and skills, or on both would go some way towards explaining developmental changes in cognitive control. However, there is little evidence concerning the coherence of children's flexibility. Most studies implicitly treat flexibility as a general capacity that can be assessed by a single rule-switching test despite the fact that external validity and construct validity of most tests has not been established.

To address this question, we gave preschool children three tests of flexibility representing two types of cognitive skills or domains. If individual children's flexibility is similar across all tests, it will imply a general capacity. If it is consistent only between two tests from the same task domain, it will suggest that flexibility is determined by task-specific skills, or by several moderately specific capacities, or both. If flexibility is inconsistent across all three tests, it will suggest that flexibility is largely determined by task-specific knowledge.

Selecting comparable tests with different content domains and task demands is challenging because most studies of young children use one test, the Dimensional Change Card Sorting test or DCCS (Zelazo, 2006). This is a *rule-switching* test; children learn two deductive binary rules for sorting two stimuli. They are told to follow one rule and, at some later time, to switch to the other rule. The test yields robust age differences; most 3-year-olds fail to follow an instruction to switch to the second rule, but most 5-year-olds correctly switch. The test classifies each child as flexible or inflexible with little further differentiation. Although recent studies have explored more sensitive measures of rule-switching efficiency in older children (e.g., Cepeda, Kramer, & Gonzalez de Sather, 2001), these paradigms are not well-suited for preschool children.

Other researchers have, however, tested preschoolers using age-appropriate tests that yield parametric estimates of flexibility. These tests involve more subtasks and switches, as well as more trials and response options, than the DCCS (Deák & Narasimham, 2003, 2014; Narasimham, Deák, &