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Cognitive flexibility children across the transition to school: A longitudinal study

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ABSTRACT

Longitudinal research exploring the development of cognitive flexibility is lacking. In this study we investigated the speed-accuracy pattern in cognitive flexibility performance in 87 5–6-year-olds across the transition to formal education. Overall, longitudinal change was observed in accuracy but not in speed of responding. Children with low accuracy scores in kindergarten were faster than those with high accuracy scores, but the low-accuracy group showed a significant performance gain in accuracy over time, whereas high-accuracy kindergartners only gained in speed. These results suggest an important role of formal schooling in cognitive flexibility in narrowing the performance gap between more and less able children. The findings also identify existence of diverse paths in development of flexible thinking.

1. Introduction

Flexible thinking in the face of ever-changing situations is crucial. This ability, known as the shifting or cognitive flexibility component of executive function (EF), involves switching between multiple and conflicting representations, strategies or responses as task demands change (Miyake et al., 2000). It

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may entail a compromise between quick and correct choices (Bogacz, Wagenmakers, Forstmann, & Nieuwenhuis, 2010). Responding quickly risks error (Ivanoff, Branning, & Marois, 2008). Although accuracy and speed are related (Pachella, 1974), it is unclear whether they involve the same processes (Cragg & Chevalier, 2012) or whether they always work in opposite directions across conditions and across people (Salthouse, 2010).

The speed-accuracy tradeoff in executive function (EF) develops over time (Davidson, Amso, Anderson, & Diamond, 2006). Unlike adults, young children are too impulsive to trade speed for correctness. Such shifting ability shows greatest gain in the preschool years but continues to develop to adulthood (Cragg & Chevalier, 2012). The first year of formal education, during which children need to adjust to a set of standards likely to be substantially different than those in early school settings and at home, provides children with opportunities to use and practice EF skills (Diamond, Barnett, Thomas, & Munro, 2007). The major aim of the present study is to examine patterns in children's speed-accuracy trade-offs in cognitive flexibility performance before and after the transition to formal education.

Cognitive flexibility enables us to see the world from a new and different perspective and is vital for adaptation and creativity (Davidson et al., 2006). We construct particular representations of different circumstances and switch between competing responses by activating and modifying representations in a dynamic way when circumstances change unpredictably (Deak & Narasimham, 2003). Doing so involves a complex cognitive mechanism comprising multiple subprocesses. Diamond (2006) proposed that flexibility incorporates two other well-known EF components: working memory for keeping task goals actively in mind and inhibition for overriding the previous task set. There is evidence that working memory, rather than inhibition, mostly accounts for cognitive flexibility in young children (Blackwell, Cepeda, & Munakata, 2009; Cepeda & Munakata, 2007). Having stronger working memory representations of the current task enhances successful switching, which cannot be explained by inhibitory abilities, motivation or general cognitive ability. Although the nature of cognitive flexibility is not yet fully understood, there is some consensus that cognitive flexibility cannot be reduced to a single component or be explained by the combination of inhibition and working memory (Cragg & Chevalier, 2012). Chevalier et al. (2012) claims that the contribution of inhibition and working memory to flexibility in 4–5-year-olds may occur through goal representation or activation.

Cognitive flexibility tasks are varied in content and complexity but all have a similar characteristic: Children must use a particular approach to respond correctly; then the rule is changed, requiring them to adopt an alternative approach (Jacques & Zelazo, 2005). In recent years, cognitive flexibility has frequently been assessed by the task-switching paradigm in school-aged children (Crone, Bunge, van der Molen, & Ridderinkhof, 2006; Davidson et al., 2006; Huizinga, Burack, & Van der Molen, 2010; Karbach & Kray, 2007). In the task-switching paradigm, participants are asked to perform the same task across all trials within simple blocks, but they must alternate between two tasks from trial to trial in mixed blocks. They must switch response when the rule changes from trial to trial (i.e., switch trials) and repeat the same response when the rule does not change (i.e., nonswitch trials). The mixed block taps into all executive functions and in particular to cognitive flexibility as it requires children to switch between two different perspectives (Diamond et al., 2007).

The indicator of cognitive flexibility (i.e., accuracy, reaction time or efficiency) varies with the age of the participant. Whereas accuracy is typically used with preschoolers, use of reaction time is reported among older children and adults. Measuring both has been suggested to allow valid comparisons across age groups (Cragg & Chevalier, 2012). Studies comparing performance of distinct age groups have shown that slowing down responses for accurate shifting is an age-related improvement (Crone et al., 2006; Davidson et al., 2006). Although the early elementary school years represent a critical period in the development of cognitive flexibility (Roebers, Rothlisberger, Cimeli, Michel, & Neuenschwander, 2011), to our knowledge there is no study examining the speed-accuracy pattern across these years. In most studies, the development of executive function has been examined by comparing performance of different age groups in cross-sectional designs (Crone et al., 2006; Davidson et al., 2006). Longitudinal studies reduce irrelevant variance stemming from cohort effects by examining changes within persons. In this respect, the present longitudinal study promises to be useful to obtain a more nuanced understanding regarding age change in performance on a cognitive flexibility task (Best & Miller, 2010).