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Individual differences in growth in executive function across the transition to school predict externalizing and internalizing behaviors and self-perceived academic success at 6 years of age

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ABSTRACT

Building on an existing latent variable analysis of executive function (EF) in children ($N = 191$, 57% boys and 43% girls) making the transition to school (Hughes et al. (2010), *Developmental Neuropsychology*, vol. 35, pp. 20–36), the current study both documented average developmental improvements from 4 to 6 years of age and examined individual differences in EF growth in relation to latent factors for two sets of child outcome measures at 6 years: (a) first-grade teachers' ratings of emotional symptoms, hyperactivity, and conduct/peer problems and (b) children's self-perceived academic and social competencies. With effects of concurrent verbal ability and EF controlled, variation in EF slopes across the transition to school predicted variation in latent constructs for (a) all four problem behavior subscales and (b) children's self-reported academic (but not social) competence. These findings underscore the clinical and educational significance of early individual differences in EF and highlight the value of adopting a developmental perspective.

Introduction

Executive function (EF) is an umbrella term that encompasses the set of higher order processes (e.g., inhibitory control, working memory, attentional flexibility), associated with the prefrontal cor-

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tex, that govern goal-directed action and adaptive responses to novel, complex, or ambiguous situations (Hughes, Graham, & Grayson, 2005). The past two decades have seen massive growth in the availability of child-friendly EF tasks (e.g., Carlson, 2005; Diamond, Prevor, Callender, & Druin, 1997; Espy, Kaufmann, McDiarmid, & Glisky, 1999; Hughes, 1998; Zelazo & Müller, 2002), leading to dramatic improvements in our understanding of the development of EF. For instance, it is now known that EF is a unitary construct with partially dissociable components (Garon, Bryson, & Smith, 2008) that begins to emerge during the first few years of life (e.g., Diamond, 1991), continues to develop through to adulthood (Huizinga, Dolan, & van der Molen, 2006), and shows strong associations with cognitive characteristics such as language ability and understanding of false beliefs (e.g., Carlson, Moses, & Breton, 2002; Hughes, 1998; Hughes & Ensor, 2007).

However, concerns have been raised about the validity of findings from studies of children's developing EF skills. For example, in their recent review, Garon et al. (2008) noted that simplifying adult tasks to make them age appropriate for young children carries the danger of losing the critical EF component. In addition, the construct validity of children's EF scores may be jeopardized by the fact that peripheral cognitive constraints (e.g., in verbal comprehension) significantly affect children's task performances. Similarly, Zelazo and Müller (2002) noted that correlations among measures can result not only from similarities in the mechanisms underlying task performance but also from age-specific effects and shared method variance (e.g., many EF tasks have a similarly strong verbal load). Fortunately, effects of measurement error can be partitioned out statistically (e.g., via latent variable modeling), and recent years have seen an increase in the accessibility of these techniques. As a result, researchers are increasingly conducting confirmatory factor analyses to test different models of EF development (e.g., Brookshire, Levin, & Song, 2004; Gathercole, Pickering, Ambridge, & Wearing, 2004; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003).

The current study builds on existing latent variable analyses of EF in a socially diverse sample of children at 4 and 6 years of age across the transition to school (Hughes, Ensor, Wilson, & Graham, 2010). The results of this prior study added to the literature on associations between individual differences in preschoolers' EF skills and individual differences in family socioeconomic status (Hughes & Ensor, 2005; Mezzacappa, 2004) and verbal ability (e.g., Hughes, 1998; Hughes & Ensor, 2007). Specifically, latent growth models showed that although both family income and verbal ability predicted individual differences in EF at 4 years (i.e., EF intercepts), only verbal ability predicted gains in EF across the transition to school (i.e., EF slopes). In particular, verbally less able children showed greater gains in EF than their peers. This may be because the changes in children's linguistic environments that accompany the transition to school are likely to be particularly marked for verbally less able children and may well contribute to developmental improvements in children's EF skills. Alternatively, the transition to school may foster children's EF skills by increasing their participation in structured activities; this effect may be particularly important for verbally less able children who are more reliant on external support. Support for this latter proposal comes from the recent finding that family chaos predicts reduced gains in EF across the preschool years (Hughes & Ensor, 2009).

The current study extends the above analyses (reported by Hughes et al., 2010) in three ways. Specifically, we document average improvements in EF from 4 to 6 years of age and examine children's EF growth in relation to both first-grade teachers' ratings of problem behaviors (emotional symptoms, hyperactivity, and conduct/peer problems) and children's self-reported academic and social success in first grade. Below, the background to each of these aims is presented in turn.

Average developmental change in EF from 4 to 6 years of age

Evidence to date suggests age-related contrasts in EF across the whole developmental span (Brocki & Bohlin, 2004; Carlson, Mandell, & Williams, 2004; Hughes & Ensor, 2007; Huizinga et al., 2006). However, most previous studies have been cross-sectional in design and have not used a latent variable approach. As a result, these findings are confounded by both cohort effects and developmental changes in how children cope with peripheral task demands. Recent research findings on the "Flynn effect," an eponymous term used to refer to the striking population gains on standardized intelligence tests seen over the past few decades (Flynn, 1984), provide a salutary reminder of the need to consider such potential confounds. Specifically, Wicherts et al. (2004) showed that measurement invariance