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The role of the executive functions in school achievement at the end of Grade 1

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ABSTRACT

The aim of this study was to determine the role of executive functions (EFs) in early school achievement when a variety of potential confounding factors were controlled. Measures of EF (inhibition, flexibility, and working memory) and school readiness were administered to a sample of 85 kindergartners (39 boys and 46 girls, 5–6 years old). School achievement was then assessed at the end of Grade 1. Results show math and reading/writing skills at the end of Grade 1 to be associated with kindergarten EFs. Only working memory contributed uniquely to the variance in school achievement after all covariates (preacademic abilities, affective variables, and family variables) were controlled and, even then, only with respect to math skills. On the other hand, working memory and inhibition had an indirect effect on reading/writing skills via anger–aggression. EF implication in school achievement is discussed in terms of task demands and child age.

Introduction

A growing body of evidence points to the implication of an executive function (EF) deficit in a variety of childhood pathologies. Such a deficit has been linked to (a) developmental psychopathologies such as attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), and Tourette's syndrome (Kenworthy, Yerys, Anthony, & Wallace, 2008; Pennington & Ozonoff, 1996), (b) cerebral damage consecutive to medical conditions such as phenylketonuria and sickle cell disease (Azadi, Seddigh, Tehrani-Doost, Alaghband-Rad, & Ashrafi, 2009; Kral, Brown, & Hynd, 2001), and (c) adverse environmental conditions such as early care deprivation (Stevens et al., 2008) and fetal alcohol

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spectrum disorder (Rasmussen, 2005). Along a parallel line, there has been mounting interest in understanding the specific role of EFs in the cognitive and affective development of normative children. Although EF deficits and their adverse consequences can be observed at all developmental stages in humans, more recent studies have focused on gaining a more thorough understanding of the preschool period for several reasons. First, preschool is a key period in the development of EFs, especially at around 4 years of age, when the central components of EF become more coordinated (Garon, Bryson, & Smith, 2008). Second, preschool skills have been found to be predictive of early and later child school achievement (Entwisle & Hayduk, 1988). This is no trivial matter considering the importance of formal schooling in most modern societies. Although some authors have recently reported links between EFs and early school success (Blair & Razza, 2007; Espy et al., 2004; McClelland et al., 2007), this association had never been investigated within the context of a longitudinal study in which special attention was paid to controlling the many well-established and potentially confounding factors that contribute to early school success, such as preacademic abilities, socioaffective adaptation, and mother's education and socioeconomic status, and in which efforts were made to avoid the numerous methodological pitfalls of EF measurement.

Executive functions

EFs consist of a set of hypothetical processes that enable the conscious control of thought and action to guide behavior toward a future goal. These processes typically include inhibition, working memory (WM), flexibility, planning, fluency, and concept formation. They can be viewed as a cognitive subcomponent of the larger self-regulation construct (Calkins & Marcovitch, 2010). Although it still lacks clarity, this psychological construct is nevertheless useful in clinical and scientific research (see Jurado & Rosselli, 2007, for a review).

Many researchers have posited inhibition, flexibility, and WM as the main components of EF (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). It has been hypothesized that these core EFs are relatively distinct, albeit interrelated, and might explain performance on the variety of more complex EF tasks. Recent neuroimaging studies have tended to support this model given that the three components, although associated with relatively distinct brain areas, have also shown areas of common activation (Collette et al., 2005; McNab et al., 2008). This structural hypothesis is still a matter of debate and all the more so when applied to young children. To date, few psychometric studies have addressed this question with preschoolers, and they have yielded somewhat conflicting results. Whereas Hughes (1998b) and Espy and colleagues (2004) did obtain the typical three-factor solution, Espy, Kaufmann, McDiarmid, and Glisky (1999) found four factors and, more recently, Wiebe, Espy, and Charack (2008) came up with only one using a confirmatory approach.

EFs and academic achievement

In school-age children, reading and writing skills have been linked to WM (St. Clair-Thompson & Gathercole, 2009; van der Sluis, de Jong, & van der Leij, 2007; Waber, Gerber, Turcios, Wagner, & Forbes, 2006), flexibility (Altemeier, Abbott, & Berninger, 2008; van der Sluis et al., 2007; Waber et al., 2006), and inhibition (Altemeier et al., 2008; Altemeier, Jones, Abbott, & Berninger, 2006; St. Clair-Thompson & Gathercole, 2009; Taylor, Schatschneider, Petrill, Barry, & Owens, 1996; Waber et al., 2006).

Math skills, for their part, have been linked to WM (Agostino, Johnson, & Pascual-Leone, 2010; Bull & Scerif, 2001; Lee, Ng, Ng, & Lim, 2004; Rasmussen & Bisanz, 2005; St. Clair-Thompson & Gathercole, 2009; van der Sluis et al., 2007; Waber et al., 2006), flexibility (Agostino et al., 2010; Bull & Scerif, 2001; Waber et al., 2006), and inhibition (Agostino et al., 2010; Bull & Scerif, 2001; Rasmussen & Bisanz, 2005; St. Clair-Thompson & Gathercole, 2009; Taylor et al., 1996; Waber et al., 2006).

Results suggest a general association between EFs and academic achievement. However, a more subtle pattern of associations emerges on closer scrutiny of the data. For example, in St. Clair-Thompson and Gathercole (2009), WM was more strongly associated with school achievement than was inhibition. The strongest association was observed between WM and reading/writing achievement. In van der Sluis and colleagues (2007) as well, WM predicted reading/writing achievement more