



Executive function mediates socio-economic and racial differences in early academic achievement



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ABSTRACT

Although associations between socio-economic status, race, and academic achievement are well established, the specific mechanisms that underlie the relation remain incompletely understood. This longitudinal investigation, involving a sample of 206 children from economically and racially diverse backgrounds, examined the influence of executive function and expressive vocabulary assessed in kindergarten on academic achievement in Grade 1. The use of structural equation modeling revealed that both SES and race had indirect effects on achievement test scores through their effects on executive function, even when accounting for differences in expressive vocabulary. As expected, executive function was more strongly related to math than literacy achievement. The results provide support for the importance of targeting executive skills and intervening early in efforts to improve academic performance in young children. Moreover, the findings suggest that improving executive function may mitigate the impact of social risk factors on academic achievement.

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1. Introduction

Current interest in identifying and understanding the factors that contribute to early academic success is unprecedented (Pianta, Cox, & Snow, 2007). An extensive literature documents the importance of contextual factors, especially socio-economic background and racial minority status, in predicting educational attainment. Much less is understood, however, about the potentially complex linkages among these contextual variables and the cognitive processes that underlie academic mastery. The present study contributes to the understanding of how socio-economic status (SES) and minority status (African American) influence academic achievement by examining prospective longitudinal associations among SES, minority status, executive function, verbal ability, and academic achievement. Specifically, we used structural equation modeling to investigate if children's executive function and verbal ability, measured when the children were in kindergarten, mediate associations found between SES and minority status and academic achievement in Grade 1.

Two of the most commonly used contextual factors to predict individual differences in school success are SES, a proxy for

an individual's or family's access to capital or the resources of a society (Coleman, 1988), and race (Burchinal et al., 2011; Sirin, 2005). These factors are often confounded in the United States, and consequently their individual influences are difficult to discern (McLoyd, 1998). There is, however, no doubt about the significance of SES and minority status on academic achievement. As documented in numerous investigations, pervasive gaps in math and literacy achievement between majority and minority students and also between high- and low-SES students are evident as early as kindergarten. Moreover, these achievement gaps persist over time (Arnold & Docrocoff, 2003; KewalRamani, Gilbertson, Fox, & Provasnik, 2007; Mistry, Benner, Biesanz, Clark, & Howes, 2010; Snyder & Dillow, 2011).

It is important to note that SES and minority status may indirectly influence academic performance, and thus researchers are challenged to identify and examine the effects of other variables that mediate the relationships. Much has been learned from research that has examined the unique effects of factors associated with SES and race which are external to the child (e.g., family's access to resources, teacher attitudes, stress, underfunded schools) on child development and academic achievement (Bradley & Corwyn, 2002; Evans, 2006; McLoyd, 1998). Additional investigations have focused on the potential effects of child characteristics, emphasizing not only *what* children know, but increasingly addressing *how* children learn. Hence, the focus has shifted from domain-specific knowledge, such as letter and number recognition, to domain-general processes (Blair, 2006; Duncan

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et al., 2007). The present study contributes to the literature by longitudinally examining the extent to which kindergarteners' executive function and expressive vocabulary underlie SES and racial differences in children's academic achievement in Grade 1 in a sample of African American and European American families from across the economic continuum.

1.1. Executive function

Executive function is the overarching term used to describe the set of higher-order processes that aid in the regulation of cognition in the service of planning, problem-solving, and goal-directed actions (Miyake et al., 2000). Executive function is conceptualized as a multifaceted construct comprised of various abilities that help facilitate cognitive regulation. It is most often examined with regards to: (1) attention shifting, defined as the ability to shift actions to changing situational demands (Zelazo, Frye, & Rapus, 1996); (2) working memory, the capability to keep and manipulate information in the mind to guide ongoing behavior (Baddeley & Hitch, 1974); and (3) inhibitory control, the facility to impede prepotent responses or ignore information that could interfere with completing a goal (Diamond, 1990). Although these abilities constitute three independent processes in older children (Miyake et al., 2000), mounting evidence suggests that the three abilities construct a unitary process in preschool children and kindergarteners (Willoughby, Blair, Wirth, & Greenberg, 2010; Hughes, Ensor, Wilson, & Graham, 2010; Wiebe, Espy, & Charak, 2008).

Executive function has garnered much recent attention due to its association with early school success. There is a growing body of evidence that executive function, second only to emergent literacy and math skills, is a positive predictor of both concurrent and future math and literacy achievement (Allan & Lonigan, 2011; Blair & Razza, 2007; Bull, Espy, Wiebe, Sheffield, & Nelson, 2011; Bull, Espy, & Wiebe, 2008; Clark, Pritchard, & Woodward, 2010; Dilworth-Bart, 2012; Duncan et al., 2007; Howse, Lange, Farran, Boyles, 2003; Lan, Legare, Ponitz, Li, & Morrison, 2011). These relations; however, tend to be stronger for early math achievement than for reading achievement (Blair & Razza, 2007; Bull, Espy, & Wiebe, 2008). Growing evidence also indicates that executive function is related to growth in achievement across the transition from kindergarten to elementary school and across the early elementary school grades (Matthews, Ponitz, & Morrison, 2009; McClelland et al., 2007; Ponitz, McClelland, Matthews, & Morrison, 2009; Welsh, Nix, Blair, Bierman, & Nelson, 2010).

Recent work has also established associations between SES and executive function in early elementary school children (Blair, 2010; Dilworth-Bart, 2012; Evans & Rosenbaum, 2008). Farah, Nobel, and colleagues (Hackman, Farah, & Meaney, 2010; Noble, McCandliss, & Farah, 2007; Noble, Norman, and Farah, 2005) have suggested that brain systems with prolonged postnatal development, including the prefrontal/executive system, are more susceptible to the impact of limited environmental resources than are earlier developing systems such as the occipitotemporal and parietal systems. Moreover, it has been proposed that exposure to the early stress associated with inadequate family resources increases the presence of classes of stress hormones and neurotransmitters, which in turn alter the development of the neural pathways associated with executive function and behavioral reactivity (Blair, 2010). This explanation has been supported by electrophysiological evidence that children from low-SES families have altered prefrontal functioning compared to children from higher SES backgrounds (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009).

To the extent that African American families experience ethnically-related stress resulting from intergenerational influences of social inequality and discrimination (Conrada et al., 2000; Kuzawa & Sweet, 2009; McLoyd, 1990), it is possible that minority

status could similarly influence children's prefrontal development and functioning. Moreover, minority status can also be an indicator or chronic or deep poverty in the United States, where the poorest families are African American, which could further exasperate the effects of chronic stress associated with low-SES. If so, minority status could exert an influence on executive functioning over and above SES. This possibility is supported by Blair and colleagues' work examining the interrelations among SES, race, parenting and household risk factors, salivary cortisol, IQ, and executive function (Blair et al., 2011). The study found that African American children (tested at ages 7-, 15-, and 24-months), compared to their European American counterparts, had higher level of resting level cortisol and experience greater parental and household risk. At age 3, these same children also had lower scores on measures of executive function and IQ. The present study extends this work by examining if differences in executive function between African American and European American children contribute to racial differences in academic achievement when accounting for variation in SES.

1.2. Verbal ability

Emergent academic skills, including vocabulary knowledge at the onset of schooling, are among the best predictors of later school achievement (Duncan et al., 2007; Snow, Burns, & Griffin, 1998). Indeed, children's verbal skills in prekindergarten and kindergarten have been shown to predict literacy and math achievement across the early elementary years (Beron & Farkas, 2004; Lonigan, Burgess, & Anthony, 2000; Kurdek & Sinclair, 2001). Stratification studies in the U.S. have found discernible influences of SES and race in early vocabulary skills (Beron & Farkas, 2004; Brooks-Gunn & Duncan, 2000; Farkas & Beron, 2004; Feagans & Farran, 1982), and it has been posited that these early differences contribute to later group differences in academic achievement. Particularly, a longitudinal examination of the children born to female respondents of the nationally representative National Longitudinal Survey of Youth 1979 cohort found that there were marked differences in vocabulary knowledge between children from low-SES and high-SES families and between African American and White children by 36 months of age, such that White children and children from high-SES families had greater verbal skills (Farkas & Beron, 2004). Although the highest rates of vocabulary growth were reported before the age of 5, stratification differences were maintained through 13 years of age. Subsequent work by Beron and Farkas (2004) also provides evidence for the assertion that these early differences could contribute to economic and racial achievement gaps in the early elementary years. In their examination of a nationally representative sample of 647 children ages 5 to 10, the authors found that children's oral language mediated the relations found between SES and reading abilities and between race and reading abilities, relations which favored White children and children from high-SES families. In fact, oral language accounted for almost all of the race effect and more than half of the SES effect. We extend this work by examining if these findings are found when children's executive function skills are also accounted for in models predicting racial and economic differences in both literacy and math achievement.

1.3. Executive function and verbal ability

Prior research has established consistent relations between executive function and verbal ability in early childhood (Blair & Razza, 2007; Blair et al., 2011; Bull et al., 2011; Dilworth-Bart, 2012; Espy, McDiarmid, Cwik, Stalets, Hamby, & Senn, 2004; Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Hughes, 1998; Müller, Zelazo, & Imrisek, 2005). Recent longitudinal work also indicates that children's verbal abilities positively predict executive function gains in 4 and 5-year old children (Fuhs & Day, 2011).

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