



# Relations between executive function, behavioral regulation, and achievement: Moderation by family income☆☆☆



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## ABSTRACT

Children's executive function (EF) and behavioral regulation skills are robust predictors of academic success. The current study examines differential associations between measures of EF, classroom behavioral regulation, and academic achievement by children's family income in a sample of 100 prekindergarten children. In correlational analyses, EF and classroom behavioral regulation were more strongly associated for children *not* in low-income families, although only one comparison between correlations reached statistical significance. In regression models controlling for age, gender, and maternal education, EF and classroom behavioral regulation were generally similarly related to achievement regardless of family income. However, inhibitory control was significantly less associated with mathematics and vocabulary for children in low-income families than for children not. These findings suggest similarities in associations between EF, behavioral regulation, and academic achievement regardless of family income, with evidence of only a few exceptions. Potential implications for early childhood interventions in low-income populations are considered.

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## 1. Introduction

Children's early development has important implications for a host of outcomes throughout their life. One developmental period of importance is the transition from early childhood environments to formal schooling, where executive function (EF) and behavioral regulation help children take advantage of learning opportunities in the classroom (McClelland & Cameron Ponitz, 2012). Specifically, children's EF and behavioral regulation are observed in their ability to sit still in classrooms, pay attention to teachers, problem solve, and be goal-directive (Blair & Diamond, 2008; McClelland & Cameron Ponitz, 2012; Morrison, Cameron Ponitz, & McClelland, 2010). Considerable evidence using a variety of methods supports the notion that EF and behavioral regulation are strong predictors of academic achievement in early childhood (e.g., Blair & Razza, 2007; Espy et al., 2004; Gathercole & Pickering,

2000), with predictive relations maintaining through college completion (McClelland, Acock, Piccinin, Rhea, & Stalling, 2013).

Given these theoretical and empirical connections, early childhood interventions have targeted EF and behavioral regulation as a mechanism to boost children's academic success (e.g., Blair & Raver, 2014; Schmitt, McClelland, Tominey, & Acock, 2015). However, it is unclear if the underlying connections between EF, behavioral regulation, and academic achievement are the same across diverse populations of children. That is, research is needed to clarify whether demographic factors (e.g., family income) moderate relations between EF and behavioral regulation measures, and if they moderate relations between these skills and academic achievement. Clarifying this issue has potential implications for the skills that early childhood interventions should target in diverse populations. The current study examines differential associations between EF, behavioral regulation, and academic skills by family income in a sample of prekindergarten children. To accomplish this goal, children were compared who were enrolled in Head Start to those who were not enrolled in, or eligible for, Head Start. However, all children were in combined Head Start and non-Head Start preschool classrooms.

### 1.1. Executive function (EF) and behavioral regulation

Executive function, including attention shifting, working memory, and inhibitory control, helps children regulate their thoughts and behavior (e.g., plan, organize, and problem solve; Blair, Zelazo, & Greenberg, 2005; McClelland, Cameron Ponitz, Messersmith, &

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Tominey, 2010). Behavioral regulation has been defined as inclusive of cognitive (e.g., EF) and emotional regulatory skills that help children stop, think, and then act in order to achieve a goal (Blair & Raver, 2015; McClelland & Tominey, 2015; Ursache, Blair, & Raver, 2012). In other words, children use EF skills along with other regulatory skills when they pay attention to teachers, follow instructions, and complete or persist on tasks and activities (McClelland & Cameron Ponitz, 2012; Morrison et al., 2010). We view EF skills as necessary for children to regulate their behaviors in the classroom along with other skills, such as emotional regulation (McClelland et al., 2010; Ursache et al., 2012).

Although there is conceptual and statistical overlap between EF and behavioral regulation, research supports the notion that EF processes are foundational for children to develop regulatory skills (Blair & Raver, 2012; McClelland & Tominey, 2015; Ursache et al., 2012). The current study uses the two terms to distinguish between EF tasks that are directly assessed (i.e., Day-Night Stroop, a Card Sort task, and the Head-Toes-Knees-Shoulders [HTKS]), and teacher-ratings of children's behavioral regulation in the classroom (which may capture EF along with other skills, such as emotional regulation or persistence). We use a multi-source approach of direct assessments of EF and teacher ratings of classroom behavioral regulation to gain a more comprehensive understanding of these skills in early childhood. Teacher ratings of children's classroom behavioral regulation complement direct assessment information by assessing children's ability to demonstrate EF-related skills in early learning environments (Cameron Ponitz, McClelland, Matthews, & Morrison, 2009; McClelland, Acock, & Morrison, 2006). Although teacher ratings may be affected by biases absent in direct assessments (Waterman, McDermott, Fantuzzo, & Gadsden, 2011), a meta-analysis shows they are significantly associated with children's academic outcomes, and this association is not significantly different from the one between direct assessments and academic outcomes (Allan, Hume, Allan, Farrington, & Lonigan, 2014).

The current study focuses on whether the observed associations between different EF tasks and behavioral regulation are the same across diverse populations of children (Caughy, Mills, Owen, & Hurst, 2013; Rhoades, Greenberg, Lanza, & Blair, 2011). If environmental and demographic factors differentially influence EF and behavioral regulation development (e.g., Burrage et al., 2008), could they also influence relations among tasks and their relations to achievement? Understanding relations among EF, behavioral regulation, and academic skills is critical to informing the development of successful early childhood interventions that target these skills, especially for children in lower-income families who are at greater risk of falling behind in schooling achievement (Reardon, 2011). In other words, our study is unique because it supports the need for a greater understanding of how school readiness skills are associated (i.e., EF, behavioral regulation, academic achievement) in diverse populations of children.

### 1.2. Theoretical perspective

Our theoretical perspective is that transactional processes of biological maturation and environmental contexts influence children's development of EF and behavioral regulation. That is, children improve on EF and behavioral regulation as they age (Best & Miller, 2010; Lee, Bull, & Ho, 2013; Wiebe, Espy, & Charak, 2008), but the rate of growth is dependent on both children's characteristics and the environmental context (Blair & Diamond, 2008; Blair & Raver, 2012). For example, studies show EF and regulatory skills are malleable to intervention effects (e.g., Blair & Raver, 2014; Schmitt et al., 2015), with other work showing that these skills also demonstrate a maturational unfolding with brain development (Garon, Bryson, & Smith, 2008). Correlational studies also show there are differences in children's development of EF and behavioral regulation based on demographic risk factors (Caughy et al., 2013; Razza, Martin, & Brooks-Gunn, 2010; Rhoades et al., 2011; Sektnan, McClelland, Acock, & Morrison, 2010). Thus, these skills likely develop at different rates, and possibly, in different ways depending

on children's early environments. However, it is unclear if these processes could also influence how the aspects of EF and behavioral regulation are associated. The current study extends previous research by examining if variation in family income is related to differential relations between aspects of EF and behavioral regulation in the classroom. Answering this question is important for our understanding of how children's environments may be related to different, but related, components of EF and behavioral regulation.

### 1.3. Family income and the associations between EF and behavioral regulation in early childhood

Poverty is one important context in which to understand EF and behavioral regulation because it is associated with lower quality home learning environments (McLoyd, 1998). Additionally, experiencing poverty is associated with elevated levels of chronic stress, which influence the EF and regulatory processes of the brain (Blair, 2010; Blair & Raver, 2012; Evans & English, 2002; Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009). Highly stressful environments cause increased neural reactivity in children, and without the necessary supportive resources (i.e., high quality childcare or home environments), can contribute to lower levels of EF and behavioral regulation (Blair, 2010). It is important to note that neural reactivity may be adaptive in some contexts, although research suggests that greater reactivity combined with fewer environmental supports is negatively associated with the development of regulatory skills and this has been linked to negative outcomes (including school achievement) in children (Blair & Raver, 2012; Blair & Raver, 2015). Therefore, there are likely multiple mechanisms through which poverty influences the development of these skills (e.g., stress, lower quality home learning environment, worse physical health), but it is unknown whether growing up in poverty might influence the relations among these skills. In other words, although poverty has been linked to lower EF and behavioral regulation, it is unclear if it also influences the relations between EF and behavioral regulation tasks in low-income samples. Addressing this issue provides important insights for better understanding the development of, and the relations between, these skills in lower-income populations.

One useful theoretical framework for investigating these relations is the ability differentiation hypothesis put forth by Tucker-Drob (2009). This hypothesis says that children with lower ability levels rely more on domain general skills (e.g., working memory) across cognitive tasks resulting in larger correlations among them. Empirically, this hypothesis was supported with longitudinal data across the lifespan (Tucker-Drob, 2009). In the present study, it would predict stronger relations between EF tasks and classroom behavioral regulation for children experiencing poverty (i.e., previous research has documented lower mean performance). In other words, children growing up in poverty might rely more on underlying domain general skills across EF and behavioral measures (e.g., working memory capacities have more of an impact on performance across tasks). However, it is unknown whether economic hardship would contribute to differential relations between EF tasks and behavioral regulation because these skills are all closely related to domain general abilities. Therefore, other factors (such as maturational rate and environmental experiences) could drive differential associations between these skills, or differential association among these skills might not exist. We compare multiple direct assessment EF tasks and teacher ratings of children's classroom behavior for children enrolled in Head Start and those not to address this question.

### 1.4. Family income and the associations between EF, behavioral regulation, and academic achievement

Children's EF and behavioral regulation skills are consistently strong predictors of academic achievement, with the strongest connections typically found with mathematics (Blair & Razza, 2007; Blair, Ursache, Greenberg, Veron-Feagans, & The Family Life Project Investigators,

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