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DEMOGRAPHIC AND FAMILIAL PREDICTORS OF EARLY EXECUTIVE FUNCTION DEVELOPMENT: CONTRIBUTIONS OF A PERSON-CENTERED PERSPECTIVE

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ABSTRACT

The development of self-regulation skills during early childhood lays the foundation for healthy development and future well-being. Recently, executive function (EF) skills, a set of inter-related abilities used in coordinated, goal-directed behavior, have been highlighted as integral components of young children's growing competence. However, very little is known about the role children's early context and experiences within the family play in the emergence of EF skills. The goal of the present study was to examine how demographic and familial risks at 2 and 6 months related to EF competence at 36 months in a large, diverse sample of primarily low-income, non-urban families from Pennsylvania and North Carolina. This study used an innovative person-centered methodological approach, latent class analysis (LCA), to model profiles of infants' home environment in order to: 1) better understand how various combinations of ecological risks predicted future EF skills, and 2) more accurately identify sub-groups of young children who were most at-risk for EF deficits. Given the diversity within our sample, we also explored how these associations varied across ethnic groups.

Results showed that the following six ecological risk profiles best captured the diverse experiences of these families: 1) Married, Low Risk, 2) Married, Stressed & Depressed, 3) Poor & Married, 4) Poor & Unmarried, 5) Poor & Single, and 6) Poor, Single, Multi-Problem. Membership in the early risk profiles was meaningfully associated with EF skills at 36 months. Specifically, profiles characterized by poor, unmarried mothers were at the highest risk for future EF problems. Mediation analyses revealed that much of the influence of early demographic and familial risks on later EF skills may be transmitted through low parental sensitivity and responsiveness to their children during infancy and children's emerging language skills during toddlerhood. However, important differences across ethnic groups were found for some mediators, including maternal negative intrusiveness and children's language skills.

The findings suggest that the early home environment may prove to be an especially fruitful context for the promotion of future EF skills. Additionally, positive parenting behaviors, including positive engagement and responsivity, should be emphasized and targeted to families that are poor and having an unmarried caregiver. If replicated, the results hold much promise for informing the more accurate and efficient use of scarce intervention resources in the future.

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Chapter 1

Introduction

The first few years of life are characterized by dramatic brain growth and accompanying improvements in physical, social-emotional, and cognitive domains (Diamond, 2002; Thompson, Easterbrooks, & Padilla-Walker, 2003). Young children's growing ability to regulate their behaviors, emotions, and thoughts in an intentional, goal-directed way is a common theme reflected in the improvements seen across these domains. Gains in self-regulation skills represent a developmental milestone during early childhood and provide one of the building blocks for healthy development and future well-being in multiple areas of life, including social relationships, mental health and academic achievement (Shonkoff & Phillips, 2000).

Recently, executive function (EF) skills, a set of inter-related abilities used in coordinated, goal-directed behavior, have been highlighted as integral components of young children's growing ability to regulate behavior, emotion, and thought. Most of this research has focused on identifying age-related differences in these abilities (Becker, Issac, & Hynd, 1987; Brocki & Bohlin, 2004; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Welsh, Pennington, & Groisser, 1991), but an increasing number of studies have established a relationship between EF skills and children's social-emotional behavior and academic competence (Blair & Razza, 2007; Espy et al., 2004; Hughes, 1998; Rhoades, Greenberg, & Domitrovich, 2009; Riggs, Jahromi, Razza, Dillworth-Bart, & Mueller, 2006). Despite the acknowledged importance of children's early environments for early learning and self-regulation (Shonkoff & Phillips, 2000), surprisingly little is known about the role children's early context and experiences within the family play in the emergence of EF skills (Carlson, 2003).

Although there is a well established link between brain development and these maturing abilities (Diamond, 2002), cognitive development is not solely determined by internal, maturational processes. Far from developing in a social vacuum, children are in constant interaction with their external environments as early as the prenatal period and the nature and quality of these environments influence children's developmental outcomes. As children are largely dependent on adults' care and nurturing during the first few years of their life, it is not surprising that caregivers play a critical role in their early development, especially in the development of cognitive and self-regulatory skills. Parents and other primary caregivers are the main partners and social agents in young children's cognitive development. They not only provide children with the physical environment in which development occurs, but also through daily, social interactions, provide them with opportunities to learn about and develop their cognitive, linguistic, emotional and self-regulatory skills (Gauvain, 2001).

The goal of the present study is to examine how family characteristics and early experiences within the family context relate to the development of EF skills in young children. This study will use an innovative person-centered methodological approach to characterize the infants' demographic and structural characteristics of the home environment in order to: 1) better understand how the interaction of numerous socioeconomic factors and maternal characteristics relate to emerging EF skills, and 2) more accurately identify sub-groups of young children who are most at-risk for EF deficits. By taking this conceptual and methodological approach I hope to elucidate the complex relationships between various combinations of ecological risks in infants' home environments at 2 and 6 months and their EF skills at 36 months old in a large, diverse sample of primarily low-income, non-urban families. I also will investigate how more proximal processes relate to membership in these profiles of ecological risk and EF performance. To do this I will explore the meditational effects of quality of the home environment, quality of parent-child interactions, and children's language abilities in the association between risk profiles and EF abilities.

In this first chapter, I will present the background, rationale and significance for the present study. In the first section I outline a conceptual framework for the study of executive function (EF). I begin by discussing how EF has been defined and conceptualized from various research perspectives. In doing this, my goal is to highlight the common themes among these perspectives that inform how EF will be operationalized in the present study. Next, I discuss how EF unfolds developmentally from birth through adulthood and provide empirical evidence that highlights why the developmental period for the present study was chosen. I conclude this section by discussing the challenges associated with measuring EF in young children and review the strategies that have been used in past research to address these issues. This information will help inform the selection of appropriate outcome measures for EF skills at 36 months in the present analyses.

In the second section, I review studies linking EF skills to children's behavior and other competencies. These studies provide empirical support for EF as a key component in children's early development. They also suggest that EF may be an important target for preventive interventions.

In the final two sections, I lay the foundation for the analytic approach taken in the present study. First, I review the limited information we have about the association between ecological risk factors and EF development. My goal is to use past research to identify key demographic and familial variables that may provide valuable information for characterizing children who are most at-risk for EF deficits during early childhood. Second, I outline the two main approaches to understanding how ecological factors affect children's development: variable-centered and person-centered approaches. In the context of EF research, I describe the limitations associated with using a variable-centered approach for characterizing ecological risks. Additionally, I describe how using a person-centered methodological approach will not only improve our knowledge about the relations between demographic and familial risk factors and emerging EF skills, but ultimately improve our ability to identify subgroups of children in need of preventive intervention services.

Executive Function: A Conceptual Framework

The Definition of Executive Function. Interest in EF as an important developmental construct largely began as a result of brain damage studies, which consistently found a family of inter-related deficits associated with prefrontal cortex (PFC) damage. These studies found that patients with PFC damage exhibited problems with inhibitory control, planning, and socially appropriate behaviors (Luria, 1973; Zelazo & Muller, 2002). The PFC plays a significant role in these processes and is associated with performance on common EF tasks that require switching, active maintenance, and inhibitory control (Diamond, 2002). Moreover, research shows that development in the PFC coincides with increasing coordination of goal-directed behaviors and increases in specific EF skills (Diamond, 2002).

Emphasis on EF as it is related to increasing regulation of thought, emotions and behaviors also has its beginnings in a developmental perspective conceptualized by Vygotsky (1962) and his student, Luria (1973). A primary focus in their research was the development of the "second signal system" which has been described as the regulatory control or mediating role that language plays in complex mental activity. Their studies found with the development of language skills, young children are increasingly able to regulate automatic responses in favor of more intentional, goal-directed behaviors. They hypothesized that these mental activities first occurred on an inter-individual level (i.e., between people interactions) and gradually became internalized occurring on an intra-individual level (i.e., within the person), ultimately resulting in what they referred to as "inner speech" (Rowe & Wertsch, 2002). Although not termed EF, their conceptualization of the "second signal system" characterizes language as an aid to developing executive function of inhibitory control and set-shifting that serves a mediating role between intention and action.

The multidimensional nature of EF is evidenced by studies in both abnormal and normal children and adults, which consistently find three related, but distinct components of EF, including working memory, inhibitory control (i.e., response inhibition), and set shifting (Hughes, 1998; Pennington, 1997; Pennington & Ozonoff, 1996; Welsh et al., 1991). In a recent paper by Garon, Bryson, and Smith (2008), EF was described as a unitary construct with the central attention system as the underlying factor involved in three related, but dissociable dimensions, which similarly included working memory, inhibitory control, and set shifting. These components encompass a set of higher-order, top-down cognitive processes that are elicited when flexible, coordinated, goal-directed behavior is needed to solve a problem (Hughes & Graham, 2002; Sonuga-Barke, Dalen, Daley, & Remmington, 2002; Welsh et al., 1991). Although there is some overlap with cognitive skills, EF is a unique construct that is distinct from sensation, perception, language, memory, and general intelligence (Blair, 2006; Pennington & Ozonoff, 1996). Although complex social behavior requires EF, many, but not all complex cognitive tasks also involve EF. What makes EF unique and especially relevant in emotion and behavior regulation in young children is its association with “context-specific action selection, especially in the face of strong competing, but contextually inappropriate responses” (Pennington & Ozonoff, 1996, p. 56) (e.g., calming down when upset and using words instead of aggression to attain a goal). EF skills are regulated actions that are needed under circumstances (especially novel ones) that require planning and decision-making, when there is a threat of danger, or when one must overcome a habitual response (Hughes & Graham, 2002).

The Development of Executive Function. Originally, researchers believed that EF skills were not evident prior to adolescence. However, substantial evidence now exists showing that rudimentary forms of EF emerge in the first year of life and continue to develop throughout childhood and until at least early adulthood (Dempster & Corkhill, 1999; Diamond, 1991; Welsh & Pennington, 1988). Numerous cross-sectional studies have examined the development of EF across childhood and into adolescence and suggest that developmental trajectories for the different components of EF vary (Becker et al., 1987; Brocki & Bohlin, 2004; Klenberg et al., 2001; Welsh et al., 1991). In general, the development of EF is presumed to occur in a stepwise fashion with key developmental periods occurring in early childhood (birth to 5), middle childhood (7-9) and early adolescence (11-13) (Anderson, 2002). Although the first evidence of EF abilities occurs from birth through age five, these skills remain quite immature (Anderson, 2002). Research consistently shows that young children have difficulty with various aspects of EF (Dowsett & Livesey, 2000; Diamond, Kirkham, Amso, 2002; Diamond & Taylor, 1996; Gerstadt, Hong, & Diamond, 1994), making this developmental period especially important for studying individual differences in these emerging abilities.

In a recent review of the developmental literature on EF in preschoolers, Garon et al. (2008) posit that EF skills emerge in a particular sequence with each component building upon already existing abilities. They suggest that EF development from birth to three years old is characterized by the emergence of the basic underlying cognitive skills necessary to perform well on EF tasks. Similar to Posner, Rothbart and colleagues (Posner & Rothbart, 2000; Rueda, Posner, & Rothbart, 2005) they concluded that the dramatic improvements in EF during this developmental period are due to increasing coordination and integration of the central attention system (Garon et al., 2008). Of the various components of EF, Garon et al. (2008) posit that development in working memory is the first to occur and is evidenced by the ability to hold simple representations in mind as early as 6 months old. Simple inhibitory control/response inhibition (e.g., stopping a pleasurable activity in response to caregivers' requests) develops next with improvements occurring toward the end of the first year of life. The integration of inhibitory control and working memory can be seen starting around 2 years old in improved performance on tasks that require a child to hold a rule in mind in order to inhibit a dominant response in favor of a subdominant one. However, even when operational, these skills can only be applied in *very* simple and controlled testing domains that reduce other aspects of cognitive and emotional load (Blair, Willoughby, Greenberg, & Werner, under review). The final and most complex EF skill to develop, which builds upon both working memory and inhibitory control, is the ability to shift from one mental set to another (i.e., set shifting). An example of shifting mental sets can be seen in Zelazo's version of the Dimension Change Card Sort (DCCS), a simplified version of the Wisconsin Card

Sort Task (WCST). Preschoolers are shown target cards varying according to two dimensions (e.g., color and shape) and during the first phase are instructed to sort a set of cards according to one dimension (e.g. color). During the switch phase, they are instructed to sort the cards according to the other dimension (e.g., shape). For this task they must shift from the color mental set to the shape mental set. These tasks are especially difficult for young children when they involve a high degree of conflict and/or overlap in the mental sets they are required to shift between, and these skills do not fully develop until the end of the preschool years (Garon et al., 2008).

Essential to the study of EF development is the maturation of the prefrontal cortex (PFC). Of all the brain regions, the PFC has the longest developmental period occurring across two decades with key development occurring from 3 to 6 years old and from 7-11 years old (Diamond, 2002). Diamond (2002) reviewed studies that examined children's improvements on a variety of EF tasks (e.g., Luria's tapping task, Day/Night, Zelazo's DCCS, go no-go tasks) and found improvements in the accuracy and speed of responses from about 3 to 7 years old, which parallels dramatic growth in neural density. Diamond (2002) suggests that children commit errors on most EF tasks because they have difficulty overcoming "attentional inertia." That is, they have trouble shifting their focus away from salient aspects of the task that were previously relevant (i.e., set shifting). With development in EF skills during the preschool years, however, children are increasingly able to inhibit these dominant responses and maintain focus on the relevant aspects of the tasks, at least in simple contexts (Diamond, 2002).

Zelazo, Frye, and colleagues propose Cognitive Complexity and Control (CCC) theory as another approach to the study of EF development during early childhood (Zelazo, Muller, Frye & Marcovitch, 2003). The CCC theory is based on the idea that across development, children are increasingly able to use more complex rules to guide their actions toward successful problem-solving. The majority of this research is based a series of studies that examined three to 5-year-old children's performance on different versions of the DCCS. Zelazo et al. (2003) found that 3- and 4-year-old children consistently failed the task, but by 5 years old they performed well. Overall, by varying the complexity of the sorting rules, Zelazo et al. (2003) confirmed that improvements in the children's performance on DCCS from 3 to 5 years old were due to their increasing ability to handle more complex rules.

Measurement of EF in Young Children. Due in part to the differing views of EF development, disagreement regarding the valid and reliable measurement of its multidimensional nature in young children is evident. Strategies used to reliably assess EF in young children have greatly improved over the past few years (Blair, Zelazo, & Greenberg, 2005; Carlson, 2003; Hughes & Graham, 2002). Whereas, in the past, researchers did not believe it was possible to measure such complex skills in preschool-age children, there are now a number of EF batteries specifically designed for use with children as young as 2 years old (Blair et al., under review; Carlson, 2005; Espy, Bully, Martin, & Stroup, 2006; Hughes & Ensor 2005; Kochanska, Murray & Harlan, 2000).

Despite these gains, a greater understanding of the psychometric properties of EF measures and how they operate in diverse populations is desperately needed (Carlson, 2005; Blair et al., 2005). Most researchers now agree that a multi-method measurement strategy must be utilized to fully capture all aspects of EF (Blair, et al. 2005; Carlson, 2003), but there is less agreement as to how to summarize the information gathered from these multiple measures. Some researchers suggest that EF tasks measure the same underlying construct, and thus a latent measurement model or some kind of composite score is most appropriate (Blair et al., under review; Blair & Peters, 2003; Wiebe, Espy, & Charak, 2008). However, others suggest that especially for very young children, these abilities (i.e., working memory, inhibitory control, set shifting), although inter-related, have not coalesced and should be examined separately (Carlson, 2005). Another important factor to consider when measuring EF in very young children is fatigue. To reduce fatigue, researchers are often forced to limit the number of tasks included in EF batteries, which translates into fewer tasks per EF component. With fewer tasks measuring the individual EF components, an aggregate measure that summarizes scores across the EF tasks may provide increased stability and lower bias than the individual component scores (Hughes & Ensor, 2005). Another area of disagreement is how to accurately score EF tasks. Some researchers dichotomize the scores and use a pass/fail approach where children must demonstrate a certain level of knowledge (beyond chance) to be considered proficient at that particular EF skill (Carlson, 2005; Diamond, Carlson, & Beck, 2005; Hughes & Ensor, 2005). However, others recommend using a continuous score claiming that by dichotomizing the score, important information about children's individual differences is lost. Finally, a significant challenge associated with measuring EF during early childhood is assuring that a task accurately captures a wide range of individual differences. That is, it is important that the task is neither too difficult nor too easy for the majority of the children of a particular age in order to avoid problems associated with ceiling and floor effects (Carlson, 2005).

Conclusions. Despite varying perspectives on how to conceptualize and measure EF development across childhood, there remain a number of consistent themes that provide the conceptual framework for the present study. First, EF is a multidimensional construct composed of three related, but distinct components of EF, which include working memory, inhibitory control and set shifting. Second, EF skills emerge during the first year of life and continue to develop in a gradual, stage-like fashion from reactive to more self-regulatory behaviors throughout early childhood. As children enter the preschool years, their ability to accomplish more complex affective and cognitive problems increases and becomes somewhat consistent and flexible across different contexts. Therefore, examining EF at the beginning of the preschool period will provide us an opportunity to explore the emergence of individual differences in these skills. Finally, measurement of EF during this early period remains quite challenging and therefore multiple strategies for scoring and summarizing the information from multiple EF tasks is necessary to gain a comprehensive picture of this complex construct.

Relations of Executive Function and Behavior, Social-Emotional Competence, and Achievement

Recently, EF abilities have been implicated in the successful development of social-emotional, behavioral, and academic competence (Blair & Razza, 2007; Espy et al., 2004; Hughes, 1998; Rhoades et al., 2009; Riggs et al., 2006). The majority of research examining the link between EF and children's behavior has focused on specific adolescent populations (e.g, adolescents with attention deficit/hyperactivity disorder (ADHD), conduct problems or antisocial behavior). In a meta-analysis examining the link between EF deficits and antisocial behavior, Morgan and Lilienfeld (2000) reported that antisocial groups performed an average of .62 standard deviations below normal comparison groups on a range of EF tasks. Research has also consistently shown that children with ADHD have significant deficits in EF skills (e.g., inhibitory control) when compared to normal populations (Charman, Carroll & Sturge, 2001; Diamond, 2002; Pennington & Ozonoff, 1996; Sonuga-Barke et al., 2002).

Other research has examined EF in younger children exhibiting early behavior problems (Cole, Usher, & Cargo, 1993; Hughes, Dunn, & White, 1998; Hughes, White, Sharpen & Dunn, 2000; Kusche, Cook, & Greenberg, 1993; Seguin & Zelazo, 2005). For instance, Rhoades et al. (2009) found that in a sample of disadvantaged preschoolers, poor inhibitory control skills were concurrently associated with internalizing behavior problems and poorer social skills, even after controlling for children's age, gender, ethnicity, verbal abilities, emotion knowledge, attention skills and maternal education and work status. Seguin and Zelazo (2005) propose that EF deficits predict individual differences in persistent physical aggression across development. Kusche et al. (1993) found that elementary school children exhibiting anxious, externalizing, and comorbid symptoms had poorer EF skills when compared to children exhibiting no symptoms. There is also longitudinal evidence of the association between early EF deficits and externalizing and internalizing behaviors during elementary school (Nigg, Quamma, Greenberg, & Kusche, 1999; Riggs, Blair, & Greenberg, 2004). Hughes and colleagues consistently report that preschool children at risk for ADHD are more likely to fail a variety of EF tasks (i.e. planning, working memory, inhibitory control, set shifting) (Hughes et al., 1998). They also report that EF skills are negatively related to antisocial behavior and positively related to prosocial behavior in peer interactions (Hughes et al., 2000). In all, these findings provide convincing evidence for a link between EF deficits and various behavior problems during childhood.

The role of EF abilities in early academic achievement has also become clearer in recent years. In a study of preschoolers, Espy et al. (2004) found that both working memory and inhibitory control contributed to the prediction of early math skills after controlling for maternal education and children's receptive vocabulary and age. Bull & Scerif (2001) found similar results in a slightly older sample of 6 to 8 year olds with inhibitory control and working memory deficits common in children with math difficulties. In a low-income, Head Start sample, Blair & Razza (2007) found that inhibitory control was a significant, unique predictor of both emerging reading and math abilities, even after controlling for children's general intelligence, effortful control, and false belief understanding.

Conclusions. Research showing the associations between EF skills and later competencies across both social-emotional and academic domains solidifies the importance of EF as a key construct in the study of children's development and a potential target for intervention. Although a great deal has been learned about the development of EF and its role in social-emotional and academic competence, most of the research has been conducted on relatively small samples and there has been very limited research regarding how family environments or other ecological factors impact the development of various EF skills in early childhood (Carlson, 2003).

Ecological Factors Influencing Early Cognitive Development

As little evidence exists on ecological factors that influence EF, empirical evidence from three areas of research helps to inform the present study. First, findings are drawn from the few studies that have examined ecological predictors of EF. Second, findings from the National Institute for Child Health and Human Development (NICHD) Study of Early Care and Youth Development and a number of smaller scale studies that focus on factors predicting early school readiness, academic achievement, and cognitive skills are reviewed. Finally, studies examining adult-reported self-regulation and effortful control are included.

Executive Function Skills. According to Bernstein & Waber (2007), EF skills unfold as a result of the interaction between the child and their social and physical worlds. As is evidenced by the prefrontal cortex's prolonged period of development and neural plasticity across the early childhood years, experience has the potential to play an important role in EF development (Changeux & Dehaene, 1989; Huttenlocher, 2002; Nelson, Thomas, & de Haan, 2006). Despite this evidence, very few empirical studies have directly examined how ecological factors influence EF development.

Some studies have shown a positive relationship between socio-economic status and neurocognitive abilities like working memory, inhibitory control, and set shifting (Mezzacappa, 2004; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005). Fewer studies, however, have examined the specific environmental processes and experiences that might explain the proximal factors that mediate the influence of distal measures of socio-economic status. A notable exception is Hughes and Ensor (2005) who found that positive parenting (composite of interviewer ratings and observations of positive control, responsiveness and talk) concurrently predicted better EF skills in a sample of primarily low income, 2-year-old children. However, this association became non-significant when verbal skills were accounted for.

A link between EF deficits and more severe adverse rearing environments has also been established. Beers and DeBellis (2002) examined EF skills in a small clinical sample of children diagnosed with maltreatment-related Post Traumatic Stress Disorder. Their results indicated that the clinical sample exhibited greater EF deficits when compared to normally developing children. Additionally, results from a study examining children in foster care showed that foster children who experienced multiple placements performed worse on an inhibitory control task as compared to foster children with only one placement or children not in foster care (Lewis, Dozier, Ackerman, & Sepulveda-Kozakowski, 2007). Overall, these studies are consistent with research that shows associations between adverse environmental experiences and frontal lobe deficits (Raine, 2002). These studies provide preliminary evidence of some important ecological factors and more proximal mediators to consider in the development of EF.

School Readiness, Academic Achievement & Cognitive Skills. In contrast to EF-specific research, a significant body of research exists that examines the ecological factors associated with young children's general school readiness, achievement, and broader cognitive skills (Gauvain, 2001; Bornstein & Bradley, 2003). Prominent among these is a group of studies that have come out of the NICHD Study of Early Care and Youth Development, which is a large-scale, longitudinal study whose original aim was to understand how child care and other ecological factors influenced children's development. Beginning in 1991, a cohort of children (*n*=1364) was recruited from several hospitals in 10 sites across the United States. Although this sample was not nationally representative, they were diverse with respect to ethnicity and economic background (see NICHD ECCRN, 2001 for details).

A number of studies have used the NICHD sample to examine how environmental risk factors relate to young children's general cognitive skills and academic success, albeit from various perspectives (Downer & Pianta, 2006; Dilworth-Bart, Khurshid, & Vandell, 2007; Fearon & Belsky, 2004; NICHD ECCRN, 2003; 2004; 2005). The majority of these studies characterized environmental risk using a composite variable, which included quality of the home environment as measured by the Home Observation Measure of the Environment (HOME), a widely used, well-established measure of quality and quantity of stimulation and support in the child's environment, and observed maternal sensitivity. Scores on both of these measures were averaged across six to fifty-four months in order to characterize the home environment prior to school entry (Downer & Pianta, 2006; NICHD ECCRN, 2003; 2004; 2005). One distinguishing feature of most of these studies was their focus on either academic achievement (NICHD 2003; 2004) or general cognitive skills, like memory and attention (Dilworth-Bart et al., 2007;

Fearon & Belsky, 2004; NICHD ECCRN, 2005), as the outcome of interest. Another distinguishing feature was their focus on either 54-month outcomes (Fearon & Belsky, 2004; Dilworth-Bart et al., 2007; NICHD, 2003) or first grade outcomes (Downer & Pianta, 2006; NICHD 2004; 2005).

The NICHD studies highlight quality of the home environment (e.g., cognitive stimulation) and maternal sensitivity as predictors of children's general intellectual abilities and school achievement (Downer & Pianta, 2006; Dilworth-Bart et al., 2007; Fearon & Belsky, 2004; NICHD ECCRN, 2003; 2004; 2005). Both NICHD ECCRN (2003) and NICHD ECCRN (2004) examined the link between family environment and academic achievement. The former study found that sustained attention and impulsivity at 54 months mediated the negative relationship between environmental risk and 54-month reading and math achievement and language skills (NICHD ECCRN, 2003). In contrast, the latter study found that although there was no direct relationship between family environment and first grade math and reading achievement, there was an indirect relationship through 54-month language skills such that family environment influenced language skills, which in turn influenced academic achievement (NICHD ECCRN, 2004). In summary, these two studies from the same dataset implicated sustained attention, impulsivity, and language skills as mediators of early family risk on later school outcomes.

In another study, the authors examined the link between early environmental risk and 54-month attention skills (Fearon & Belsky, 2004). For this study they created a cumulative risk index that summed nine risk factors to which the child was exposed (i.e., poverty, father absence, maternal depression, maternal social support, education, verbal IQ, observed support for cognitive development, difficult child temperament). They found that the total number of risks was positively related to ratings of attention and behavior problems, and child-assessed inattention and impulsivity. Upon further investigation, they found that the relationships between total risk and inattention and impulsivity were moderated by 15-month attachment status. That is, attachment security served as a protective factor such that the relationship between environmental risk and attention problems was weaker for children with secure attachments.

Researchers have found similar relationships between the quality of the family environment and early school readiness and cognitive abilities in a number of other smaller studies as well. In a sample of low-income, African American kindergarten children, Connell and Prinz (2002) found that a multi-dimensional measure of parent-child interaction quality at the beginning of the school year (i.e., goal-directed behavior, parental control, quality of instruction and affective mutuality) was positively related to children's receptive communication skills, but not overall cognitive skills as measured by the Battelle developmental inventory at the end of the school year. In a study of low-income, single Black mothers of preschoolers, Jackson, Brooks-Gunn, Huang, and Glassman (2000) showed that maternal education, income, financial strain, instrumental support and depressive symptoms were important factors related to quality of parenting which in turn was concurrently related to children's school readiness. Using data from the Family Life Project, Burchinal and colleagues found that social adversity as measured by a cumulative risk composite (i.e., maternal education, family income, single-parenthood, parental unemployment and neighborhood safety) was negatively related to children’s cognitive skills at 15 months and that this association was partially explained by parent-child interactions at 6 and 15 months (i.e., engagement, harshness, learning and literacy activities) (Burchinal, Vernon-Feagans, Cox, & Key Family Life Project Investigators, 2008).

Although these studies provide some evidence that the family environment, specifically quality and sensitivity of parent-child interactions, plays an important role in predicting early school readiness, academic achievement, and cognitive skills, there are several reasons why more research is needed. First, the vast majority of the aforementioned studies were conducted with the same sample of children (i.e., NICHD Study of Early Care and Youth Development), which because of differential attrition was slightly more "advantaged" than the original sample (Downer & Pianta, 2006; Fearon & Belsky, 2004;

NICHD ECCRN, 2003; 2004; 2005). Despite the strengths associated with this comprehensive study, there are a number of limitations in the conclusions that can be drawn regarding the relation of early ecological factors on later EF development. Second, there was limited measurement of EF skills; attention was measured by scores on the Continuous Performance Task, which primarily assesses sustained attention and impulsivity, as opposed to working memory, inhibitory control or set shifting. Second, the NICHD studies were limited to measures of 54-month and first grade skills. Because a number of EF abilities start to come online prior to 54 months, a careful examination of EF at a younger age would likely provide a greater opportunity to examine the origin of individual differences.

Self Regulation & Effortful Control. Research on ecological predictors of adult-reported, behavioral self-regulation and effortful control during early childhood offers additional information in the study of EF development. Self-regulation, which has been broadly defined as the ability to flexibly and voluntarily regulate behaviors in accordance with contextual demands, is hypothesized to develop in parallel with children's increasing cognitive abilities (Kopp, 1982). A number of studies have illustrated the significant role that sensitive, consistent, stimulating caregiving experiences play in the development of children's self-regulation abilities (Karreman, van Tuijl, van Aken, & Dekovic; Kopp, 1982; Kopp, 1991). A related construct, effortful control, which is defined as the self-regulatory aspect of temperament that enables children to regulate their anger and approach systems (Rothbart, 1989; Rothbart & Bates, 1998), is also relevant in this discussion. Studies of preschool-age children have demonstrated consistent links between quality of parent-child interaction and effortful control (Kochanska et al., 2000; Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000), although the direction of these effects remains unclear. It is possible that children who have difficulty regulating elicit controlling responses from parents, whereas children who are better able to regulate elicit warm responses from their parents (Rothbart, Posner, & Kieras, 2006).

The Role of Sociocultural Background. The relations between ecological factors and early cognitive development may vary as a function of the families' sociocultural backgrounds (i.e., race and ethnicity) for a number of reasons. First, children's exposure to various types of risk factors, including parenting practices and contextual experiences, vary by ethnicity above and beyond socioeconomic differences (Bradley, Corwyn, Burchinal, McAdoo, & Garcia Coll, 2001; Klimer, Cowen, Wyman, Work, & Magnus, 1998; Le et al., 2008). Second, research and theory suggests that the meaning, salience and impact of risk factors on developmental outcomes vary by children's cultural background (Berger, Brooks-Gunn, Paxon, & Waldfogel, 2008; Feldman & Masalha, 2007; Garcia Coll & Magnusson, 1999). Certain family structures or maternal characteristics might hold different meaning and experiences for ethnic minorities. For instance, Dunifon & Kowaleski-Jones (2002) found that the association between family structure and children's outcomes varied by race. For white families, children from single-parent homes had poorer academic and behavioral competence in comparison to children in two-parent families, whereas for African American children, there was no significant association between family structure and children's outcomes. Similarly, in the large, nationally representative Fragile Families study, Berger et al. (2008) found that maternal employment in the first year of the child's life was only negatively related to children's receptive vocabulary skills at three years old for white children, not African American or Hispanic children. This evidence suggests that in the present study, it is important to explore how the relationship between ecological risks and children's later EF skills varies as a function of race. Because in the present study, geographic location (i.e., site) is confounded with race, we will do this by examining how these relations function across three site-race groups, Pennsylvania white (PA white), North Carolina white (NC white), and North Carolina African American (NC AA).

Conclusions. The aforementioned empirical evidence indicates that two broad domains, family structure and the quality of the home environment, have been most often related to the development of school readiness, cognitive development and self-regulatory skills. Because many of the aforementioned studies relied on environmental risk composites, it is difficult to unpack which specific ecological factors were related to children's outcomes. However, for the family structure domain it appears that family socio-economic status and maternal education, intelligence, and depression are risk factors for children's poor cognitive outcomes. For the quality of home environment domain, it appears that parent-child interactions that assess both maternal sensitivity and quality and quantity of stimulation directed toward the child are important factors to consider. Additionally, children's sociocultural background may be an important moderating factor to consider in these relations as well.

Although these studies provide us with a starting point for understanding the predictors of EF development, it is unlikely that the identification of any one of these ecological risk factors provides sufficient information to determine which children are most at-risk for poor cognitive outcomes. One primary goal of the present study is to identify profiles (i.e., combinations) of demographic and familial risk factors during infancy (i.e., 2 and 6 months) that are associated with EF skills at 36 months old. By identifying these factors during infancy, we hope to gain a greater understanding of which sub-groups of children are most at-risk for EF deficits and therefore may be targets for preventive intervention services. In order to address these aims, a methodological approach is necessary that appropriately models how co-occurring ecological risk factors relate to later EF development.

Methodological Approaches to Understanding How Ecological Factors Affect Development

There are two main approaches to understanding how ecological factors affect individual development. The first and most widely used approach is the variable-centered approach where variables and how they relate to one another are the primary focus. The second, which has a more limited history, is a holistic, person-centered approach where people are the focus and are viewed as the organizing forces in development. The assumptions and methodological implications associated with each approach are reviewed below.

Variable-Centered Approach. To date, the majority of developmental and risk factor research has been based on a variable-centered approach (Magnusson & Bergman, 1988; Magnusson & Bergman, 1990; Wohlwill, 1973) and research on EF development is no exception (Hughes & Ensor, 2005, 2007; Mezzacappa, 2004; Noble et al., 2007; Noble et al., 2005). Historically, the variable-centered approach gained popularity in developmental psychology because of interest in identifying universal laws of development (Laursen & Hoff, 2006). A second, more practical reason for the overwhelming emphasis on variable-centered analyses is the well developed statistical techniques and widely available computer software based on variable-centered methodologies (e.g., regression, structural equation modeling).

Despite the well-established legacy of variable-centered methods in the field of developmental psychology, implicit in this framework are assumptions that may limit its value. The variable-centered approach is useful if the goal of a study is to determine the relative importance of variables in explaining variance in an outcome or to identify processes that are universal in a specified population (Laursen & Hoff, 2006). Although variable-centered research on predictors of EF development is informative in understanding how *individual* ecological factors predict EF skills, it does not give a complete picture of the contextual processes. The assumptions associated with the variable-centered approach typically include the following: 1) the relationship between the predictors and the outcome is identical across the entire study population, 2) the relationships between variables are linear, and 3) there are no unidentified subgroups within the population (Laursen & Hoff, 2006). According to these assumptions, Noble's work, for example, suggests that all low socio-economic status (SES) children are at equal risk for poor EF development regardless of other ecological factors like maternal sensitivity or quality of stimulation in the home environment (Noble et al., 2007; Noble et al., 2005). However, this is unlikely to be the case. In variable-centered analyses, there is limited power to detect and model complex, higher-order interactions between variables (Magnusson & Bergman, 1990). Therefore, variable-centered work typically does not speak to the higher-order interactions like that between SES and social support, for instance, due to power issues related to small sample sizes. It is possible that poor children whose mothers have access to high levels of social support are at no more risk for EF deficits than higher SES children, but using a variable-centered approach may obscure these effects.

Holistic, Person-Centered Approach. Developmental psychology has recently seen a renewed emphasis on holistic approaches in the study of human development (Bergman, Cairns, Nilsson & Nystedt, 2000; Cairns, 1979; Lerner, 1984; Lerner, 2006). With this renewed emphasis has come the resurgence of ideas first put forth during the early 20th century by some of psychology's most prominent scholars. The work of these scholars suggests that developmental studies must recognize that individuals should be embedded within their environment instead of isolated from it (Allport, 1937; Lewin, 1935). More contemporary theorists have concurred with and extended these views through concepts discussed in developmental systems theory (Lerner, 1984; Lerner, 2006), developmental science (Cairns, 1979), and the bioecological model of development (Bronfenbrenner & Morris, 2006). Despite the use of different terminology, these contemporary perspectives maintain a similar emphasis; namely, the integration of multiple domains of individual development (e.g., biological, behavioral, social, cognitive) and multiple levels of ecology (e.g., individual, family, peers, community) within a single, holistic model of individual development.

For a number of important reasons, a variable-centered statistical approach does not align well with this holistic view of human development. First, the holistic view posits that human development is at least partially a unique process for each individual (Bergman & El-Khouri, 2001; Bergman & Magnusson, 1997; Cairns & Cairns, 1994; Cairns, 2000; Cicchetti & Rogosch, 1996). Second, because non-linear relationships between variables and higher-order interactions are common, models that do not capture such complex relationships may be inaccurate and misleading (Bergman et al., 2000). Third, one of the main aims of variable-centered methods is to isolate the unique impact of one variable, but this may obscure how variables work together within developmental processes (Bergman et al., 2000;

Magnusson, 1999). Finally, it can be difficult if not impossible to translate aggregated results from variable-centered analyses into meaningful information about individual-level processes. A number of statisticians have illustrated the problems with using group-level statistics (e.g., means, correlations) to make conclusions about individual-level processes. For instance, the mean obtained from averaging across the group may not correspond to the mean for any actual individual or subgroup that exists in the study population (Molenaar, 2004; Von Eye & Bergman, 2003; von Eye & Bogat, 2006). Taken together, these points suggest that because of the complex, interactional nature of human development, the *person* in context, not the variable should be the center of analysis in studies where the goal is to understand and explain complex developmental phenomenon that may vary across subgroups (Magnusson, 1985, 1988, 1995).

Classifying individuals into subgroups of like individuals is intuitive, can be easily translated into meaningful information, and has a long history in human development (Bergman & Magnusson, 1987; Block, 1971; Thomas, Chess, & Birch, 1968; Werner & Smith, 1992). The person-centered approach recognizes the complex, interactional nature of the multiple factors that contribute to children's development (Laursen & Hoff, 2006). Whereas variable-centered analyses describe the mythical "average person," person-centered analyses are aimed at identifying particular constellations of characteristics that describe real sub-groups of children (Lewin, 1931; Magnusson & Bergman, 1990). In a person-centered approach the significance of any one ecological factor gains meaning only in so far as how it is related to other aspects of the person-environment system. In other words, the whole is greater than the sum of the individual parts (Magnusson, 1995). The person-centered approach is vital in studies like the present where the goal is to understand complex, multi-determined developmental phenomenon and identify groups of children who are at highest risk for maladaptive outcomes.

One such person-centered approach is called latent class analysis (LCA; Goodman, 1974; Lazarsfeld & Henry 1968). LCA is based on a measurement model (i.e., takes measurement error into account) and assumes that underlying subgroups or latent classes exist in a specified population. In the past, LCA has been used to model multidimensional constructs such as child temperament (Stern, Arcus, Kagan, Rubin, & Snidman, 1995), problem behavior (Lanza, Collins, Schafer, & Flaherty, 2005), depression (Lanza, Flaherty, & Collins, 2003; Sullivan, Kessler, & Kendler, 1998), and substance use (Chung, Park, & Lanza, 2005; Guo, Collins, Hill, & Hawkins, 2000; Lanza & Collins, 2002). More recently, LCA has been used to model multiple risk factors and examine the relationships between early profiles of risk and children's later developmental outcomes (e.g., Lanza, Rhoades, Nix, & Greenberg, under review; Lanza, Rhoades, Greenberg, & Cox, under review; Parra, DuBois, & Sher, 2006). With LCA, one can model complex interactions among multiple risk factors and identify a set of mutually exclusive and exhaustive set of latent classes, which are referred to as risk profiles in this study. The present study will use this person-centered approach to model multiple ecological risks in order to better understand how *combinations* of risks rather than *individual* risk factors are associated with later EF competence. The LCA model posits that although true class membership is latent and therefore unknown, it can be inferred through a set of observed, categorical variables. In the present study, the demographic and familial risk factors measured at the 2- and 6-month home visits will be used as the observed indicators.

Conclusions. Person- and variable-centered methods are complementary perspectives that can provide answers to different research questions. Together these approaches can contribute to the larger body of knowledge regarding how ecological risk factors relate to EF development (e.g., Bergman & Trost, 2006; Laursen, Furman, & Mooney, 2006; Laursen & Hoff, 2006). Although a number of previous variable-centered studies were reviewed in the sections above that identified individual ecological factors that are important to consider in the development of EF, we are unaware of any studies that have take a person-centered approach. Through the use of LCA, in addition to more traditional, variable-centered techniques, this study will provide a rich picture of the relations between combinations of ecological risk profiles and later EF skills, and the more proximal processes that help explain these relations. These findings will not only greatly enhance our knowledge about the relations between ecological factors and EF development but also improve our ability to identify those groups of children who are most at-risk for developing EF deficits in the future. Ultimately, a person-centered approach can assist policy makers in targeting those children who most need prevention services, thereby more efficiently allocating limited prevention resources.

Aims & Hypotheses

The overarching goal of the present study is to utilize a person-centered approach to model profiles of demographic and familial risks during infancy and to examine how membership in these various risk profiles relates to individual differences in the emergence of EF skills at 36 months. To accomplish this goal, the following three research aims will be addressed:

Aim 1. Identify a model of ecological risk profiles that characterizes demographic and familial risks at 2 and 6 months old.

Previous work with these data suggests that we are likely to uncover between four and six risk profiles (Lanza et al., under review), including at least one profile where the probabilities of having any of the risk factors are near zero (e.g., low risk profile). The remaining three to five profiles should be composed of various combinations of risk factors. Although we expect some similarity across subgroups, there should be important differences as well. For instance, our previous work showed that children in all but one of the risk profiles (the low risk group) were likely to be characterized by the low-income risk factor, but varied in the probabilities of the other risks. For instance, one profile was characterized by low income in combination with multiple risks (e.g., low maternal education, single parent, unmarried parent), whereas another profile was characterized by low income and just one other risk, increased probability of having a teen mother. We also hypothesize that there will be both overlapping and unique profiles within and across the site-race groups. Given ethnicity differences in poverty and single parenthood, we expect there will be greater overlap in the profiles that emerge in the two white groups (i.e., PA white and NC white) in comparison to those that emerge in the NC AA group. Also, we hypothesize that a greater number of profiles will be characterized by married parents and therefore greater diversity within those married profiles for the white samples (e.g., a low-risk, married profile and a higher-risk married profile). For the African American sample, we hypothesize that there will be a greater number of profiles characterized by single parents and therefore greater diversity within those single-parent profiles (e.g., a high-risk single-parent profile and a lower risk single-parent profile).

Aim 2. Examine the relation between early ecological risk profiles and 36-month EF performance.

Based on the previous work with these data (Lanza et al, under review), we expect to show that although low-income groups are likely to be associated with poorer EF outcomes in general, it is low-income status in combination with other risks (e.g., poverty, low maternal education, maternal depression) that will be associated with even greater risk of poor EF outcomes. We expect the association between ecological risks and EF to be similar for both site-race groups in some cases and different in others. Specifically, we hypothesize that for all site-race groups profiles characterized by married parents and low probabilities of other ecological risks will be associated with better EF performance in comparison to profiles characterized by single-parenthood and increased probabilities of other risks. However, we also expect some profiles to be differentially related with later EF by site-race group. Given research that highlights racial differences in the association between single-parent status and children's developmental outcomes (e.g., Dunifon & Kowaleski-Jones, 2002), we hypothesize that profiles characterized by single-parent status and few other risks (i.e., the lower risk single-parent profile) will be associated with better EF outcomes in comparison to the higher-risk single-parent profile, particularly in the African American sample.

Aim 3. Investigate the potential mediating effects of home quality, parent-child interactions and child language skills in the relation between early ecological risk profiles and 36-month EF performance, controlling for family income.

Given the large body of evidence reviewed above highlighting family structural and demographic characteristics, maternal sensitivity, and quality of stimulation directed toward the child in the cognitive and self-regulatory development of young children (Downer & Pianta, 2006; Fearon & Belsky, 2004; Hughes & Ensor, 2005; NICHD ECCRN, 2003; 2004; 2005), we hypothesize that quality of the home environment and the quality of parent-child interactions will significantly mediate the association between ecological risk profiles and later EF skills, above and beyond any effects of family income. More specifically, we hypothesize that children in higher-risk profiles will be exposed to lower quality home environments and lower quality interactions with their mothers, which in turn will be related to lower EF skills. Additionally, based on theory and empirical evidence showing significant associations between ecological factors and children's language and EF skills (Noble et al., 2005; 2007), we expect that at least part of the association between ecological risk profiles and later EF will be explained by children's language abilities, above and beyond any effects of family income. More specifically, we hypothesize that children in higher-risk profiles will have lower language skills which in turn will be related to lower EF skills. Few researchers have examined how these meditational effects vary by race or family structure and therefore we have no hypotheses regarding differences by race or specific ecological profiles.

Through the use of innovative, person-centered analytic techniques, this study will provide a rich picture of the relations between particular profiles of early demographic and familial risks and later EF skills. These findings will not only greatly enhance our knowledge about the relations between ecological factors and EF development and the mechanisms that explain these associations, but also improve our ability to identify those subgroups of children who are most at-risk for and target those processes that contribute to the development of future EF deficits.

Chapter 2

Methods

Study Design and Participants

The Family Life Project. Data for the present study come from a large, longitudinal study called the Family Life Project (FLP). FLP was designed to study young children and their families who lived in two of the four major geographical areas of the United States with high poverty rates (Dill, 2001). Specifically, three counties in Eastern North Carolina (NC) and three counties in Central Pennsylvania (PA) were selected to be indicative of the Black South and Appalachia, respectively. The FLP adopted a developmental epidemiological design in which sampling procedures were employed to recruit a representative sample of 1292 children whose mothers resided in one of the six counties at the time of the child's birth. In addition, low-income families in both states and African American families in NC were over-sampled to ensure adequate power for dynamic and longitudinal analyses of families at elevated psychosocial risk (African American families were not over-sampled in PA because the target communities were at least 95% non-African American).

In PA, families were recruited in person from three hospitals that represented a weighted probability sample of seven total hospitals that delivered babies in the three target counties and provided 89% coverage of all babies born to residents. PA hospitals were sampled because the number of babies born in all seven target hospitals far exceeded the number needed for purposes of the design. In NC, families were recruited in person and by phone. In-person recruitment occurred in all three of the hospitals that delivered babies in the target counties. Phone recruitment occurred for families who resided in target counties but delivered in non-target county hospitals. These families were located through systematic searches of the birth records located in the county courthouses of nearby counties. At both sites, recruitment occurred seven days per week over the 12-month recruitment period spanning September 15, 2003 through September 14, 2004 using a standardized script and screening protocol.

FLP recruiters identified 5471 (59% NC, 41% PA) women who gave birth to a child in the 12-month period. A total of 1515 (28%) of all identified families were determined to be ineligible for participation for three primary reasons. These were: not speaking English as the primary language in the home, residence in a non-target county, and intent to move within three years. Of the 3956 eligible families, 2691 (68%) families agreed to participate if chosen. Of the 2691 eligible families, 1571 (58%) families were selected to participate. Selection rates were based on sampling fractions that were continuously adjusted to achieve the desired sample over a 12-month recruitment period. Of those families selected to participate in the study, 1292 (82%) families completed a home visit at 2 months of child age, at which point they were formally enrolled in the study.

The Present Study. To characterize ecological risk early in development, measures were administered to the families at both 2- and 6-month home visits. Because we were interested in demographic and psychosocial characteristics of the biological mothers, the sample was limited to those families where the biological mother completed both the 2- and 6-month home visits (N = 1155). Of the mothers in these families, approximately 60% were white, 39.7% were African American and 0.3% were another ethnicity. Of the children in these families, approximately 59% were white and 41% were African American. Child's gender was about evenly distributed with 49% female and 51% male. The average age of mothers at the 2-month data collection was 25.9 (SD = 5.8) years old. The average age of children at this time was 2.6 (SD = 1.3) months old. Approximately 13% of the original sample (from the 2-month visit) was not present at the 36-month visit. Attrition analyses for the present study indicated that children who were missing outcome data at the 36 month visit were more likely to be from North Carolina, have a single mother, have a mother who is unmarried, have a mother with less than a high school diploma, and have a mother who smoked while pregnant.

It is important to remember that geographic location (i.e., site) and race are confounded in this sample. Of the 1155 families included in the present analyses, 694 were from NC and 461 were from PA. In the NC families, the majority of children were African American (67%), whereas in the PA families all children were white (100%). For this reason, the majority of the results presented below will be reported by site-race groups, which include PA white, NC white, and NC AA.

Procedures

Data were collected during home visits where two trained interviewers went to the families' homes on two occasions about one week apart for the 2-, 6- and 24-month visits and on one occasion for the 36-month visits. Interviewers collected survey and observational data on the primary caregiver (in our case the biological mother), target child, and when applicable the secondary caregiver (e.g., father, grandmother) during home visits that lasted approximately 2-3 hours. The survey data was recorded using laptop computers and observational data was videotaped to allow for coding at a later time. For those caregivers who were at an 8^{th} grade reading level or above according to the Kfast literary screener (Kaufman & Kaufman, 1994), some of the surveys were completed using the laptop computer on their own. For those who read below an 8^{th} grade reading level, all questions were read to them (for a detailed description of sample selection and data collection procedures, see Crouter, Lanza, Piretti, Goodman, & Neebe, 2006).

Measures: Ecological Risk Factors

One of the primary aims of the present study is to model ecological risk profiles that characterize family characteristics and children's experiences within the family context at 2 and 6 months old. Data on ten risk factors from the following domains were collected at the 2- and/or 6-month home visits: family demographics/structure, family psychological characteristics/status, and home environment. Below is a description of the measures from each domain included in the risk model. These domains were chosen based on empirical evidence and theoretical support for their role in children's early cognitive development.

For the purpose of the present study, all risk factors were coded as dichotomous indicators (e.g., 0 = risk factor not present, 1= risk factor present). Two coding strategies were used. First, for some risk factors there were logical cut-offs (e.g., 0 = less than high school diploma, 1 = high school diploma or higher). For others, already established cut-offs (e.g., 1.5 for income-to-needs ratio) were used whenever possible. For variables where this was not the case, we carefully examined the distributions and considered the following cut points: one SD above/below the mean, 1.5 SD above/below the mean, and the bottom/ top quartile of the sample. The standard deviation approach relies on normal, symmetric distributions, and in our case, the distributions for some continuous variables were highly skewed and non-normal. Therefore, to identify a consistent number of at-risk children, we used the bottom/top quartile approach to create cut points for the two continuous variables (stress and social support) where there were not logical or already established cut points. See Table 1 for descriptives of the risk factor variables by site-race groups.

Table 1 Descriptive Statistics: Percentages of Children from each Site-Race Group with Risk Factor.

	% At-Risk (*N* Missing)			
	PA	NC	NC	
	White	White	AA	
Risk Factor	(*N* = 461)	(*N* = 226)	(*N* = 468)	p-value[1]
Poverty	36.2 (0)$_a$	38.9 (0)$_a$	72.9 (0)	***
Single	16.5 (0)$_a$	11.5 (0)$_a$	59.8 (0)	***
Unmarried	36.9 (0)	25.7 (0)	70.5 (0)	***
Teen Mother	32.8 (199)$_a$	40.4 (85)$_a$	63.5 (172)	***
No HS Diploma	14.3 (0)$_a$	18.6 (0)$_{ab}$	24.2 (0)$_b$	***
Mood Problems	40.1 (0)	27.9 (0)$_a$	28.4 (0)$_a$	***
Smoked While Pregnant	30.2 (0)$_a$	24.8 (0)$_a$	15.0 (0)	***
High Stress	24.7 (92)$_a$	23.8 (58)$_a$	31.4 (98)$_a$	ns
Low Social Support	18.9 (11)$_a$	19.3 (3)$_a$	32.0 (27)	***
Crowded House	18.0 (0)	28.8 (0)	43.4 (0)	***

Note. Percentages in the same row that share subscripts do not differ at $p < .05$ according to chi-square test of independence pair-wise comparisons. AA = African American.

[1]P-value based on chi-square test of independence between each risk factor and site-race group.

*** $p < .001$.

Income-to-Needs Ratio. At the 6-month visit, mothers were asked to report the total income from all sources for all members of the household. Persons were considered to be a member of the household if they spent the night at the home at least three days per week. To calculate the income-to-needs ratio, this number was divided by the federal poverty threshold for 2004, adjusted for number of people in the household. An income-to-need ratio of 1.00 or greater indicates that the family income is at or below the poverty level, adjusted for family size. For the purpose of the present study, families with an income-to-need ratio of 1.5 or higher were coded as at-risk.

Single Status. Mothers were asked to report if there was a spouse or other partner that lived in the house. Those who reported no spouse or live-in partner were considered single and therefore coded as at-risk.

Marital Status. Mothers who reported being unmarried at the 2-month home visit were coded as at-risk.

Teen Mother. At the 2-month visit, mothers were asked to report the age (in years) at which they gave birth to their first child. For the present study, we defined a teen mother as someone who had her first child at 19 years old or younger.

Maternal Education. Mothers were asked to report the total number of years of education they had completed at the time of the 2-month visit. Responses were categorized into one of six groups: 1) less than high school diploma or GED, 2) high school diploma or GED, 3) high school diploma or GED and other training, 4) some college, but no degree, 5) associates degree, or 6) four-year college degree or higher. For the purpose of the present study, mothers with less than a high school diploma or GED were coded as at-risk.

Maternal Depression. Two measures of maternal depression were used in the present study. To assess current symptoms, mothers were asked to complete the Brief Symptom Inventory-18 (BSI-18; Derogatis, 2000) at the 2- and 6-month visits. This instrument is a short, highly sensitive, self-report screening index for psychological distress. The BSI-18 contains eighteen items that are divided evenly across three dimensions: somatization, depression, and anxiety. The present study used the Global Severity Index (GSI) which is calculated by summing scores for the three individual scales. To asses a history of mental illness, at the 2-month visit, mothers were also asked to report if they had ever been told by a doctor or other medical professional that they had depression or other mental illness. These measures were used in concert to account for current and past mental health status. First, a composite BSI-18 variable was created by averaging the BSI-18 GSI subscales at 2 and 6 months. Next, the maternal depression risk variable was created using the 'or' rule to indicate at-risk status. Mothers who scored at the 75th percentile or higher on the 2/6-month composite BSI-18 variable (a score of 51 or higher for this sample) or who reported being diagnosed with depression or another mental illness were coded as at-risk for the present study.

Prenatal Smoking. Mothers were asked to report on prenatal smoking behavior at the 2-month home visit. They were asked to indicate if they had ever smoked (any amount) during the course of their pregnancy (0 = never smoked, 1 = smoked at least once). For the purpose of the present study, mothers who reported ever smoking during their pregnancy were coded as at-risk.

Stress/Support. Two measures were used to assess the families' experience of stress and support. At the 2-month visit, mothers were asked to complete the Life Experiences Survey (LES; Sarason, Johnson & Siegel, 1978). This scale was designed to assess presence of positive and negative events that have the potential to affect family functioning. It contains 49 self-report items that asks participants to identify major life events that occurred to them in the previous 6-month period, including whether the event was perceived as positive or negative, as well as the impact it had on them (from 0 = ‘no effect' to 4 = ‘great effect'). The internal consistency for this scale was good with an alpha of 0.80. The LES contains 4 subscales: total positive events, sum of weighted positives, total negative events, sum of weighted negatives. For the purpose of the present study, the sum of weighted negatives was used and a score at the 75th percentile or higher (a score of 10 or greater for this sample) was coded as at-risk.

At both the 2- and 6-month visits, mothers were also asked to complete a modified version of short form of the Questionnaire of Social Support (Crnic & Greenberg, 1987). This 16-item measure was designed to assess social support satisfaction with respect to community involvement, friendship, family, and intimate relationships and accordingly contains these four subscales (community involvement, friendship, family, and intimate relationships). Scale scores are created by taking the mean of the items in that scale where response options for each item range from 1 = 'very dissatisfied' to 4 = 'very satisfied'. Participants are also given the choice to rate the item as not applicable and are treated as missing in calculating the scale scores. For the present study, the family and intimate relationships subscales were used as research has shown that these domains are especially important for families with young children (Crnic, Greenberg, & Slough, 1986). First, a composite variable was created by averaging the family and intimate relationships subscale scores at 2 and 6 months. Families who scored at the 25th percentile or lower (a score of 3.11 for this sample) on this composite were coded as at-risk.

Crowded Household. Mothers were asked to report the total number of adults and children living in the home at the 2- month visit. Persons who spent the night at the house for three or more days per week were considered members of the household. They were also asked to report how many rooms there were in the home (e.g., living room, bedrooms, kitchen, dining room). Entryways, hallways, patios, and bathrooms were not included in this number. This information was used to determine the ratio of people to rooms, which serves as a good proxy for residential density (Evans, Saegert, & Harris, 2001). This variable was created by dividing the total number of adults and children living in the home by the total number of rooms in the home at the 2-month visit. Families who scored at the 75th percentile or higher (1 or higher in this sample) on this variable were coded as at-risk.

Outcome Measures: Executive Function

Interviewers administered a total of three EF tasks at the 36-month home visit[1]. All of the tasks were administered with flipbooks in a quiet space with minimum distractions. One home visitor administered the task to the child (i.e., the administrator), while the other home visitor recorded the child's responses with a laptop computer (i.e., the scorer). When it was possible, the administrator was seated directly across from the child at a table. The flip book was placed between the child and administrator approximately 12 inches from the child. The tasks were also videotaped so that a certain percentage could be coded for reliability purposes.

Because of the multifaceted nature of the tasks designed to assess EF, they often require the child to use multiple components of EF to succeed. However, the three EF tasks used in the present study were designed to primarily assess one of the following constructs: working memory, inhibitory control, or set shifting. Descriptions of each measure and the summary scores that were calculated are presented below.

For both methodological and theoretical reasons, researchers have measured EF in several different ways in the past (Blair et al., under review; Carlson, 2005; Espy et al., 2006; Hughes & Ensor 2005; Kochanska et al., 2000). Overall, these strategies vary along two main dimensions. Some researchers use continuous indicators (e.g., total percent correct on all trials), while others use dichotomous (e.g., pass/fail) indicators of EF. In the dichotomous versions, children must demonstrate a certain level of knowledge to 'pass' a task. Based on previous research, children who get 75% or more trials correct 'pass' and those who receive less than 75% correct 'fail' the task (Carlson, 2005; Diamond et al., 2005). In addition, researchers have debated whether to model EF as one underlying construct by creating a composite score (Blair et al., under review; Blair & Peters, 2003; Wiebe et al., 2008) or to model the individual components separately (Carlson, 2005). Given this debate, in addition to composite scores, the present study will explore the EF components separately because it is possible that the relations between ecological risk and later EF skills may vary as a function of the specific component being examined. For instance, some research has shown that working memory and inhibitory control are more strongly related to academic and behavioral outcomes compared to other EF components (Espy et al., 2004; Hughes et al., 1998).

In the present study, we used both individual-task scores and two EF composites. For the individual-task scores, two summary scores, *total percent correct* and *3-category* (i.e., fail/low pass/high pass), were calculated for each EF task for children who completed the task and received scores on at least 50% of the items within that task. The *total percent correct* scores were calculated by dividing the total raw score (i.e., total number of correct items) by the number of items completed. For the *3-category* score, children were given a score of zero (fail) if they got 50% or less of the items correct (50% would be chance responding). They were given a score of one (low pass) if they got between 51% and 74% of the items correct. They were given a score of two (high pass) if they got 75% or more of the items correct. See Table 2a for descriptive information on the continuous EF outcomes and Table 2b for the categorical EF outcomes.

Table 2a Descriptive Statistics: Means and Standard Deviations for Continuous EF Outcomes for each Site-Race Group.

	M (SD)			
	PA	NC	NC	
EF Outcome	White	White	AA	p-value[1]
EF Mean Total % Correct (*N* = 925)	.52 (.21) (*n* = 391)	.46 (.19) (*n* = 164)	.36 (.18) (*n* = 379)	***
Operation Span % Correct (*N* = 838)	.32 (.27)$_a$ (*n* = 359)	.27 (.26)$_a$ (*n* = 149)	.14 (.18) (*n* = 330)	***
Spatial Conflict Arrows % Correct (*N* = 858)	.71 (.27) (*n* = 357)	.60 (.29)$_a$ (*n* = 154)	.59 (.29)$_a$ (*n* = 347)	***
Something's the Same % Correct (*N* = 863)	.56 (.26)$_a$ (*n* = 370)	.51 (.27)$_a$ (*n* = 155)	.38 (.23) (*n* = 338)	***

Note. Percentages in the same row that share subscripts do not differ at $p < .05$ according to the Tukey post-hoc comparisons. AA = African American.

[1]P-value based on one-way ANOVA to test mean group differences in each EF outcome.

*** $p < .001$.

Table 2b Descriptive Statistics: Percentages of Children with Fail, Low Pass, and High Pass Scores for Individual EF Tasks by Site-Race Group.

EF Outcome	PA White	NC White	NC AA	p-value[1]
Operation Span (N = 838)	(n = 359)	(n = 149)	(n = 330)	
% Fail	21.5	24.2	43.9	
% Low Pass	66.6	67.8	54.6	***
% High Pass	12.0	8.1	1.5	
Spatial Conflict Arrows (N = 858)	(n = 357)	(n = 154)	(n = 347)	
% Fail	23.3	38.3	41.5	
% Low Pass	14.9	18.8	19.3	***
% High Pass	61.9	42.9	39.2	
Something's the Same (N = 863)	(n = 370)	(n = 155)	(n = 338)	
% Fail	36.5	46.5	66.6	
% Low Pass	30.5	29.0	25.2	***
% High Pass	33.0	24.5	8.3	

Note. AA = African American.

[1]P-value based on chi-square test of independence between EF 3-category score and site-race group.

*** $p < .001$.

Working Memory. Operation Span assessed children's working memory abilities and required them to hold information in mind and act on it in order to accomplish the goals of the game. For this task, children were presented a series of pages with increasing numbers of houses containing different animals and colors (i.e., one animal and one color in each house). For each trial, children were first shown a page with an animal and a dot of color in the house(s). The administrator asked the child to name the color and then the type of animal in each house. Next, the administrator showed a page with the same number houses as the previous page, but this time with no animals or colors. For each house, the child was asked to name the animal that *was* in that house. Children were presented with one one-item (i.e., one house on the page) practice trial (i.e., the administrator provides feedback if the child answers incorrectly, but the trial is still scored), two two-item trials (i.e., two houses on the page), and two three-item trials (i.e., three houses on the page). For each house, the scorer recorded if the child named the correct animal. In all, there were 11 trial items.

Inhibitory Control. The Spatial Conflict Arrows task, which is similar to a traditional Simon task (e.g., Davidson, Amso, Anderson, & Diamond, 2006), assessed children's inhibitory control abilities. The task required children to inhibit an automatic or more natural tendency (e.g., point in the same direction of an arrow) for an opposite or more unnatural tendency (e.g., point in the opposite direction of an arrow). In other words, it required children to inhibit a pre-potent response. In this task, children were presented with a response card with two large, black circles referred to as 'buttons.' One button was on the left side of the page and the other button was on the right side. With the use of a flipbook, the administrator presented a series of pictures of left- and right-pointing arrows with various page placements (i.e., center, left, right). Children were given the response card and instructed to touch the button that the arrow was pointing to. There are four rounds where the arrows are placed in the center of the page (i.e., central presentation) and then 32 rounds where the arrows are placed on the right or left side of the page (i.e., lateral presentation). The first two central presentation rounds are teaching trials and therefore are unscored. For the lateral rounds, there are non-conflict and conflict trials. For the non-conflict trials, the arrow is pointing in the same direction as the presentation side (i.e., the arrow is pointing left and is presented on the left side of the page). For the conflict trials, the arrow is pointing in the opposite direction as the presentation side (i.e., the arrow is pointing left, but it is presented on the right side of the page). For each trial, the scorer recorded if the child touched the left or the right button. In all, there were 37 trial items. Following administration, a computer algorithm was used to determine if the child touched the correct button (0 = incorrect, 1 = correct).

Based on this, two types of summary scores were calculated, one based on all of the items and the other based on the conflict trials only. For the purpose of the present study, only the conflict- trial scores will be used because they provide a greater executive demand and therefore are a more valid measure of the child's inhibitory control abilities.

Set Shifting. The Something's the Same task is similar to Zelazo's Dimensional Change Card Sort (Zelazo et al., 2003) and was designed to assess children's set shifting abilities in young children. It required children to shift attention from one dimension of a picture to another dimension of the picture. Children were presented with pages with pictures that varied by size, color, and type of picture. For each trial, the administrator first showed the child a page with two pictures (i.e., blue chair, blue cat) and verbally identified what the two pictures have in common (i.e., 'Here are two pictures, they are both blue'). Then, the administrator showed the child a page with a new picture (i.e., red cat) in addition to the two previously presented pictures. The child was instructed to point to one of the two pictures that were first presented, which matched the new picture (i.e., size, color, type of picture). For each trial, the scorer recorded which picture the child pointed to. Following administration, a computer algorithm was used to determine if the child pointed to the picture that correctly matched the new picture (0 = incorrect, 1 = correct). In all, there were 11 trial items.

Composite EF Scores. As EF has been conceptualized as one overall construct, we also created two composite EF scores that encompass the children's scores on all of the EF tasks. Children received these composite scores if they had summary scores on at least one of the EF tasks. Total percent correct scores for the three EF tasks were significantly, moderately related with correlations ranging from .20-.34. The *Mean Total Percent Correct* score was calculated by dividing the sum of the percent correct scores from all three EF tasks by the number of EF tasks completed by the child. Fail/low pass/high pass scores (3-category score) for the three EF tasks were significantly related (p-values < .001 for chi-square analyses for all pair-wise associations). The *Mean 3-Category* score was calculated by dividing the sum of the 3-category scores from all three EF tasks by the number of EF tasks completed by the child.

Measures: Mediation Variables

The third aim of the present study is to explore the possible mediating effects of the quality of the home environment and parent-child interactions as well as the children's language skills in the association between early ecological risk profiles and 36-month EF performance. In other words, we are interested in understanding if the association between early ecological risk and later EF performance can be explained by the following constructs.

Quality of Home Environment. Home visitors completed a subset of the Home Observations for the Measurement of the Environment (HOME; Bradley & Caldwell, 1988) at the end of the 6-month visit. The HOME Inventory is designed to measure the quality and quantity of stimulation and support available to a child in the home environment. The focus is on the child *in* the environment, with the child as a recipient of inputs from objects, events, and transactions occurring in connection with the family surroundings. The Infant/Toddler version of the Inventory (IT-HOME) is aimed for use during infancy (birth to age three). A total of 28 items from the responsivity, acceptance, and learning materials subscales are used in the FLP. Each item is scored in binary fashion (0 = no, 1 = yes). Information used to score the items is obtained during the course of the home visit by means of observation and semi-structured interview. These constructs figured importantly in the central questions of this study, and previous studies have found them to be significant predictors of young children's development (e.g., NICHD ECCRN, 2006). For the purpose of the present study, we used the total score, which is a sum of the 45 items. However, because the HOME subscales (i.e., responsivity, acceptance and learning materials) were only moderately related (r = .30-.41), it was important to examine how relations varied by subscale. Research by Bradley and colleagues have demonstrated the importance of examining the individual subscales in addition to the total score (see Bradley et al., 2001) and therefore the present study will do the same.

Parent-Child Interactions. During the 6-month visit, the mother and infant were videotaped during a 10-minute, free-play interaction. The procedure for this interaction was taken from previous research (Cox et al., 1999; NICHD ECCRN, 1999). Mothers were given a set of toys and instructed to play with their children as they normally would. The videotaped interactions were later coded for maternal sensitivity, detachment, intrusiveness, positive regard, negative regard, and animation in interacting with the child. Ratings for each code were made on a 1-5 scale, where 1 = ‘not at all characteristic' and 5 = ‘highly characteristic'.

Through factor analysis, FLP researchers have found evidence for two broad parenting constructs: positive engagement and negative intrusiveness. Maternal positive engagement (α=.89) was defined as the mean of mothers’ scores for four characteristics: detachment (reverse-scored; level of emotional uninvolvement or disengagement), positive regard (level of positive feelings expressed toward child), animation (level of energy), and stimulation for development (appropriate level of scaffolding of activities with child). Maternal negative intrusiveness (α=.69) was defined as the mean of mothers’ scores for three characteristics: sensitivity (reversed, level of responsiveness to child’s needs, gestures, and expressions), intrusiveness (degree to which mother imposed her own agenda on the interaction ignoring the baby’s signals) and negative regard (level of harsh, negative feelings expressed toward child). Reliability was determined by calculating the intra-class correlation for ratings made by two coders to approximately 30% of the tapes randomly drawn at the 15-month assessment period. Reliability was acceptable for both negative intrusiveness (*r* = .88) and positive engagement (*r* = .80). In the present study, positive engagement and negative intrusiveness were moderately, negatively related (*r* = -.34).

Language Ability. The Expressive Communication subscale of the Preschool Language Scale-4 (PLS-4; Zimmerman, Steiner, & Pond, 2002) was used to evaluate children's *expressive language* at the 24-month home visit. The PLS age standard scores were used for the present study (*M* = 100, *SD* = 15). Previous work has shown that the PLS-4 correlates with other standard measures of language development, with internal consistencies ranging from .67 to .88 for the subscales, and test re-test reliabilities ranging from .82 to .95 (Zimmerman et al., 2002).

Overview of Analytic Plan

The analytic plan for this study was as follows: First, descriptive statistics were explored for all ecological risk factors and EF outcomes by site-race groups. Second, latent class analysis was used to identify and describe family ecological risk profiles. Third, using a classify/analyze approach we used information from the LCA model to assign children to family risk profiles and then examined the mean differences in EF scores across these risk profiles. Finally, we specified path models to explore home quality, parent-child interactions, and children's language skills as mediators in the association between membership in the family risk profiles and later EF skills.

Chapter 3

Results

Descriptive Statistics

Table 1 shows the percentage of children who were classified as at-risk for each of the risk factors within each site-race group. For each site-race group, p-values in this table correspond to the chi-square test of differences in the proportion of children at-risk across the three site-race groups. If the chi-square indicated significant differences among the three groups, follow-up analyses were conducted for each pair-wise comparison to determine which site-race groups were different from one another. Significant differences were found between site-race groups for all risk factors except for high stress. Specifically, a greater percentage of NC AA children were classified as at-risk for nine of the ten risk factors in comparison to the two white groups. More NC AA children were poor, were living in single-parent households, had unmarried parents, had a mother who was a teenager when she gave birth to her first child, had a mother who was less likely to have smoked while she was pregnant, had a mother with low social support, and lived in a crowded household as compared to both the PA and NC white children. Thus, rural African American families in NC are much more likely to be poor, single parents with lower education than are white rural families from PA or NC. For most ecological factors, similar percentages of PA and NC white children were classified at-risk, with the exception of having an unmarried mother, having a mother with mood problems, and living in a crowded household. More PA white children had a mother with mood problems as compared to NC white children; whereas, more NC white children had unmarried mothers and lived in a crowded household as compared to PA white children.

Table 2a shows the means and standard deviations for the continuous, 36-month EF outcomes for each site-race group. One-way ANOVA results indicated significant mean differences among the three groups. Follow-up analyses were conducted with Tukey's post-hoc tests to determine which site-race groups were different. Significant differences were found between site-race groups. NC AA children had lower scores than both the PA and NC white children on all EF measures except Spatial Conflict where they and NC white children both scored lower than PA children. For Spatial Conflict and the EF composite score, PA white children scored higher on average than both NC groups.

For the overall EF mean 3-category score, PA white children scored an average of 1.06 (*SD* = .57), just above an average score of 'low-pass.' NC white children scored an average of .87 (*SD* = .55), just below an average score of 'low-pass.' NC AA children scored an average of .63 (*SD* = .51), an average score between 'low-pass' and 'fail'. Similar to the EF mean total percent correct score reported above, means for the 3-category score were significantly different across site-race groups ($F = 59.72$, $p < .001$), with PA white children scoring the highest followed by NC white, who performed better than the NC AA children, but worse than the PA white children, and finally the NC AA children who scored significantly lower than both white groups. Table 2b shows the percentage of children with fail, low-pass, and high-pass scores on the three individual EF tasks. Chi-square tests were calculated to determine if there were differences across site-race groups. Again, there were significant differences across site-race groups on all EF measures. Pair-wise comparisons between the proportion of children who scored fail and those who passed (low or high pass) found the following differences among the site-race groups. For Operation Span, more NC AA children scored fail (in comparison to low or high pass) as compared to the white children. For Spatial Conflict, more NC children scored fail (in comparison to low or high pass) as compared to the PA white children. For Something's the Same, more NC AA children scored fail (in comparison to low or high pass) as compared to the white children.

In sum, there are important site-race differences in both the prevalence of early risk factors and 36-month EF performance. The most striking differences are between the NC AA children and the white children, with a greater percentage of NC AA children being exposed to early risk factors and showing the poorest EF outcomes overall. Few differences were found between PA and NC white children.

Aim 1: Latent Class Analysis Model Building and Selection

LCA was used to identify subgroups of individuals characterized by unique combinations or profiles of ecological risk factors. Our goal is to empirically identify qualitatively distinct subgroups that best represent the number of overlapping and unique risk profiles present across the three site-race groups, PA white, NC white, and NC AA. In FLP, site and race are confounded and therefore there is reason to believe that the prevalence of risk profiles will vary considerably across groups, particularly for African American families compared to white families. For example, as shown in Table 1, NC AA families had twice the rate of poverty and four to five times the rate of single-parenthood than the NC or PA white families. Thus, similar to previous work where site and race were confounded (Lanza, Rhoades, Nix, & Greenberg, under review), we incorporated site-race into the risk profile model. As in structural equation modeling, grouping variables can be included in the LCA model to compare the prevalence of each latent class across groups. Ultimately, our goal is to be able to directly compare the prevalence of the particular risk profiles across site-race groups. Therefore, our final baseline LCA model must include the full sample and incorporate the site-race variable as a grouping variable.

To identify a baseline LCA model, we first conducted separate LCA models within each site-race group to better understand the risk profiles that were unique to or common across site-race groups. Second, we combined the site-race groups and conducted LCA models with the full sample in order to obtain one LCA model that accurately represented all of the risk profiles that emerged in the first step. Third, we compared the definitions and prevalence rates of the classes that emerged in the final LCA model (step 2) to the definitions of the classes that emerged in the site-race models (step 1). Parameter restrictions were then employed to fine tune the final model to most accurately reflect the risk profiles that emerged across the site-race groups.

For each model, multiple sets of starting values were specified in order to assess model identification. We used the G-squared test statistic, information criteria (i.e., AIC, BIC), and model identification (i.e., only those models that were well-identified are considered and reported below) to guide the model selection process. In general, a low AIC/BIC reflects an optimal balance of model fit and parsimony. However, it is important to consider model interpretability as well (Collins & Lanza, in press). Two sets of parameters are estimated in a latent class model: 1) the probability of membership in each risk profile, and 2) item-response probabilities for each risk factor given membership in a particular risk profile. Membership probabilities range from zero to 1.0 indicating the proportion of the sample that belongs to each profile. Item-response probabilities range from zero to 1.0 indicating the probability of exposure to a risk factor given membership in a particular risk profile. An item-response probability of .50 means that there is an equal chance of having or not having that risk given membership in that risk profile. In other words, item-response probabilities of .50 indicate that a particular risk factor is not helpful in discriminating people in that risk profile, whereas item-response probabilities close to zero or 1.0 are very helpful. Similar to factor loadings in factor analysis, item-response probabilities are used to label the subgroups or latent classes. Risk factors with high item-response probabilities (higher than .50) were used to guide our choice of label and description of the risk profiles below.

Step 1: Site-Race Specific LCA Models. Initial site-race specific models demonstrated that PA and NC white were similar in number and composition of risk profiles and therefore we combined them for further analyses (see Appendix A for details of the separate PA white and NC white LCA models). In the combined PA/NC white sample (*n* = 687), we ran LCA models with 1-5 class models with measurement constrained to be equal across groups, which essentially means that the structure of the risk profiles was forced to be the same across the PA and NC samples. We did this by specifying the item-response probabilities to be equal across groups. The 4-class model had the lowest BIC and the 5-class model had the lowest AIC (see Table 3). In the 4-class model, three married classes and one single-parent class emerged. The married classes included: 1) a low-risk class, 2) a class characterized by maternal mood problems, high stress, and low social support, and 3) a class characterized by being poor, having a teen mother, and living in a crowded household. The single-parent class was characterized by being poor and having a teen mother with mood problems who smoked while pregnant. In the 5-class model, a new partnered, unmarried class with several other risk factors (poor, teen mother, mood problems, smoked while pregnant, crowded household) emerged. The 5-class model appeared to provide the best fit for the PA and NC white data because it not only recovered the four classes from the separate PA and NC white analyses, but it also added a conceptually important and distinct married class with increased risk of poverty.

Table 3 Fit Statistics for the PA/NC White and NC AA Site-Race Specific LCA Models.

No. of Classes	G sq.	df	AIC	BIC
PA/NC White (N = 687)				
1	1709.66	2037	1729.66	1774.99
2	981.93	2025	1025.93	1125.64
3	891.00	2013	959.00	1113.10
4	798.50	2001	890.50	1098.99
5	753.77	1989	869.77	1132.65
NC AA (N = 468)				
1	999.97	1013	1019.97	1061.46
2	684.19	1002	726.19	813.31
3	588.24	991	652.24	784.99
4	546.90	980	632.90	811.28
5	504.29	969	612.29	836.30

Note. AA = African American. G sq. = G-square statistic; df = degrees of freedom; AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria. Lower AIC, BIC indicates more optimal model fit.

Next, we explored measurement invariance in the measurement of the 5-classes for the PA and NC white samples. After carefully reviewing the models from the site-race specific analyses above and considering evidence from the measurement invariance test, we chose the 5-class model with equal measurement across groups because it provided a good balance between model fit and parsimony and it accurately reflected the risk profiles identified in Appendix A in the separate PA white and NC white analyses[2]. See Table 4 for the item-response probabilities and class prevalences for the PA/NC white 5-class model.

Table 4 PA/NC White: Item-Response Probabilities and Prevalence Rates for the 5-Class Model.

	Risk Profile				
Risk Factor	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor, Partnered, Unmarried	Poor, Single, Multi-Prob.
Poverty	.12	.41	**.61**	**.51**	**.81**
Single	.00	.03	.00	.00	**.72**
Unmarried	.08	.06	.33	**1.00**	**.97**
Teen Mother	.11	.47	**.84**	**1.00**	**.58**
No HS Diploma	.00	.04	.40	.18	.46
Mood Problems	.19	**1.00**	.19	**.78**	.46
Smoked While Pregnant	.09	.35	.35	**.99**	**.52**
High Stress	.10	**.69**	.03	.22	.46
Low Social Support	.08	**.51**	.18	.17	.32
Crowded House	.10	.18	**.57**	**.52**	.24
	Class Membership Probabilities				
PA White	53%	11%	7%	7%	22%

NC White	48%	12%	25%	1%	14%

Note. Item-response probabilities over .50 are bolded.

In the NC AA sample (*n* =468), we considered LCA models with 1-5 classes. The 3-class model had the lowest BIC and the 5-class model had the lowest AIC (see Table 3). In the 3-class model, one married (low risk) class and two single-parent classes emerged. Both single-parent classes were characterized by being poor and having an unmarried, teen mother. However, in one class the mothers appeared to have few risks other than being poor with some demographic risk and in the other the mothers were also poor but had multiple problems including mood problems, higher levels of stress and lower levels of social support. In the 4-class model, both the married, low risk and poor single-parent classes re-emerged. However, the single, multi-problem group split into two groups; these single-parent classes were distinguished primarily by whether mothers had a high school diploma or not. In the 5-class model, an additional married class emerged, but had several risks (poor, teen mother, crowded household). After reviewing the 3-5 class solutions, we chose the 5-class model for the NC AA sample because it provided a nuanced picture of risk in these families and included three classes that overlapped with those found in the PA/NC white analyses. See Table 5 for the item-response probabilities and class prevalences for the NC AA 5-class model.

In summary, a total of seven risk profiles emerged in the site-race specific analyses, three of which emerged in both the white & African American samples, two of which were unique to the white sample and two of which were unique to the African American sample. Overall, these LCA models demonstrated the need for both overlapping and site-race specific classes.

Table 5 NC African American: Item-Response Probabilities and Prevalence Rates for the 5-Class Model.

	Risk Profile				
Risk Factor	Married, Low Risk	Poor & Married	Poor & Single	Poor, Single, Multi-prob., w HS diploma	Poor, Single, Multi-prob., low ed.
Poverty	.14	**.74**	**.84**	**.69**	**1.00**
Single	.03	.06	**.85**	**.79**	**.89**
Unmarried	.02	.26	**.99**	**.89**	**.89**
Teen Mother	.25	**.60**	**.76**	**.65**	**.87**
No HS Diploma	.00	.20	.21	.00	**1.00**
Mood Problems	.04	.33	.02	**.77**	**.70**
Smoked While Pregnant	.00	.19	.12	.27	.18
High Stress	.04	.42	.18	**.60**	.40
Low Social Support	.06	.24	.20	**.62**	**.71**
Crowded House	.31	**.70**	.40	.20	**.60**
Class Membership Probabilities	12%	18%	41%	17%	12%

Note. Item-response probabilities over .50 are bolded.

Step 2: Full-Sample LCA Models. In the full-sample (n = 1155) analyses, we considered models with 1-7 classes with measurement constrained to be equal across the two groups (i.e., PA/NC white, NC AA). The 5-class model had the lowest BIC and the 7-class model had the lowest AIC (see Table 6). In the 5-class model, three married classes, one unmarried class, and one single class emerged. The married classes included: 1) a low risk class, 2) a class with maternal mood problems, high stress and low social support and 3) a poor class characterized by having a teen mother and living in a crowded household. The unmarried class was characterized by being poor, having a teen mother, having a mother with mood problems and having a mother who smoked while pregnant. The single-parent class was characterized by being poor and having a teen mother. In the 6-class model, an additional single-parent class emerged, this time with numerous risks (poor, teen mother, mood problems, high stress and low social support). It is important to note that six of the seven classes that emerged in the site-race specific analyses re-emerged in this full-sample model (see Table 7). In the 7-class model, similar to the NC AA analyses, the single, multi-problem class split into two classes with one having a high school diploma and the other not. We believe that because of the large degree of overlap between these two single, multi-problem classes, there was not enough differentiation (i.e., class separation) to warrant a 7-class model and therefore we chose the more parsimonious, 6-class model as the final LCA model (see Table 7).

Table 6 Fit Statistics for Full-Sample LCA Models with 1-7 Classes with Equal Measurement.

No. of classes	G sq.	df	AIC	BIC
1	3178.90	2037	3198.90	3249.41
2	1662.57	2025	1706.57	1817.71
3	1419.67	2013	1487.67	1659.43
4	1273.34	2001	1365.34	1597.73
5	1180.84	1989	1296.84	1589.84
6	1106.13	1977	1246.13	1599.76
7	1044.02	1965	1208.02	1622.28

Note. G sq. = G-square statistic; df = degrees of freedom; AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria. Lower AIC, BIC indicates more optimal model fit.

Table 7 Full Sample: Item-Response Probabilities and Prevalence Rates for the 6-Class Model.

Risk Factor	Risk Profile					
	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor & Unmarried	Poor & Single	Poor, Single, Multi-Prob.
Poverty	.11	.33	**.68**	**.72**	**.83**	**.84**
Single	.01	.01	.00	.48	**.87**	**.76**
Unmarried	.07	.11	.21	**.99**	**.96**	**.81**
Teen Mother	.14	.44	**.66**	**.69**	**.75**	**.73**
No HS Diploma	.01	.03	.26	.41	.25	.39
Mood Problems	.16	**1.00**	.24	.41	.07	**.89**
Smoked While Pregnant+	.08	.37	.21	**.59**	.13	**W: .66** AA: .23
High Stress	.10	**.65**	.21	.28	.21	**.63**
Low Social Support	.08	.48	.16	.20	.25	**.72**
Crowded House	.10	.12	**.71**	.33	.40	.36
	Class Membership Probabilities					
PA/NC White	50%	12%	11%	23%	---	5%
NC AA	11%	---	17%	---	49%	23%

Note. Item-response probabilities over .50 are bolded. W = White and AA = African American.

+Two item-response probabilities for Smoking While Pregnant are reported above for the Poor, Single, Multi-Problem profile because the prevalence of this risk factor was allowed to vary across the white and African American groups for this profile.

Step 3: Fine Tuned Final LCA Model. Finally, the classes that emerged in the final LCA (step 2) were compared to the classes that emerged in the site-race specific models (step 1). Two main issues stood out. First, because two of the classes in the final model were unique to the white families and one was unique to the NC AA families, to stabilize the final model and reduce sparseness, we employed constraints for three prevalence estimates. That is, we constrained the prevalence of the married class characterized by high stress and maternal mood problems and the unmarried class characterized by a variety of risks to be zero for the NC AA group. For the whites, we constrained the prevalence of the single class without multiple risks to zero. By constraining these prevalence rates to be zero, we are essentially saying that these classes do not exist for the specified site-race group. Second, for whites, smoking while pregnant was an important risk that helped define the single, multi-problem class in the site-race specific models. In the full-sample model, the prevalence rate for whites in this class was quite low (4.5%). As this model constrained smoking to be equal across groups and a larger proportion of the NC AA belonged to this class, smoking did not emerge as a risk factor in the full-sample analyses. When we allowed the item-response probability for smoking while pregnant to be estimated differently in the white and NC AA groups, we were able to recover the original site-race specific classes much better. Therefore, we allowed the prevalence of smoking to vary across groups for individuals in this single, multi-problem class (see Table 7).

Finally, we explored measurement invariance to statistically test if the measurement of the 6-classes was the same across the white and African American samples (see Table 8). After carefully reviewing the models from the site-race specific analyses and considering evidence from the measurement invariance tests, the fine-tuned, 6 -class model described above provided the best balance between model fit and parsimony and it accurately reflected the heterogeneity in the white and African American samples[3]. For these reasons it will be used as the final model in all further analyses.

Table 8 Fit Statistics for Competing 6-Class Models with PA/NC White & NC AA Groups.

Model	Measurement Equal Across Groups[1]	Select Prevalences Fixed to Zero[2]	Smoking Prevalence Equal for Groups[3]	G sq.	df	AIC	BIC
1	Yes	No	Yes	1106.13	1977	1246.13	1599.76
2	No	No	Yes	960.09	1917	1220.09	1876.84
3	Yes	Yes	Yes	1126.71	1980	1260.71	1599.19
4	No	Yes	Yes	1042.54	1950	1236.54	1726.57
5[+]	Yes	Yes	No	1119.10	1979	1255.10	1598.62

Note. G sq. = G-square statistic; df = degrees of freedom; AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria. Lower AIC, BIC indicates more optimal model fit.

[1]This column describes if measurement was constrained to be equal across white and African American groups (i.e., yes) or if measurement was allowed to vary across white and African American groups (i.e., no).

[2]This column describes if prevalences were fixed to zero for the Married, Stressed & Depressed and Poor & Unmarried profiles for the African American group and the Poor & Single profile for the white group (i.e., yes) or if all prevalences were estimated for both white and African American groups (i.e., no).

[3]This column describes if the item-response probability for the smoking risk factor was allowed to vary across white and African American groups for the Single, Multi-Problem profile (i.e., yes) or if the item-response probability was constrained to be equal across white and African American groups (i.e., no).

[+]Final baseline model.

The Risk Profiles. The classes that emerged in the final, full-sample model presented in Table 7 represent six distinct profiles of child ecologies. The two main distinguishing characteristics of the risk profiles were family structure and poverty. Overall, there were three profiles characterized by having a married mother, two of which were poor and one which was not por. The remaining three profiles were characterized by having an unmarried mother, all of which were poor.

The first risk profile was labeled *Married, Low Risk* because children from this profile had very low probabilities of being exposed to any of the ten risk factors. For the white children, this was by far the more prevalent subgroup, with approximately half belonging to this profile. For the NC AA children, only 11% belonged to the Married, Low Risk profile. This is likely due to the fact that only about a third of NC AA children had parents who were married. As was explained above, the prevalence for the next risk profile was set to zero for the NC AA children. For the white children, however, approximately 12% belonged to the second profile, which was labeled *Married, Stressed & Depressed*. Although married, this group had increased probabilities of having a mother with mood problems and being exposed to high levels of stress.

The remaining risk profiles all had increased probabilities of being poor. The third risk profile was labeled *Poor & Married* and was more evenly represented in the white and NC AA groups (11% and 17%, respectively). In addition to exposure to poverty, children from this risk profile had increased probabilities of having a mother who was a teenager when she gave birth to her first child, and living in a crowded household. It is interesting note that this is the only married group with poverty as a risk factor. The fourth profile was set to zero for the NC AA children, but nearly a quarter of white children belonged to the fourth risk profile, which was labeled *Poor & Unmarried*. White children from this profile had increased probabilities of being poor, having a mother who was a teenager when she gave birth to her first child, and having a mother who smoked while pregnant. They were about equally as likely to have a parent with a partner (i.e., partner, but not married) as without (i.e., single with no partner). The prevalence for the fifth risk profile was set to zero for the white children. For the NC AA children, however, nearly half of them belonged to this profile, which was labeled *Poor & Single*. Despite being exposed to some demographic risks (i.e., poverty, single-parent, unmarried mother, teen mother), NC AA children from this risk profile had very low probabilities of other risks. Finally, the sixth risk profile was labeled *Poor, Single, Multi-Problem*. Children from this risk profile were likely to be exposed to a host of demographic and familial risks. Similar to the children from the Poor & Single profile, they had increased probabilities of being poor, living in a single-parent household, and having an unmarried mother who had her first child when she was a teenager. However, unlike the Poor & Single profile, children in the Single Multi-Problem risk profile also had increased probabilities of having a mother with mood problems, being exposed to high stress and low social support. For white children in this profile, increased probability of having a mother who smoked while she was pregnant was also a risk factor. For the NC AA children, Poor, Single, Multi-Problem was the second most prevalent risk profile with about a quarter of the children belonging to this group, but for the white children, this was by far the least prevalent risk profile with only 5% of the children belonging to this group.

Aim 2: Relations between Risk Profiles & 36-month Executive Function Outcomes

The second aim of the present study was to examine the association between the early risk profiles and 36-month EF abilities. We employed a classify/analyze approach in which we used the posterior probabilities obtained from the LCA model to assign each child to the profile in which they had the highest posterior probability[4] (see Lanza et al., 2007). The posterior probabilities indicate the probability of an individual belonging to each of the specified risk profiles given their observed data and the parameter estimates in the final LCA model. According to Nagin's (2005) criteria, average posterior probabilities of membership in the assigned profiles for the white sample were quite high, with average probabilities of .91 for the Married Low-Risk profile, .75 for Married Stressed & Depressed, .75 for Poor and Married, .83 for Poor & Unmarried, and .74 for Poor, Single, Multi-Problem. For the NC AA sample, average posterior probabilities of membership in the assigned profiles were similarly high, with average probabilities of .82 for the Married Low-Risk profile, .82 for Poor and Married, .89 for Poor & Single, and .84 for Poor, Single, Multi-Problem. Table 9 shows the proportion of white and NC AA children who were assigned to each of the risk profiles. The majority of white children were assigned to the Married, Low Risk profile and the majority of NC AA children were assigned to the Poor & Single risk profile. Overall, the proportions of children within each assigned risk profile closely correspond to the prevalence estimates in the LCA model suggesting that classification error introduced by using a classify/analyze strategy will have little impact on inferences made based on the assigned class variable (see Table 7). Because only 3% of the white sample was assigned to the Single, Multi-Problem profile and preliminary analyses indicated large standard errors associated with the estimates for this group, we do not include this group in the results reported below relating risk profile membership to EF outcomes.

Table 9 Percentage of Children Assigned to Each Risk Profile by Site-Race Group.

	Assigned Risk Profile					
Site-Race Group	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor & Unmarried	Poor & Single	Poor, Single, Multi-Prob.
PA/NC White (*N* = 687)	51	12	9	25	---	3
NC AA (*N* = 468)	11	---	14	---	52	23

Note. Dashes indicate that percentages were not calculated because the prevalence rate for that profile was set to zero or was too small to analyze for that site-race group. AA = African American.

To examine differences in their EF skills at 36 months, we examined how the children within each risk profile performed on the 3-category and mean percent correct EF variables for the three individual and two composite measures of EF. Results for the 3-category and mean percent variables were nearly identical and therefore, to ease interpretation, we only present results from the mean percent variables below. Table 10 presents the means and standard deviations for the EF composite variable (mean total percent correct) for each assigned risk profile by site-race groups. One-way ANOVA with Tukey's post-hoc comparisons were used to identify mean differences in the EF composite score across risk profiles within each sample. Significant differences were found for both white and NC AA children (F = 5.69, p < .001; F = 4.98, p = .002, respectively). The results showed that white children assigned to the Married Low, Risk profile had significantly higher overall EF scores, but only in comparison to children assigned to the Poor & Unmarried risk profile. NC AA children assigned to the Married, Low Risk profile had significantly higher overall EF scores than the children assigned to the Poor & Single or Poor, Single, Multi-Problem risk profiles. Although not statistically significant, children in the Poor & Married risk profile also appear to have lower mean scores for both site-race groups.

Table 10 Means and Standard Deviations for 36-month EF Mean Total Percent Correct for each Assigned Risk Profile by Site-Race Group.

	EF Mean Total % Correct (SD)					
Site-Race Group	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor & Unmarried	Poor & Single	Poor, Single, Multi-Prob.
PA/NC White	$.53_{a}$ (.19) n = 300	$.50_{ab}$ (.20) n = 62	$.48_{ab}$ (.19) n = 50	$.43_{b}$ (.24) n = 124	---	---
NC AA	$.45_{a}$ (.21) n = 44	---	$.37_{ab}$ (.18) n = 59	---	$.35_{b}$ (.18) n = 194	$.34_{b}$ (.16) n = 82

Note. Means in the same row that share subscripts do not differ at p < .05 according to the Tukey post-hoc comparisons. Dashes indicate that means were not calculated because the prevalence rate for that profile was set to zero or was too small to analyze for that site-race group. AA = African American.

Next we examined the three EF tasks individually to determine differences related to the early risk profiles. Table 11 shows the means and standard deviations for the individual EF tasks for each of the assigned risk profiles by site-race group. Utilizing one-way ANOVA with Tukey's post-hoc comparisons, significant differences were found for Operation Span and Something's the Same for the white children ($F = 3.26$, $p = .011$; $F = 6.91$, $p < .001$, respectively). For Operation Span and Something's the Same, white children assigned to the Married Low, Risk profile had significantly higher EF scores, but only in comparison to children assigned to the Poor & Unmarried risk profile. Additionally, for Something's the Same, white children assigned to the Married, Stressed & Depressed risk profile had significantly higher scores than the children assigned to the Poor & Unmarried risk profile. For NC AA children, significant differences were found for Spatial Conflict and Something's the Same ($F = 3.43$, $p = .017$; $F = 2.88$, $p = .036$, respectively). NC AA children assigned to the Married, Low risk profile scored significantly higher on the Spatial Conflict task in comparison to both children assigned to the Poor & Married and Poor, Single, Multi-Problem risk profiles. For Something's the Same, NC AA children assigned to the Married, Low Risk profile only scored significantly higher than those children in the Poor & Single risk profile.

Overall, these results suggest that for white children, membership in the Poor & Unmarried risk profile was consistently related to lower EF skills than those children in the Married, Low Risk profile. For NC AA children, the primary differences in 36-month EF skills existed between children in the single-parent profiles (Poor & Single or Poor, Single, Multi-Problem) compared to those in the Married, Low Risk profile. NC AA children in both single risk profiles had consistently lower EF skills than those children in the Married, Low Risk profile. Also noteworthy is that the specific EF tasks that were most related to risk during infancy varied for the two site-race groups. For white children, risk during infancy was most consistently related to EF performance on the working memory and set shifting tasks (Operation Span and Something's the Same), whereas for NC AA children, risk during infancy was most consistently related to EF performance on the inhibitory control and set shifting tasks (Spatial Conflict and Something's the Same).

Table 11 Means and Standard Deviations for Individual EF Task Total Percent Correct Scores for each Assigned Risk Profile by Site-Race Group.

	M (SD)					
EF Task	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor & Unmarried	Poor & Single	Poor, Single, Multi-Prob.
PA/NC White						
Operation Span	$.34_a$ (.27) *n* = 281	$.28_{ab}$ (.27) *n* = 63	$.24_{ab}$ (.22) *n* = 46	$.25_b$ (.28) *n* = 105	---	---
Spatial Conflict	$.68_a$ (.27) *n* = 276	$.67_a$ (.30) *n* = 62	$.66_a$ (.27) *n* = 49	$.63_a$ (.30) *n* = 110	---	---
Something's the Same	$.58_a$ (.25) *n* = 285	$.56_a$ (.25) *n* = 64	$.52_{ab}$ (.26) *n* = 48	$.44_b$ (.29) *n* = 114	---	---
NC AA						
Operation Span	$.19_a$ (.25) *n* = 38	---	$.15_a$ (.18) *n* = 52	---	$.14_a$ (.16) *n* = 169	$.11_a$ (.17) *n* = 71
Spatial Conflict	$.71_a$ (.23) *n* = 42	---	$.54_b$ (.32) *n* = 57	---	$.59_{ab}$ (.30) *n* = 174	$.55_b$ (.26) *n* = 74
Something's the Same	$.47_a$ (.22) *n* = 39	---	$.40_{ab}$ (.23) *n* = 55	---	$.36_b$ (.24) *n* = 173	$.36_{ab}$ (.22) *n* = 71

Note. Means in the same row that share subscripts do not differ at $p < .05$ according to the Tukey post-hoc comparisons. Dashes indicate that means were not calculated because the prevalence rate for that profile was set to zero or was too small to analyze for that site-race group. AA = African American.

Aim 3: Mediation Analyses

The final aim of this study was to investigate the role that quality of the home environment, parent-child interactions, and children's language skills had in the relations between risk profiles and later EF abilities. To do this, we dummy-coded the assigned risk profiles (with Married, Low Risk as the reference group) and used them as categorical predictors in the mediation models presented below.

Preliminary Analyses. First, we examined descriptive statistics for the possible mediator variables for each assigned risk profile and tested for mean differences between profiles using ANOVA with Tukey's post-hoc comparisons within the two samples. Income was also explored to determine if there were mean differences within and across the 'not-poor' and 'poor' profiles. It was important to account for any income differences between risk profiles (above and beyond the poverty status risk factor included as part of the risk profiles) because several studies have found strong associations between income and various children's outcomes (e.g., Duncan & Brooks-Gunn, 1997). Our goal was to determine if the associations between risk profiles and EF held even after controlling for family income level.

The top half of Table 12 shows the means and standard deviations for quality of the home environment (total score and three subscales) at 6 months, quality of parent-child interactions at 6 months, children's language skills at 24 months, and income levels for each of the assigned risk profiles for the PA/NC white sample. With regards to the quality of their home environments and interactions with their mothers, white children assigned to the Married, Low Risk and Married, Stressed & Depressed risk profiles (the two non-poor profiles) consistently had more positive experiences. Their HOME total scores were significantly higher than those of children assigned to all of the other (poor) risk profiles. In general, these patterns were similar across the responsivity, acceptance and learning materials subscales of the HOME. White children assigned to the Married, Low Risk profile also experienced greater maternal positive engagement than those children assigned to the other risk profiles, with the exception of Married, Stressed & Depressed. For maternal negative intrusiveness, white children assigned to the Married, Low Risk profile were exposed to lower levels of intrusiveness than children assigned to the Poor & Married or Poor & Unmarried risk profiles. For language skills, children assigned to the Married, Low risk profile had higher abilities at 24 months, but only in comparison to those children assigned to the Poor & Unmarried risk profile. Income levels at 6-months were highest for the families of white children assigned to the Married, Low risk profile, followed by Married, Stressed & Depressed and finally families of children assigned to the Poor & Married and Poor & Unmarried profiles.

The bottom half of Table 12 shows the means and standard deviations for the mediation model variables for the NC AA sample. The NC AA children assigned to the Married, Low risk profile had higher HOME total scores than children assigned to either single risk profile. Also, children assigned to the Poor & Married profile had higher total HOME scores than children assigned to the Poor & Single risk profile. Similar patterns emerged for the responsivity and learning materials subscales of the HOME, but for the acceptance subscale there were no significant differences across risk profiles. For maternal positive engagement, children assigned to the Married, Low Risk and the Poor & Married profiles were exposed to higher levels of engagement as compared to the two single risk profiles. For maternal negative intrusiveness, children assigned to the two married profiles were exposed to lower levels of intrusiveness than children in the Poor & Single profile, but not significantly lower than children in the Poor, Single, Multi-Problem profile. African American children did not significantly differ in 24-month language skills based on their profile assignment. Income levels, however, did significantly vary across risk profiles. Children assigned to the Married, Low Risk profile were from families with significantly higher income at 6-months than children assigned to any of the other risk profiles. Also, children assigned to the Poor & Married profile were from families with higher income than those assigned to either single risk profile.

Table 12 Means and Standard Deviations for Mediation Model Variables for each Assigned Risk Profile by Site-Race Group.

	M (SD)					
Variable	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor & Unmarried	Poor & Single	Poor, Single, Multi-Prob.
PA/NC White						
6m HOME: Total	25.59_{a} (2.22) *n* = 347	25.36_{a} (2.39) *n* = 83	22.89_{b} (3.71) *n* = 61	23.02_{b} (3.71) *n* = 166	---	---
6m HOME: Responsivity	9.89_{a} (1.48) *n* = 347	9.81_{a} (1.45) *n* = 83	8.56_{b} (2.44) *n* = 61	8.53_{b} (2.46) *n* = 167	---	---
6m HOME: Acceptance	7.21_{bc} (.89) *n* = 347	7.31_{c} (.78) *n* = 83	6.74_{ab} (1.03) *n* = 61	6.76_{a} (1.00) *n* = 166	---	---
6m HOME: Learning Materials	8.48_{b} (.97) *n* = 347	8.24_{b} (1.12) *n* = 83	7.59_{a} (1.49) *n* = 61	7.73_{a} (1.63) *n* = 166	---	---
6m Maternal Positive Engagement	3.39_{c} (.74) *n* = 338	3.21_{bc} (.64) *n* = 81	2.87_{ab} (.81) *n* = 53	2.91_{a} (.70) *n* = 159	---	---
6m Maternal Negative Intrusiveness	2.33_{a} (.57) *n* = 338	2.48_{ab} (.52) *n* = 81	2.69_{b} (.63) *n* = 53	2.68_{b} (.58) *n* = 159	---	---
24m Language Skills	105.61_{b} (15.91) *n* = 315	100.87_{ab} (16.02) *n* = 79	99.76_{ab} (13.25) *n* = 51	96.58_{a} (15.59) *n* = 151	---	---
6m Income	60,000 (33,000) *n* = 350	45,000 (26,000) *n* = 84	$28,000_{a}$ (17,000) *n* = 62	$24,000_{a}$ (16,000) *n* = 170	---	---
NC AA						
6m HOME: Total	23.11_{c} (3.09) *n* = 51	---	21.75_{ac} (3.02) *n* = 65	---	20.21_{b} (4.11) *n* = 236	20.36_{ab} (4.14) *n* = 105
6m HOME: Responsivity	9.27_{c} (1.50)	---	8.62_{ac} (1.80)	---	7.82_{b} (2.27)	8.02_{ab} (2.29)

	n = 51		*n* = 66		*n* = 237	*n* = 105
6m HOME: Acceptance	6.33$_a$ (.91) *n* = 51	---	6.24$_a$ (.84) *n* = 66	---	6.03$_a$ (1.02) *n* = 237	5.92$_a$ (1.06) *n* = 105
6m HOME: Learning Materials	7.51$_c$ (1.62) *n* = 51	---	6.88$_{abc}$ (1.74) *n* = 65	---	6.36$_a$ (2.36) *n* = 236	6.44$_{ab}$ (2.29) *n* = 105
6m Maternal Positive Engagement	3.10$_b$ (.71) *n* = 49	---	2.88$_b$ (.89) *n* = 63	---	2.46$_a$ (.83) *n* = 228	2.53$_a$ (.76) *n* = 103
6m Maternal Negative Intrusiveness	2.83$_a$ (.67) *n* = 49	---	2.85$_a$ (.56) *n* = 63	---	3.12$_b$ (.68) *n* = 228	3.12$_{ab}$ (.75) *n* = 103
24m Language Skills	99.76$_a$ (11.96) *n* = 40	---	97.48$_a$ (11.91) *n* = 63	---	98.62$_a$ (13.83) *n* = 213	95.87$_a$ (12.23) *n* = 92
6m Income	48,000 (21,000) *n* = 52	---	27,000 (18,000) *n* = 68	---	17,000$_a$ (17,000) *n* = 241	18,000$_a$ (18,000) *n* = 105

Note. Means in the same row that share subscripts do not differ at $p < .05$ according to the Tukey post-hoc comparisons. Dashes indicate that means were not calculated because the prevalence rate for that profile was set to zero or was too small to analyze for that site-race group. AA = African American.

Next, we examined the bivariate relations between overall EF skills and each of the possible mediator variables and household income (see Table 13). Despite the differences in the levels of the mediator variables described above, the correlations were remarkably similar across site-race groups. For the white sample, all of the possible mediation variables were significantly related to both EF composites. Results suggested that children who were exposed to higher levels of home environment quality (including responsivity, acceptance, and learning materials), maternal positive engagement, children's language skills, and household income were more likely to have higher EF skills at 36-months. Those children exposed to greater maternal negative intrusiveness were more likely to have lower EF skills. The strongest association was between the children's 36-month EF and 24-month language skills.

For the NC AA sample, all possible mediator variables were significantly related to EF skills, with the exception of the association between EF and acceptance and EF and maternal negative intrusiveness. Otherwise, similar to the white sample, overall quality of the home environment, responsivity within the home, learning materials within the home, maternal positive engagement, children's language skills and household income were positively associated with 36-month EF skills.

Table 13 Correlations between EF and Variables in the Mediation Models by Site-Race Group.

	EF Total Mean % Correct	
Variable	PA/NC White	NC AA
6m HOME: Total	.19*** (*n* = 551)	.17** (*n* = 372)
6m HOME: Responsivity	.18*** (*n* = 552)	.15** (*n* = 373)
6m HOME: Acceptance	.09* (*n* = 551)	.09 (*n* = 373)
6m HOME: Learning Materials	.12** (*n* = 551)	.11* (*n* = 372)
6m Maternal Positive Engagement	.19*** (*n* = 531)	.19*** (*n* = 359)
6m Maternal Negative Intrusiveness	-.17*** (*n* = 531)	-.05 (*n* = 359)
24m Language Skills	.38*** (*n* = 542)	.23*** (*n* = 352)
6m Income	.18*** (*n* = 555)	.16** (*n* = 379)

Note. AA = African American.

* $p < .05$, ** $p < .01$, *** $p < .001$

Mediation Analyses. The goal of these analyses are to investigate the possible indirect or mediated effects of quality of the home environment, parent-child interactions, and children's language skills on the association between risk profile membership during infancy and EF skills at 36-months. To test for mediation, the risk profiles (dummy-coded with the Married, Low Risk profile as the reference group) were specified to predict the mediation variable and the EF outcome, and the mediator was specified to predict 36-month EF abilities. To help account for missing data across time points, we used full-information maximum likelihood estimation in AMOS 16.0. Due to the positive association between household income and EF abilities, income was included as a covariate. The mediation model isolates the direct effects for membership in each of the risk profiles on EF skills. The direct effects indicate if there is a unique association between membership in the risk profiles and later EF skills, after controlling for the effects of the mediator. To determine if the effect of membership in each of the risk profiles on EF skills was significantly mediated by the specified mediator, we used Sobel's test (1982).

Separate mediation models were run for the white and the NC AA samples because groups were comprised of different sets of risk profiles. Separate models were run for each mediator (i.e., 6-month HOME total score, 6-month HOME responsivity, 6-month HOME acceptance, 6-month HOME learning materials, 6-month maternal positive engagement, 6-month maternal negative intrusiveness, 24-month language) and the EF total mean percent correct variable below. Results for the white sample will be presented first, followed by those for the NC AA sample. In all figures presented below, bolded paths represent associations that were significantly mediated, and numbers in parentheses represent standardized estimates for when the mediator was not in the model.

Mediation Results: PA/NC White. Figure 1 presents the results of the mediation model with 6-month HOME total score specified as a mediator in the association between risk profiles and 36-month EF skills for white children. Membership in either poor profile relative to the Married, Low Risk profiles was significantly, negatively associated with overall quality of the home environment at 6 months. That is, children in the Poor & Married and Poor & Unmarried were exposed to lower quality home environments at 6 months, on average, in comparison to children in the Married, Low Risk profile. Home quality at 6 months was, in turn, positively associated with EF skills at 36 months, indicating that children with higher quality home environments were more likely to have higher EF skills. With quality of the home environment in the model, the direct effect of membership in the Poor & Unmarried profile on EF remained significant, indicating there was a unique association with EF even after controlling for home quality. Using the Sobel (1982) test, we found that the mediated effects of home quality at 6 months on the association between two of the three risk profiles and 36-month EF skills were significant (Poor & Married: $t = -2.71$, $p < .01$; Poor & Unmarried: $t = -2.84$, $p < .01$).

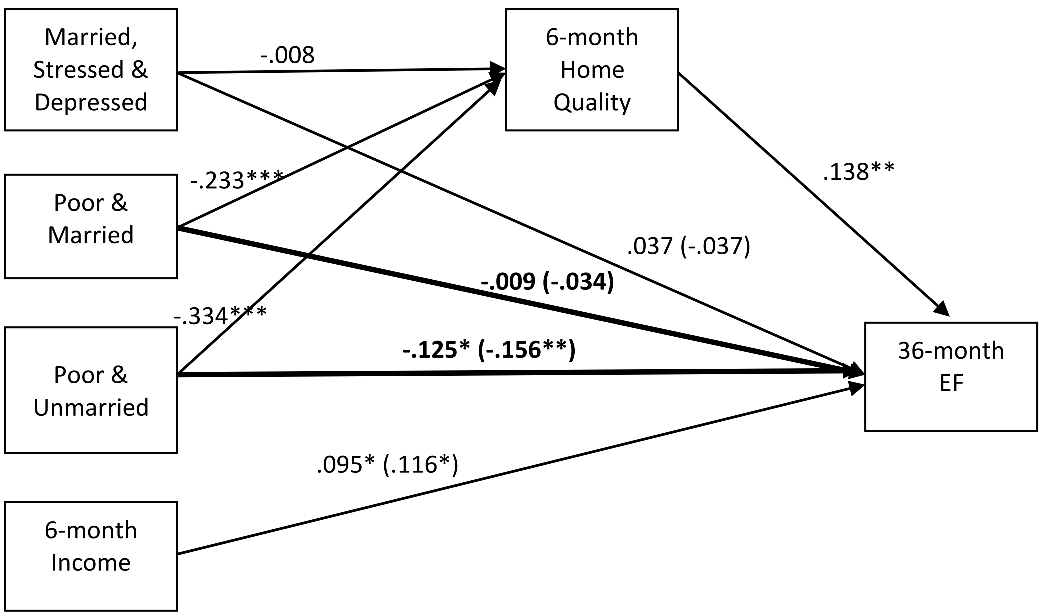

Figure 1 Standardized estimates for path model with 6-month home quality as a mediator of the association between risk profiles & 36-month EF skills in the PA/NC white sample.

The total score for the HOME is made up of three subscales measuring responsivity to the child, acceptance of the child, and presence of learning materials in the home. To determine which specific aspects of the home environment were mediators in the association between risk profiles and later EF skills, we examined each subscale in separate mediation models. For white children, responsivity was the only significant mediator of the association between any of the assigned risk profiles and EF skills. (Poor & Married: $t = -2.29$, $p <.05$; Poor & Unmarried: $t = -2.45$, $p < .05$).

Figure 2 presents the results of the mediation model with 6-month maternal positive engagement specified as the mediator. Again, membership in the poor risk profiles relative to the Married, Low Risk profiles was significantly, negatively associated with maternal positive engagement at 6 months. That is, children in the Poor & Married and Poor & Unmarried risk profiles were exposed to lower maternal positive engagement at 6 months, on average, in comparison to children in the Married, Low Risk profile. Positive engagement at 6 months was, in turn, positively associated with EF skills at 36 months, indicating that children exposed to greater maternal positive engagement were more likely to have higher EF skills. With maternal positive engagement in the model, the direct effect of Poor & Unmarried on EF skills remained significant, indicating a unique association with EF even after controlling for positive engagement. Using the Sobel (1982) test, we found that the mediated effects of maternal positive engagement at 6 months on the association between two of the three risk profiles and 36-month EF skills were significant (Poor & Married: $t = -2.62$, $p < .01$; Poor & Unmarried: $t = -2.84$, $p < .01$).

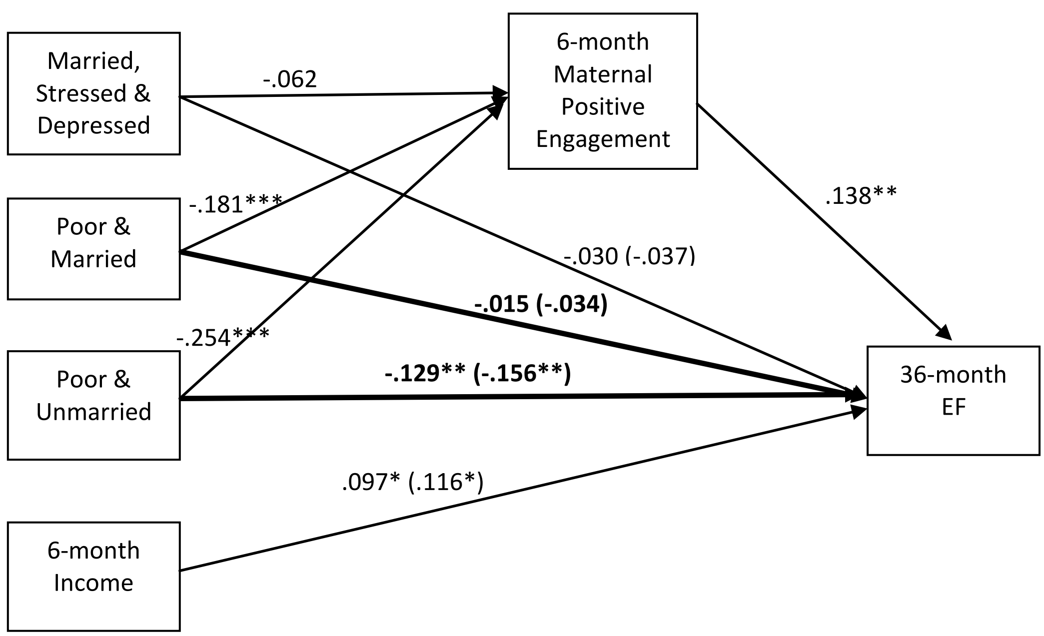

Figure 2 Standardized estimates for path model with 6-month maternal positive engagement as a mediator of the association between risk profiles & 36-month EF skills in the PA/NC white sample.

Figure 3 presents the results of the mediation model with 6-month maternal negative intrusiveness specified as the mediator. Membership in the two poor risk profiles relative to the Married, Low Risk profiles was significantly, positively associated with maternal negative intrusiveness at 6 months. That is, children in the Poor & Married and Poor & Unmarried risk profiles were exposed to greater maternal negative intrusiveness at 6 months, on average, in comparison to children in the Married, Low Risk profile. Negative intrusiveness at 6 months was, in turn, negatively associated with EF skills at 36 months, indicating that children exposed to greater negative intrusiveness were more likely to have lower EF skills. With maternal negative intrusiveness in the model, the direct effect of Poor & Unmarried on EF skills remained significant, indicating a unique association with EF even after controlling for negative intrusiveness. Using the Sobel (1982) test, we found that the mediated effects of maternal negative intrusiveness at 6 months on the association between two of the three risk profiles and 36-month EF skills were significant (Poor & Married: $t = -2.48$, $p < .05$; Poor & Unmarried: $t = -2.74$, $p < .01$).

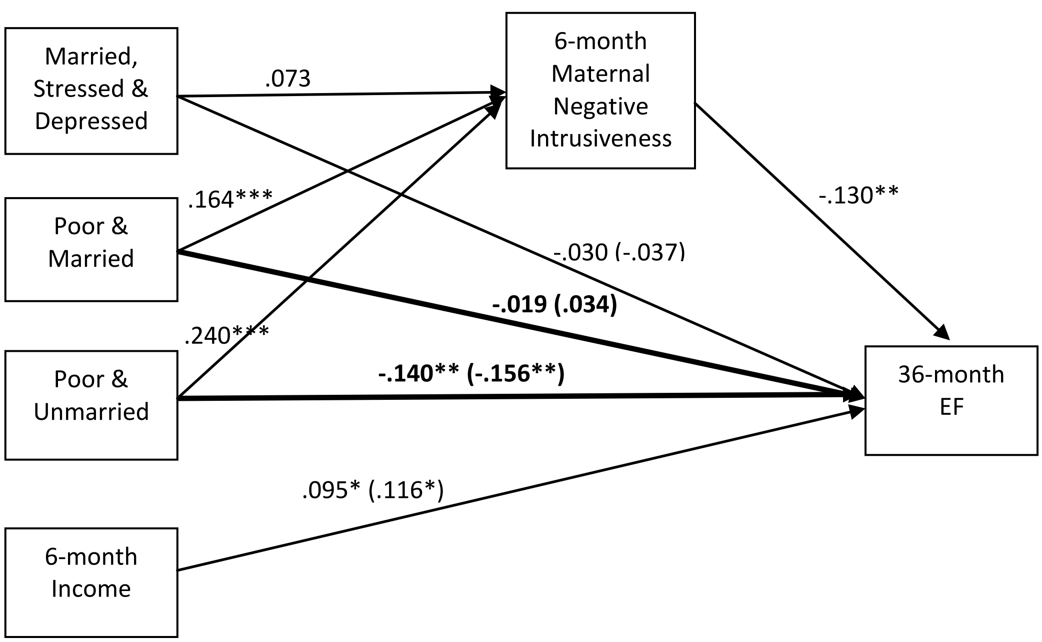

Figure 3 Standardized estimates for path model with 6-month maternal negative intrusiveness as a mediator of the association between risk profiles & 36-month EF skills in the PA/NC white sample.

Figure 4 presents the results of the mediation model with 24-month language skills specified as the mediator. Membership in each of the assigned risk profiles relative to the Married, Low Risk profiles was significantly, negatively associated with language skills at 24 months. Language ability at 24 months was, in turn, positively associated with EF skills at 36 months, indicating that children with higher language skills were more likely to also have higher EF skills. With language ability in the model, the direct effects of each risk profile on EF were non-significant suggesting that language mediated a significant proportion of the effect of risk profile membership and later EF. The Sobel (1982) test confirmed that the mediated effects of language ability at 24 months on the association between all risk profiles and 36-month EF skills were significant (Married, Stressed & Depressed: t =-4.65, p < .05; Poor & Married: t = -2.24, p <.05; Poor & Unmarried: t = -3.79, p < .001).

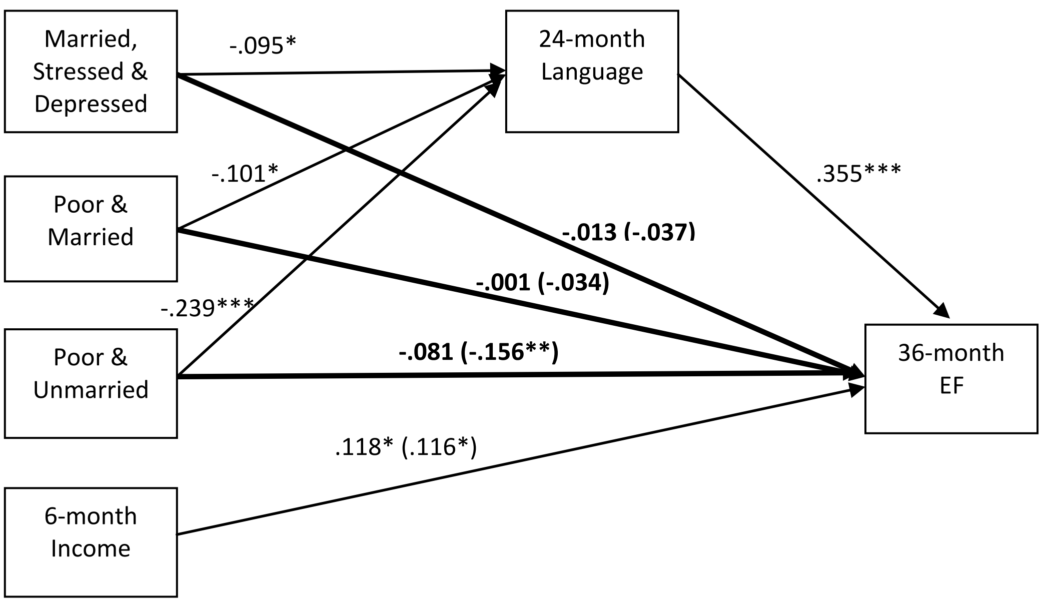

Figure 4 Standardized estimates for path model with children's 24-month language skills as a mediator of the association between risk profiles & 36-month EF skills in the PA/NC white sample.

M*ediation Results: NC AA.* Figure 5 presents the results of the model with 6-month HOME total score specified as a mediator for NC AA children. Membership in both single risk profiles (Poor & Single and Poor, Single, Multi-Problem) relative to the Married, Low Risk profiles, were significantly, negatively associated with overall quality of the home environment at 6 months. That is, children in the two single-parent profiles were exposed to lower quality home environments. Home quality at 6 months was positively associated with EF skills at 36 months. With home environment in the model, the direct effects of Poor, Single, Multi-Problem on EF skills remained significant, indicating a unique association with EF after controlling for home quality. The direct effect for Poor & Single was non-significant, suggesting significant mediation. The Sobel (1982) test found that the mediated effects of home quality at 6 months on the association between the both single-parent profiles and 36-month EF skills were significant (Poor & Single: $t = -2.55$ $p = .01$; Poor, Single, Multi-Problem: $t = -2.43$ $p = .02$). As in the white sample, when each subscale of the HOME was examined as mediators, results indicated that only responsivity was significantly related to EF skills for NC AA children (Poor & Single: $t = -2.17$ $p = .03$; Poor, Single, Multi-Problem: $t = -2.02$ $p = .04$).

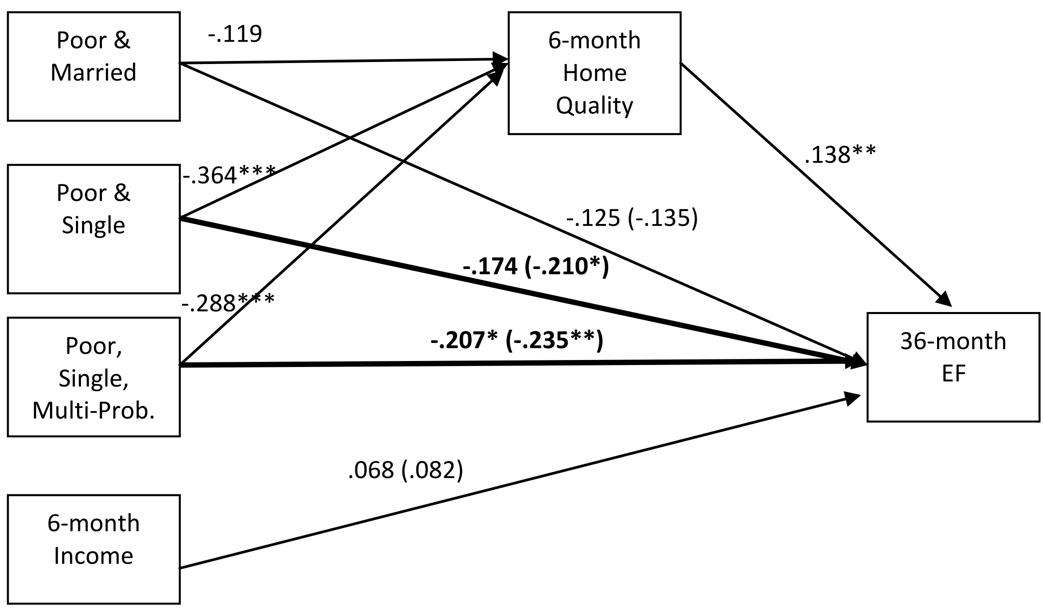

Figure 5 Standardized estimates for path model with 6-month home quality as a mediator of the association between risk profiles & 36-month EF skills in the NC AA sample.

We examined both maternal positive engagement and negative intrusiveness at 6 months as mediators of the association between membership in the risk profiles and later EF skills for NC AA children. They were entered in separate mediation path models; only maternal positive engagement was significant for the African American children. Figure 6 presents this model. Again, membership in both single risk profiles (Poor & Single and Poor, Single, Multi-Problem) relative to the Married, Low Risk profiles, was significantly, negatively associated with maternal positive engagement at 6 months. Positive engagement was, in turn, positively associated with EF skills at 36 months. With maternal positive engagement in the model, the direct effects for both single-parent profiles remained significant, again indicating unique associations between the single risk profiles and later EF skills after controlling for positive engagement. Using the Sobel (1982) test, we found that the mediated effects of maternal positive engagement at 6 months on the association between the two single-parent profiles and 36-month EF skills were significant (Poor & Single: $t = -2.63$ $p = .01$; Poor, Single, Multi-Problem: $t = -2.46$ $p = .01$). Finally, we entered language at 24 months as the mediator of the association between membership in the risk profiles and later EF skills and found that language was not a significant mediator of this association for NC AA children.

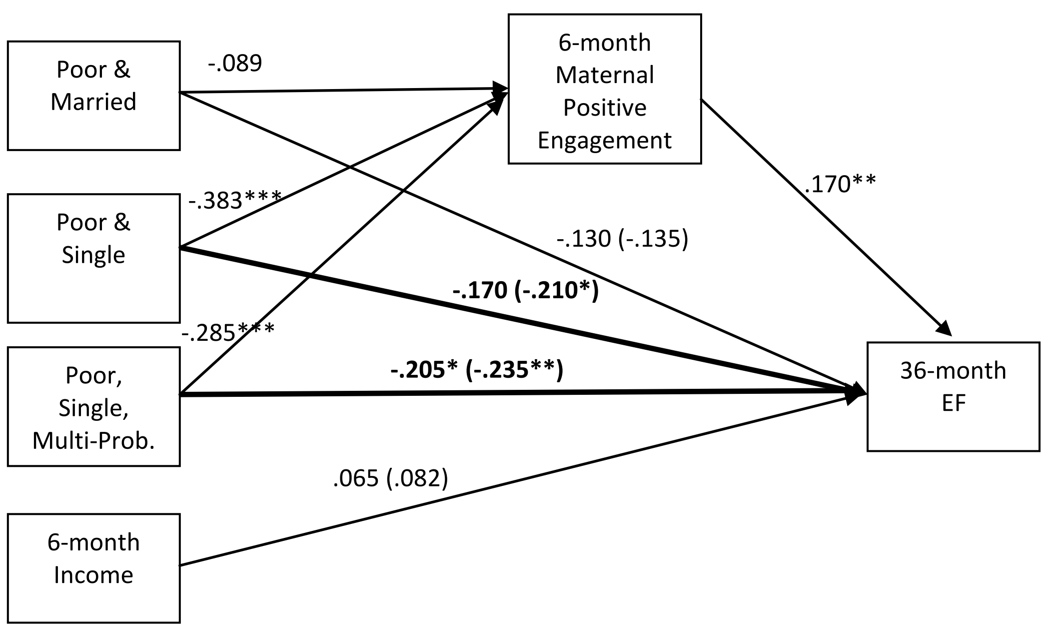

Figure 6 Standardized estimates for path model with 6-month maternal positive engagement as a mediator of the association between risk profiles & 36-month EF skills in the NC AA sample.

Chapter 4

Discussion

Although a large body of work has investigated the association between individual ecological risk factors and children's general intellectual ability (Downer & Pianta, 2006; Dilworth-Bart, Khurshid, & Vandell, 2007; Fearon & Belsky, 2004; NICHD ECCRN, 2003; 2004; 2005), few studies have specifically examined the role these factors play in the early development of executive function (EF) skills. Given both theory and empirical evidence that cites a protracted period of development for the brain areas associated with EF skills (Nelson et al., 2006), early experiences in the child's caregiving environment are likely to play an prominent role. The few studies that have examined the association between ecological risks and EF skills were mostly conducted with small samples, have not examined early EF development prior to school entry, focused mainly on how individual variables were concurrently associated with EF skills, and did little to explore the mechanisms that explain these associations (Hughes & Ensor, 2005; Noble et al, 2005, 2007; Mezzacappa et al., 2004). The present study extended and built upon the existing work in this area by addressing many of these limitations.

A Person-Centered Approach to Ecological Risk

By using an innovative, person-centered approach to characterize ecological risk, subgroups of families were identified within both white and African American non-urban samples that varied in poverty, family structure/composition, and levels of stress. In particular, this approach allowed us to identify the diversity that exists in families with married and unmarried mothers. Within the married families, we identified three distinct subgroups that varied in poverty, teen motherhood, crowded household, maternal mood problems, and life stress. We also found that these married profiles at 6 months varied on average levels of responsivity, acceptance, learning materials and maternal positive engagement and negative intrusiveness. Within the unmarried families, we identified three subgroups that varied in having a partner, smoking while pregnant, and levels of stress/support. As hypothesized, we identified a greater number of married profiles within the white sample (67% of white sample were married) and a greater number of single-parent profiles within the African American sample (60% of African American sample were single). The person-centered approach also allowed us to balance model complexity and parsimony. That is, of all 512 possible combinations between the nine risk factors, six profiles succinctly described ecological risk in this diverse sample of white and African American families. This is in part because risk often includes a number of factors that are not independent (e.g., single, poor, teen mother). As hypothesized, there were overlapping and unique profiles within and across site-race groups; two profiles were present in both white and African American samples (i.e., Married, Low Risk and Poor & Married), two profiles were unique to white children (i.e., Married, Stressed & Depressed and Poor & Unmarried), and two profiles were unique to African American children (i.e., Poor & Single and Poor, Single, Multi-Problem).

By using a person-centered approach, our findings advance the understanding of how ecological risks relate to children's EF development by providing a more nuanced look at higher-risk families. They also provide further support for recent research and theory, which suggests that there is substantial diversity in the developmental experiences and contexts of low-income children living in single and two-parent homes, within and across ethnic groups (Bradley et al., 2001; Dunifon & Kowaleski-Jones, 2002; Foster & Kalil, 2007; Garcia Coll et al., 1996; Murry, Bynum, Brody, Willert, & Stephens, 2001).

Ecological Risks & Executive Function Skills

The six family ecological risk profiles identified during infancy were meaningfully associated with EF skills over two years later when EF skills are just emerging. Like previous research, we found that socioeconomic risk was negatively related to children's EF skills (Hughes & Ensor, 2005; Mezzacappa, 2004; Noble et al., 2005; Noble et al., 2007). However, our findings extended this work in several important ways, which go beyond socioeconomic risk. First, by assessing ecological risk at both 2 and 6 months, we can conclude that characteristics of the child's earliest environment, beyond socioeconomic status, contribute to future EF. Second, by assessing EF at 36 months we extend downward previous work which focused on preschool and school-age children. Third, with a relatively large sample, we had the power to detect differences across ethnic groups. Finally, as opposed to conclusions regarding *individual* risks and their association with EF development, a person-centered approach allowed us to make conclusions regarding the EF performance of children exposed to various *combinations* of risks.

Specifically, results showed that EF skills at 36 months varied considerably across profiles in both white and African American samples. Although white and African American children within the Married, Low Risk profile consistently performed well on the EF tasks as expected, the most at-risk profiles varied by race. For white children, those who were members of the Poor & Unmarried profile during infancy consistently performed poorer on the EF tasks at 36 months in comparison to the children in the Married, Low Risk profile. For African American children, those who were members of either single-parent profile (Poor & Single or Poor, Single, Multi-Problem) during infancy performed equally poorly on the EF tasks at 36 months in comparison to the children in the Married, Low Risk profile. Overall, these findings confirmed our hypotheses that family ecologies during infancy would be significantly associated with future EF competence.

However, unlike previous variable-centered analyses that have focused solely on socioeconomic risk for poor EF development (Noble et al., 2007; Noble et al., 2005), the present study found that low income (i.e., poverty) alone was not sufficient in predicting EF skills. Instead, low income in combination with marital status was most consistently associated with later EF development. Regardless of race, children whose parents were unmarried (whether they were single or living with a significant other) and poor during their infancy had lower EF scores at 36 months in comparison to children whose parents were married and not poor. These findings provide further support for the link between family structure and children's development. Previous work has found that children from households with single (unmarried) parents have access to fewer economic and psychological resources (Carlson & Corcoran, 2001; McLanahan & Sandefur, 1994) and that compared to married parents, on average, they give less time and attention to their children, have weaker control, make fewer demands and exhibit lower levels of warmth toward their children (Astone & McLanahan, 1991; Amato, 1987). In turn, the lack of such resources has been associated with poorer academic, behavioral and social-emotional competence for children in single-parent families (Carlson & Corcoran, 2001; McLanahan, 1997; McLanahan & Sandefur, 1994; Smith, Brooks-Gunn, & Klebanov, 1997). Similarly, our findings suggest that the associations between family structure and children's outcomes may be mediated by the differentiated behaviors shown in the different risk profiles.

Several pathways or mechanisms have been proposed to help explain this negative association between single-parent contexts and children's developmental outcomes, one of which focuses on economic strain and its associated psychological distress (Brody, Murray, Kim, & Brown, 2002; Jackson, Brooks-Gunn, Huang, & Glassman, 2000; McLoyd, 1990). Although the present study does not address this relationship explicitly, our findings provide some support for this hypothesized mechanism. We found that African American children who were members of the Poor, Single, Multi-Problem profile, which was characterized by poor, single mothers with increased probabilities of mood problems (in combination with several other risks), performed much lower on the EF tasks at 36 months in comparison to children in the married, non-poor profiles that were not characterized by mood problems. A generalized association between maternal depression and children's poor outcomes was not supported in the present study, however. Similar to work by Petterson and Alber (2001), we found that the association between maternal depression and children's early cognitive skills does not operate in the same way in poor, single-parent and non-poor, two-parent contexts. Unlike children in the Poor, Single, Multi-Problem profile, white children who were members of the Married, Stressed, & Depressed profile characterized by married parents with increased probabilities of maternal mood problems (in combination with high stress) performed on par with those in the lower-risk, married profile (not characterized by maternal mood problems). Although this evidence is contrary to previous studies that have found negative associations between maternal depression and children's outcomes generally (Burt, Hay, Pawbly, Harold, & Sharp, 2004; Dodge, Pettit, & Bates, 1994; Gutman, Sameroff, & Cole, 2003), it reaffirms the importance of exploring how these associations vary within different family structures and contexts.

Because of the person-centered nature of the present analyses, it is important to note that we were unable to isolate the association between maternal depression and children's outcomes because our profiles captured the intersection of several risks. Therefore we cannot make specific conclusions regarding the association between maternal depression and children's skills per se. We can only make inferences regarding how subgroups of children who were exposed to maternal mood problems in combination with other risks varied on EF outcomes. Also, it is difficult to make direct comparisons between the Single, Multi-Problem and Married, Stressed and Depressed profiles as they were confounded with race. However, it is worth considering the differential impact maternal depression (in combination with other risks) has on children's development outcomes within single and two-parent contexts across ethnic groups in future research.

Although low-income appears to play a prominent role in the development of children's EF skills, it is worth noting that not all poor profiles in the present study were associated with the lowest EF outcomes. Unlike many studies where economic status is confounded with family structure, we identified one risk profile present in both ethnic groups that was characterized by poor, *married* mothers (Poor & Married). One may assume that economic risk in this context would also be associated with poorer outcomes for children, but our findings indicate that children in the Poor & Married profiles performed somewhere between those in the Married, Low Risk and the poor, unmarried/single-parent profiles. That is, both white and African American children in the Poor & Married profile appeared to have slightly higher EF scores than those in the poor, unmarried/single-parent profiles and slightly lower EF scores that those in the non-poor, married profiles. It appears that being a member of the Poor & Married profile conferred some benefit for EF skills in comparison to being members of the poor and single-parent profiles. It is possible that within a two-parent context, children are exposed to more cognitive stimulation through increased opportunities for communication and interactions with adults. Also, it is possible that the presence of two parents decreases children's exposure to the stress associated with being poor. In other words, within the context of poverty, having an additional caregiver in the home may buffer children against the potentially negative effects being poor has on EF development. These findings help us begin to disentangle income from family structure and suggest that income level, alone, does not completely explain the association between family structure and children's EF development. Instead, these findings suggest that income and marital status may simply be markers for more proximal processes.

Executive Function Task-Specific Relations. This study assesses EF at a very early age in which little research has been conducted. Although much debate remains as to how to operationalize EF in young children, new tasks developed by Blair & Willoughby that were used here appeared to better capture both individual differences and developmental change than tasks used in previous work with young children (Blair et al., under review; Blair & Peters, 2003; Carlson, 2005; Wiebe, Espy, & Charak, 2008). Our findings confirm that EF can be reliably measured with a composite score in children as young as three years old (Blair et al., under review; Blair & Peters, 2003; Hughes & Ensor, 2005). However, in addition to examining EF as a unitary construct, the present study also investigated working memory, inhibitory control, and set shifting tasks separately to determine if specific ecological risk profiles predicted individual components of EF differently. Findings clearly indicated that risk profiles were more strongly associated with performance on specific EF tasks and that these associations varied for white and African American children. For white children, it appeared that much of the link between ecological risks and later EF skills was a result of performance on the working memory and set shifting tasks, whereas for African American children performance differences by risk profiles were found on the inhibitory control and set shifting tasks. Several factors may account for these findings. It is possible that the EF tasks differ in their ability to detect individual differences in young white and African American children. That is, the working memory task (Operation Span) may have been too difficult for African American children (43% of African American children failed compared to 22% of white children) and the inhibitory control task (Spatial Conflict) may have been too easy for white children (90% of white children passed compared to 75% of African American children) and therefore these specific tasks may have been unable to accurately assess individual differences for children of different races. These results suggest that the EF tasks operated somewhat differently in the two samples. However, because African American children scored substantially lower on the EF tasks in general, compared to the white children (M = .36, SD = .18 for African American children and M = .50, SD = .21 for white children), it is difficult to disentangle overall ethnic differences from ability level on specific EF tasks. That is, we are unable to disentangle difficulty level of the task from the component being measured by the task (i.e., working memory, inhibitory control, set shifting). Therefore, any conclusions regarding how exposure to particular combinations of risks during infancy are differentially related to working memory, inhibitory control and set shifting abilities in white and African American samples are difficult to make using the present analyses. As only one task measured each component and tasks were administered in a uniform order for all children, we must remain cautious when interpreting these task-specific results because factors like fatigue and task difficulty may bias our conclusions. More experimental work may be useful here to disentangle these issues. Moreover, as all FLP children received the same EF tasks again at 4 and 5 years old, looking at future developmental patterns may be informative prior to further interpretation of these data.

Mechanisms in the Link between Ecological Risk & Executive Function Skills

Theory suggests that EF skills unfold as a result of the interaction between children and their social and physical worlds (Berstein & Weber, 2007; Luria, 1973; Vygotsky, 1962), but up to this point, few empirical studies have examined the specific processes that explain how ecological factors influence EF development. Our findings contribute to this work by investigating the role of parent-child interactions and children's language skills in this developmental process. As expected, we found that the associations between specific ecological risk profiles and later EF skills were partially mediated by several proximal processes, including the quality of parent-child interactions at 6 months and children's language skills at 24 months, even after controlling for income level.

Previous work highlights the role of high quality home environments and maternal sensitivity in the development of general cognitive abilities, academic achievement, and EF skills (Downer & Pianta, 2006; Dilworth-Bart et al., 2007; Fearon & Belsky, 2004; Hughes & Ensor, 2005; NICHD ECCRN, 2003; 2004; 2005; Noble et al., 2007). Additionally, in recent work from the FLP, Blair and collegaues found that both positive and negative parenting uniquely predicted a latent variable of EF, even after controlling for child's age and gender and maternal education (Blair et al., under review). Results from the present study confirm these findings and suggest that much of the negative influence of early demographic and familial risks on later EF development may be transmitted through low parental sensitivity and responsiveness to their children during infancy in high-risk contexts. For both site-race groups, maternal responsivity and positive engagement helped explain the association between the higher-risk profiles and poorer EF skills. That is, children who were members of the higher-risk profiles were exposed to poorer interactions with their mother (in comparison to children in the Married, Low Risk profile), which in turn were related to poorer EF skills. That is, lower sensitivity and responsiveness partially mediated the effect on lower EF. Maternal negative intrusiveness also helped explain this association, but only for white children. These results suggest that regardless of families' income levels, the ecological risk profiles that we identified, through association with proximal processes, influence the development of children's emerging EF abilities.

Overall, these findings reaffirm the critical role that caregivers play in children's development, particularly cognitive development. Through daily, social interactions, mothers, who are engaged and responsive to their infants, provide them with opportunities to learn about and develop their EF skills. Research suggests that there are two ways such parenting behaviors exert their influence on young children's developing cognitive capacities. First, through contingent, responsive interactions with their social world, infants recognize they can have an effect on their environment. Knowledge of this agency thus increases their motivation to learn how to control and interact with their external world, which may provide more chances to practice their EF skills. Second, through increased security that develops as a result of responsiveness, infants explore their environments more readily thereby increasing their access to and interaction with cognitively stimulating materials (Watson & Ramey, 1971; Bornstein & Tamis-LeMonda, 1997). It is likely, then, that the infants in the present study whose mothers were rated higher on positive engagement and responsivity were exposed to more supportive, interactive environments during infancy that stimulated and rewarded their cognitive advances, thus explaining their greater EF skills at 36 months.

Language ability was also a significant mediator in the association between early ecological risk and later EF, but only for the white sample. Although ecological risks were not related to language skills in the same way for white and African American children, we did find that for both ethnic groups, better language skills at 24 months were related to better EF skills at 36 months, as hypothesized. These findings coincide with several other studies that have found a moderate, positive association between young children's EF and language skills (e.g., Hughes & Ensor, 2005; Blair & Razza, 2007). They also support the theoretical work by Vygotsky and Luria who described language as a tool that children use to mediate intention and action, particularly in the regulation of their emotions, behaviors and cognitions (Luria, 1973; Vygotsky, 1962). Language may give children the space between their thoughts and actions that is needed to regulate their attention and impulses in an effortful way to accomplish goal-oriented tasks. In other words, children with better language skills may be more likely to utilize strategies like self-talk to successfully problem-solve and work through challenging tasks like those that require executive functions.

Ecological Risks & Race

Research and theory suggests that the meaning, salience and impact of risk factors vary by children's cultural background (Bradley, Corwyn, McAdoo, & Garcia Coll, 2001; Garcia Coll & Magnusson, 1999; Klimer, Cowen, Wyman, Work, & Magnus, 1998). For instance, theorists have suggested that the meaning of living in a single-parent household may vary by race (Dunifon & Kowaleski-Jones, 2002; Foster & Kalil, 2007). In one study, Dunifon & Kowaleski-Jones (2002) found that white children from single-parent homes had lower math skills and higher levels of delinquency in comparison to children from two-parent families. However, math ability and delinquency rates were unrelated to single-parent status for African American children. Given the high prevalence of single-parent, African American families, there may be greater diversity in the outcomes of African American children living in single-parent contexts. Based on this work, we hypothesized that not all single-parent profiles would be associated with poor EF outcomes, particularly for African American children. In other words, we would have expected that children in the Poor & Single profile, which was characterized by demographic and economic risks, but had low probabilities of high stress, maternal depression, and low social support would have fared better with regards to their EF development than children in the Single, Multi-Problem profiles. However, our findings indicated that membership in both single, African American profiles were associated with poorer EF skills. This finding might be explained by the similar low income levels within these single-parent profiles. Children in the Poor & Single profile were also exposed to similarly low levels of maternal responsiveness and positive engagement at 6 months, which may have also contributed to their low EF scores. It is also possible that although mothers did not report high levels of subjective life stress in the Poor & Single profile, they were in fact exposed to events that are generally perceived as quite stressful, which could negatively affect their children's cognitive development. We must be cautious when interpreting self-reported life stress, particularly in low-income, minority samples because they may have a different metric by which they measure stress relative to their life experiences. Previous work has shown that life event checklists like the one used in the present study have been shown to underestimate exposure to stress in minority populations (e.g., Turner & Avison, 2003). Another potential explanation is that because African American children scored low on the EF tasks, overall, differentiation of their EF skills may be difficult at this age. It is possible that measures of EF at older ages may better differentiate EF skills of children in these higher-risk, single-parent profiles for African American children. It should also be noted that the restriction in range of EF scores for the African American children may have hindered our ability to predict their EF skills.

Few studies have examined how mediators differentially explain the association between ecological risks and later development across ethnic groups (Bradley et al., 2001; Bradley & Corwyn, 2003; Feldman & Masalha, 2007). Those that have investigated how race moderates these associations generally find that there are far more similarities than differences across ethnicities (Bradley et al., 2001; Bradley & Corwyn, 2003). Bradley and colleagues, however, report that the associations between experiences within the home environment and children's developmental outcomes are generally stronger in magnitude for non-poor European American children than poor minority children. They conclude that this provides further evidence that processes typically measured to assess the quality of children's experiences within the home may be less culturally relevant for ethnic minorities.

The present study is the first, to our knowledge, to examine how the specific proximal processes explaining the associations between ecological risks and children's EF outcomes vary across ethnic groups. Despite the similar relations that were observed between poor, unmarried profiles and poorer

EF outcomes across site-race groups, we found some differences in the processes that accounted for these associations. For instance, although the quality of parent-child interactions played an important role in the association between early ecological risk and later EF for both races, positive engagement, not negative-intrusiveness, appeared to play a significant role in this association for African American children, whereas positive engagement *and* negative intrusiveness were important for white children. For African American children, maternal negative intrusiveness and EF skills were unrelated. That is, regardless of the level of maternal negative intrusiveness African American children were exposed to at 6 months, their EF skills at 36 months appeared to be unaffected. These findings support theories on the differential impact of parenting strategies on children's developmental outcomes within families of different cultural backgrounds (Garcia Coll et al., 1996; McLoyd, Hill, & Dodge, 2005). Several studies have shown that African American parents are more likely to use "no nonsense" parenting, which is characterized by high levels of parental control (including physical punishment) within the context of a warm parent-child relationship (Brody & Flor, 1998; McLoyd, 1990). Typically this more authoritarian parenting style has been associated with poorer developmental outcomes for children; however, there is less support for this relationship within African American samples, particularly those living in disadvantaged, economically strained neighborhoods (e.g., Steinberg, Darling, & Fetcher, 1995).

It is also interesting to note that the proximal processes that mediated the association between ecological risk and later EF skills varied across specific risk profiles for white and African American children. For instance, for white children, the association between membership in the poor profiles (Poor & Married and Poor & Unmarried) and EF skills was consistently mediated by the proximal processes describe above (maternal responsiveness, positive engagement, and negative intrusiveness). However, the association between membership in the Married, Stressed and Depressed profile and later EF was only significantly mediated by language skills for the white children. For the African American children, mediation was most consistent for the link between membership in the poor, single-parent profiles (Poor & Single and Poor, Single, Multi-Problem) and EF skills. In the case of the Poor & Married profile for the African American children, the lack of mediation was due, at least in part, to the non-significant association between membership in this profile and all of the mediators. African American children who were members of the Poor & Married profile appeared to differ little from children in the Married, Low Risk profile on levels of home quality, parent-child interactions, and language skills. As discussed in the section above, this suggests that having married parents may provide a buffer against some of the negative effects associated with poverty, at least for African American children.

Another significant difference across site-race groups emerged for the meditational role of children's 24-month language skills. Language ability was a significant mediator in the association between early ecological risk and later EF for the white sample, but not the African American sample. Previous work has demonstrated the importance of children's language in the association between ecological risks and later cognitive development (NICHD, 2004; Noble et al., 2005; Noble et al., 2007). Given this and other research that shows the importance of early environmental experiences in the development of children's language abilities (Pungello, Iruka, Dotterer, Mills-Koonce, & Reznick, 2009; NICHD ECCRN, 2000), we expected ecological risks during infancy to be negatively related to language skills at 24 months for both white and African American children. Although this was the case for white children, the ecological risk profiles for the African American sample did not significantly vary on their language skills. That is, African American children in the Married, Low Risk profile had similar levels of language ability as compared those children in the higher-risk, single-parent profiles. These findings may reflect the unique experiences African American children have in single-parent contexts in comparison to white children. The range of risk and protective factors associated with different family structures vary considerably across races (e.g., Dunifon & Kowaleski-Jones, 2002; Foster & Kalil, 2007). Research suggests that poor, single African American mothers are more likely to have access to outside resources and social support associated with multigenerational, extended family networks (Hill, 1972). This additional support may also be reflected in increased numbers of adults within the household, which may benefit children's outcomes through greater access to positive interactions, including more language-rich interactions with adults.

Prevention Implications

Previous research showing the associations between EF skills and later competencies across both social-emotional and academic domains solidifies the importance of EF as a potential target for intervention (Blair & Razza, 2007; Espy et al., 2004; Hughes, 1998; Rhoades et al., 2009; Riggs, et al., 2006). Despite its importance, however, very few interventions have specifically targeted and measured their impact on children's EF skills. Results from evaluations of three school-based cognitive and social-emotional curriculums for preschoolers have demonstrated positive impacts on children's EF development (Bierman et al., 2007; Diamond, 2007; Riggs, Greenberg, Kusche, & Pentz, 2006). These studies suggest that preschool curriculum-based preventive interventions have the potential to improve young children's EF skills, but less is known about how family-based interventions may influence EF development. Results from the present study suggest that the early home environment may prove to be an especially fruitful context for the promotion of future EF skills. Specifically, findings from the present study have implications for both the specific subgroups of children and family and child processes that should be targeted in the promotion of young children's EF development.

One proposed strategy for more efficiently allocating limited prevention resources is to target those groups who are at the most risk for future problems (e.g., Collins, Murphy, & Bierman, 2004). Instead of identifying individual variables associated with more risk, on average, the present study used a person-centered approach to identify subgroups of children exposed to varying combinations of demographic and familial risks early in infancy that were shown to vary in level of EF skills two years later. With this more nuanced picture of ecological risks, prevention scientists and policy makers may be able to more accurately and efficiently target intervention resources to the children and families in most need of these services. Results from the present study suggest that for white children, interventions aimed at promoting EF skills should target families with poor, unmarried parents (with or without a live-in partner), whereas for African American children, families with poor, single, unmarried parents (regardless of levels of maternal depression, stress or support) should be targeted. These findings align well with targeted preventive interventions like the Nurse Family Partnership that aims to recruit poor, unmarried mothers with the goal of improving outcomes for both mother and child (Olds et al., 2004).

Additionally, results from the mediation analyses suggest that maternal responsivity and engagement may be important parent-child processes to target for interventions aimed at promoting EF development in these at-risk groups. Although we cannot specify causal links in the present study, recent evidence from one family-based intervention suggests that children's EF skills can be enhanced through improved parenting behaviors. In a randomized evaluation of the Family Check-Up, a brief intervention based on motivational interviewing for high-risk families, Lunkenheimer et al. (2008) found that children's improvements in inhibitory control skills from 3 to 4 years old occurred as a result of the intervention's positive impact on parents' positive behavior support (controlling for child gender, ethnicity and parental education). In other words, parents who were randomly assigned to receive the intervention demonstrated greater positive behavioral support (positive reinforcement, engaged interactions, proactive parenting), which in turn lead to children's improved inhibitory control skills one to two years later. This along with evidence from the present study indicates that positive parenting behaviors, including positive engagement and responsivity, should be emphasized in prevention programs aimed at improving young children's EF abilities.

Despite the racial differences found in the role of language as a mediator of the link between ecological risk and later EF, language skills may still be an important target for preventive interventions as well. Several language-based interventions designed to increase young children's language skills through structured, high quality verbal interactions with parents and/or teachers have found positive effects on expressive language and early literacy skills (Madden, O'Hara, & Levenstein, 1984; Whitehurst et al., 1994; Whitehurst et al., 1999). However, none of these interventions measured their impact on EF skills. Results from the REDI (Research-based, Developmentally Informed) preschool intervention provide some evidence of an intervention with specific language and early literacy components that has demonstrated a positive impact on EF skills (Bierman et al., 2008). It would be interesting in future analyses for studies like this to examine if intervention effects on EF skills can be at least partially explained by improvements in children's language skills.

Limitations and Future Analyses

The aforementioned conclusions must be tempered by several important limitations associated with the sample, measures, and analytic strategies used in the present study. First, although representative of the regions in which they were drawn, participants in this study were limited to non-urban Appalachian and Black Southern regions of the United States. Non-urban white and African American children and families, like those in the present study, have been underrepresented in child development research and therefore are important populations to study (Dill, 2001; Morris & Monroe, 2009). However, despite the contribution this study makes in furthering our knowledge of this understudied population, it is important to recognize that the conclusions drawn from our analyses may not generalize beyond this population. Second, because all African American families were drawn from North Carolina and nearly all white families were drawn from Pennsylvania, it is impossible to disentangle the effects of geographic location from the effects of race. Third, because of the unbalanced nature of our sample (i.e., n = 468 African American children, n = 687 white children) our ability to detect differences across the risk profiles for the African American sample may have been limited due to reduced power. Therefore any conclusions regarding ethnic differences should be interpreted with caution. Fourth, because of the longitudinal nature of these analyses, attrition is also a limitation. Although a relatively small group (13%), those families who were not present at the 36-month visit appeared to be more at-risk (e.g., more likely to have a single mother, have a mother who is unmarried, have a mother with less than a high school diploma, and have a mother who smoked while pregnant) and therefore longitudinal analyses may include a slightly more advantaged sample. Future analyses should utilize modern missing data techniques, like multiple imputation, to account for these effects. Although these are legitimate limitations of the present analyses, problems of generalization like these are not unique to this type of analysis. Regardless, it will be important in future analyses to replicate these findings with a more nationally representative sample of both urban and non-urban children of different ethnicities from various geographical regions to disentangle site and race and to determine if the associations between ecological risks and EF generalize to other samples.

Generalization issues may also arise due to the sensitivity of the LCA models to changes in risk indicators and sample characteristics. Like other data-driven models, the subgroups derived from LCA are sensitive to the size and characteristics of the sample used in the analysis. Also, the addition or elimination of risk factors may result in changes to the number and interpretation of the risk profiles derived from the LCA model. One important domain of risk that was not accounted for in the present study was the genetic risk for poor EF development. It is possible that mothers with poor EF skills provide poorer quality home environments and interact with their infants in a way that limits their EF development. Therefore, future analyses should incorporate measures of mothers EF abilities in order to determine if the link between ecological risks, parent-child interactions, and EF remain after controlling for the genetic influence in children's EF development. Another important limitation was our decision to focus on the measurement of risk at only two time points (i.e., 2 and 6-month home visits). Many of the constructs may be better represented by variables that reflect stability or instability across several occasions. Future research should consider examining risk indicators like family structure (e.g., single-parent status) and maternal depression across time to determine if stability or instability of risk differentially predicts children's EF outcomes. Finally, another important dimension of the family structure, particularly in poor, African American families, that was not included in the present study is presence of additional adults in the home, other than romantic partners. Kellam and colleagues have documented the ameliorative effects the presence of grandmothers in single-parent households has on mental health outcomes for poor, urban, African American children (Kellam, Esminger, & Turner, 1977). Future work should include indicators that characterize the types of other adults that are present in the child's early environment in order to better capture variations in single-parent ecologies.

Another possible limitation to the present study was our treatment of the ecological risk profiles. Firstly, we chose to dichotomize all measures of ecological risks, including three that were originally continuous. Although it might seem undesirable to transform variables on a continuous scale into categorical variables, there is a long history of conceptualizing risk in this way (e.g., Rutter, 1979; Farrington & Loeber, 2000). Also, it is generally easier to think about the presence or absence of a risk factor for a particular child or family as opposed to exposure to a certain level of risk along a continuum. This is especially true when considering a large number of risk factors, like in the present study. Although we believe our chosen cut points were justified by logical or already established criteria for most measures, we acknowledge that choosing alternative cut points may have resulted in different conclusions. Secondly, we chose to use a classify/analyze strategy as our primary approach to examine the association between ecological risk profiles and later EF skills. This decision was made because of the complexity of statistical models required to address the research questions involving mediating variables. A model-based approach to examining the relation between risk profiles and later EF skills is limited because predicting an outcome from a latent independent variable is not straight-forward. The classify/analyze approach, however, is limited in that classification error is not modeled. To the extent that individuals' posterior probabilities of membership in each class diverge from zero and one, the measurement error associated with assigning children to risk profiles can bias inference. However, because average posterior probabilities were very high and the overall pattern of associations between risk profiles and EF skills were replicated using the LCA framework (where classification error is modeled), we have increased confidence that results using the classify/analyze approach are reasonable.

Conclusions & Contributions

The study of EF skills, particularly in young children, has received increased scholarly attention in recent years due to studies linking its development with a wide variety of positive academic and social outcomes. However, few studies place this process within one of the most important developmental contexts for young children, the home environment. Despite the acknowledged importance of children's early experiences in their developing cognitive and regulatory abilities, there is a dearth of empirical research examining how ecological factors influence the emergence of EF skills. Through the use of an innovative, person-centered approach to characterizing ecological risk, the present study addressed this gap and made three key contributions.

First, through the use of a new lens (person-centered approach) to the study the intersection of multiple risk factors, this study found that specific combinations of risks (namely, low-income and unmarried/single-parenthood) are more strongly associated with poor EF outcomes in comparison to individual risks, regardless of race. Second, mediation analyses enabled us to identify the specific proximal processes (maternal engagement and responsivity and children's language ability) that help explain why more distal demographic and familial risks are associated with future EF skills, thus improving our understanding of the important developmental pathway from ecological risks to EF skills. Finally, investigating these associations in a large, ethnically diverse sample of young children and their families, gave us the unique opportunity to model the diversity within and across profiles of single/unmarried and married families in both white and African American samples, thus revealing several important commonalities and differences in these processes. Overall, this study provides an important first step toward elucidating the complex relations between children's earliest experiences in the home and their future EF development and if replicated, may lead to more effective targeting of scarce early intervention resources to those at greatest risk for EF deficits.

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Footnotes

[1] Two additional EF tasks designed to measure inhibitory control were administered to children at the 36-month visit. One task was similar to other “Go, no-go” tasks and required children to push a button for one stimulus and inhibit pushing the button for a second stimulus. The other task was similar to Diamond’s Day/Night task and required children to say ‘meow’ to pictures of cats and ‘woof’ to pictures of dogs. Due to missing data problems and concerns about the validity of these data, these two tasks were not included in the present analyses.

[2] To test measurement invariance, we used the G-squared difference test for two nested models: 1) the 5-class model with measurement constrained to be equal across the PA white and NC white groups (i.e., the equal measurement model), and 2) the 5-class model with measurement allowed to vary across the PA white and NC white groups (i.e., the free measurement model). According to the G-squared difference test, the two models were significantly different ($p < .001$). However, in cases like the present where the difference in degrees of freedom is quite large (i.e., 50), Collins and Lanza (in press) suggest that the G-squared difference test may not be accurate and therefore it is important to also consult the AIC and BIC. In our case, the AIC was slightly lower for the free-measurement model (860.97 vs. 869.77) and the BIC was substantially lower for the equal-measurement model (1132.65 vs. 1350.46), suggesting partial measurement invariance When there is statistical support for two models, Collins and Lanza (in press) recommend choosing the more parsimonious model, which in our case is the equal-measurement model.

[3]To examine the fit of the 6-class model, we examined the G-squared and information criteria (i.e., AIC and BIC) for a series of five 6-class models with varying parameter constraints: Model 1) model with measurement constrained to be equal across the white and African American groups (i.e., the equal measurement model), Model 2) model with measurement allowed to vary across the white and African American groups (i.e., the free measurement model), Model 3) Model 1 with prevalences fixed

to zero for the Married, Stressed & Depressed and Poor & Unmarried profiles for the African American group and the Poor & Single profile for the white group, Model 4) Model 2 with prevalences fixed to zero for the Married, Stressed & Depressed and Poor & Unmarried profiles for the African American group and the Poor & Single profile for the white group, and Model 5) Model 3 with smoking allowed to vary across white and African American groups for the Single, Multi-Problem profile. In concert with above, we used the G-squared difference test to explore measurement invariance across the white and African American groups.

The G-squared difference test between Model 1 and 2 found that they were significantly different ($p < .001$). The AIC was slightly lower for Model 2 (i.e., the free model), but the BIC was substantially lower for Model 1 (i.e., the equal model). Similarly, the G-squared difference test between Model 3 and Model 4 found these two models were significantly different ($p < .001$). Like above, the AIC was slightly lower for Model 4 (i.e., the free model) and the BIC was slightly lower for Model 3 (i.e., the equal model), suggesting partial measurement invariance. For both comparisons, the equal measurement models appeared to provide a good balance between model fit and parsimony and therefore were preferred over the free measurement models. Finally, because the G-square statistic, AIC and BIC were lower for Model 5 in comparison to Model 4, Model 5 appeared to provide a significantly better fit than Model 4 and therefore was chosen for the final 6-class model.

[4] An alternative strategy for examining the relations between ecological risk profiles and EF skills is through a LCA framework (Lanza et al., 2007). Like in the classify/analyze approach, results yielded in the LCA framework found some evidence that the greatest risk for overall EF deficits was associated with membership in the Poor & Unmarried risk profile for white children, and membership in either single risk profile (Poor & Single or Poor, Single, Multi-Problem) for the African American children. Details for the results of these analyses are presented in Appendix B.

Appendix A

Site-Race Specific LCA Models for PA White and NC White

In the PA white sample (*n* = 461), we considered LCA models with 1-5 classes. The 2-class model had the lowest BIC and the 5-class model had the lowest AIC (see Table A1). The 2-class model provided an overly simplistic view of risk with one married, low-risk class and one partnered, unmarried higher-risk class (poor, teen mother, mood problems, smoked while pregnant). In the 3-class model, the low-risk class remained and the higher-risk class broke into two classes; one single-parent class and one partnered, unmarried class. In the 4-class model an additional married class with mood problems emerged. In the 5-class model the classes from the 4-class model re-emerged along with an additional partnered, unmarried class. Since this second partnered, unmarried class only represented 6% of PA white children, it did not significantly add to the conceptualization of risk and therefore we chose the more parsimonious, 4-class model. See Table A2 for the item-response probabilities and class prevalences for the PA white 4-class model.

In the NC white sample (*n* = 226), we considered LCA models with 1-4 classes. The 2-class model had the lowest BIC and the 4-class model had the lowest AIC (see Table A1). Similar to the PA white sample, the 2-class model showed one married, low-risk class and one partnered, unmarried class with a variety of risks (poor, teen mother, crowded household). In the 3-class model, an additional married class emerged that was characterized by being poor, maternal mood problems, high stress, and low social support. In the 4-class model, the partnered group split into a poor, single-parent class and a more risky partnered, unmarried class (poor, teen mother, no high school diploma, smoked while pregnant, crowded household). We chose the 4-class model because it presented a more nuanced model of risk as compared to the 3-class model and it more closely resembled the classes we identified in the PA white sample. See Table A3 for the item-response probabilities and prevalence rates for the NC white 4-class model.

After comparing the classes that emerged from the PA and NC white samples, we found that most classes were conceptually similar. For example, both had two married classes, one of which was low-risk and the other which was characterized by maternal mood problem as well as elevated risk in other areas (e.g., high stress, low social support). They also both had a partnered, unmarried class with a variety of overlapping risks (e.g., poor, teen mother, smoked while pregnant). Finally, they both had a poor, single-parent class. Although in comparison to the PA white sample, the single-parent class in the NC white sample appeared to have fewer risks, it is important to note that this class did have elevated (i.e., item response-probabilities close to .50) rates of similar risks (e.g., teen mother, smoked while pregnant).

Table A1 Fit Statistics for the PA White and NC White Site-Race Specific LCA Models.

No. of Classes	G sq.	df	AIC	BIC
PA White (N = 461)				
1	1105.57	1013	1125.57	1166.91
2	543.89	1002	585.89	672.69
3	479.78	991	543.78	676.05
4	419.89	980	505.89	683.62
5	384.74	969	492.74	715.94
NC White (N = 226)				
1	564.99	1013	584.99	619.19
2	374.03	1002	416.03	487.86
3	320.61	991	384.61	494.06
4	286.59	980	372.59	519.67

Note. AA = African American. G sq. = G-square statistic; df = degrees of freedom; AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria. Lower AIC, BIC indicates more optimal model fit.

Table A2 PA White: Item-Response Probabilities and Prevalence Rates for the 4-Class Model.

	Risk Profile			
Risk Factor	Married, Low Risk	Married & Depressed	Poor, Partnered, Unmarried w/ Probs.	Poor, Single, Multi-Prob.
Poverty	.11	.11	**.58**	**.81**
Single	.00	.00	.00	**.80**
Unmarried	.08	.02	**.61**	**.95**
Teen Mother	.06	.28	**.72**	**.64**
No HS Diploma	.00	.00	.22	.45
Mood Problems	.10	**.66**	**.56**	**.58**
Smoked While Pregnant	.07	.12	**.62**	**.53**
High Stress	.04	.43	.18	**.52**
Low Social Support	.00	.47	.13	.39
Crowded House	.03	.19	.41	.19
Class Membership Probabilities	39%	18%	23%	21%

Note. Item-response probabilities over .50 are bolded.

Table A3 NC White: Item-Response Probabilities and Prevalence Rates for the 4-Class Model.

	Risk Profile			
Risk Factor	Married, Low Risk	Poor, Married, Stressed & Depressed	Poor, Partnered, Unmarried w/ Probs.	Poor & Single
Poverty	.17	**.64**	**.72**	**.78**
Single	.01	.09	.00	**.94**
Unmarried	.07	.00	**.55**	**1.00**
Teen Mother	.24	.44	**.91**	.42
No HS Diploma	.03	.08	**.59**	.47
Mood Problems	.20	**1.00**	.27	.09
Smoked While Pregnant	.10	.43	**.51**	.44
High Stress	.09	**1.00**	.20	.27
Low Social Support	.09	**.56**	.29	.29
Crowded House	.17	.23	**.67**	.31
Class Membership Probabilities	61%	9%	19%	11%

Note. Item-response probabilities over .50 are bolded.

Appendix B

Results for Association between Risk Profiles and EF Skills Using the LCA Framework

To examine the association between risk profiles and EF skills within the latent class model, we incorporated EF as a covariate of risk profile membership using Proc LCA (Lanza et al., 2007). Multinomial logistic regression was used to obtain a set of logistic regression coefficients, which were transformed into odds ratios that describe the relation between risk profiles and EF performance (Bandeen-Roche, Miglioretti, Zeger, & Rathouz, 1997; Chung, Flaherty, & Schafer, 2006; Dayton & Macready, 1988). The odds ratios were estimated within each group, allowing us to examine how the relations between risk profiles and EF vary across PA/NC white and NC AA groups. Because risk profile membership is latent, we only know the probability that each child belongs to each risk profile. For this reason, in these analyses risk profile membership must be treated as the dependent variable and 36-month EF abilities must be treated as the independent variable or covariate. Like in regression analyses where the standardized association between two variables is the same regardless of which variable is entered as the independent or dependent variable, reversing the independent and dependent variable does not affect the underlying relations among the variables. As in any correlational analyses, causal order is largely dependent on theory rather than the statistical approach and therefore we believe the labeling of risk profiles as the dependent variable and 36-month EF as the independent variable is only statistically relevant. Theoretically, because the risk profiles represent risk at 2 and 6 months and the EF measures represent the children's abilities several months later at 36-months-old, we will refer to EF as an outcome rather than a covariate below.

Table B1 presents the odds ratios associated with membership in each risk profile (relative to the Married, Low Risk profile) given EF performance on the composite EF score (mean total percent correct across three tasks) for both site-race groups. To facilitate interpretation, we reversed (so that higher scores indicates poorer EF skills) and standardized the EF scores (M = 0, SD = 1). In this case, the odds ratios represent the increased odds of being a member of a particular risk profile during infancy compared to the Married, Low Risk profile, corresponding to a one standard deviation decrease in EF at 36 months. For example, White children have 1.1 increased odds of being a member of the Poor & Unmarried risk profile during infancy compared to the Married, Low Risk profile, corresponding to each one-unit decrease in EF mean total percent correct at 36 months.

For the white children, EF mean total percent correct was most strongly associated with membership in the Married, Stressed & Depressed risk profile, with children scoring one standard deviation below the mean having 1.2 increased odds of membership in this risk profile compared to the Married, Low Risk profile for white children. Children in the Poor & Married and Poor & Unmarried profiles were also at greater risk for EF deficits, relative to children in the Married, Low Risk profile. For African American children, the EF composite score was most strongly associated with membership in the Poor, Single, Multi-Problem risk profile. African American children scoring one standard deviation below the mean for the total mean percent correct score had 1.9 increased odds of membership in this risk profile compared to the Married, Low Risk profile. Membership in the Poor & Single profile was also associated with increased odds of lower scores on the EF composite score, relative to the Married, Low Risk profile.

Table B1 also shows the odds ratios associated with membership in each risk profile given EF performance on the individual EF tasks for both site-race groups. For both white and African American, children, risk profile membership was not significantly related to performance on the Operation Span task. For Spatial Conflict, poorer performance was associated with the highest odds of membership in the Married, Stressed & Depressed and Poor & Unmarried risk profiles for white children and membership in the Poor, Single, Multi-Problem and Poor & Married risk profiles for the African American children. For Something's the Same, poorer performance was associated with the highest odds of membership in the Poor & Unmarried risk profile for white children and membership in the two single risk profiles for the African American children.

Table B1 Odds Ratios for 36-month EF Outcomes by Site-Race Group.

	Risk Profile					
36m EF Outcome	Married, Low Risk	Married, Stressed & Depressed	Poor & Married	Poor, Unmarried w/ Probs.	Poor & Single	Poor, Single, Multi-Prob.
EF Mean Total % Correct (Reverse Scored) (N = 934; p < .001)						
PA/NC White	ref	1.22	1.15	1.14	---	---
NC AA	ref	---	1.58	---	1.65	1.86
Operation Span % Correct (Reverse Scored) (N = 838; p = ns)						
PA/NC White	ref	1.39	1.26	1.39	---	---
NC AA	ref	---	1.40	---	1.42	1.71
Spatial Conflict % Correct (Reverse Scored) (N = 858; p < .05)						
PA/NC White	ref	1.32	1.23	1.33	---	---
NC AA	ref	---	2.31	---	1.76	2.16
Something's the Same % Correct (Reverse Scored) (N = 863; p < .001)						
PA/NC White	ref	1.26	1.45	1.85	---	---
NC AA	ref	---	1.63	---	2.00	1.86

Note: For each row, ref indicates the reference class in the logistic regression model; p-values represent overall relation between risk profile membership and 36-month EF outcome based on log-likelihood difference test; dashes indicate that odds ratios were not calculated because the prevalence rate for that profile was set to zero or was too small to analyze for that site-race group.

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