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Demographic and Familial Predictors of Early Executive Function Development: Contribution of a person-centered perspective

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Abstract

Executive function (EF) skills are integral components of young children's growing competence, but little is known about the role of early family context and experiences in their development. We examined how demographic and familial risks during infancy predicted EF competence at 36 months in a large, predominantly low-income sample of non-urban families from Pennsylvania and North Carolina. Using latent class analysis, six ecological risk profiles best captured the diverse experiences of these families. Profiles with various combinations of family structure, income, and psychosocial risks were differentially related to EF. Much of the influence of early risks on later EF appears to be transmitted through quality of parent-child interactions during infancy. Findings suggest that early family environments may prove to be especially fruitful contexts for the promotion of EF development.

Keywords

executive function; risk; person-centered; low-income; parent-child interactions

Early childhood is characterized by dramatic brain growth and accompanying improvements in physical, social-emotional, and cognitive development (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 provides one of the building blocks for future well-being (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 regulatory abilities and have been implicated in the development of both social-emotional

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and academic competence (Blair & Razza, 2007; Espy et al., 2004; Hughes, 1998; Rhoades, Greenberg, & Domitrovich, 2009; Riggs, Jahromi, Razza, Dillworth-Bart, & Muller, 2006).

Despite the acknowledged importance of children's early environments for learning and self-regulation (Shonkoff & Phillips, 2000), relatively little is known about specific relations between aspects of children's early family context and the emergence of EF skills (Carlson, 2003). As is evidenced by the prefrontal cortex's (the brain area associated with EF development) prolonged period of development and neural plasticity across the early childhood years, ecological factors have the potential to play an important role in EF development (Huttenlocher, 2002; Nelson, Thomas, & de Haan, 2006). Parents not only provide children with the physical environment to facilitate development, but provide them with daily opportunities to develop their cognitive, linguistic, emotional, and self-regulatory skills (Gauvain, 2001). Given the central role of parenting and the dearth of research examining the influence of ecological factors on children's early EF development, this study explores how demographic and familial characteristics relate to the emergence of EF skills and the role of parent-child interactions and children's language skills.

Executive Function during Early Childhood

EF is a multidimensional construct that encompass a set of higher-order, top-down cognitive processes, which are elicited when flexible, coordinated, goal-directed behavior is needed to solve a problem (Hughes & Graham, 2002; Welsh et al., 1991). Distinct from other more general cognitive abilities, EF is composed of three related, but distinct components including working memory, inhibitory control, and attention flexibility or set shifting (Blair, 2006; Hughes, 1998; Pennington & Ozonoff, 1996; Welsh, Pennington, & Groisser, 1991). 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). Overall, 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).

EF skills emerge during the first year of life and develop in a gradual, stage-like fashion from reactive to more self-regulatory behaviors throughout early childhood (Diamond, 1991; Garon, Bryson, & Smith, 2008; Welsh & Pennington, 1988). EF development occurs 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 some EF abilities emerge before age five, these skills remain quite immature and can often only be applied in *very* simple and controlled testing context that reduce other aspects of cognitive and emotional load (Anderson, 2002; Best, Miller, & Jones, 2009; Willoughby, Blair, Wirth, Greenberg, & the Family Life Project Investigators, in press). Zelazo and colleagues' Cognitive Complexity and Control (CCC) theory suggests that across early childhood, children are increasingly able to use more complex rules to guide their actions toward successful problem-solving (Zelazo, Muller, Frye & Marcovitch, 2003).

Although research consistently shows that young children have difficulty with various aspects of EF (Diamond, Kirkham, Amso, 2002; Diamond & Taylor, 1996; Gerstadt, Hong, & Diamond, 1994; Zelazo et al., 2003), as children enter the preschool years, their ability to accomplish more complex affective and cognitive problems increases and becomes more consistent and flexible across different contexts (Garon et al., 2008). Therefore, examining EF at the beginning of the preschool period provide an opportunity to explore the emergence of individual differences in EF skills.

Ecological Factors Influencing Early Cognitive Development

Although numerous studies suggest that family structure and the quality of the home environment play important roles in the development of school readiness, cognitive development, and self-regulatory skills (Downer & Pianta, 2006; Kopp, 1991; NICHD Early Child Care Research Network, 2003; 2004; 2005), relatively few directly examine how ecological factors influence EF development. Some studies have shown a positive relationship between socio-economic status and EF skills (Mezzacappa, 2004; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005), and consistent with research that shows positive associations between adverse environmental experiences and frontal lobe deficits (Raine, 2002), a link between EF deficits and more severe adverse rearing environments has also been established (Beers & DeBellis, 2002; Lewis, Dozier, Ackerman, & Sepulveda-Kozakowski, 2007). However, only a few studies have examined specific contextual processes that might explain associations between these distal factors and EF development. One exception is Hughes and Ensor (2005, 2007) who found that positive parenting (composite of interviewer ratings and observations of positive control, responsiveness and talk) predicted better EF skills in a sample of primarily low-income, 2-year-old children, but this association became non-significant when verbal skills were accounted for. More recent work highlights the role of parental scaffolding, independent of more general child skills including language and intelligence (Bernier, Carlson, & Whipple, 2010; Bibok, Carpendale, & Muller, 2009; Hughes & Ensor, 2009). Despite these advances, it is clear that there is a need for further investigation into the specific ecological antecedents that contribute to individual differences in EF development (Carlson, 2009).

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 family structure, vary by ethnicity above and beyond socioeconomic differences (Bradley, Corwyn, Burchinal, McAdoo, & Garcia Coll, 2001; Klimer, Cowen, Wyman, Work, & Magnus, 1998). 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; Garcia Coll & Magnusson, 1999). For instance, Dunifon & Kowaleski-Jones (2002) found that 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. Similarly, Berger et al. (2008) found that maternal employment during the child's infancy was only negatively related to later child receptive vocabulary skills for white children, not African American or Hispanic children. For these reasons, the present study explores how the relationship between ecological risks and children's later EF skills varies as a function of race.

Methodological Approaches to Understanding How Ecological Factors Affect Development

To date the majority of developmental and risk factor research has been based on a variable-centered approach (Magnusson & Bergman, 1988) and research on EF development is no exception. Despite the well-established legacy of variable-centered methods in the field of developmental psychology, implicit in this framework are assumptions (e.g., there are no unidentified subgroups within the population) that may limit its value (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. In general, variable-centered frameworks have found that the accumulation of risks, rather than any single risk factor, accounts for the preponderance of negative developmental outcomes (Rutter, 1979; Sameroff, Seifer, Baldwin, & Baldwin, 1993). Although it is statistically possible to examine higher-order interactions within a variable centered framework, there is limited statistical power to so (Magnusson & Bergman, 1990), which often results in the conclusion that specific combinations of risks are no more predictive of outcomes than a the total number of risks.

In contrast, the person-centered approach has increased statistical power to detect the complex, interactional nature of the multiple factors that contribute to children's development and therefore is aimed at identifying particular constellations of characteristics that describe sub-groups of children (Laursen & Hoff, 2006; Magnusson & Bergman, 1990). 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). In a person-centered approach, the significance of any one ecological factor gains meaning only in so far as 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, which aligns well with contemporary, holistic theories of human development (Bergman, Cairns, Nilsson & Nystedt, 2000; Lerner, 2006). 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.

Latent class analysis (LCA; Goodman, 1974; Lazarsfeld & Henry 1968) is one person-centered approach which 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. 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, in press; Parra, DuBois, & Sher, 2006). With LCA, one can model complex interactions among multiple risk factors and identify a set of mutually exclusive and exhaustive latent classes, referred to as risk profiles herein.

The Current Study

Here we utilize person-centered profiles of demographic and familial risks during infancy and examine how membership in these risk profiles predicts later individual differences in EF skills at 36 months. To accomplish this goal, we first identify a model of ecological risk profiles at 2 and 7 months old.

After establishing the model of risk profiles we examine differences in how profiles are related to 36-month EF outcomes. Because of the established association between children’s language skills and EF, we covaried 24-month language skills in our examination of the association between risk profiles and EF. Although much of this person-centered work is exploratory and descriptive in nature, we hypothesize that similar to past work, low-income profiles are likely to be associated with poorer EF outcomes in general (Mezzacappa, 2004; Noble et al., 2007; Noble, et al., 2005). However, because there is likely to be variability among the structure and experiences of low-income families, we predict that low-income status in combination with other risks (e.g., low maternal education, maternal depression) will be associated with greater risk of poor EF outcomes. We hypothesize that profiles including two-parent families 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 hypothesize that profiles characterized by single-parent status and few other risks will be associated with better EF outcomes.

Finally, we will examine the potential role of parent-child interactions in mediating the relation between early risk profiles and 36-month EF performance, controlling for family income and children's language skills. Given recent work highlighting the role of parenting behaviors in young children's EF development (Bernier et al., 2010; Bibok, et al., 2009; Hughes & Ensor, 2009), we hypothesize that 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 and child's language skills. That is, children in higher-risk profiles will be exposed to lower quality interactions with their mothers which in turn will be related to lower EF skills.

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 sampling design to recruit a representative sample of 1292 children whose mothers resided in these 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).

The Present Study—Because we were interested in demographic and psychosocial characteristics of the biological mothers during children's infancy, the sample here was limited to 1155 families where the biological mother completed both the 2- and 7-month home visits (N = 694 were from NC and 461 from PA.). Approximately 60% of mother s were white and 40% were African American and about half the children were male. Mother's age at the 2-month data collection was 25.9 (SD = 5.8) years old. Of the 13% of the original sample not present at 36-months, attrition analysis showed that of the 10 risk factors included in the present models, significant differences were evident for only three: those missing were more likely to have a mother who was single, had less than a high school diploma, and smoked while pregnant. Also, those not present at the 36-month visit were more likely to be from NC.

As site and race were confounded in this sample, (of the NC families, the majority (67%) of children were African American, whereas in the PA families all children were white), results presented below will be reported by site-race groups.

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-, 7- and 24-month visits and on one occasion for the 36-month visits. Interviewers collected survey and observational data on the mother and target child during visits that lasted approximately 2–3 hours. The survey data was recorded using laptops and observational data was videoed for later coding. For a detailed description of sample selection and data collection procedures, see Crouter, Lanza, Piretti, Goodman, & Neebe (2006).

Measures: Ecological Risk Factors

All risk factors were coded as dichotomous indicators (e.g., 0 = risk factor not present, 1= risk factor present). The following strategies were used to create the cut points: 1) logical cut-offs (e.g., 0 = less than high school diploma, 1 = high school diploma or higher), 2) already established cut-offs (e.g., 1.5 for income-to-needs ratio) or 3) the bottom/top quartile approach (for continuous variables). See Table 1 for descriptives of the risk factor variables by site-race groups.

Household Income (Poverty)—At the 7-month visit, mothers reported the total household income from all sources. Persons were considered to be a member of the household if they spent the night at the home at least three days per week. The income-to-needs ratio was calculated by dividing this number by the 2004 federal poverty threshold, adjusted for size of household. An income-to-need ratio of 1.00 or greater indicated that the family income was at or below the poverty level, adjusted for family size. Families with greater than 1.5 income-to-needs ratio were coded as at-risk.

Marital Status—Mothers who reported being unmarried were coded as at-risk.

Partner Status—Mothers reported if there was a spouse or other partner that lived in the house. Those who reported no spouse *or* live-in partner were considered unpartnered (i.e., no partner) and therefore coded as at-risk.

Teen Mother—Mothers reported the age at which they gave birth to their first child. We defined a teen mother as someone who had her first child at 19 years old or younger.

Maternal Education—Mothers reported the number of years of education completed at the 2-month visit. Mothers with less than a high school diploma or GED were coded as at-risk.

Maternal Depression—Two measures of maternal depression were used. To assess current symptoms, mothers completed the Brief Symptom Inventory-18 (BSI-18; Derogatis, 2000) at the 2- and 7-month visits. This short, self-report screening index for psychological distress contained 18 items assessing three dimensions: somatization, depression, and anxiety. We used the Global Severity Index (GSI) which sums scores from the three scales and then created a combined average score across the 2-and 7-month visits. To asses a history of mental illness, at the 2-month visit, mothers reported if they had ever been told by a doctor or other medical professional that they had depression or other mental illness. The maternal depression risk variable was created using the 'or' rule; mothers who scored at the 75^{th} percentile or higher on the BSI-18 composite (a score of 51 or higher) *or* who reported being diagnosed with depression or another mental illness were coded as at-risk.

Prenatal Smoking—Mothers reported on prenatal smoking at the 2-month visit by indicating if they had ever smoked (any amount) during the course of their pregnancy (0 = never smoked, 1 = smoked at least once). Mothers who reported ever smoking during pregnancy were coded as at-risk.

Life Stress—At the 2-month visit, mothers completed the Life Experiences Survey (LES; Sarason, Johnson & Siegel, 1978). The LES assessed presence of 49 positive and negative events that have the potential to affect family functioning. Respondents indicated 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 was high (alpha = .80). Here, the sum of weighted negatives was used and a score at the 75^{th} percentile or higher (a score of 10 or greater) was coded as at-risk.

Social Support—At both 2 and 7 months, mothers completed a modified version of the Questionnaire of Social Support (Crnic & Greenberg, 1987). This 16-item measure likert measure assessed social support satisfaction on subscales related to community involvement, friendship, family, and intimate relationships. Here, a composite of the family and intimate relationships subscales was used at 2 and 7 months. Families who scored at the 25^{th} percentile or lower were coded as at-risk.

Crowded Household—Mothers reported the total number of adults and children living in the home at 2 months. Persons who spent the night at the house for three or more days per week were considered household members. They also reported the number of rooms in the home. A ratio of people to rooms was computed to serve as a proxy for residential density (Evans, Saegert, & Harris, 2001). Families who scored at or above the 75^{th} percentile were coded as at-risk.

Outcome Measures: Executive Function

Interviewers administered EF tasks at the 36-month home visit with flipbooks in a quiet space with minimum distractions. One home visitor administered the task to the child (i.e., the examiner), while the other visitor recorded the child's responses with a laptop computer (i.e., the scorer). The tasks were also videotaped so that a certain percentage could be coded for reliability purposes (see Willoughby et al., 2009 for further details).

EF was assessed with three tasks modeled on tasks previously used successfully with young children[1]. These included a span-type *working memory* measure in which children had to hold in mind two pieces of information simultaneously and activate one while overcoming interference from the other; a spatial conflict *inhibitory control* task in which a pattern of stimulus specific responding is established which had to be overridden; and an item selection *attention flexibility* or set shifting measure in which children attended to one dimension (e.g., size) along which 2 items are similar and then were asked to identify a second dimension (e.g., shape) along which a new item was similar to one of the two original items. All tasks were scored as percent correct responding.

In the *working memory* task, children were presented with a line drawing of an animal figure above which was a color dot. Both the animal and color dot were located within the outline of a house. After establishing that the child knew both colors and animals in a pretest phase, the examiner asked the child to name the animal and then to name the color. The examiner then flipped a page containing only the outline of the house to cover the page with the animal and the color dot. The examiner then asked the child which animal was/is/lives in the house. In all, there were 11 trial items. The task required children to perform the operation of naming and holding in mind two pieces of information simultaneously and to activate the animal name while overcoming interference occurring from naming the color.

[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.

The spatial conflict *inhibitory control* task was a Simon task similar to that used by Gerardi-Caulton (2000) and Diamond, Barnett, Thomas, & Munros (2007) in which children alternate same-side and opposite side responding to line drawings of a toy car and a toy boat. A response card with a picture of the car was placed in front of the child on the right and a picture of the boat was placed in front of the child on the left. Next, the examiner flipped pages on which were printed pictures of the car or the boat in either the same side or the opposite side position. The child was asked to point to the shape on their response card that corresponded to the picture in the flipbook. Children were presented with 16 same-side trials and then were presented with 16 intermixed same-side and opposite-side trials. Percent correct responding on opposite-side trials was used for analysis. This task was preceded by a pretest phase in which children responded to centrally presented line drawings (a sun and a star) to left (sun) and right (star) targets.

The item selection *attention flexibility* task was modeled on the Flexible Item Selection Task developed by Jacques and Zelazo (2001). In the version of the task developed for flipbook administration, children were first presented with a page on which there were two line drawn items that were similar in terms of shape, size or color. The examiner drew the child's attention to the dimension along which the items were similar, stating "See, here are two pictures. These pictures are the same, they are both (cats, blue, big, etc.)". The examiner then flipped a page which presented the same two items again, to the right of which was a dashed vertical line and a picture of a third item. The new third item was similar to one of the first two items along a second dimension that was different from the similarity of the first two items. That is, if the first two items were similar in terms of shape, the third item would be similar to one of the first two items in terms of either size or color. When the new, third item was presented to the child, the examiner stated to the child, "See, here is a new picture. The new picture is the same as one of these two pictures. Show me which of these two pictures is the same as this new picture." This task was preceded by a pretest in which children demonstrated knowledge of color, shape, and size. Percent correct responding on 14 trials was used for analysis.

EF Scoring—As is standard for EF measures (Zelazo, 2006), children were required to successfully complete pretest trials for all tasks in which they clearly demonstrated knowledge of the rules for the task and the ability to successfully complete the pretest trials as instructed. Children were also required to complete 75% of test trials in a given task in order to receive a score for that task. Of 1,105 children administered the EF tasks, 764 successfully completed the working memory span task, 795 successfully completed the attention flexibility task, and 866 successfully completed the spatial conflict inhibitory control task. In addition to the individually measured components (i.e., working memory, inhibitory control, attention flexibility), EF has also been conceptualized as one overall construct and tasks from this battery have previously been demonstrated to have one underlying factor (Willoughby et al., in press). Therefore, we created a composite EF score that encompassed all three EF tasks by taking the mean percent correct responding across the three EF tasks described above. Total percent correct scores for the tasks were significantly, moderately related with correlations ranging from .20–.34 in the present sample. Children received the composite score if they had summary scores on at least one of the EF tasks.

Measures: Mediation Variables

Parent-Child Interactions—At 7 months, the mother and infant were videotaped during a 10-minute, free-play interaction. In the procedure mothers were given a set of toys and instructed to play with their children as they normally would (Cox, Paley, & Burchinal, 1999; NICHD ECCRN, 1999). The interactions were 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'.

Previous reports indicated that the coding captures two broad parenting constructs: positive engagement and negative intrusiveness (Garrett-Peters, Mills-Koonce, Adkins, Vernon-Feagans, & Cox, 2008). Maternal positive engagement (α=.89) was 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 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). The intra-class correlation for ratings made by two coders to approximately 30% of the tapes were acceptable for both negative intrusiveness (r = .88) and positive engagement (r = .80). Positive engagement and negative intrusiveness were moderately, negatively related (r = -.34).

Language Skills—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 (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 was as follows: First, LCA was used to identify and describe family ecological risk profiles. The demographic and familial risk factors measured at the 2 and 7 months were used as the observed indicators for the LCA model. All LCA analyses were conducted using PROC LCA Version 1.2.4 (Lanza et al., 2010), a SAS® procedure for conducting LCA. PROC LCA is available for download free of charge at http://methodology.psu.edu/. Second, using a classify/analyze approach, information from the LCA model was used to assign children to risk profiles and the mean differences in EF scores were examined across these risk profiles. To account for the association between children’s EF and language skills, we covaried 24-month language skills in our examination of the association between risk profiles and EF. Partial η^2 was calculated to determine the effect sizes for the impact of risk profile membership on EF development. Finally, we specified path models to explore parent-child interactions (positive engagement and negative intrusiveness) as mediators in the association between membership in the risk profiles and later EF skills.

Results

Descriptive Statistics

Table 1 shows the percentage of children who were classified as at-risk for each risk factor and the mean EF score for each site-race group. Significant differences were found between site-race groups for all risk factors except for high stress[2]. Specifically, more NC African American children were poor, were living in single-parent households and crowded households, had unmarried parents, had a teen mother, had low social support, and had

[2]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.

mothers who were less likely to have smoked during pregnancy, as compared to both the PA and NC white children. For most ecological factors, similar percentages of PA and NC white children were classified at-risk. However, more PA white children had a mother with mood problems as compared to NC white children and more NC white children had unmarried mothers and lived in a crowded household as compared to PA children. One-way ANOVA results indicated significant mean EF differences among the three groups. Tukey's post-hoc tests found that NC African American children had lower scores than both the PA and NC white children on overall EF skills and PA white children scored higher on average than both NC groups.

In sum, there were significant site-race differences in the prevalence of early risk factors and 36-month EF performance between the NC African American children and the white children, with a greater percentage of NC African American children being exposed to early risk factors and showing the poorest EF outcomes. In comparison to the differences found between the NC African American and white children, relatively few differences were found between PA and NC white children.

Identifying Latent Classes of Risk

LCA was used to identify subgroups of individuals characterized by unique combinations or profiles of ecological risk factors. We incorporated site-race into the risk profile model as a grouping variable to compare the prevalence of each latent class across groups. For each model, multiple sets of starting values were specified to assess model identification. We used the G-squared test statistic, information criteria (i.e., AIC, BIC), and model interpretability to guide model selection. Two sets of parameters were estimated in LCA: 1) the prevalence of each risk profile for each site-race group, and 2) item-response probabilities for each risk factor given latent class. Item-response probabilities indicate the probability of exposure to a risk factor given membership in a particular risk profile. For a thorough introduction to LCA we refer the reader to Collins and Lanza (2010).

We first conducted separate LCA models within each site-race group to understand the risk profiles that were unique to or common across site-race groups and to ensure that the final model adequately reflected risk profiles that emerged in the group-specific analyses. Because initial models demonstrated that PA and NC white children were similar in number and composition of risk profiles, we combined them for further analyses. Overall, the site-race specific LCA models demonstrated the need for both overlapping and site-race specific classes. Next, we combined the site-race groups and conducted LCA models with the full sample to obtain an overall model of risk. We considered models with 1–7 classes with item-response probabilities constrained to be equal across the two site-race groups to ensure that the risk profiles could be interpreted the same way across groups. We selected a 6-class model based on the criteria described above[3] (see Table 2).

Parameter restrictions were employed to fine tune the final model to best reflect the risk profiles. Because two of the classes were unique to the white families and one was unique to the NC African American families, we constrained certain latent class prevalences to zero within each group. By constraining these prevalence rates to be zero, we are essentially saying that these classes do not exist for the specified site-race group. We also allowed the

[3]The 5-class model had the lowest BIC and the 7-class model had the lowest AIC. In the 5-class model, three married classes (one low risk and two higher risk classes), one poor, single-parent class, and one poor, single-parent with no partner class emerged. In the 6-class model, an additional poor, multi-problem single-parent, no partner class emerged. In the 7-class model, the single, multi-problem class split into two classes with one having a high school diploma and the other not. 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.

item-response probability for smoking while pregnant to be estimated differently in the white and NC African American groups (African Americans had lower rates of smoking). Table 3 presents the final parameter estimates for the 6-class model and shows the six profiles that emerged in the final, full-sample model. 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, one of which was poor (i.e., below the poverty threshold) and two which were not poor (i.e., above the poverty threshold). 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 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, approximately half of the sample. For the African American children, only 11% belonged to the Married, Low Risk profile. It should be noted that only a third of NC African American children had married parents. The next profile, *Married, Stressed & Depressed* included approximately 12% of white children. This married group had increased probabilities of having a mother with mood problems and high levels of stress. As noted above, the prevalence for this risk profile was set to zero for the NC African American children.

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 African American groups (11% and 17%, respectively). In addition to poverty, children from this 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, labeled *Poor & Unmarried*, was set to zero for the NC African American children, but nearly a quarter of white children lived in ecologies with high poverty, a teen mother at her first birth, and a mother who smoked while pregnant. They were about equally as likely to have a parent with a partner (i.e., not married, but had a significant other) as without (i.e., not married with no significant other). The fifth profile, *Poor, Unmarried & No Partner* contained nearly half of the NC African American children. Despite being exposed to some demographic risks (i.e., poverty, single-parent, unmarried mother, teen mother), this profile had very low probabilities of other risks. The prevalence for the fifth risk profile was set to zero for the white children. Finally, the sixth risk profile, *Poor, Unmarried & No Partner, Multi-Problem*, was characterized by a host of demographic and familial risks including increased probabilities of being poor, having a single mother, having a teen parent, having a mother with mood problems, and being exposed to high stress and low social support. For white children, increased probability of having a mother who smoked while she was pregnant was also a risk factor. For the African American children, Poor, Unmarried & No Partner, 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 the least prevalent risk profile with only 5% of the children belonging to this group.

Relations between Risk Profiles & 36-month Executive Function Outcomes

To examine the association between the early risk profiles and 36-month EF abilities, we employed a classify/analyze approach using the LCA model results to assign each child to the profile in which they had the highest posterior probability[4] (see Lanza et al., 2010). The average posterior probabilities of membership in this study, ranging from .74-.91 for the white profiles and .82-.89 for the African American profiles, was high (Nagin, 2005), and the proportions of children assigned to each risk profile closely corresponded to the prevalence estimates in the LCA model suggesting that little classification error was introduced by using a classify/analyze strategy (see Figure 1). Because only 3% of the white

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sample was assigned to the Poor, Unmarried & No Partner, Multi-Problem profile and preliminary analyses indicated large standard errors for this group, we did not consider this group for the white children in the remaining analyses.

General linear models were estimated to identify mean differences in the EF composite score across risk profiles within each sample, controlling for 24-month language skills. Table 4 presents the adjusted means and standard errors for the EF composite variable (mean total percent correct) for each assigned risk profile by site-race groups. Risk profile membership was a significant predictor of EF skills for both white and NC African American children, with small to medium effect sizes ($F = 2.42$, $p = .047$, $\eta^2 = .02$; $F = 4.57$, $p = .004$, $\eta^2 = .04$, 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 African American children assigned to the Married, Low Risk profile had significantly higher overall EF scores than the children assigned to any of the three higher-risk profiles (Poor & Married; Poor, Unmarried & No Partner; and Poor, Unmarried & No Partner, Multi-Problem).

Next, we estimated general linear models for risk profiles predicting each of the three EF tasks individually, adjusted for language skills. Table 5 shows the adjusted means and standard errors (adjusted for 24-month language skills) for the three EF tasks for each of the assigned risk profiles by site-race group. Risk profile membership was only a significant predictor of scores on the attention flexibility task for the white children ($F = 3.65$, $p = .006$, $\eta^2 = .03$), with children assigned to the Married Low, Risk or Married, Stressed & Depressed profiles scoring significantly higher than children assigned to the Poor & Unmarried risk profile. Otherwise, white children scored similarly on the working memory and inhibitory control tasks, regardless of risk profile membership. For NC African American children, risk profile membership approached significance in the prediction of all three EF tasks (Working Memory: $F = 2.26$, $p = .082$, $\eta^2 = .02$; Inhibitory Control: $F = 2.51$, $p = .059$, $\eta^2 = .02$; Attention Flexibility: $F = 2.17$, $p = .092$, $\eta^2 = .02$). Overall, NC African American children assigned to the Married, Low risk profile scored significantly higher in comparison to children assigned to the higher-risk profiles (Poor & Married; Poor, Unmarried & No Partner; Poor, Unmarried & No Partner, Multi-Problem).

In summary, these results suggest that for white children, membership in either of the married profiles (regardless of other risks) conferred the greatest protection from poor EF; whereas for the NC African American children, only membership in the most positive environment (Married, Low Risk) was related to better EF in comparison to the higher-risk profiles (regardless of marital status). Although there were notable task-specific differences between site-race groups, the patterns within site-race groups were generally similar to those for the EF composite. Moreover, previous work with these tasks suggests one underlying EF factor (Willoughby et al., in press) and therefore we chose to use the EF composite variable in all further analyses.

Mediation Analyses

The final analysis investigated the role that quality of parent-child interactions had in the relations between early risk profiles and later EF abilities. To do this, we dummy-coded the

[4]An alternative strategy for examining the relations between ecological risk profiles and EF skills is through a LCA framework (Lanza et al., 2010). 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, Unmarried & No Partner or Poor, Unmarried & No Partner, Multi-Problem) for the African American children.

assigned risk profiles (with Married, Low Risk as the reference group) and used them as categorical predictors in mediation analyses. First, we examined descriptive statistics for the variables in the mediator models for each risk profile and tested for mean differences between profiles using ANOVA with Tukey's post-hoc comparisons. The top half of Table 6 shows the means and standard deviations for these variables for each risk profiles for the PA/NC white sample. White children in the Married, Low Risk profile experienced greater maternal positive engagement than those children in other risk profiles, with the exception of Married, Stressed & Depressed. White children in the Married, Low Risk profile were also exposed to lower levels of intrusiveness than children in the Poor & Married or Poor & Unmarried risk profiles. For language skills, children in the Married, Low risk profile had higher abilities at 24 months, but only in comparison to those children in the Poor & Unmarried risk profile. Income levels at 7-months were highest for the families of white children in the Married, Low risk profile, followed by Married, Stressed & Depressed and finally families of children in the Poor & Married and Poor & Unmarried profiles.

The bottom half of Table 6 shows the means and standard deviations for the NC African American sample. Children in the Married, Low Risk and the Poor & Married profiles were exposed to higher levels of engagement as compared to the two single-parent risk profiles. Children in the two married profiles were exposed to lower levels of intrusiveness than children in the Poor, Unmarried & No Partner profile, but not significantly lower than children in the Poor, Unmarried & No Partner, 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 with children in the Married, Low Risk profile being from families with significantly higher income at 7-months than children in any other profiles, and children in the Poor & Married profile having higher income than those in either single-parent risk profile.

Next, we examined the correlations between the EF composite and each mediator, income, and children's language skills (see Table 7). Despite the differences in the levels of the mediator variables described above, the correlations were quite similar across site-race groups. For both white and African American samples, children who were exposed to higher levels of maternal positive engagement, children's language skills, and household income were more likely to have higher EF skills at 36-months with the strongest association between the children's language skills and EF. For the white, but not African American children, greater maternal negative intrusiveness was related to lower EF skills.

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 36-month EF, and the mediators were specified to predict EF. We used full-information maximum likelihood estimation in AMOS 16.0, which uses all available information to account for missing data. Due to the positive association between household income and language with EF abilities, income (measured at the 7-month visit) and 24-month language were included as covariates. To determine if the effect of membership in each of the risk profiles on EF was significantly mediated by quality of parent-child interactions, we used Sobel's test (1982). Separate mediation models were run for the white and the NC African American samples because groups were comprised of different sets of risk profiles.

Mediation Results: PA/NC White—Figure 2 presents the results of the mediation model for 7-month maternal positive engagement and negative intrusiveness as mediators for PA/NC white children. Both mediators were included in the same model in order determine to what extent each aspect of parenting mediated the association between risk profile and EF abilities, controlling for the other aspect of parenting (Preacher & Hayes, 2008). Membership in the poor risk profiles relative to the Married, Low Risk profile was significantly, negatively associated with maternal positive engagement and positively associated with negative intrusiveness at 7 months. That is, children in the Poor & Married and Poor & Unmarried risk profiles were exposed to lower maternal positive engagement and higher negative intrusiveness at 7 months, on average, in comparison to children in the Married, Low Risk profile. Both mediators, in turn, were associated with EF skills at 36 months. Specifically, children exposed to greater maternal positive engagement and children exposed to lower negative intrusiveness were more likely to have higher EF skills. Using the Sobel (1982) test, we found that the mediated effects for both maternal positive engagement (Poor & Married: $t = -1.98$, $p = .05$; Poor & Unmarried: $t = -2.07$, $p < .05$) and for negative intrusiveness (Poor & Married: $t = -2.01$, $p < .05$; Poor & Unmarried: $t = -2.14$, $p < .05$) at 7 months were uniquely significant for the Poor & Married and Poor & Unmarried risk profiles.

Mediation Results: NC African American—Figure 3 presents the results of the mediation model for 7-month maternal positive engagement and negative intrusiveness as mediators for NC African American children. Membership in both single-parent risk profiles (Poor, Unmarried & No Partner and Poor, Unmarried & No Partner, Multi-Problem) relative to the Married, Low Risk profile, was significantly negatively associated with maternal positive engagement at 7 months and significantly positively associated with negative intrusiveness at 7 months. Positive engagement was, in turn, positively associated with EF skills at 36 months, whereas there was no significant association between negative intrusiveness and EF skills. Using the Sobel (1982) test, we found that the mediated effects of maternal positive engagement at 7 months on the association between the two single-parent profiles and 36-month EF skills were uniquely significant (Poor, Unmarried & No Partner: $t = -2.58$ $p = .01$; Poor, Unmarried & No Partner, Multi-Problem: $t = -2.42$ $p < .05$). Negative intrusiveness did not significantly mediate any of the associations between risk profiles and EF skills for the African American children.

Discussion

Ecological Risks & Executive Function Skills

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. The six family ecological risk profiles identified here during infancy were meaningfully associated with emerging EF skills over two years later. Like previous research, we found that socioeconomic risk (Hughes & Ensor, 2005; Mezzacappa, 2004; Noble et al., 2005; Noble et al., 2007) and parenting behaviors (Bernier et al., 2010; Bibok, et al., 2009; Hughes & Ensor, 2009) were significantly related to children’s EF skills. However, our findings extended this work in several important ways. First, we can conclude that characteristics of the child’s earliest environment during infancy contribute to future EF development at 36 months old. Second, the mediation models revealed that the links between socioeconomic risk and EF skills are at least partially explained by associated variations in parenting behaviors. Finally, a person-centered approach allowed us to make conclusions regarding the EF performance of children exposed to various *combinations* of risks and our diverse sample allowed us to examine how these associations varied by site-race group.

Specifically, results showed that EF skills at 36 months varied 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 consistently performed poorer on the EF tasks at 36 months in comparison to those in the Married, Low Risk profile. For African American children, those who were members of any of the higher-risk, poor profiles (Poor & Married; Poor, Unmarried & No Partner; Poor, Unmarried & No Partner, Multi-Problem) during infancy performed equally poorly on the EF tasks 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, even after accounting for children's language skills.

Our findings suggest that exposure to poverty was the most consistent predictor of poor EF skills. For African American families, this was true regardless of marital status, but for white families this appeared to only be the case for low-income, single-parent families. Numerous studies demonstrate the negative effects of economic strain and its associated psychological distress on children's developmental outcomes (Brody, Murray, Kim, & Brown, 2002; Jackson, Brooks-Gunn, Huang, & Glassman, 2000; McLoyd, 1990). However, it is worth noting that economic strain and psychological distress are not mutually exclusive. In the present analyses, two profiles were characterized by a high incidence of stress and depression, one of which was also characterized by poor, unmarried mothers (Poor, Unmarried & No Partner, Multi-Problem in the African American sample) and the other which was characterized by non-poor, married mothers (Married, Stressed & Depressed in the white sample). Similar to previous work, a generalized association between maternal depression and children's poor outcomes was not found in the present study (Petterson & Alber, 2001). Instead, we found that the association between maternal depression and children's early cognitive skills does not operate in the same way in poor, African American single-parent and non-poor, white two-parent contexts. Unlike the African American children in the Poor, Unmarried & No Partner, Multi-Problem profile, white children who were members of the Married, Stressed, & Depressed profile did not perform significantly worse than those in the Married, Low Risk profile. Thus, maternal depression may have a differential effect on child outcomes in different family contexts. It is possible that within a two-parent context, children are exposed to more cognitive stimulation than children in a single-parent context with a depressed mother through increased opportunities for communication and interactions with a non-depressed caregiver. Also, it is possible that the presence of two parents decreases children's exposure to the stress associated with having a depressed mother. Overall, these findings suggest that psychological distress alone does not negatively impact EF development, but instead the intersection of psychological distress *and* having a poor, unmarried mother puts children at the highest risk of poor EF development.

On the other hand, two risk profiles were characterized by a high incidence of poverty but varied in marital status (Poor & Married; Poor & Unmarried). Of these two groups, white children in the two-parent households seemed to be buffered from the negative effects of poverty, as only children in the Poor & Unmarried risk profile performed significantly worse on the EF tasks. In the African American families a different picture emerged regarding the effects of poverty (and the economic strain that is implied by living in poverty). In this group, protection from the deleterious effects of poverty on the development of EF was found only when children were surrounded by positive factors across the board in the Married, Low Risk profile. That is, even a two-parent household could not mitigate the negative effects of poverty on EF development for the African American children. Therefore, for African American families, it was not family structure, but rather economic deprivation that appeared to be the common denominator in the prediction of EF deficits. Taken together, these results begin to disentangle income from family structure and suggest that neither income level nor marital status, alone, may be sufficient in predicting children's EF development.

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Overall, our findings provide some support for the link between family structure and children’s development (Carlson & Corcoran, 2001; McLanahan, 1997; McLanahan & Sandefur, 1994; Smith, Brooks-Gunn, & Klebanov, 1997), but also remind us that the meaning, salience and impact of risk factors may vary by children's cultural background (Bradley et al., 2001; Foster & Kalil, 2007; Garcia Coll & Magnusson, 1999; Klimer et al., 1998). Specifically, it has been suggested that for African American children, single-parenthood may not necessarily be associated with poorer developmental outcomes than two-parent contexts (Dunifon & Kowaleski-Jones, 2002). Given the high prevalence of single-parent, African American families, and their known variation, we hypothesized that not all African American single-parent profiles would be associated with poor EF outcomes. We expected that African American children in the Poor, Unmarried & No Partner profile would have fared better in EF development than African American children in the Poor, Unmarried & No Partner, Multi-Problem profile. However, our findings indicated that membership in both single-parent, African American profiles were associated with poorer EF skills. This finding might be explained by the similar low income levels and low levels of maternal positive engagement within these single-parent profiles. It is also possible that although mothers in the Poor, Unmarried & No Partner profile did not report high levels of subjective life stress, they were in fact exposed to events that are generally perceived as quite stressful. We must be cautious when interpreting self-reported stress in low-income, minority samples as 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 here underestimate stress exposure in minority populations (e.g., Turner & Avison, 2003). It should also be noted that both the restriction in range of EF scores for the African American children as well as the early age at which EF was assessed may have hindered our ability to predict their EF skills.

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 until recently few studies have examined how ecological factors influence EF development. Previous work has highlighted the role of both home environments and maternal sensitivity in predicting general cognitive abilities and academic achievement, and EF skills (Downer & Pianta, 2006; Hughes & Ensor, 2005; NICHD ECCRN, 2003; 2004; 2005; Noble et al., 2007). Results here suggest that much of the negative influence of early demographic and familial risks on later EF may be transmitted through the quality of interactions mothers have with their children during infancy. For white children, it was membership in profiles characterized by poverty where parenting mediated the process, whereas, for African American children, it was membership in the single-parent households (but not poor, two-parent households) where maternal positive engagement mediated the effect of risk on EF.

These results confirm recent studies, which find that general environmental stress and chaos predicts lower levels of EF skills, where as sensitive, engaging interactions with parents (e.g., maternal scaffolding) are predictive of increased EF competence (Bernier et al., 2010; Bibok, et al., 2009; Hughes & Ensor, 2009). Quality of parenting may exert influence on children’s development in two ways. First, through contingent, responsive interactions, infants recognize they can influence their environment. This sense of agency may increase 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 relationship security derived from positive interactions, infants are more likely to explore their environments increasing their interaction with cognitively stimulating materials (Ainsworth, Blehar, Waters & Wall, 1978; Bornstein & Tamis-LeMonda, 1997).

Another important consideration in the prediction of EF and the role of parent-child interactions is language development. Similar to other studies, we found that better language skills were related to better EF skills, regardless of race (e.g., Hughes & Ensor, 2005; Blair & Razza, 2007). It is worth noting that despite this strong association, risk profiles were significant predictors of future EF skills and that this association could be at least partially explained by parenting behaviors, even after controlling for children's language skills. Parent-child interactions play an important role in the development of both language and EF. Considering the theoretical support for the association between EF and language development and the role of social interaction (Luria, 1973; Vygotsky, 1962), one may hypothesize that language helps facilitate EF development and both are influenced by demographic and familial risks. However, it is also possible that these ecological risks influence a third variable like social interaction opportunities or exposure to cognitively stimulating interactions, which in turn shapes both EF and language development. Future research focused on specifying these causal paths is needed to more fully understand the complex associations between risk, parenting, and children's EF and language development.

Race & Mechanisms in the Link of Risk & EF

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). Those that have investigated how race moderates these associations generally find that there are far more similarities than differences (Bradley et al., 2001; Bradley & Corwyn, 2003). This study examined how proximal processes explaining the associations between risks and EF outcomes vary across ethnic groups. Despite the similar relations observed between poor, unmarried profiles and poorer EF outcomes across site-race groups, we found maternal negative intrusiveness only helped explain this association for white children. For African American children, maternal negative intrusiveness and EF skills were unrelated. Therefore, even though poor, unmarried risk profiles showed higher levels of intrusiveness for African American children, this did not help explain the negative association between risk and EF. Although the present study did not officially test moderation, these findings suggest that the relationship between parenting and EF varies for white and African American children. 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 parenting style, which one might expect to be more intrusive due to its higher levels of parental control, 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).

Prevention Implications

Previous research has pointed to the importance of EF as a potential target for intervention, yet few interventions have specifically targeted and measured their impact on children's EF skills. Results from two school-based cognitive and social-emotional curriculums for preschoolers have demonstrated positive impacts on children's EF development (Bierman et al., 2008; Diamond et al., 2007). 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 here suggest that the early home environment may prove to be an especially fruitful context to promote EF skills. Findings here, if replicated, point to specific subgroups of children as well as 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 groups at greatest risk (e.g., Collins, Murphy, & Bierman, 2004). The person-centered approach used here suggests that interventions to promote EF skills should target families with poor, unmarried and married parents. Additionally, the mediation analyses suggest that maternal engagement may be an important parent-child intervention target and recent evidence suggests that children's EF skills can be enhanced through improved parenting behaviors (Lunkenheimer et al., 2008).

Limitations and Future Analyses

The aforementioned conclusions must be tempered by several study limitations. First, it is possible that the mediation analyses in this study were underpowered. According to Preacher and colleagues, bootstrapping is often preferred over the Sobel test as it provides increased power to detect mediated effects, especially with small sample sizes (Preacher & Hayes, 2004). A Monte Carlo study conducted by MacKinnon and colleagues found that the Sobel test performed best with sample sizes greater than 50 (MacKinnon, Warsi, & Dwyer, 1995). In the present study, we had 687 children for the white sample and 468 children for the African American sample. To be thorough, however, we reran our original models using the bootstrapping option in Mplus and found nearly identical results (Muthen & Muthen, 2007). It is important to note, however, that although Mplus provides the option of using bootstrapping with some missing data, it does not allow for missingness on any of the predictor variables (in our case, class membership, children's language skills, and family poverty) and therefore the Mplus analyses had to be conducted using a slightly smaller sample ($n = 612$ for the white sample and $n = 332$ for the African American Sample). For these reasons, we chose to present the mediation results using the Sobel test based on the full data set.

Second, although representative of their regions, participants were limited to non-urban Appalachian and Black Southern regions of the US and conclusions may not generalize beyond non-urban populations. Third, as all African American families were drawn from North Carolina and more than half of white families were drawn from Pennsylvania, it not possible to disentangle the effects of geographic location from the effects of race. Fourth, because of the smaller sample size of African American families, our lower power reduced our ability to detect differences across the African American family risk profiles. Therefore, conclusions regarding ethnic differences should be interpreted with caution. Finally, because the LCA subgroups are sensitive to sample size and sample characteristics (like other data-driven models) as well as changes in risk indicators, generalization issues may arise.

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. Through the use of a new lens (person-centered approach) to study the intersection of multiple risk factors, we found that specific combinations of risks are more strongly associated with poor EF outcomes in comparison to individual risks and that these combinations may vary by race. We also identified the specific proximal processes (maternal engagement) 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. Also by investigating these associations in a large, ethnically diverse sample of young children and their families, we were able 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.

References

Ainsworth, MDS.; Blehar, MC.; Waters, E.; Wall, S. Patterns of Attachment. Hillsdale, N.J.: Erlbaum; 1978.

Anderson P. Assessment and development of executive function during early childhood. Child Neuropsychology 2002;8(2):71–82. [PubMed: 12638061]

Beers SR, DeBellis MD. Neuropsychological function in children with maltreatment-related posttraumatic stress disorder. American Journal of Psychiatry 2002;159(3):483–486. [PubMed: 11870018]

Berger L, Brooks-Gunn J, Paxon C, Waldfogel J. First-year maternal employment and child outcomes: Differences across racial and ethnic groups. Children and Youth Services Review 2008;30:365–387. [PubMed: 20336171]

Bergman, LR.; Cairns, RB.; Nilsson, L.; Nystedt, L. Mahwah, NJ: Lawrence Erlbaum Associates; 2000.

Bergman, LR.; Magnusson, D. A person approach to the study of the development of adjustment problems: An empirical example and some research strategy considerations. In: Magnusson, D.; Ohman, A., editors. Psychopathology: An interactional perspective. Academic Press; 1987. p. 383-401.

Bernier A, Carlson SM, Whipple N. From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. Child Development 2010;81(1):26–339.

Bernstein, JH.; Weber, DP. Executive capacities from a developmental perspective. In: Meltzer, L., editor. Executive function in education: from theory to practice. New York, NY: The Guilford Press; 2007.

Best JR, Miller PH, Jones LL. Executive function after age 5: Changes and correlates. Developmental Reivew 2009;29(3):180–200.

Bibok, MB.; Carpendale, JIM.; Muller, U. Parent scaffolding and the development of executive function. In: Lewis, C.; Carpendale, JIM., editors. Social interaction and the development of executive function. New Directions in Child and Adolescent Development. Vol. 123. 2009. p. 17-34.

Bierman KL, Domitrovich CE, Nix RL, Gest SD, Welsh JA, Greenberg MT, Blair C, Nelson KE, Sukhdeep G. Promoting academic and social-emotional school readiness: The Head Start REDI program. Child Development 2008;79(6):1802–1817. [PubMed: 19037951]

Blair C. How similar are fluid cognition and general intelligence? A developmental neuroscience perspective on fluid cognition as an aspect of human cognitive ability. Behavioral and Brain Sciences 2006;29:109–160. [PubMed: 16606477]

Blair C, Razza RP. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. Child Development 2007;78(2):647–663. [PubMed: 17381795]

Blair C, Willoughby M, Greenberg MT, Werner E. The development of executive function and effortful control at two-years of age in children from low-income, rural communities. (under review).

Blair C, Willoughby M, Mills-Koonce R, Granger DG, Greenberg MT. Key Family Life Project Investigators. The measurement of executive function in 3-year-olds: Early prediction from child and family characteristics in a population-based, longitudinal sample. (under review).

Block, J. Lives through time. Berkeley, CA: Bancroft Books; 1971.

Bornstein MH, Tamis-LeMonda CS. Maternal responsiveness and infant mental abilities: Specific predictive relations. Infant Behavior and Development 1997;20(3):283–296.

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Bradley, RH.; Corwyn, RF. Age and ethnic variation in family process mediators of SES. In: Bornstein, MH.; Bradley, RH., editors. Socioeconomic status, parenting, and child development. Mahwah, NJ: Lawrence Erlbaum Associates; 2003. p. 161-188.

Bradley RH, Corwyn RF, Burchinal M, McAdoo HP, Garcia Coll C. The home environments of children in the United States Part II: Relations with behavioral development through age thirteen. Child Development 2001;72(6):1868–1886. [PubMed: 11768150]

Brody GH, Flor DL. Maternal resources, parenting practices, and child competence in rural, single-parent African American families. Child Development 1998;69(3):803–816. [PubMed: 9680686]

Brody GH, Murry VM, Kim S, Brown AC. Longitudinal pathways to competence and psychological adjustment among African American children living in rural single-parent households. Child Development 2002;73(5):1505–1516. [PubMed: 12361315]

Carlson SM. Executive function in context: Development, measurement, theory and experience. Monographs of the Society for Research in Child Development 2003;68(3):138–151. [PubMed: 14723274]

Carlson, SM. Social origins of executive function development. In: Lewis, C.; Carpendale, JIM., editors. Social interaction and the development of executive function. New Directions in Child and Adolescent Development. Vol. 123. 2009. p. 87-97.

Carlson MJ, Corcoran ME. Family structure and children's behavioral and cognitive outcomes. Journal of Marriage and Family 2001;63:779–792.

Collins, LM.; Lanza, ST. Latent class and latent transition analysis: With applications in the social, behavioral, and health sciences. New York: Wiley; 2010.

Collins LM, Murphy SA, Bierman K. A conceptual framework for adaptive preventive interventions. Prevention Science 2004;5(3):185–196. [PubMed: 15470938]

Cox, MJ.; Paley, B.; Payne, CC.; Burchinal, P. The transition to parenthood: Marital conflict and withdrawal and parent-infant interaction. In: Cox, M.; Brooks-Gunn, J., editors. Conflict and cohesion in families: Causes and consequences. Mahwah, NJ: Lawrence Erlbaum; 1999. p. 87-104.

Crnic, K.; Greenberg, MT. Maternal stress, social support, and coping: Influences on the early mother-infant relationship. In: Boukydis, C., editor. Research on support for parents and infants in the postnatal period. Norwood, NJ: Ablex; 1987. p. 25-40.

Crouter AC, Lanza ST, Piretti A, Goodman BW, Neebe E. The O*Net Jobs Classification System: A primer for family researchers. Family Relations 2006;55(4):461–472.

Derogatis, L. Brief Symptom Inventory 18. Minneapolis, MN: NCS Pearson, Inc; 2000.

Diamond, A. Frontal lobe involvement in cognitive changes during the first year of life. In: Gibson, KR.; Petersen, AC., editors. Brain maturation and cognitive development: Comparative and cross-cultural perspectives. Hawthorne, NY: Aldine de Gruyter; 1991.

Diamond, A. Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy and biochemistry. In: Stuss, DT.; Knight, RT., editors. Principles of frontal lobe function. 2002. p. 466-503.

Diamond A, Barnett SW, Thomas J, Munros S. Preschool program improves cognitive control. Science, 318 2007;(5855):1387–1388.

Diamond A, Kirkham N, Amso D. Conditions under which young children can hold two rules in mind and inhibit a prepotent response. Developmental Psychology 2002;38(3):352–362. [PubMed: 12005379]

Diamond A, Taylor C. Development of an aspect of executive control: Development of the abilities to remember what I said and to "do as I say, not as I do". Developmental Psychobiology 1996;29(4): 315–334. [PubMed: 8732806]

Dill, BT. Rediscovering rural Amercia. In: Blau, JR., editor. Blackwell companions to sociology. Malden, MA: Blackwell Publishing; 2001. p. 196-210.

Downer JT, Pianta RC. Academic and cognitive functioning in first grade: Associations with earlier home and child care predictors and with concurrent home and classroom experiences. School Psychology Review 2006;35(1):11–30.

Dunifon R, Kowaleski-Jones L. Who's in the house? Race differences in cohabitation, single parenthood, and child development. Child Development 2002;73(4):1249–1264. [PubMed: 12146746]

Evans GW, Saegert S, Harris R. Residential density and psychological health among children in low-income families. Environment and Behavior 2001;33(2):165–180.

Espy KA, McDiarmid MM, Cwik MF, Stalets MM, Hamby A, Seen TE. The contribution of executive functions to emergent mathematic skills in preschool children. Developmental Neuropsychology 2004;26(1):465–486. [PubMed: 15276905]

Foster EM, Kalil A. Living arrangements and children's development in low-income white, Black, and Latino families. Child Development 2007;78(6):1657–1674. [PubMed: 17988313]

Garcia Coll, C.; Magnusson, K. Cultural influences on child development: Are we ready for a paradigm shift?. In: Masten, AS., editor. Cultural processes in child development: The Minnesota symposia on child psychology. Vol. Vol. 29. Mahweh, NJ: Lawrence Erlbaum Associates; 1999. p. 1-24.

Garon N, Bryson SE, Smith IM. Executive function in preschoolers: A review using an integrative framework. Psychological Bulletin 2008;134(1):31–60. [PubMed: 18193994]

Garrett-Peters P, Mills-Koonce R, Adkins D, Vernon-Feagans L, Cox M. Early environmental correlates of maternal emotion talk. Parenting: Science and Practice 2008;8(2):117–152.

Gauvain, M. The social context of cognitive development. New York, NY: Guilford Press; 2001.

Gerardi-Caulton G. Sensitivity to spatial conflict and the development of self-regulation in children 24–36 months of age. Developmental Science 2000;3:397–404.

Gerstadt CL, Hong Y, Diamond A. The relationship between cognition and action: Performance of children 3 1/2–7 years old on a Stroop-like day-night test. Cognition 1994;53:129–153. [PubMed: 7805351]

Goodman LA. Exploratory latent structure analysis using both identifiable and unidentifiable models. Biometrika 1974;61:215–231.

Hughes C. Executive function in preschoolers: Links with theory of mind and verbal ability. British Journal of Developmental Psychology 1998;16(2):233–253.

Hughes C, Ensor R. Executive function and theory of mind in 2 year olds: A family affair? Developmental Neuropsychology 2005;28(2):645–668. [PubMed: 16144431]

Hughes C, Ensor R. Executive function and theory of mind: Predictive relations from ages 2 to 4. Developmental Psychology 2007;43(6):1447–1459. [PubMed: 18020823]

Hughes, CH.; Ensor, RA. How do families help or hinder the emergence of early executive function?. In: Lewis, C.; Carpendale, JIM., editors. Social interaction and the development of executive function. New Directions in Child and Adolescent Development. Vol. 123. 2009. p. 35-50.

Hughes C, Graham A. Measuring executive function in childhood: Problems and solutions? Child and Adolescent Mental Health 2002;7(3):131–142.

Huttenlocher, PR. Neural plasticity: The effects of environment on the development of the cerebral cortex. Cambridge, MA: Harvard University Press; 2002.

Jackson AP, Brooks-Gunn J, Huang C, Glassman M. Single mothers in low-wage jobs: Financial strain, parenting, and preschoolers' outcomes. Child Development 2000;71(5):1409–1423. [PubMed: 11108104]

Jacques S, Zelazo PD. The Flexible Item Selection Task (FIST): A measure of executive function in preschoolers. Developmental Neuropsychology 2001;20:573–591. [PubMed: 12002094]

Kopp, CB. Young Children's Progression to Self-Regulation. In: Bullock, M., editor. The Development of Intentional Action, Cognitive, Motivational and Interactive Processes. Basel, Switzerland: S. Karger; 1991.

Lanza, ST.; Lemmon, D.; Dziak, JJ.; Huang, L.; Schafer, JL.; Collins, LM. PROC LCA & PROC LTA User's Guide Version 1.2.4. University Park, PA: The Pennsylvania State University, The Methodology Center; 2010.

Lanza ST, Rhoades BL, Nix R, Greenberg MT. Early multilevel risk profiles and late childhood academic and behavioral problems: A person-centered approach. Development and Psychopathology. (in press).

Laursen B, Hoff E. Person-centered and variable-centered approaches to longitudinal data. Merrill-Palmer Quarterly 2006;52(3):377–389.

Lazarsfeld, PF.; Henry, NW. Latent structure analysis. Boston: Houghton Mifflin; 1968.

Lerner, RM. Developmental science, developmental systems, and contemporary theories of human development. In: Lerner, RM.; Damon, W., editors. Handbook of Child Psychology: Vol. 1, Theoretical models of human development. Hoboken, NJ: John Wiley and Sons; 2006.

Lewis EE, Dozier M, Ackerman J, Sepulveda-Kozakowski S. The effect of placement instability on adopted children's inhibitory control abilities and oppositional behavior. Developmental Psychology 2007;43(6):1415–1427. [PubMed: 18020821]

Lunkenheimer ES, Dishion TJ, Shaw DS, Connell AM, Gardner F, Wilson MN, et al. Collateral benefits of the Family Check-Up on early childhood school readiness: Indirect effects of parents' positive behavior support. Developmental Psychology 2008;44(6):1737–1752. [PubMed: 18999335]

Luria, AR. The working brain: An introduction to neuropsychology. New York: Basic Books Inc; 1973.

Magnusson, D.; Bergman, LR. Individual and variable-based approaches to longitudinal research on early risk factors. Studies of psychosocial risk: The power of longitudinal data. Rutter, M., editor. New York, NY: Cambridge University Press; 1988. p. 45-61.

Magnusson, D.; Bergman, LR. A pattern approach to the study of pathways from childhood to adulthood. In: Robins, LN.; Rutter, M., editors. Straight and devious pathways from childhood to adulthood. New York, NY: Cambridge University Press; 1990. p. 101-115.

Mezzacappa E. Alerting, orienting, and executive attention: Developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children. Child Development 2004;75(5):1373–1386. [PubMed: 15369520]

Muthen, L.; Muthen, B. Mplus Version 5. Los Angeles, CA: Muthen & Muthen; 2007.

MacKinnon DP, Warsi G, Dwyer JH. A simulation study of mediated effect measures. Multivariate Behavioral Research 1995;30(1):41–62. [PubMed: 20157641]

McLanahan, S. Parent absence or poverty: What matters more?. In: Duncan, GJ.; Brooks-Gunn, J., editors. Consequences of growing up poor. New York: Russell Sage Foundation; 1997. p. 35-48.

McLanahan, S.; Sandefur, G. Growing up with a single parent: What hurts, what helps?. Cambridge, MA: Harvard University Press; 1994.

McLoyd VC. The impact of economic hardship on Black families and children: Psychological distress, parenting, and socioemotional development. Child Development 1990;61(2):311–346. [PubMed: 2188806]

Nagin, D. Group-based modeling of development. Cambridge, MA: Harvard University Press; 2005.

Nelson, CA.; Thomas, KM.; de Haan, M. Neural bases of cognitive development. In: Kuhn, D.; Siegler, RS.; Damon, W.; Lerner, RM., editors. Handbook of Child Psychology. Vol. Vol. 2. Hoboken, NJ: John Wiley and Sons; 2006. p. 3-57.

Noble KG, McCandliss BD, Farah MJ. Socioeconomic gradients predict individual differences in neurocognitive abilities. Developmental Science 2007;10(4):464–480. [PubMed: 17552936]

Noble KG, Norman MF, Farah MJ. Neurocognitive correlates of socioeconomic status in kindergarten children. Developmental Science 2005;8(1):74–87. [PubMed: 15647068]

NICHD Early Child Care Research Network (NICHD ECCRN, 1999). Child care and mother-child interaction in the first three years of life. Developmental Psychology 35(6):1399–1413. [PubMed: 10563730]

NICHD Early Child Care Research Network (NICHD ECCRN, 2000). Characteristics and quality of child care for toddlers and preschoolers. Applied Developmental Science 4(3):116–135.

NICHD Early Child Care Research Network (NICHD ECCRN, 2003). Do children's attenion processes mediate the link between family predictors and school readiness? Developmental Psychology 39(3):581–593. [PubMed: 12760525]

NICHD Early Child Care Research Network (NICHD ECCRN, 2004). Multiple pathways to early academic achievement. Harvard Educational Review 74(1):1–29.

NICHD Early Child Care Research Network (NICHD ECCRN, 2005). Predicting individual differences in attention, memory, and planning in first graders from experiences at home, child care, and school. Developmental Psychology 41(1):99–114. [PubMed: 15656741]

Parra GR, DuBois DL, Sher KJ. Investigation of profiles of risk factors for adolescent psychopathology: A person-centered approach. Journal of Clinical Child and Adolescent Psychology 2006;35(3):386–402. [PubMed: 16836476]

Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. Journal of Child Psychology and Psychiatry 1996;37(1):51–87. [PubMed: 8655658]

Petterson SM, Albers AB. Effects of poverty and maternal depression on early childhood development. Child Development 2001;72(6):1794–1813. [PubMed: 11768146]

Preacher KJ, Hayes AF. SPSS and SAS procedures for estimating indirect effects in simple mediation models. Behavior Research Methods, Instruments, & Computers 2004;36(4):717–731.

Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behavior Research Methods 2008;40(3):879–891. [PubMed: 18697684]

Raine A. Annotation: The role of prefrontal deficits, low autonomic arousal, and early health factors in the development of antisocial and aggressive behavior in children. Journal of Child Psychology and Psychiatry 2002;43(4):417–434. [PubMed: 12030589]

Rhoades BL, Greenberg MT, Domitrovich CE. The contribution of inhibitory control to preschoolers' social-emotional competence. Journal of Applied Developmental Psychology 2009;30:310–320.

Riggs NR, Jahromi LB, Razza RP, Dillworth-Bart JE, Muller U. Executive function and the promotion of social-emotional competence. Journal of Applied Developmental Psychology 2006;27:300–309.

Rutter, M. Protective factors in children's responses to stress and disadvantage. In: Kent, MW.; Rolf, JE., editors. Primary prevention of psychopathology: Vol 3. Social competence in children. 1979. p. 49-74.

Sameroff AJ, Seifer R, Baldwin CP, Baldwin A. Stability of intelligence from preschool to adolescence: The influence of social and family risk factors. Child Development 1993;64:80–97. [PubMed: 8436039]

Sarason I, Johnson J, Siegel J. Assessing the impact of life changes: Development of the Life Experiences Survey. Journal of Consulting and Clinical Psychology 1978;46:932–946. [PubMed: 701572]

Shonkoff, JP.; Phillips, DA., editors. From neurons to neighborhoods: The science of early childhood development. Washington, D.C: National Academy Press; 2000.

Smith, J.; Brooks-Gunn, J.; Klebanov, P. Consequences of living in poverty for young children's cognitive and verbal ability and early school achievement. In: Duncan, GJ.; Brooks-Gunn, J., editors. Consequences of growing up poor. New York: Russell Sage Foundation; 1997. p. 132-189.

Sobel, ME. Asymptotic intervals for indirect effects in structural equations models. In: Leinhart, S., editor. Sociological methodology 1982. San Francisco: Jossey-Bass; 1982. p. 290-312.

Steinberg, L.; Darling, NE.; Fetcher, AC. Authoritative parenting and adolescent adjustment:An ecological journey. In: Moen, P.; Elder, GH.; Lascher, K., editors. Examining lives in context:Perspectives on the ecology of human development. Washington, DC: American Psychological Association; 1995. p. 423-466.

Thomas, A.; Chess, S.; Birch, HG. Temperament and behavior disorders in children. Oxford, England: New York University Press; 1968.

Thompson, RA.; Easterbrooks, MA.; Padilla-Walker, LM. Social and emotional development in infancy. In: Lerner, RM.; Easterbrooks, MA.; Mistry, J., editors. Handbook of psychology: Developmental psychology. Vol. Vol. 6. Hoboken, NJ: John Wiley & Sons, Inc; 2003. p. 91-112.

Turner RJ, Avison WR. Status variations in stress exposure: Implications for the interpretation of research on race, socioeconomic status, and gender. Journal of Health and Social Behavior 2003;44:488–505. [PubMed: 15038145]

Vygotsky, LS. Thought and language. Oxford, England: Wiley; 1962.

Welsh MC, Pennington BF. Assessing frontal lobe functioning in children: Views from developmental psychology. Development Neuropsychology 1988;4(3):199–230.

Welsh MC, Pennington BF, Groisser DB. A normative-developmental study of executive function: A window on prefrontal function in children. Developmental Neuropsychology 1991;7(2):131–149.

Werner, EE.; Smith, RS. Overcoming the odds: High risk children from birth to adulthood. Ithaca, NY: Cornell University Press; 1992.

Willoughby M, Blair C, Wirth RJ, Greenberg MT. the Family Life Project Investigators. The Measurement of executive function at age 3: Psychometric properties and criterion validity of a new battery of tasks. Psychological Assessment. (in press).

Zelazo PD. Implications of 3-yr.-olds' successful performance on a No Conflict version of the Dimensional Change Cared Sort. Psychological Reports 2006;98(3):858–860. [PubMed: 16933685]

Zelazo PD, Muller U, Frye D, Marcovitch S. The development of executive function. Monographs of the Society for Research in Child Development 2003;Vol. 68(3):11–27.

Zimmerman, L.; Steiner, VG.; Pond, RE. Preschool Language Scale Fourth Edition (Technical Report). San Antonio: TX: Pearson; 2002.

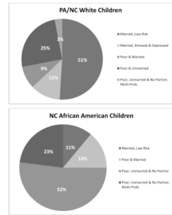

Figure 1.

Percent of children assigned to each risk profile by site-race group

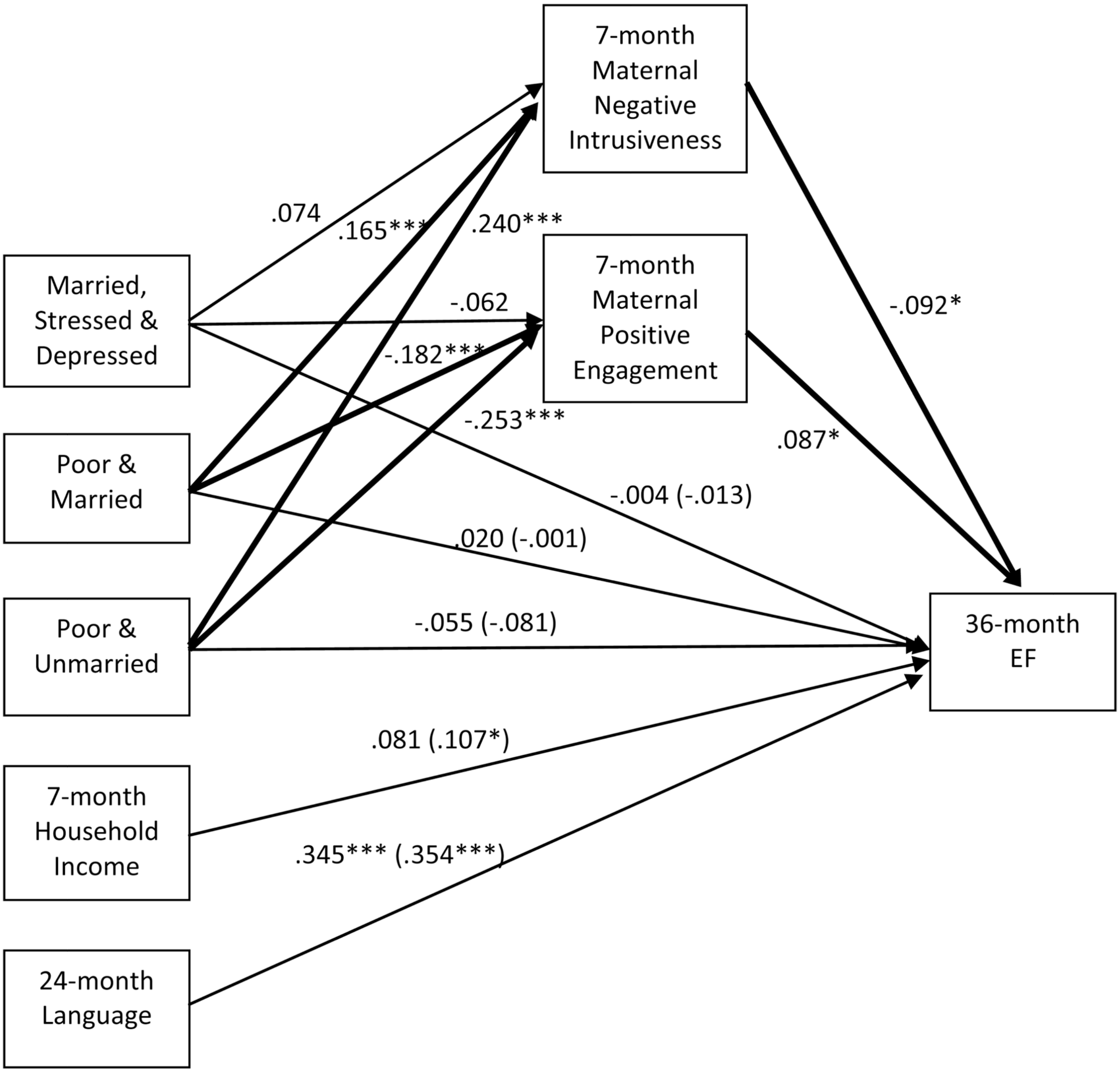

Figure 2.

Standardized estimates for path model with 7-month maternal positive engagement and negative intrusiveness as mediators of the association between risk profiles & 36-month EF skills in the PA/NC white sample. Bolded paths represent associations that were significantly mediated, and numbers in parentheses represent standardized estimates for when the mediators were not in the model.

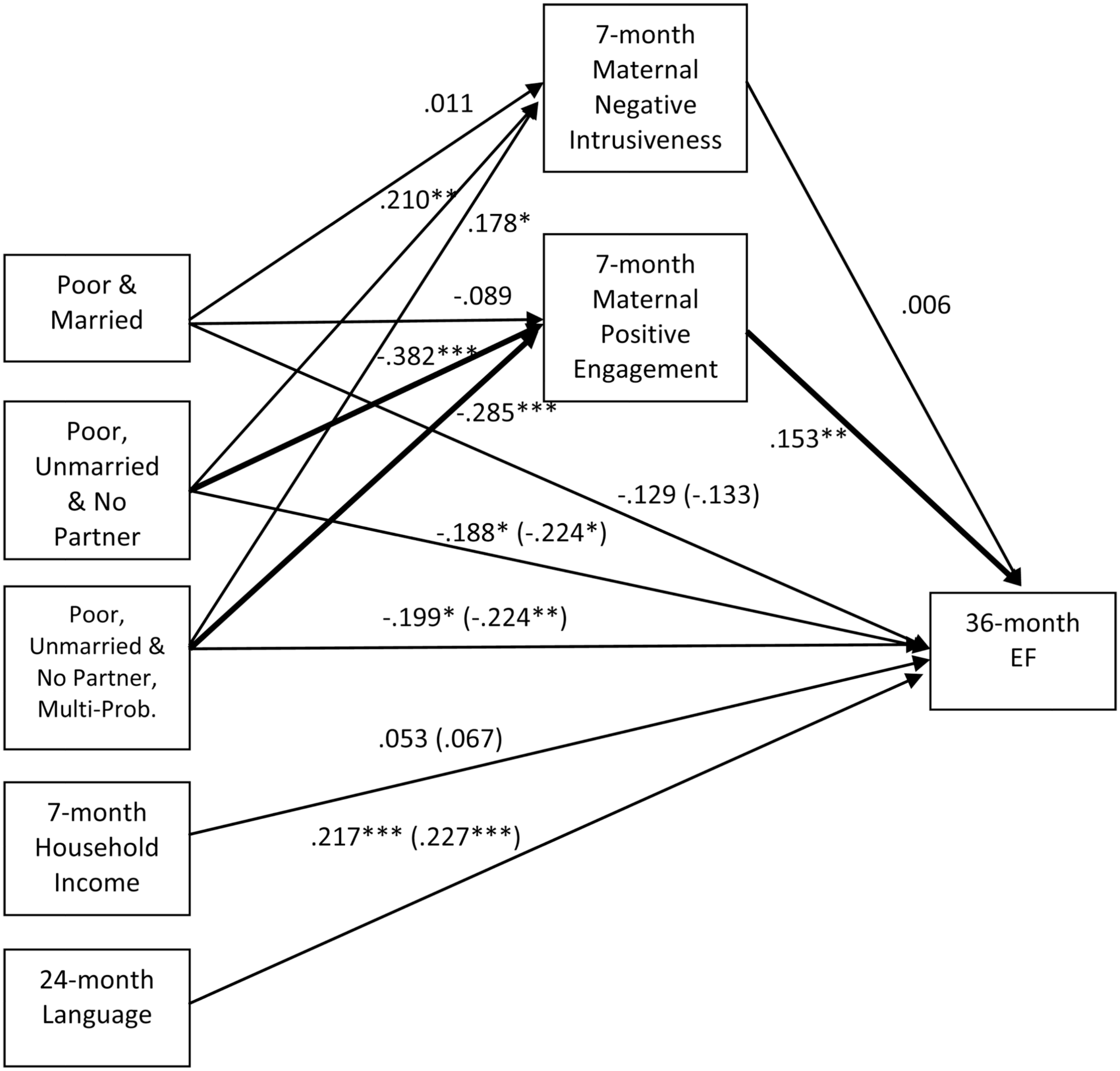

Figure 3.
Standardized estimates for path model with 7-month maternal positive engagement and negative intrusiveness as mediators of the association between risk profiles & 36-month EF skills in the NC African American sample. Bolded paths represent associations that were significantly mediated, and numbers in parentheses represent standardized estimates for when the mediators were not in the model.

Table 1

Descriptive Statistics: Percentages of Children from each Site-Race Group with Risk Factor and mean EF Score for each Site-Race Group

Risk Factor	PA White (*N* = 461)	NC White (*N* = 226)	NC African American (*N* = 468)	p-value[1]
	% At-Risk (*N* Missing)			
Poverty	36.2 (0)$_a$	38.9 (0)$_a$	72.9 (0)$_b$	***
Unmarried	36.9 (0)$_a$	25.7 (0)$_a$	70.5 (0)$_a$	***
No Partner	16.5 (0)$_a$	11.5 (0)$_a$	59.8 (0)$_b$	***
Teen Mother	32.8 (199)$_a$	40.4 (85)$_a$	63.5 (172)$_b$	***
No HS Diploma	14.3 (0)$_a$	18.6 (0)$_{ab}$	24.2 (0)$_b$	***
Mood Problems	40.1 (0)$_a$	27.9 (0)$_b$	28.4 (0)$_b$	***
Smoked While Pregnant	30.2 (0)$_a$	24.8 (0)$_a$	15.0 (0)$_b$	***
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)$_b$	***
Crowded House	18.0 (0)$_b$	28.8 (0)$_b$	43.4 (0)$_b$	***
	Mean (*SD*)			
EF Mean Total % Correct	52 (.21)$_a$	.46 (.19)$_b$	.36 (.18)$_c$	***

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 for the risk factors. Means in the same row do not differ at $p < .05$ according to Tukey post-hoc comparisons for the EF means.

[1]For risk factors, p-value based on chi-square test of independence between each factor and site-race group. For EF outcomes, p-value based on one-way ANOVA to test mean group differences .

***$p < .001$.

Table 2

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 3

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

	Risk Profile					
Risk Factor	**Married, Low Risk**	**Married, Stressed & Depressed**	**Poor & Married**	**Poor & Unmarried**	**Poor, Unmarried & No Partner**	**Poor, Unmarried & No Partner, Multi-Prob.**
Poverty	.11	.33	**.68**	**.72**	**.83**	**.84**
Unmarried	.07	.11	.21	**.99**	**.96**	**.81**
No Partner	.01	.01	.00	.48	**.87**	**.76**
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 African American	11%	---	17%	---	49%	23%

Note. Item-response probabilities over .50 are bolded. W = White and AA = African American. Dashes indicate that class membership probability was fixed to zero for that site-race group.

+Two item-response probabilities for Smoking While Pregnant are reported above for the Poor, Unmarried & No Partner, Multi-Prob. profile because the prevalence of this risk factor was allowed to vary across the white and African American groups for this profile.

Table 4

Adjusted Means and Standard Errors for 36-month EF Mean Total Percent Correct for each Assigned Risk Profile by Site-Race Group

	Adjusted EF Mean Total % Correct (SE)					
Site-Race Group	**Married, Low Risk**	**Married, Stressed & Depressed**	**Poor & Married**	**Poor & Unmarried**	**Poor, Unmarried & No Partner**	**Poor, Unmarried & No Partner, Multi-Prob.**
PA/NC White	52_a	$.50_{ab}$	$.49_{ab}$	$.45_b$	---	---
	(.01)	(.02)	(.03)	(.02)		
	n = 292	*n* = 67	*n* = 48	*n* = 121		
NC African American	$.45_a$	---	$.37_b$	---	$.35_b$	$.33_b$
	(.03)		(.02)		(.01)	(.02)
	n = 37		*n* = 57		*n* = 181	*n* = 77

Note. Means in the same row that share subscripts do not differ at $p < .05$ according to the pair-wise 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.

Table 5

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

	Adjusted Mean Total % Correct (SE)					
EF Task	**Married, Low Risk**	**Married, Stressed & Depressed**	**Poor & Married**	**Poor & Unmarried**	**Poor, Unmarried & No Partner**	**Poor, Unmarried & No Partner, Multi-Prob.**
PA/NC White						
Working Memory	33_a	$.28_a$	$.25_a$	$.28_a$	---	---
	(.02)	(.03)	(.04)	(.03)		
	n = 273	*n* = 63	*n* = 44	*n* = 102		
Inhibitory Control	$.69_a$	$.67_a$	$.67_a$	$.64_a$	---	---
	(.02)	(.04)	(.04)	(.03)		
	n = 268	*n* = 62	*n* = 47	*n* = 107		
Attention Flexibility	$.57_{ab}$	$.57_{ab}$	$.53_{bc}$	$.47_c$	---	---
	(.01)	(.03)	(.04)	(.02)		
	n = 277	*n* = 64	*n* = 46	*n* = 111		
NC African American						
Working Memory	$.21_a$	--	$.16_{ab}$	---	$.13_b$	$.12_b$
	(.03)		(.02)		(.01)	(.02)
	n = 32		*n* = 50		*N* = 158	*n* = 66
Inhibitory Control	$.70_a$	---	$.54_b$	---	$.59_b$	$.55_b$
	(.05)		(.04)		(.02) *n*	(.03)
	n = 36		*n* = 55		*N* = 161	*n* = 70
Attention Flexibility	$.46_a$	---	$.40_{ab}$	---	$.35_{ab}$	$.37_b$
	(.04)		(.03)		(.02)	(.03)
	n = 33		*n* = 53		*n* = 160	*n* = 66

Note. Means in the same row that share subscripts do not differ at $p < .05$ according to the pair-wise 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.

Table 6

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, Unmarried & No Partner**	**Poor, Unmarried & No Partner, Multi-Prob.**
PA/NC White						
6m Maternal Positive Engagement	3.39_a	3.21_{ab}	2.87_b	2.91_b	---	---
	(.74)	(.64)	(.81)	(.70)		
	n = 338	*n* = 81	*n* = 53	*n* = 159		
6m Maternal Negative Intrusiveness	2.33_a	2.48_{ab}	2.69_b	2.68_b	---	---
	(.57)	(.52)	(.63)	(.58)		
	n = 338	*n* = 81	*n* = 53	*n* = 159		
24m Language Skills	105.61_a	100.87_{ab}	99.76_{ab}	96.58_b	---	---
	(15.91)	(16.02)	(13.25)	(15.59)		
	n = 315	*n* = 79	*n* = 51	*n* = 151		
6m Income	$60{,}000_a$	$45{,}000_b$	$28{,}000_c$	$24{,}000_c$	---	---
	(33,000)	(26,000)	(17,000)	(16,000)		
	n = 350	*n* = 84	*n* = 62	*n* = 170		
NC African American						
6m Maternal Positive Engagement	3.10_a	---	2.88_a	---	2.46_b	2.53_b
	(.71)		(.89)		(.83)	(.76)
	n = 49		*n* = 63		*n* = 228	*n* = 103
6m Maternal Negative Intrusiveness	2.83_a	---	2.85_a	---	3.12_b	3.12_{ab}
	(.67)		(.56)		(.68)	(.75)
	n = 49		*n* = 63		*n* = 228	*n* = 103
24m Language Skills	99.76_a	---	97.48_a	---	98.62_a	95.87_a
	(11.96)		(11.91)		(13.83)	(12.23)
	n = 40		*n* = 63		*n* = 213	*n* = 92
6m Household Income	$48{,}000_a$	---	$27{,}000_b$	---	$17{,}000_c$	$18{,}000_c$

Variable	M (SD)					
	Married, Low Risk	**Married, Stressed & Depressed**	**Poor & Married**	**Poor & Unmarried**	**Poor, Unmarried & No Partner**	**Poor, Unmarried & No Partner, Multi-Prob.**
	(21,000)		(18,000)		(17,000)	(18,000)
	n = 52		*n* = 68		*n* = 241	*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.

Table 7

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

	EF Total Mean % Correct	
Variable	**PA/NC White**	**NC African American**
6m Maternal Positive Engagement	.19***	.19***
	(*n* = 531)	(*n* = 359)
6m Maternal Negative Intrusiveness	-.17***	-.05
	(*n* = 531)	(*n* = 359)
24m Language Skills	.38***	.23***
	(*n* = 542)	(*n* = 352)
6m Household Income	.18***	.16**
	(*n* = 555)	(*n* = 379)

* $p < .05$

** $p < .01$

*** $p < .001$