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Early executive and school functioning: Protective roles of home environment by income

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ABSTRACT

This study used data from the Family Life Project ($N = 1227$), a longitudinal study of child development. We tested a three-way interaction in which positive parenting and learning materials in the home from age 6–36 months and family income predicted children's executive functioning (EF) at 58 months. We also tested whether this interaction predicted early school functioning, specifically behavioral and academic skills in the 1st grade. The interactive effects of positive parenting and learning materials differed by family income. For children in families of lower income, more learning materials and positive parenting predicted better EF, and in turn, better early school functioning. For children in families of higher income, only positive parenting significantly predicted EF, which in turn, predicted better early school functioning. Findings suggest that more targeted policy and program support for enrichment and positive parenting may bolster efforts to combat poverty.

Children raised in poverty are at risk for developing lower levels of executive function (EF) skills than their more affluent peers, placing them at risk for lower academic achievement that compounds across development (Blair & Raver, 2016a, 2016b; Hackman & Farah, 2009; Lawson et al., 2014). Many studies have demonstrated that poverty represents a probabilistic indicator of risk for lower exposure to specific environmental factors associated with cognitive and EF development, including critical aspects of caretaking (e.g., positive parenting) and material resources (e.g., toys, learning materials) shown to positively impact neurodevelopment (Huston & Bentley, 2010). However, while studies have examined how factors in the home environment may mediate the association between poverty and later EF, fewer studies examine whether poverty moderates the strength of association between these factors and cognitive development (Huston & Bentley, 2010; Rosen et al., 2019, b; Sarsour et al., 2011).

Recently evidence has emerged that poverty may act to moderate developmental processes such that children raised in the context of poverty may achieve developmental goals through different pathways (see Gatzke-Kopp, 2016). Poverty reflects a broad range of inter-related risk factors shown to impact cognitive development, with evidence that heritable contributions to cognitive function are suppressed in low-income samples (Hanscombe et al., 2012; Hart, Soden, Johnson, Schatschneider, & Taylor, 2013). Research further suggests that poverty is related to the early development of children's neural capacity (Johnson, Riis, & Noble, 2016), which may influence the extent to which children can benefit from positive environmental influences or their resilience to environmental risks. These findings suggest caution in presuming that poverty merely reflects an increased presence of mediating risk factors in developing effective intervention strategies for mitigating those risks. The present study examines poverty as an environmental context which may moderate the strength or nature of risk pathways to better inform intervention efforts. Specifically, we examine the interplay between social (e.g., positive parenting) and material resources (e.g., developmentally appropriate toys to support sensory and motor stimulation) during infancy and toddlerhood in predicting preschool EF, and in turn, academic and behavioral adjustment in grade school, in a socioeconomically diverse sample; furthermore, we examine whether the independent or interactive effects of the environmental factors vary by family income.

Executive functioning in early childhood

Within normative development, EF skills emerge in infancy and continue to develop throughout early childhood as a function of ongoing myelination and maturation of the frontal cortex, setting stage for further cognitive gains and adjustment to developmental tasks (De Luca

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et al., 2003; Hughes, 2011; Welsh, Pennington, & Groisser, 1991). Research suggests that cognitive flexibility begins to develop between 3 and 5 years old, during which time children begin to demonstrate the ability to follow basic task switching rules (Doebel & Zelazo, 2015). The ability to incorporate more complex switching rules rapidly improves between 7 and 9 and continues into adolescence along with increased attentional control, efficiency, and resistance to distraction. Inhibitory processes begin to emerge around 1 years old, with significant improvements occurring through 6 years old and continuing into middle childhood (Anderson, 2002). Basic skills of working memory emerge in infancy and continue development into late adolescence with increasing capacity to hold larger amounts of information in mind and to combine information into more complex and efficient representations (Luciana, Conklin, Hooper, & Yarger, 2005; Reynolds & Romano, 2016).

Early EF skills are critical for school performance, including children's academic functioning and ability to regulate behavior in a structured school environment (Blair, 2002). For example, EF skills such as inhibitory control enable children to focus attention in the classroom and maintain control over how they express themselves when distressed (e.g., resisting the urge to respond with aggression or crying). Thus, EF is critical to children's behavioral development as well as their cognitive development. Research indeed shows that EF, particularly in the preschool years, significantly predicts children's achievement in reading, math, and science as they enter school (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Nayfeld, Fuccillo, & Greenfield, 2013). Further studies extend these findings, demonstrating associations between EF levels in preschool and academic achievement, socioemotional outcomes, and risky behaviors in early adolescence (Sabol & Pianta, 2012; EF measured at 54 months) and in adulthood, including substance use, criminal behavior, teenage pregnancy and school dropout (Moffitt et al., 2011; EF measured at 3–5 years old). Given the developmental importance of early childhood EF, it is critical to understand how contextual factors during infancy and early childhood may predict EF development during this time. Thus, the current study focuses on the role of the early home environment in children's EF development before school entry and later academic and behavioral performance in school.

Home environment: learning materials in early childhood

Age-appropriate toys are invaluable in children's cognitive development. Children's early experiences interacting with objects provides critical sensory and motor information, and as children learn to manipulate objects purposefully, they begin to develop mastery over cause-and-effect processes (Ferrara, Hirsh-Pasek, Newcombe, Golinkoff, & Lam, 2011; Yogman et al., 2018). As they grow, toys become more complex to support greater levels of coordination, and imaginary play that supports social learning about relationships, emotions, and empathy. For instance, a toddler working to put shapes into various slots is exercising working memory - by recalling which shapes have been recently tried, cognitive flexibility - in rotating shapes to identify new strategies for task completion, and inhibiting or regulating feelings of frustration to persevere at the task at hand. However, most studies assessing the impact of toys have been conducted with middle class to high income children (Ferrara et al., 2011; Yogman et al., 2018).

Some research has found that less exposure to stimulating learning materials mediates the association between low socioeconomic status and lower EF performance (Bradley & Corwyn, 2002; Rosen et al., 2019, b; Sarsour et al., 2011). These findings are consistent with the Family Investment Theory, which purports that families' experience of economic strain limits their ability to invest financially in their children's development as resources must be prioritized to securing shelter and food (Huston & Bentley, 2010). Although poverty may be a probabilistic indicator of reduced access to developmentally stimulating toys, many families are able to access such resources through hand-me-downs or second-hand purchases, resulting in considerable variance in the presence of stimulating toys even among low-income families. If the lack of stimulating toys reflects an independent mechanistic pathway by which children raised in poverty experience less cognitive development, then the association between learning materials and cognitive function should not be moderated by poverty, but demonstrate the same strength across income levels. However, poverty encompasses a wide range of correlated risk factors, many of which are known to impact cognitive development including malnutrition (Brown & Pollitt, 1996) and exposure to environmental toxins (Gatzke-Kopp et al., 2021). As such, the extent to which learning materials enhance cognitive development may be mitigated in the context of poverty. Examining poverty as a moderating influence on child development can inform intervention practices by identifying malleable environmental exposure that will have the greatest impact on children's cognitive outcomes.

Home environment: positive parenting in early childhood

In addition to the importance of physical materials and opportunities for children to explore and interact with their environment, extensive research has examined the importance of positive parenting in supporting EF development (Bernier et al., 2010, b; Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Fay-Stammbach, Hawes, & Meredith, 2014; Hughes, Roman, Hart, & Ensor, 2013; Merz, Landry, Montroy, & Williams, 2017; Sarsour et al., 2011; Towe-Goodman et al., 2014). Positive parenting includes parents' demonstration and provision of emotional warmth, stimulation, engagement and responsiveness. Similar to material enrichment, positive parenting may create a social home environment conducive to practicing regulatory skills, aiding in the development of associated brain structures. For instance, warm and sensitive parenting in infancy likely creates a fertile learning environment in which children's experience of stress is less frequent and they experience recovery from distress more rapidly, which supports effective development of the pre-frontal cortex (Hodel, 2018).

In a recent meta-analysis, Valcan, Davis, and Pino-Pasternak (2018) investigated the relationship between types of parenting behaviors and EF in children 0–8 years old. Results incorporating 42 longitudinal studies demonstrated that parental warmth and sensitivity was as significantly associated with children's EF ($r = 0.25$) as were parenting practices that directly scaffolded children's cognitive functioning ($r = 0.20$). Additional studies further indicate that EF mediates the relationship between early parenting and children's later academic and social performance (Bindman, Pomerantz, & Roisman, 2015). Within the current Family Life Project sample, Vernon-Feagans, Willoughby, and Garrett-Peters (2016) documented that warmth and sensitive parenting in the first three years of life was associated with better EF at 36 months as well as a trend for faster growth in EF from 36 to 58 months, both of which were in turn related to better behavioral regulation at the end of kindergarten (i.e., emotional symptoms, conduct problems, prosocial behavior, peer relationship problems and hyperactivity/inattention). Such findings are replicated and extended in the NICHD Study of Early Child Care and Youth Development, with maternal parenting in the first three years of life predicting EF at 54 months, and EF in turn predicting academic achievement in elementary (i.e., 1st – 5th grade) and high school (i.e., 15 years old; Bindman et al., 2015). Such studies support the association between early parenting and EF as well as later child behaviors.

Similar to learning materials, positive parenting has been identified as a mediator between socioeconomic status and EF development, with Family Stress Theory positing that families' experience of economic stress can influence parents' psychological well-being, resulting in lower parental warmth and responsiveness (Huston & Bentley, 2010). For example, in a 2015 study, Hackman and colleagues explored maternal sensitivity and home enrichment (including toys) as mediators between SES and EF. Single mediator models indicated that sensitivity and enrichment in infancy (measured at 6–15 months) and early childhood (measured at 36–54 months) predicted working memory at 54 months. However, in multiple mediator models, only sensitivity and enrichment in early childhood predicted working memory. This suggests that there is shared variance among sensitivity and enrichment in infancy and early childhood, and prediction of EF may be largely driven by early childhood factors, compared to infancy. However, it is worth noting that these models included single components of EF rather than comprehensive measures, which may account for differences in findings when compared to other studies supporting the effects of parenting and learning materials in infancy.

Notably, as with the examination of learning materials- the mediational pathway presumes that parenting is inherently associated with poverty and does not account for the potential protective role that positive parenting may have in this context. For young children, the stress that accompanies poverty may not be directly meaningful until they reach an age where they engage in a greater degree of social referencing and comparisons. In the first few years of life, how children are impacted by poverty may depend primarily on their parents' emotional well-being and ability to scaffold positive development. In other words, parents may serve as a conduit or a buffer to effects of poverty on young children's well-being. Relying on mediation models does not provide the opportunity to examine the magnitude of effect that positive parenting can have in the context of poverty. Understanding critical pathways of potential resilience would greatly inform targeted intervention efforts for supporting low-income families and reducing disparities in children's cognitive and academic development.

Early positive parenting, learning materials, and executive functioning

Masten, Best, and Garmezy's (1990) risk-protective model posits that certain characteristics of parents and children, including early environments, may promote resilience in the development of children at risk. Further developmental theories also highlight the interaction of multiple environmental characteristics influencing children's development, rather than one characteristic working in isolation (Bronfenbrenner & Morris, 2007). For children in the context of poverty, it is important to understand those early proximal characteristics and processes that facilitate resilience. As discussed previously, positive parenting and learning materials within the early childhood home provide benefits for EF and later child behavior (Fenesy & Lee, 2018; Rosen et al., 2019, b; Vernon-Feagans et al., 2016). However, it is less understood how these characteristics may interact together as a process for resilience. We examine whether positive parenting and learning materials have an interactive effect in mitigating the disadvantage children living in poverty may have in cognitive development and later functioning. Specifically, we examine whether the presence of learning materials in the home are only beneficial in the context of positive parenting. Though our aims are largely exploratory, previous research does demonstrate a relationship between positive parenting and brain development (Belsky & De Haan, 2011). Such research suggests that warm and sensitive parenting in infancy and toddlerhood creates a fertile learning environment in which children's experience of stress and related hormones is less frequent and they experience recovery from distress more rapidly, which supports effective development of the prefrontal cortex (Kolb et al., 2012). Thus, while we would expect independent direct effects of both learning materials and parental warmth for high income children, low income children (whom are often in more stressful/vulnerable environments and have limited access to high quality child care outside the home; Blair & Raver, 2016a, 2016b) may require parenting characterized by warmth and sensitivity - such that for low income children we predict a main effect of positive parenting and a conditional effect (interaction) that learning materials are only beneficial in the context of positive parenting.

Masten et al.'s (1990) model also posits that high distal risk, including poverty, increases the importance of protective characteristics in resilience, resembling a compensatory relationship. This raises a question of whether protective processes of the home environment are more salient for families in poverty. Although it is likely that cognitive stimulation through enriched environments and positive parenting are beneficial for all children, it is also possible that the strength of association may differ across economic groups. Research suggests that children in homes of higher income often have a greater variety of pathways and environmental contexts for EF development, including quality child-care and cognitively stimulating trips outside of the home (Bradley, Corwyn, McAdoo, & García Coll, 2001; Burchinal, Nelson, Carlson, & Brooks-Gunn, 2008). Having a myriad of high-value inputs may decrease the impact of isolated risk factors such as lower positive parenting. For example, in a 2011 study, Oxford and Lee assessed the interaction of mother's parental behavior (i.e., parental support and cognitive stimulation assessed at 36 months) and socioeconomic advantage/disadvantage (assessed from 6 to 24 months) on school readiness (prosocial problem solving, language and attention assessed at 54 months) and early school achievement (math and reading assessed in first grade). Socioeconomic advantage/disadvantage was measured via mother's age, education, presence of biological father in the home, and income to needs ratio. On average, mothers in the socioeconomic advantage group had post high school education, were in their late 20s when their child was born, had the biological father of their child present in the home for the first two years of the child's life, and had an average income-to-needs ratio of 3.79. On average, mothers in the socioeconomic disadvantage group had a high school education, were in their early 20s when their child was born, did not have the biological father of their child present in the home for the first two years of the child's life, and had an income-to-needs ratio of 1.29. Results for the full sample (socioeconomically advantaged and disadvantaged children together) indicated a significant mediation in which parental behavior predicted school readiness, in turn predicting school achievement. However, when assessing by economic status, results indicated a direct effect of parental sensitivity on math achievement for children of socioeconomic disadvantage, yet no effect of sensitivity in the socioeconomically advantaged families, indicating differences in protective processes by economic status.

It is also worth noting that in many studies assessing income differences, variation is limited to the upper end of income, with few participants experiencing severe poverty, and majority of samples are situated in urban and suburban communities (Hoff, Laursen, Tardif, & Bornstein, 2002; Rosen et al., 2019, b; Sarsour et al., 2011). Thus, it is particularly important to include more socioeconomically disadvantaged and/or rural families in the examination of early environment and children's development.

The present study

The present study builds on previous research and uses a rural socioeconomically diverse sample to assess whether the effects of early childhood learning materials and positive parenting (assessed from 6 to 36 months) on EF (assessed at 58 months), as well as their potential interactions, are similar in families of higher and lower income. We also assess how these early factors, through the mediation of EF, predict early school functioning, including teachers' report of child behavioral adjustment and academic performance in the first grade. We chose to assess positive parenting and learning materials as an average across 6 to 36 months to represent the significant period of infancy and toddlerhood and reduce likelihood of measurement error, compared to using a single time point. This methodology is consistent with previous studies demonstrating that parenting from 0 to 3 years old predicts EF around 54 to 58 months and, in turn, predicts later child functioning in elementary school and beyond (Bindman et al., 2015; Sabol & Pianta, 2012). Furthermore, as environmental factors and children's cognitive development are likely already intertwined in early life, we controlled for children's early EF (assessed at 36 months) when predicting their EF right before school entry (assessed at 58 months), so that findings would reflect the association between early environment and EF development in preschool years. Poverty was assessed through the average household income-to-needs ratio across infancy and early childhood (6 to 58 months) to represent the broader context for children's continuing development and for the effects of early environmental factors.

Based on theory and literature highlighting the importance of early home environments and the interaction of multiple characteristics influencing child development, we hypothesize that there will be an interaction between learning materials and positive parenting, such that the beneficial effect of learning materials will increase with the presence of positive parenting (Bronfenbrenner & Morris, 2007; Masten et al., 1990). Given previous research demonstrating EF sensitivity to early parenting and learning materials and EF's impact on later child behavior, we further hypothesize that this interaction between the home environments will be associated with children's EF development such that better parenting and more learning materials will predict better EF performance at 58 months after controlling for 36-month EF, which in turn predicts better school performance (Bindman et al., 2015; Fenesy & Lee, 2018; Rosen et al., 2019, b). Considering previous theory and discussion, we also hypothesize that the interaction of the home environment will be moderated by poverty level, such that the effect of parenting and learning materials on EF will be stronger as a family's poverty level increases (Masten et al., 1990).

Method

Participants

Data used in the present study were drawn from the Family Life Project, a prospective longitudinal cohort study. Between September 2003 and August 2004, participating families were recruited from hospitals at the time of the child's birth, in six rural counties in North Carolina and Pennsylvania characterized by high rates of poverty. Participants at both sites were oversampled for poverty, and African American families were oversampled in the North Carolina counties. A total of 1292 families were enrolled in the study. Over the ensuing decade, participants completed assessments in a series of home visits. When children began attending school, teachers were asked to provide ratings on children's behavioral and social adjustment. Complete details of sampling structure and study procedures of the Family Life Project can be found in Vernon-Feagans et al., 2013. All procedures were approved by the Institutional Review Board at the University of North Carolina, with reliance from the Pennsylvania State University IRB. Parents provided written consent for their participation and for their child's participation, as well as permission to contact the child's teacher.

Of the original 1292 families, 65 were excluded because no data were available on any main study variable, resulting in a total of n = 1227 children (49.2% female) in the current analyses. The excluded participants did not differ significantly from the analysis sample in terms of the child's sex, race, or the family's income-to-needs ratio at the time of recruitment. Slightly over half of the analysis sample identified their child as Caucasian (56.3%), with the remaining identifying their child as African American (42.3%), or other races (1.4%). At the year of the child's birth, 64.1% of the families had annual incomes ≤200% of the federal poverty threshold (i.e., very poor or nearly poor); 59.7% of the families resided in North Carolina, and 40.7% resided in Pennsylvania. Among the mothers (99.6% biological mothers and 0.4% grandmothers or other female relatives who assumed the maternal role; M_{age} = 25.93 years at child birth, SD = 6.05), 24.5% did not hold a high school diploma, 61.5% held a high school diploma but not a college degree, and 14.0% held a college degree.

Measures

Family income-to-needs ratio. To obtain an index of poverty status, family income-to-needs ratio was calculated by dividing the family's annual income by the federal poverty threshold corresponding to the family's household size for each year. Income-to-needs ratio scores were computed at six time points prior to school entry (6-, 15-, 24-, 36-, 48-, and 58-month). Scores were relatively stable, with the correlation coefficients between consecutive time points ranging from 0.67 to 0.85. To represent each family's overall economic condition as a broad context for children's development, an average score across the six time points was calculated and used in subsequent analyses. Although the original averaged score ranged from 0 to 11.85, the sample mean of income-to-needs ratio was below 2, which was the threshold qualifying families for many federal and state subsidies (Garrett-Peters et al., 2016). To eliminate the impact of outliers, income-to-needs ratio scores higher than 5 (n = 38) were recoded as 5 before entered into the analysis (see Table 1 for descriptive statistics).

Positive parenting. Positive parenting was assessed at the 6-, 15-, 24-, and 36-month home visits with observational ratings of both structured and unstructured interactions. At each visit, the mother-child dyad was observed during a 10-min interactive task appropriate to the child's age. At the 6-month and 15-month visits, caregivers were instructed to play with the child as they normally would using a set of standardized toys. At the 24-month and 36-month visits, the caregivers were asked to assist the child in completing a series of puzzles (up to 3 with increasing complexity). The interactions were video-recorded and trained coders later rated caregiver behaviors on 5-point Likert scales (from 1 "not at all characteristic" to 5 "highly characteristic"). Based on previous work, a composite score reflecting positive parenting during interactive tasks was created for each age by averaging ratings on the parent's sensitive responsiveness (awareness of, and prompt responses to, child signals), positive regard (expression of positive affection toward the child), reversely coded detachment (emotional disengagement and failure to attend to the child's needs), animation (level of energy during the interaction), and stimulation of development (appropriate attempts to facilitate/scaffold activities; National Institute of Child Health and Human Development Early Child Care Research Network, 1999; Vernon-Feagans et al., 2013). Thirty percent of the families were double-coded, and the intra-class correlation coefficients for all subscales as well as the *positive parenting* composite were above 0.80 (Vernon-Feagans et al., 2012).

In addition to the structured observations, positive parenting was rated by the research assistant based on their observations across the entirety of the home visit using the Parental Emotional and Verbal Responsivity subscale of the HOME Inventory (Caldwell & Bradley, 1984). Because each home visit was typically at least 2 h long and consisted of individual assessments of child behavior and parental responses to questionnaires, research assistants had ample opportunity to observe parents interacting with their child as they typically do in their home environment. The infancy version (used at the 6-, 15-, and 24-month visits) of this subscale included 11 items, and the toddler version (used at the 36-month visit) included 7 items. The items described the mother's display of positive affection to child, verbal/vocal responsiveness, and age-appropriate scaffolding behaviors (e.g., "Caregiver caresses, kisses, or cuddles child during visit"; "Caregiver responds verbally to child's vocalizations or verbalizations"; "Caregiver helps child demonstrate some achievement during visit"). Trained home visitors dichotomously rated each item (0 "not observed" and 1 "observed") based on their observation over the course of the home visit. Then, an average score across all items were calculated (possible range = 0–1) for each age. This subscale demonstrated good internal reliability (Cronbach's α = 0.76–0.78 for the four time points) with the current sample.

There were significant correlations across ages for positive parenting assessed during interactive tasks (rs = 0.55–0.65, $ps < 0.05$) and for that assessed over the home visit (rs = 0.20–0.39, $ps < 0.05$). Positive parenting assessed in the two contexts were respectively averaged across ages. The two averaged scores were highly correlated, $r = 0.57$, $p < .001$, and were thus standardized and averaged into a composite score that reflects positive parenting in the first three years of life. The descriptive

Table 1
Descriptive statistics and bivariate correlations among main study variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Income-to-needs ratio	–											
2. SP composite score	0.49*	–										
3. Learning materials	0.45*	0.52*	–									
4. EF – 36 months	0.23*	0.28*	0.26*	–								
5. EF – 58 months	0.29*	0.39*	0.31*	0.32*	–							
6. Conduct Problems	−0.18*	−0.20*	−0.23*	−0.15*	−0.26*	–						
7. Hyperactivity	−0.20*	−0.24*	−0.20*	−0.21*	−0.35*	0.61*	–					
8. WJ LW	0.27*	0.27*	0.22*	0.20*	0.35*	−0.19*	−0.33*	–				
9. WJ PV	0.36*	0.39*	0.34*	0.26*	0.41*	−0.19*	−0.24*	0.49*	–			
10. WJ WA	0.27*	0.29*	0.29*	0.20*	0.41*	−0.23*	−0.33*	0.83*	0.49*	–		
11. WJ PC	0.27*	0.30*	0.26*	0.22*	0.39*	−0.22*	−0.32*	0.87*	0.51*	0.78*	–	
12. WJ AP	0.33*	0.36*	0.31*	0.35*	0.49*	−0.17*	−0.31*	0.61*	0.56*	0.62*	0.64*	–
Mean	1.76	0.00	0.83	−0.54	0.29	0.28	0.75	108.69	98.65	106.49	98.71	102.47
Standard deviation	1.21	0.90	0.15	0.54	0.48	0.41	0.65	12.99	10.30	11.19	13.85	14.47
Minimum	0.00	−5.33	0.11	−1.98	−1.98	0.00	0.00	41	56	42	37	23
Maximum	5.00	1.81	1.00	1.18	1.40	2.00	2.00	141	139	133	127	154

Notes. SP = Sensitive parenting; SP composite score is the average of standardized *sensitive parenting during interactive tasks* and *sensitive parenting over home visit* scores. EF = Executive functioning. WJ = Woodcock-Johnson Tests (LW = letter-word identification, PV = picture vocabulary, WA = word-attack, PC = passage comprehension, AP = applied problems). $^*p < .05$.

statistics of the positive parenting ratings are displayed in Table 1; given the possible ranges, mothers on average tended to display most positively responsive behaviors over the course of the home visit and showed moderate levels of positive parenting during the interactive tasks, although there was wide variability across the sample.

Learning materials. The presence of learning materials at home was assessed using the Provision of Appropriate Play Materials subscale of the HOME inventory (Caldwell & Bradley, 1984). This subscale consisted of 9 items in the infancy version (used at the 6-, 15-, and 24-month visits) and 11 items in the toddler version (used at the 36-month visit), listing a series of age-appropriate toys/learning materials (e.g., "Push or pull toy"; "2 or more toys or games requiring refined movements are available to the child.") and parental behaviors that facilitated/modeled the use of materials (e.g., "Caregiver provides toys for child to play with during visit"; "Caregiver reads a newspaper daily in the home."). Research assistants rated each item on a dichotomous scale based on observations and mothers' reports on whether the condition was characteristic of the home environment (0 "no" and 1 "yes"). An average score across items were computed for each age (see Table 1 for descriptive statistics; $rs = 0.55–0.65$, $ps < 0.05$ across scores from different ages). This subscale demonstrated satisfactory internal reliability (Cronbach's $\alpha = 0.77–0.88$ for the four time points) with the current sample.

Notably, although the original HOME Inventory includes additional subscales, the larger FLP study only assessed Learning Materials, Parental Responsivity, and Harsh Parenting. Therefore, we were not able to create a more comprehensive measure of cognitive stimulation. However, our positive parenting measures (see above) included several items capturing parents' cognitive stimulating behaviors (e.g., the parental responsivity measure in the HOME inventory included items of verbal/vocal responsivity and stimulation "caregiver spontaneously vocalizes to child at least twice", "caregiver tells child name of object or person during the visit"; the observed measure of positive parenting during structured tasks also included ratings of parents' developmental stimulation).

EF. Children's EF was measured through a battery of tasks administered during home visits when the child was 36, 48, and 58 months of age. The battery included six tasks to assess working memory (Working Memory Span task; Pick the Picture game), inhibitory control (Spatial Conflict Arrow task; Silly Sounds Stroop task; Animal Go No-Go task), and attention shifting (Something is the Same game). One task (Pick the Picture game) that was relatively difficult for young children was not included in the 36-month assessment, while all six tasks were administered at the 48- and 58-month assessments. As detailed in previous studies using this sample (Willoughby, Blair, Wirth, & Greenberg, 2012; Willoughby et al., 2012), a longitudinally-scaled expected a posteriori (EAP) score was generated for each task at each assessment based on the item response theory. Longitudinal confirmatory factor analyses further showed that children's performances on the five/six tasks were best represented by a single factor at each assessment (Willoughby et al., 2012). Thus, the EAP scores were averaged across all tasks at each assessment to form a global EF measure for the given age (see Table 1 for descriptive statistics of the average scores). The current study focused on the average EF score at the 58-month assessment right before school entry, and the 36-month EF score was included as a covariate when predicting 58-month EF, so that results would represent EF development in preschool years. Details about the task battery as well as the psychometric properties and validities of the resultant factor score can be found in Willoughby et al., 2012.

School functioning outcomes

Externalizing problems. When children were in the 1st grade, their teachers completed the Strengths and Difficulties Questionnaires (SDQ; Goodman, 1997). Externalizing behavioral problems, including conduct problems and hyperactivity/inattention, were assessed through two subscales of SDQ. The Conduct Problems subscale included items describing children's aggressive (e.g., "Often fights with other children or bullies them") and antisocial behaviors (e.g., "Often lies or cheats"); the Hyperactivity/Inattention subscale assessed over-activity (e.g., "Restless, overactive, cannot stay still for long") and difficulty in sustaining attention (e.g., "Easily distracted, concentration wanders"). Items were rated on 3-point Likert scales ranging from 0 (not true) to 2 (certainly true), and the average score of the 5 items were calculated for each subscale. Both subscales showed good internal reliability (Cronbach's $\alpha = 0.80$ for Conduct Problems and 0.89 for Hyperactivity with the current sample). Descriptive statistics of subscale scores were presented in Table 1. A latent factor was modeled using the Conduct Problems and Hyperactivity scores to represent externalizing behavioral problems in the 1st grade.

Academic skills. In the spring of 1st grade, children participated in a series of cognitive assessments, including five subtests of the *Woodcock-Johnson III Test of Achievement:* Letter-Word Identification, Picture Vocabulary, Word-Attack, Passage Comprehension, and Applied Problems (see Woodcock, McGrew, & Mather, 2001 for descriptions of the tests and establishment of reliability and validity). Children's standardized scores were computed for each subtest based on normative references for their specific age (see Table 1 for descriptive statistics). The five subtests assessed children's skills in reading and mathematical problem-solving. As the current study is interested in the general potential for academic achievement rather than specific domains of ability, scores of the subtests were used to model a latent factor reflecting general academic skills in the 1st grade.

Maternal IQ. The Wechsler Adult Intelligence Scale – Third Edition (WAIS-III; Wechsler, 1997) was administered to mothers during the 48-month home visit. The present study used the full-scale IQ score, which is comprised of indices of verbal comprehension, perceptual reasoning, working memory, and processing speed. The mean IQ of the entire sample was slightly lower than the population average ($M = 91.86$, $SD = 14.87$).

Analytic strategies

Preliminary analyses examined descriptive statistics of main study variables and bivariate correlations (see Table 1). This study aimed to examine the interplay between positive parenting and learning materials in the home environment in predicting children's EF development before school entry and further, their behavioral and academic functioning in the 1st grade. Moreover, we aimed to examine whether the effects of parenting and learning materials varied by family income-to-needs ratio. Thus, a three-way interaction was tested within a structural equation model, which incorporated measurement models of latent variables (i.e., externalizing problems and academic skills) and a path model examining direct and indirect associations among observed/latent variables. Positive parenting, learning materials, family income-to-needs ratio (referred to as family income thereafter), and corresponding two-way (positive parenting × learning materials, positive parenting × family income; learning materials × family income) and three-way (positive parenting × learning materials × family income) interaction terms were entered as predictors of children's EF at 58 months. Regression paths were further specified to examine the association between 58-month EF and the two latent variables of school functioning (i.e., externalizing problems and academic skills, which were examined in the same model; see Fig. 1). The indirect effects of predictors on school functioning variables through 58-month EF were estimated using bootstrapping with 1000 replications. The remaining direct effects of predictors on school functioning were also examined as regression paths in the model.

Child sex (0 = female, 1 = male), primary race (dichotomously coded as 0 = Caucasian, 1 = African American and others), state of residence (0 = North Carolina, 1 = Pennsylvania), maternal age at child birth, and maternal education and IQ were initially entered as covariates in the models. Maternal education was coded into three categories (did not complete high school, completed high school but not college, and completed college). Two variables were then created through simple effect contrast coding, using the second category as the reference. Thus, in the subsequent analyses, "below high school" and "college or above" respectively compared parents who did not complete high school and parents who obtained a college degree to those who completed high school but not college. EF at 58 months and school functioning outcome were initially regressed on all covariates, and correlational paths were specified between the covariates and all predictors. Furthermore, children's EF at 36 months was included as an additional covariate when predicting 58-month EF, so as to examine the effect of predictors on EF development in preschool years. Correlations were added between the two latent outcome variables, and among the main predictors (including the interaction terms). Correlational paths among covariates were specified based on theoretical rationale and modification indices. Then, correlation or regression paths involving covariates that were not statistically significant and did not impact results (i.e., main findings did not change when these paths were taken out) were trimmed out for parsimony, resulting in the final model reported below. A model comparison showed that model fit was not significantly impacted by trimming out these paths.

Among the main study variables, missingness was minimal for family income, positive parenting, and learning materials (missing rates <0.2%), whereas the missing rates for children's EF at 58 months and school functioning at the 1st grade ranged from 15.6% to 16.3%. A series of *t*-tests suggested that children who had missing data on the school functioning variables did not differ from the rest of the sample on

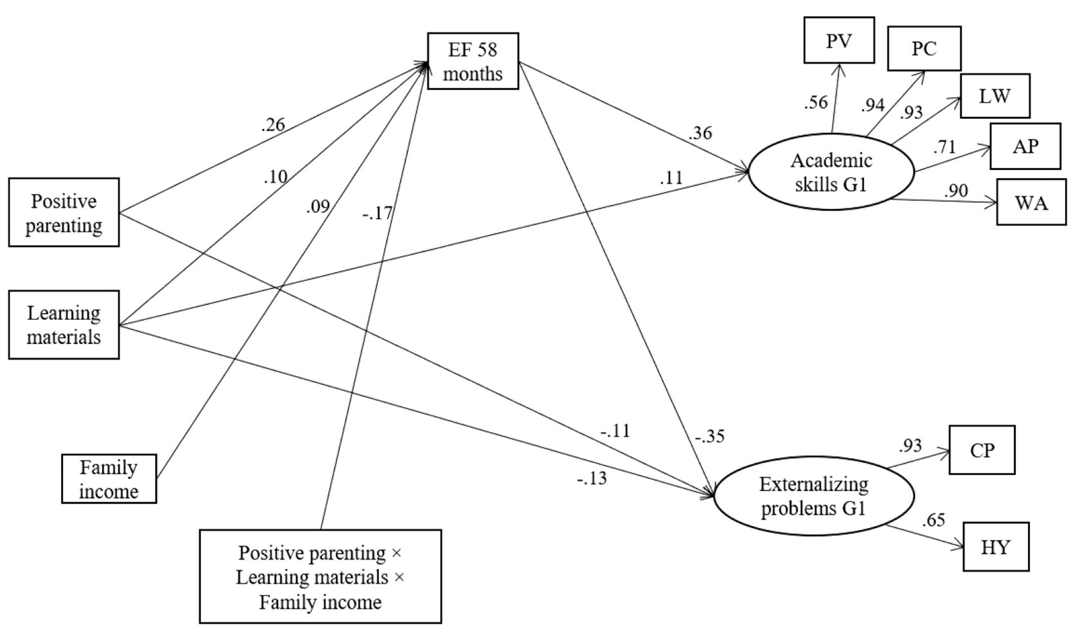

Fig. 1. Factor structures and regression paths (with standardized factor loadings and regression coefficients) among main study variables.
Notes. Covariates and the two-way interaction terms (learning materials × positive parenting, positive parenting × income, and learning materials × income) were specified in the model but not depicted here as they did not significantly predict EF at 58 months or the school functioning outcomes. Only the statistically significant regression paths ($p < .05$) are depicted. G1 = 1st grade; EF = Executive functioning before school entry; CP = Conduct problems; HY = Hyperactivity/Inattention. LW = letter-word identification, PV = picture vocabulary, WA = word-attack, PC = passage comprehension, and AP = applied problems, all sub-tests of the Woodcock-Johnson test.

positive parenting, learning materials, family income or the demographic covariates. Children at the North Carolina site were more likely to be missing EF data at 58 months, and missingness in EF was also correlated with lower levels of positive parenting; no significant relations were found of missingness in EF with any other demographic covariates, learning materials, or family income.

Analyses were conducted in R, and the model was fitted using the R package *lavaan* version 0.6–6 (Rosseel, 2012). Full information maximum likelihood estimation was used and robust (Huber-White) standard errors were obtained. Model fit was evaluated based on the chi-squared fit test (scaled as equal to the Yuan-Bentler test statistic), the comparative fit index (CFI), the incremental fit index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). Positive parenting, learning materials, family income and covariates were all centered around sample means; the interaction terms were computed using centered variables.

Results

Bivariate correlations (Table 1) showed that higher levels of family income, positive parenting, and learning materials at home were all significantly correlated with better EF at both 36 and 58 months, as well as less conduct problems, less hyperactivity/inattention symptoms, and higher scores on all five Woodcock-Johnson subtests in the 1st grade. We then examined the structural equation model to investigate their joint and interactive effects after controlling for covariates. The chi-squared test statistic indicated a statistically significant discrepancy between the final model and the data, χ^2 (137) = 604.47, $p < .001$, but all other indices suggested satisfactory fit, CFI = 0.96, TLI = 0.93, RMSEA = 0.05, SRMR = 0.07. As the chi-squared fit statistic is overly sensitive to trivial discrepancies with large sample sizes as in the current study (Fan, Thompson, & Wang, 1999), the model was not rejected solely based on this test, and we proceeded to examining the regression paths (see Table 2).

The effects of parenting, learning materials, and family income in predicting children's EF

As shown in Table 2 and Fig. 1, both positive parenting and learning materials in the first three years of life had positive main effects on children's EF before school entry, after controlling for covariates including earlier EF measured at 36 months. Because all predictors and covariates were centered around sample means, these main effects suggested that higher levels of positive parenting and learning materials were associated with faster EF gains in preschool years at the average levels of family income and covariates. After controlling for the effects of these two predictors and the covariates, family income still had a significant main effect on EF, such that higher income was associated with higher EF prior to school entry after accounting for earlier EF. None of the two-way interactions among positive parenting, learning materials, and family income was significant. However, there was a significant three-way interaction among the three predictors, supporting the hypothesis that the interactive effect of parenting and learning materials differed by poverty.

To interpret the three-way interaction, we examined the simple slopes of learning materials as a function of positive parenting in low-income versus higher-income families (see Fig. 2). For lower-income families (income-to-needs ratio = 0.85, i.e., the average level among families with income-to-needs ratio below the sample median), the positive association between learning materials and EF at 58 months was only significant at medium (mean) or high (one standard deviation above mean) levels of positive parenting, but not at low (one standard deviation below mean) levels of positive parenting. For higher-income families (income-to-needs ratio = 2.68, i.e., the average level among families with income-to-needs ratio above the sample median), there was a significant positive association between learning materials and 58-month EF at low (one standard deviation below mean) levels of positive parenting, but not at medium (mean) or high (one standard deviation above mean) levels. Specifically, when there were medium or high levels of positive parenting, children from higher-income families showed relatively better EF before school entry regardless of the amount of learning materials observed in the home environment. Although not depicted, we also probed the simple slopes of positive parenting, and found that it was significantly associated with faster EF development at all levels of learning materials (mean, one deviation above or below mean) among lower-income families. Among higher-income families, higher levels of positive parenting were significantly associated with better EF development at medium or low (mean or one standard deviation below mean) levels of learning materials, but not at high (one standard deviation above mean) levels of learning materials. As evident in Fig. 2, children from higher-income families who had a greater amount of learning materials at home showed better EF before school entry regardless of the level of positive parenting.

Table 2
Parameter estimates of regression paths.

Dependent variable / Predictor	*beta*	*SE*	β
EF at 58 months			
State of residence	0.05	0.03	0.05
Child sex	−0.12*	0.03	−0.13
Maternal education (below high school)	0.03	0.04	0.03
Maternal education (college or above)	0.10*	0.04	0.07
Maternal IQ	0.003*	0.001	0.09
EF at 36 months	0.16*	0.03	0.18
Learning materials	0.33*	0.14	0.10
Positive parenting	0.14*	0.02	0.26
Income	0.04*	0.02	0.09
Learning materials × Positive parenting	−0.19	0.18	−0.07
Learning materials × Income	−0.03	0.13	−0.01
Positive parenting × Income	0.01	0.02	0.01
Learning materials × Positive parenting × Income	−0.37*	0.12	−0.17
Externalizing problems in the 1st grade			
Maternal age	−0.01	0.003	−0.06
Child sex	0.26*	0.04	0.22
Maternal education (below high school)	0.01	0.05	0.01
Maternal education (college or above)	−0.17*	0.06	−0.10
Maternal IQ	0.002	0.002	0.05
EF at 58 months	−0.35*	0.04	−0.28
Learning materials	−0.53*	0.20	−0.13
Positive parenting	−0.07*	0.04	−0.11
Income	−0.01	0.03	−0.02
Learning materials × Positive parenting	−0.20	0.22	−0.06
Learning materials × Income	0.04	0.18	0.01
Positive parenting × Income	−0.01	0.03	−0.01
Learning materials × Positive parenting × Income	0.26	0.18	0.10
Academic skills in the 1st grade			
Child race	4.05*	0.93	0.15
Maternal education (below high school)	−1.74	0.96	−0.06
Maternal education (college or above)	0.17	1.20	0.004
Maternal IQ	0.14*	0.04	0.16
EF at 58 months	10.04*	1.07	0.36
Learning materials	9.66*	4.15	0.11
Positive parenting	0.65	0.65	0.04
Income	1.00	0.55	0.09
Learning materials × Positive parenting	−7.31	4.31	−0.09
Learning materials × Income	3.76	3.75	0.05
Positive parenting × Income	0.37	0.55	0.03
Learning materials × Positive parenting × Income	−4.18	2.88	−0.07

Notes. beta = Unstandardized coefficient; *SE* = Standard error; β = Standardized coefficient. State of residence was coded as 0 (North Carolina) and 1 (Pennsylvania). Child sex was coded as 0 (female) and 1 (male). Race was dichotomously coded as 0 (Caucasian) and 1 (African American and others). EF = Executive functioning. The maternal education variables respectively reflect the effects of not completing high school and having completed college when compared to mothers who completed high school but not college. Income = Family income-to-needs ratio. * $p < .05$.

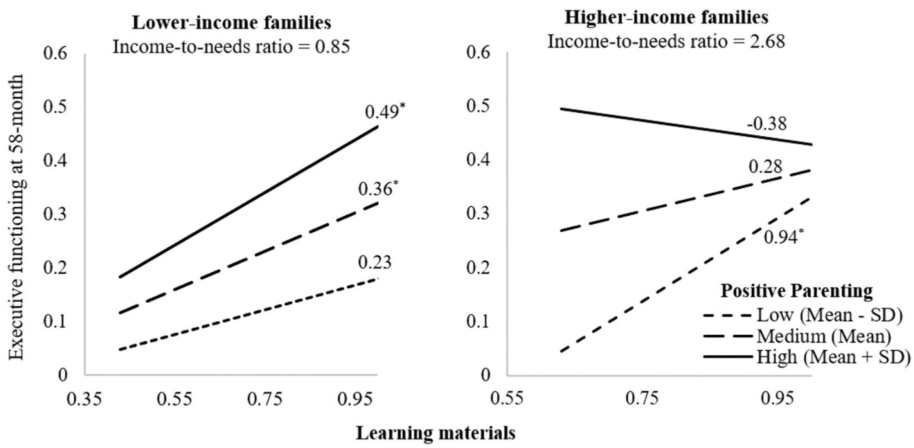

Fig. 2. The interactive effect of positive parenting and learning materials on children's executive functioning varied by family income.

Notes. Mean and SD represent the average level and standard deviation of positive parenting in the current sample. The two income-to-needs ratio scores (0.85 and 2.68) used to probe simple slopes represent the average levels among families with income-to-needs ratio below the sample median (lower-income families) and families with family-to-needs ratio above the sample median (higher-income families) respectively. The range of learning materials depicted here (x axis) covered 95% of scores among the lower- or higher-income families. *$p < .05$.

Indirect and direct paths predicting school functioning outcomes

We further examined the regression paths predicting school functioning outcomes (see Table 2 and Fig. 1) to understand the indirect effects through EF and the remaining direct effects of predictors. As expected, better EF before school entry was associated with higher levels of academic skills and lower levels of externalizing problems. The indirect effects of predictors on the school functioning outcomes through EF were estimated through bootstrapping. For parsimony, only the indirect effects where the predictors were significantly associated with EF were reported in detail below with bootstrapped unstandardized coefficients, standard errors, and *p* values.

Regarding the main effects, more positive parenting was associated with higher levels of academic skills and lower levels of externalizing problems in school through better EF before school entry (indirect effect on academic skills: coefficient = 1.38, $SE = 0.29$, $p < .01$; indirect effects on externalizing problems: coefficient = −0.05, $SE = 0.01$, $p < .01$). Similarly, more learning materials was associated with higher levels of academic skills and lower levels of externalizing symptoms through better EF (indirect effect on academic skills: coefficient = 3.28, $SE = 1.44$, $p = .01$; indirect effects on externalizing problems: coefficient = −0.11, $SE = 0.05$, $p = .01$). After accounting for the effect of positive parenting and learning materials, higher family income was also related to higher levels of academic skills and lower levels of externalizing symptoms through better EF before school entry (indirect effect on academic skills: coefficient = 0.37, $SE = 0.18$, $p = .02$; indirect effects on externalizing problems: coefficient = −0.01, $SE = 0.01$, $p = .02$). Through the effect on EF (see Fig. 2), the three-way interaction also had significant indirect effects on academic skills (coefficient = −3.56, $SE = 1.36$, $p < .01$) and externalizing problems (coefficient = 0.12, $SE = 0.05$, $p < .01$). The two-way interactions (positive parenting × learning materials, positive parenting × family income, and learning materials × family income) did not have significant indirect effects on the school functioning outcomes through EF prior to school entry (*ps* > 0.05).

After accounting for the indirect paths through executive functioning, family income did not have any significant direct effect on children's school functioning. However, learning materials at home had additional effects on both academic skills (positively associated) and externalizing problems (negatively associated) even after accounting for the indirect effects. Additionally, positive parenting had a direct effect on children's externalizing symptoms (negatively associated) after accounting for the indirect effect through EF, but not on academic skills. The two-way and three-way interactions among family income, parenting, and learning materials did not have significant direct effects on school functioning.

Discussion

This study explored the interplay of early positive parenting and learning materials in the home in association with children's EF development before school entry and whether such associations differed across family income. We also assessed the effects of income, learning materials, and positive parenting on early school functioning, specifically children's behavioral and academic skills in the 1st grade, through the mediation of EF. Supporting our hypotheses, results indicated an association between more positive parenting and better EF before school entry (after accounting for EF at 36 months) across family income, and EF before school entry subsequently predicted both behavioral and academic outcomes in 1st grade. Interestingly however, learning materials was only a significant predictor of EF when there was adequate positive parenting among families of lower income, and when positive parenting was at lower levels among families of higher income. A significant interaction indicated that for families with relatively lower income-to-needs ratios (e.g., at or below 0.85), positive parenting and learning materials may function as compensatory factors in facilitating children's EF development, and subsequently predicted better behavioral and academic outcomes in 1st grade. These results highlight the significance of learning materials and positive parenting to jointly support children's development even in the context of significant poverty. These findings have important implications for reducing educational disparities across economic class and suggest that programs with an integrative focus on parenting and learning materials within the home in low income families may be a valuable supplement to programs designed to provide economic assistance.

The roles of home environment in predicting children's EF by family income

When the home environment predictors were placed into a single model with income-to-needs ratio, we were able to examine their interactive effects in predicting children's EF. For children in families of lower income, this study supports previous research demonstrating early childhood relationships between learning materials and EF as well as between positive parenting and EF (Bernier et al., 2012; Merz et al., 2017; Sarsour et al., 2011). Results also support previous theory highlighting the importance of interactions within the early childhood environment as critical for development of resilience in children at risk (Bronfenbrenner & Morris, 2007; Masten et al., 1990). Further interaction between these home contexts suggests that, for low-income children in particular, both early learning materials and positive parenting may be necessary but insufficient alone. While positive parenting may construct an emotionally supportive learning environment for the child, the addition of learning materials in the home may provide a mechanism for cognitive stimulation that parent and child can use during their interactions and individual child play. Similarly, presence of learning materials without positive parenting may be ineffective. In fact, results indicated that learning materials were only significantly associated with EF development at medium or high levels of positive parenting, but not at low levels of positive parenting. Early learning materials can create a stimulating home for a child to explore, providing toys designed to foster EF skills. However, positive parenting may serve as an important means for children to engage with these materials effectively. The addition of positive parenting, including warmth and responsiveness, likely creates a stimulating home environment in which a parent engages children with these materials and a child feels comfortable exploring his or her environment, in turn optimizing the benefits of learning materials. This somewhat coincides with previous research supporting enhanced development in the presence of caregiver stimulation. For example, previous work exploring the effects of early deprivation on children's development highlight early childhood as a sensitive period in which early parenting and cognitive stimulation are critical for cognitive development, with low levels of stimulation contributing to reduced cognitive development (Nelson, 2007; Nelson, Furtado, Fox, & Zeanah, 2009).

Interestingly, in homes of higher income, children showed relatively higher levels of EF when either more learning materials or higher levels of positive parenting was present. In other words, children in higher-income families were only at a disadvantage in EF before school entry if there was a lack of both learning materials and positive parenting. Such differences by income support theory that high distal risks, such as poverty, increase the importance of protective characteristics in development and resilience (Masten et al., 1990). Though rural families overall tend to have less access to high value inputs (e.g., quality daycares, museums, parks and other stimulating resources outside of the home) compared to urban families, when analyzing variances within rural communities, families of higher income may have (relatively) more access to these inputs compared to rural families in poverty (Allard, 2009). Specifically, rural families of higher income may have more access to resources within their neighborhoods or may have more ability to travel to these resources. This increased access may reduce the significance of positive parenting or learning materials in the home alone. For example, children in families of higher income may often have access to high-quality child care outside the home that provides them with warm and responsive interaction with adults as well as exposure to learning materials. It is possible that through these additional avenues these children receive cognitive stimulation and emotional support that lessen the significance of learning materials or positive parenting in the actual home.

In comparison, children in homes of lower socioeconomic status, may not have as many opportunities for outside positive experiences, and thus maintain a higher reliance on qualities of the home environment. However, it is also important to note that it was relatively less likely for there to be a low number of learning materials or low quality of parenting in the home of higher income families, thus reducing the variance to be examined. For example, in the current sample, higher-income families (income-to-needs ratio above sample median) had relatively smaller variances on the measure of learning materials (standard deviation = 0.12, range = 0.34–1.00) compared to lower-income families (income-to-needs ratio below sample median; standard deviation = 0.16, range = 0.11–1.00). Although this further highlights the disparity in resources between higher- and lower-income households, the limited range may have contributed to non-significant findings for children in homes of higher socioeconomic status. Further replication research is warranted.

It is worth noting that after accounting for the effect of parenting, learning materials, and other covariates, there was still a significant main effect of family income on children's EF gains in preschool years. This suggests that there may be other factors associated with poverty (e.g., sleep, family emotional atmosphere, etc.; Bernier et al., 2010, b; Eisenberg et al., 2001) that are associated with children's cognitive development, calling for further research inquiry.

Direct and indirect associations between environmental factors and school functioning

For children in poverty, learning materials and positive parenting also predicted behavioral and academic adjustment in first grade, with a significant mediation through children's EF before school entry. For children in families with higher income, positive parenting predicted behavioral and academic adjustment in first grade, with a significant mediation through EF. This supports previous research suggesting that early learning materials and parenting are critical in developing a solid foundation for children's later school performance (Raby, Roisman, Fraley, & Simpson, 2015; Rosen et al., 2019, b) and furthermore, supports EF as a mechanism in this relationship (Bindman et al., 2015; Fenesy & Lee, 2018). Specifically, learning materials and positive parenting in early childhood create a supportive environment for healthy EF development. In turn these cognitive skills lay a foundation for better behavioral regulation and academic achievement in school settings (Blair, 2002).

Notably, while positive parenting was related to better academic adjustment among both lower and higher income families in this sample, a previous study found differential effects of positive parenting by socioeconomic status. In a diverse sample of urban, suburban, and rural families, Oxford and Lee (2011) showed that positive parenting was related to better math skills only among socioeconomically disadvantaged families, but not among advantaged families. It is possible that the discrepancy between the current and the previous findings regarding the effect of parenting is due to the all-rural nature of the current sample. Rural and urban families often differ in their access to resources as well as exposure to stressors (Miller, Votruba-Drzal, & Coley, 2019), which may be another layer of broader context beyond family income that influences the role of home environment in children's development. For example, previous research suggests that the family may have a greater influence on children's development in rural families compared to urban families given higher isolation of families within rural communities compared to urban communities (Tine, 2017). Furthermore, Oxford and Lee's (2011) study assessed distinct domains of math and reading achievement, whereas the present study focused on general academic ability. Future research may wish to further assess how particular components of home contexts interact to impact specific academic skill sets. For example, whether specific types of learning materials are more directly related to math or reading skill development, or whether different aspects of sensitivity (e.g., warmth, responsiveness, etc.) are more important in supporting engagement with different types of learning materials.

Additionally, it is important to note some non-significant findings. Specifically, though main hypotheses regarding the three-way interaction's effect on school functioning through EF were significant, the two-way and three-way interactions did not have significant direct effects on school functioning and the two-way interactions (positive parenting × learning materials, positive parenting × family income, and learning materials × family income) did not have significant indirect effects on school functioning outcomes through EF. The non-significant two-way interactions likely indicate the complexity of the interplay among various environmental factors in shaping children's EF. For example, there was not a significant interaction between positive parenting and learning materials in predicting EF across the sample. However, when the third factor (income) was introduced, differences emerged as reflected in the three-way interaction. This also highlights the importance of assessing broader socioeconomic contexts when examining specific qualities of the home environment as predictors of children's cognitive development. Additionally, three-way interactions demonstrated no direct effect. It may be the case that variances of these interacting factors are explained through EF rather than a direct impact.

Applied implications

Collectively, findings highlight potential early intervention mechanisms in supporting early skills and may suggest differences in intervention and prevention targets based on family economic characteristics. For example, children in homes of lower income may benefit most from comprehensive interventions including an early focus on support for increased learning materials in the home, strengthening sensitivity of the family and monitoring children's EF development (e.g., The Parent-Child Home Program, Home Instruction for Parents of Preschool Youngsters [HIPPY]). Such programs demonstrate effectiveness in supporting children's early school functioning and warrant further evaluation in rural settings (Allen, Sethi, & Astuto, 2007; Johnson, Martinez-Cantu, Jacobson, & Weir, 2012). In contrast, for children in homes of higher socioeconomic status, it may be most cost-effective to conduct pre-assessment and target children who are at potential risk for delayed EF development (e.g., children from households with both lower parenting quality and a lack of cognitively stimulating environment despite being economically affluent). Providing more tailored interventions based on family characteristics, may optimize children's benefits from their home environment and strengthen school functioning skills in both higher and lower socioeconomic groups, helping to decrease gaps in achievement between these children.

With these recommendations in mind, it is important to note that findings do not suggest a lack of value in current policies and interventions provided for low income families, such as nutrition and financial assistance (SNAP, WIC, TANF, etc.), but may suggest that additional support for enrichment and parenting education may provide even greater returns in efforts to combat the disparities in child development associated with poverty.

Limitations

In light of these findings, several limitations must also be considered. First, as discussed previously, though this study was able to identify beneficial relationships in home contexts, the limited range of learning materials in homes of higher socioeconomic status may have impacted findings. Future research may wish to include additional variability (e.g., through targeted recruitment). Similarly, future studies may also gather additional data on children's outside-home cognitive experiences to test hypotheses regarding additional pathways/opportunities for early cognitive development. Third, though this study provides valuable insights on a rural high-risk sample that is often understudied in the literature, generalizability is limited. Additional research may include both urban and rural participants to assess potential differences in effects.

Conclusion

In sum, this study demonstrated important relationships in early home contexts supporting cognitive processes and early school performance for children in families of lower and higher socioeconomic status. Optimizing these contexts in a targeted way may result in greater achievement for these children while maximizing the cost-effectiveness of prevention and intervention efforts. Further exploration of early home contexts and cognitive processes can potentially add to efforts in closing achievement gaps and strengthening child outcomes.

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