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Maternal Language and Child Vocabulary Mediate Relations Between Socioeconomic Status and Executive Function During Early Childhood

M. Paula Daneri[a], **Clancy Blair**[a], **Laura J. Kuhn**[b], **FLP Key Investigators**

[a]Department of Applied Psychology, New York University, New York, NY, 10003, USA

[b]FPG Child Development Institute, University of North Carolina – Chapel Hill, Chapel Hill, NC 27599, USA

Abstract

This article examined longitudinal relations among socioeconomic risk, maternal language input, child vocabulary, and child executive function in a large sample (N=1,009) recruited for a prospective longitudinal study. Two measures of maternal language input derived from a parent-child picture book task, vocabulary diversity and language complexity, showed variation by socioeconomic risk at child ages 15, 24, and 36 months. Maternal vocabulary diversity at child age 24 months and maternal language complexity at child age 36 months mediated the relation between socioeconomic risk and 48-month child executive function, independent of parenting sensitivity. Moreover, 36-month child vocabulary mediated the relation between maternal language input and child executive function. These findings provide novel evidence about mechanisms linking socioeconomic risk and child executive function.

Keywords

maternal input; executive function; vocabulary

It is well established that socioeconomic status (SES) is positively associated with child executive function (EF; Hackman & Farah, 2009). Recent meta-analysis shows that children growing up in higher-income homes are more likely to demonstrate better EF skills than their less economically advantaged peers (Lawson, Hook, & Farah, 2017). Theoretical models propose that the quality of the environment in the early years plays an important role in the relation between SES and child EF (Ursache & Noble, 2016). As studies broadly supporting this hypothesis emerge (Bernier, Carlson, & Whipple, 2010), researchers have begun to examine what specific aspects of the early environment drive child EF development in the early childhood period. Although prior work points to both parenting quality (Blair et al., 2011) and children's vocabulary (Fuhs & Day, 2011) as important factors that promote early EF, little research to date has investigated on the potential contribution of maternal language input.

Address correspondence to: M. Paula Daneri, 196 Mercer Street, 8th floor, New York University, New York City, NY, 10012, USA, Phone: 212-992-9328, Fax: 212-995-4408, Paula.daneri@nyu.edu.

The current study addresses this gap in the literature by examining whether SES-related disparities in maternal language input are associated with child EF and whether child vocabulary mediates this association. Given our explicit interest in isolating the association between maternal language and child EF, we control for observed parenting quality to determine if maternal language predicts child EF above and beyond the general quality of parent-child interactions. Our study addresses these questions using data from a large, prospective longitudinal sample of children and families in predominantly low-income and non-urban communities.

SES, Maternal Linguistic Input, and Child Vocabulary Development

The development of children's early cognitive abilities is influenced by their interactions with adults within their environments (Nelson, 1998). Prior research provides robust evidence for the association between family SES and the quality of language input children receive during parent-child interactions, demonstrating that mothers in higher SES homes are more likely to provide children with a greater amount and variety of language input than those in lower SES homes (Hart & Risley, 1995; Hoff, Laursen, & Tardif, 2002; Rowe, 2008). Specifically, higher SES mothers are more likely to use more diverse and varied vocabulary (Vernon-Feagans et al., 2008), longer sentences (Hoff, 2003), and more complex grammatical structures (Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007).

Understanding variation in mothers' language input is critical because a wealth of evidence suggests that maternal language input is associated with children's vocabulary development (Pace, Luo, Hirsh-Pasek, & Golinkoff, 2017). For instance, children of mothers who use a higher number of word types, meaning more diverse vocabularies, are more likely to have larger vocabularies (Bornstein, Haynes, & Painter, 1998; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; Pan, Rowe, Singer, & Snow, 2005). Studies also show that mothers who use longer sentences, a proxy for complex language, generally children with larger vocabularies (Hoff, 2003; Rowe, 2008). Importantly, maternal language mediates the relation between SES disparities and child vocabulary (Hoff, 2003; Huttenlocher,Waterfall, Vasilyeva, Vevea, & Hedges, 2010). Prior analyses of the current dataset show that a composite of maternal language complexity, which included a measure of utterance length, partially mediated the association between SES-related risk and measures of child receptive and expressive language at 36 months (Vernon-Feagans, Cox, & FLF Key Investigators, 2013). Further, a study of socioeconomically-diverse families showed that mothers' number of different words mediated the association between family SES and child vocabulary at 26 months (Huttenlocher et al., 2010). Thus, higher quality maternal language may ameliorate some of the negative effects of poverty on children's vocabulary development.

Maternal Linguistic Input and Child Executive Function

Although maternal language input has been largely studied in relation to child language development, theoretical and empirical accounts support associations between language input and child cognition more broadly (Bates, 2014; Nelson, 1998). Exposure to language helps children to develop fundamental abilities like joint attention, object category formation, and representational thinking that underlie higher-order cognitive skills (Ganea, Shutts, Spelke, & DeLoache, 2007; Iverson & Goldin-Meadow, 2005; Waxman & Markow, 1995). Prior analyses of the current sample showed that maternal vocabulary at 6 months and change in maternal vocabulary between 6 and 15 months each independently predicted child cognitive ability at 15 months (Burchinal, Vernon-Feagans, Cox, & Key Family Life Project Investigators, 2008). In another sample, parent use of wh-questions during a play session at 24 months was positively associated with children's reasoning skills at 36 months (Rowe, Leech, & Cabrera, 2016). Maternal language input has also been associated with children's theory of mind (de Rosnay & Hughes, 2006), including a study in which maternal use of words relating to mental states (e.g,. think, believe) in a sample of children between two and four years of age was associated with theory of mind twelve months later (Ruffman, Slade, & Crowe, 2002).

In addition to this general evidence, theoretical work specifically links maternal language input with child EF early in development (Ursache & Noble, 2016). EF refers to the effortful cognitive processes engaged when resolving conflict, holding multiple pieces of information in mind, or managing and integrating information (Blair & Ursache, 2011). One framework for understanding the role of maternal language in supporting child EF development is the hierarchical competing systems model (Marcovitch & Zelazo, 2009). Within this model, reflective cognition, a process in which children move from a habit-based to a reflective system, is critical for the development of EF. This process of moving to intentional action is most efficient when children have the vocabulary to support representational thinking (Zelazo, 2015). Thus, when mothers expose their children to language that is rich in vocabulary diversity, they are providing them more opportunities to form mental constructs to reflect upon. Simply put, when a child learns a new word from a mother's labeling of an object, that child has been given a new opportunity for reflection, which in turn supports the development of EF.

Maternal use of complex language also provides children with the opportunity to develop skills underlying EF. A second critical component to the development of EF is the ability to understand if-then conditions or hierarchical systems (Frye, Zelazo, & Burack, 1998). When mothers demonstrate how words are combined to communicate, they are exposing their children to the set of rules (or syntax) that governs language. In turn, as children learn to combine words meaningfully, they gain experience with a system of rules that differentially applies under specific conditions (Landau & Gleitman, 1985). That is, there are unique rules governing the different conditions of speech, such as nouns and verbs. When mothers expose their children to more complex sentences they are helping to support this type of conditional thinking.

Despite the theoretical and empirical evidence pointing to an association between maternal-child verbal interactions and the development of child EF, relatively few studies have examined associations between the two. One study using a socioeconomically diverse sample of preschoolers found a significant correlation between maternal language complexity, measured as mean length utterance, at 24 months and child EF at 48 months (Hughes & Ensor, 2009). Another study of school-aged children found that a broad measure of family language input composed of number of word types, bound morphemes, and conjunctions concurrently predicted children's EF performance as well as brain activation, measured using fMRI, during an EF task (Sheridan, Sarsour, Jutte, D'Esposito, & Boyce, 2012). Additional analyses suggested that family language input may have mediated the relation between SES and child EF; however, the sample size was not large enough to formally test that model. Critically, however, these initial studies did not examine the longitudinal associations between maternal language input and child EF despite significant growth in child skills over the early childhood period.

Longitudinal Associations among Maternal Language, Child Language, and Child EF

Given the rapid changes that children undergo in both EF and verbal communication skills during the first few years of life, it is important to understand how mother-child verbal exchanges may change over this period as this could inform how maternal language input relates to later child EF. One possibility is that different aspects of maternal language input support the development of EF as children become more experienced with language and learn to extrapolate meaning from complex language input. That is, children generally speak their first words around their first birthday and continue building a vocabulary base over the following months and years (Hoff & Shatz, 2009). During this time, mother-child conversations tend to focus on providing children with the vocabulary needed to create the representations that define their worlds. Later in the second year and into the third year of life, most children begin to combine words and speak in sentences (Hoff & Shatz, 2009). During this period, mothers are likely to expand their language usage to include information about objects that are not present and supply additional contextual information. Thus, as children’s own language abilities develop, they become more attuned to the pattern and structure of language and seek to derive deeper meaning from words (Harris, Golinkoff, & Hirsh-Pasek, 2011; Kemler-Nelson, Egan, & Holt, 2004)

Empirical evidence supports a developmental progression in which different aspects of maternal language predict child language over time as children’s own language abilities become more developed. Rowe (2012) found that when children were 18 months, the number of words mothers used was most predictive of children’s later vocabulary, as this was a time when children needed repeated exposure to acquire new vocabulary. At 30 months, the number of different words, or vocabulary diversity, that mothers used was most predictive of later vocabulary, likely because children had become efficient at acquiring new words by that age. Finally, by 42 months, maternal use of decontextualized language, language that refers to objects that are not in the immediate present, was most predictive of children’s vocabulary. The pattern revealed in this study suggests that as children mature, different aspects of maternal language input support word learning. Specifically, the pattern suggests that diversity in maternal vocabulary becomes important once children become efficient word learners, whereas more sophisticated language, in Rowe’s (2012) study operationalized as decontextualized language and in the current study operationalized as longer sentence structures, becomes more important once children begin to express themselves in sentences. This pattern of differential support in maternal language, however, has yet to be examined for cognitive abilities other than language, like EF.

In the current study, we build upon the small set of studies described above to examine the association between SES-related disparities in maternal language input and SES-related disparities in child EF. We propose that at 24 months, when children are rapidly acquiring vocabulary, the number of different words, or diversity in vocabulary, is the aspect of maternal language input most likely associated with later child EF. By age 36 months children have acquired a foundational vocabulary that supports more advanced linguistic and cognitive skills. Specifically, children begin to combine words in sophisticated ways and engage in emergent reflective skills. As such, we propose by 36 months children will have shifted their focus in maternal input to language complexity, where longer sentences afford more opportunities to hear sophisticated sentence constructions.

Child Vocabulary as a Mediator of Maternal Language Input and EF

Given the theoretical role of vocabulary as foundational for the development of early reflective and EF skills (Zelazo, 2015), it is also relevant to consider the role of children's own language skills during this period of cognitive development. There is now growing evidence supporting theoretical frameworks that posit child vocabulary as a precursor to child EF (Fuhs & Day, 2011). Two prior analyses of the current dataset identified associations between children's early language development and later EF (Kuhn et al., 2014; Kuhn, Willoughby, Vernon-Feagans, & Blair, 2016). One of these analyses found that children with higher expressive language ability as measured through a standardized assessment at 24 and 36 months tended to have higher EF at 48 months (Kuhn et al., 2014). The other showed that the rate of change in children's vocabulary use between 15 and 36 months during a parent-child book sharing interaction positively predicted child EF at 60 months and child EF growth from 36 to 60 months (Kuhn et al., 2016). Collectively, this work suggests that child vocabulary independently predicts later EF abilities and within a larger developmental framework may mediate association between maternal language input and child EF. Considering this alongside the robust evidence showing that maternal language input predicts later child vocabulary (Hoff, 2003; Huttenlocher et al., 1991), it is likely that within a larger developmental framework, child vocabulary may mediate association between maternal language input and child EF.

Parenting Sensitivity and Child Executive Function

Maternal language input in the context of SES-related risk is an important consideration for child EF. However, the limited research that exists has failed to account for an important confounder: parenting sensitivity. Prior literature shows that parenting sensitivity, characterized by warmth and reciprocity between caregivers and their children, is associated with both maternal language input and child EF (Blair et al., 2011). A prior analysis of the current dataset examining sources of variation in maternal language input revealed that parenting quality was positively associated with both the diversity as well as complexity of maternal language during the first year of children's lives (Vernon-Feagans et al., 2008). Furthermore, a prior analysis with the current dataset found that a composite of sensitive parenting between child age 6 and 24 months mediated the relation between SES and child EF at 36 months (Blair et al., 2011). Based on this, we include parental sensitivity as a predictor in our models examining the relation from maternal language input to child EF.

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Current Study

In the current study we draw on the various literatures described earlier to examine the association between SES-related disparities in maternal language input and child EF using a large, longitudinal sample. First, we examine the extent to which a composite of SES-related risk factors measured at child age 6 months predicts variation in vocabulary diversity, measured as the number of different words (NDW), and language complexity, measured as mean length utterance (MLU), that mothers used during picture book interactions when children were 15, 24, and 36 months. We hypothesize that SES-related risk will be negatively associated with both measures of maternal input at all time points. Then, we test a mediational model examining the extent to which the association between SES and 48-month child EF is attributable to maternal linguistic input. In order to capture variation in the relation between mothers' language and child outcomes over time we include both measures of maternal language input (NDW and MLU) at all three time points (15, 24, and 36 months) simultaneously in our model. We hypothesize that 24-month NDW and 36-month MLU will mediate the relation between SES-related risk and child EF. Finally, we test the extent to which child vocabulary at 36 months mediates the relation between maternal linguistic input and child EF. We hypothesize that child vocabulary will mediate the relation between 24-month NDW and child EF, and between 36-month MLU and child EF. Moreover, we hypothesize that both maternal language input and child vocabulary will mediate the relation between SES-related risk and child EF. In our analyses we control for a number of relevant variables that could reasonably account for any observed associations, most notably the quality of parenting that a child receives. To our knowledge, this is the first study to examine associations from both maternal NDW and MLU across time to child EF and to examine the role of child vocabulary as a mediator in that relation.

Method

Participants

The *Family Life Project* (FLP) was designed to study young children and families in two of the four major geographical areas of the United States with high poverty rates. Specifically, three counties in Eastern North Carolina (NC) and three counties in Central Pennsylvania (PA) were selected to be indicative of Black and White families in the South and White families in Appalachia, respectively. The FLP adopted a developmental epidemiological design in which sampling procedures were employed to recruit a representative sample of 1,292 children whose families resided in one of the six counties at the time of the child's birth. Low-income families in both states and African-American families in NC were over-sampled (African-American families were not over-sampled in PA because the African American populations of these counties was <5%). A comprehensive description of the sampling plan and recruitment procedures are provided by Vernon-Feagans et al. (2013).

Procedure

Data used in the current analyses were collected between May of 2004 and November of 2008 during home visits when children were 6, 15, 24, 36, and 48 months of age. Two research assistants (RAs) completed each home visit for data collection, which included questionnaires, parent-child interactions, and direct child assessments. At 6 months, the primary caregiver - the biological mother in the vast majority (96%) of the sample - completed a series of questionnaires that included information about family demographics. At 15, 24, and 36 months, the mother and child completed a picture book task from which maternal language was obtained as well as a mother-child interaction from which sensitive parenting was coded. Children completed a standardized receptive vocabulary assessment at 36 months and an EF battery at 48 months. Child assessments were performed at a portable table, with the RA sitting across from the child.

Measures

SES-related risk—As with prior analyses of the FLP (Vernon-Feagans et al., 2013), we computed an SES-related risk composite of seven variables measured at 6 months: family income-to-needs ratio, maternal education, constant spouse or partner living in the home, hours of employment, occupational prestige, household density, and neighborhood safety. A continuous risk index was generated by reverse-scoring the positively framed indicators, standardizing each measure, and averaging the standardized variables. Correlation coefficients among the seven indicators included in the SES-related risk index ranged from $r = -.13 – .52$, p's < 0.001.

Maternal linguistic input—Maternal language input was coded from digital video recordings of a picture book sharing task between the mother and the child at 15, 24, and 36 months. Mothers were told to go through a wordless picture book with their child as they normally would and alert the RA when they were done. All words were removed from the books for this task. If the mother had not indicated being done after 10 minutes, the RA terminated the task. Because there was variability in the length of the picture book session, we added time (measured in minutes) as a covariate in our analyses.

Mothers and their children shared the books *No David!* (Shannon, 1998) or *David Gets in Trouble* (Shannon, 2002) at 15 months, *Frog on his own* (Mayer, 1973) or *A boy, a dog, and a frog* (Mayer, 1967) at 24 months, and either *A boy, a dog, a frog, and a friend* (Mayer & Mayer, 1971) or *Frog, where are you?* (Mayer, 1969) at 36 months.

The task was transcribed offline by trained graduate students using Systematic Analysis of Language Transcripts (SALT, Miller & Chapman, 1985). A graduate student who spent one year learning SALT conventions and developing a training manual trained transcribers, who themselves trained for at least three months before transcribing videos. To ensure accuracy in the transcription process, coders transcribed 20 cases that were reviewed by the senior transcriber and transcripts were regularly reviewed and any issues were discussed and resolved with the senior graduate student (Kuhn et al., 2014).

For coding purposes, utterances were defined as a sequence of words preceded and followed by a change in conversational turn or a change in intonation pattern. Nonverbal utterances, unintelligible speech, and abandoned utterances were not included. Two measures of maternal language input from the transcriptions were used in the current analyses: the number of different words (NDW) that mothers used throughout the session and mean length utterance (MLU). NDW is a measure of the diversity of vocabulary that the mother used that was calculated as the number of unique free morphemes (word roots) the mother used throughout the interaction. Thus, the words "frog" and "frogs" were counted as only one unique word, and "jump" and "jumping" were also counted as one unique word. MLU is a general measure of complexity of maternal language that was calculated by dividing the total number of utterances by the total number of morphemes.

Parenting Sensitivity—Children and their mothers completed a 10 minute semi-structured free-play task at the 15-month assessment and a 10 minute puzzle task at the 24- and 36-month assessments. The free-play interaction involved asking each mother to use a standardized set of toys and to play with her infant as she normally would. The puzzle task presented the child with a series of three increasingly difficult jig-saw puzzles to complete and asking the mother to assist the child in any way that she chose. These parent-child interactions were video recorded, and the following seven aspects of parenting were later coded: sensitivity, detachment, intrusiveness, stimulation, positive regard, negative regard, and animation in interacting with the child (Cox, Paley, Burchinal, & Payne, 1999; NICHD Early Child Care Research Network, 1997). Coders were initially trained by a master coder and certified once they demonstrated reliability of .80 or above with the master coder for each subscale. After certification, coders continued to double code 20% of all videos to ensure that ICCs remained at or above .80. Ratings for each subscale were made on a scale ranging from 1 ("not at all characteristic") to 5 ("highly characteristic).

Factor analysis of the parenting variables yielded two dimensions of parenting behavior (Mills-Koonce et al., 2011; Vernon-Feagans et al., 2013). Based on those results, we created a composite measure corresponding to the first factor (sensitive parenting) at each time point, which was calculated as the average of the sensitivity, detachment (reversed), stimulation, positive regard, and animation codes. Cronbach's alpha for the composite was greater than .80 at each time point. In the current analyses we averaged the three time points into a single composite of sensitive caregiving.

Child receptive vocabulary—Children completed the receptive vocabulary portion of the Wechsler Preschool and Primary Scale of Intelligence – Third Edition (WPPSI-III, Wechsler, 2002) at 36 months of age. The WPPSI is a standardized assessment of children's general intellectual functioning that includes a receptive vocabulary subscale. To assess their receptive vocabulary, children are shown four images and asked to point to the one that depicts a specific concept. The WPPSI has high test-retest reliability (.90) and high internal consistency (.95, Wechsler, 2002). Standard scores were used in the current analyses.

Child EF—Children were administered six tasks designed to assess three components of EF at 48 months: working memory, inhibitory control, and attention shifting. Tasks were administered using an open spiral-bound flipbook and each task took approximately 5 minutes to administer. Preceding the test trials in each task, RAs administered training trials and children completed up to three practice trials. RAs discontinued the task for those children who did not demonstrate an understanding of the task. Below is a description of each task.

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Working Memory Span (WM): Working memory was assessed with a span task. In this task children see the outline of a house with an animal and a colored dot inside it. Children are prompted to name the animal and the color of the dot. Then they are shown a blank house and asked to either report the animal or the color they had seen in the previous house. In order to perform correctly, children must hold two pieces of information in mind (i.e., the animal and the color) but only activate the prompted feature (e.g., animal) while suppressing the other (e.g., color). Trials increase in difficulty by adding more houses to each page, with each house containing different animals and colors.

Pick the Picture (PTP): Working memory was also assessed using a self-ordered pointing task. Children are presented with pages with the same items dispersed across different locations. Children are instructed to touch a new picture on each page that she has not previously touched so that each picture “gets a turn”. The way in which pictures are arranged on the page is randomly changed each time the child turns the page. Difficulty increases as more items, up to six, are added to the pages. This task assess working memory by having children update the list of objects they have touched each time the page is turned.

Spatial Conflict (SC): The SC is a Simon-type task that assesses inhibitory control. Children are presented with a response card that depicts two black circles (“buttons”), one on either side of the page. Each page on the flipbook depicts an arrow, and children are instructed to touch the button on the response card corresponding to the side to which the arrow is pointing. The task proceeds in three blocks: the first eight trials depict all stimuli centrally, items 9–22 depict left-facing arrows on the left and right-facing arrows on the right of the page, and items 23–35 depict most arrows on the opposite side to which they are facing. This order allows for the child to first understand the task, then to develop a prepotency to touch the response card based on the location of the arrow, and finally tests inhibitory control on items where the location of the arrow does not watch where it is pointing.

Something’s the Same (STS): Attention shifting was assessed with the STS. In this task, children are first presented with two items on a page that are similar in either size, shape, or color. The RA points out the way in which the two objects are similar and then flips the page. The next page has the same two items in addition to a new third item, which is similar to the one of the two original items along a second dimension that is different from the similarity of the first two items. The RA then points out the new picture and says “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”.

Silly Sounds Stroop (SSS): The Silly Sounds Stroop task assesses inhibitory control by asking children to make the sound of a dog when they see a picture of a cat and to make the sound of a cat when they see a picture of a dog.

Animal Go/No Go (GNG): A standard Go/No-Go task, GNG assesses children’s inhibitory control by requiring that children click a response button every time they see an animal on the page except when they see the pig Animals are shown one at a time. The standard order of consecutive go trials between no-goes is: one-go, three-go, three-go, five-go, one-go, one-go, and three-go.

Scoring: Children needed to complete at least 75% of trials for each task in order for their performance to be analyzed. Tasks were scored using Item Response Theory (IRT) as this is a more precise way to estimate children's EF abilities than percent correct scores. Expected a posteriori (EAP) scores were derived for each task at each time point and averaged within each time point to obtain an EF composite score (Willoughby, Wirth, & Blair, 2011). As is typical of EF measures (Willoughby, Holochwost, Blanton, & Blair, 2014), scores were weakly to moderately correlated (*r*s = .12 – .27). In order to address this issue, we used a formative composite, as this has been found to more appropriately represent the overarching construct of EF than a latent factor, which is limited to measurement of the shared variance between tasks which are only weakly to moderately correlated (Willoughby et al., 2014).

Covariates—Covariates included child sex (Male=0, Female=1), child ethnicity (1= African American, 0 = Other), the family's state of residence (PA=0, NC=1), and child age when the outcome data were collected.

Attrition

Due to the longitudinal nature of the study, not all 1,292 FLP participants completed the EF battery. The current sample was restricted to those 1,009 participants who had valid EF data at 48 months. Participants with valid EF data did not differ from the rest of the sample in terms of sex, race, or income-to-needs ratio, but were more likely to live in North Carolina, $t(1290) = 2.98$, $p = .003$.

Analytic Plan

In order to address our research questions, we carried out three sets of analyses. First, we explored whether there were disparities in the quality of maternal language input across levels of SES-related risk in this large, socioeconomically diverse sample. We conducted ordinary least squares regression to determine whether 6-month SES-related risk predicted maternal NDW and MLU at 15, 24, and 36 months while controlling for demographic covariates and the length of the picture book task. Next, we explored whether maternal language input predicted later child EF and whether it mediated some of the effect from early SES-related risk to child EF. To test this, we first regressed child EF on maternal NDW and MLU at 15, 24, and 36 months and covariates. Then, we conducted a mediational analysis to determine whether maternal NDW and MLU at 15, 24, and 36 months mediated the relation between 6-month SES-related risk and 48-month EF while controlling for parenting sensitivity (see Figure 1). Finally, we examined the extent to which child vocabulary mediated the relation between maternal language input and child EF, as well as the relation between SES-related risk and child EF. To test this, we first regressed child vocabulary on maternal NDW and MLU at 15, 24, and 36 months and covariates. Once we established those relations, we conducted a mediational analysis to determine whether child receptive vocabulary at 36 months mediated the relation between maternal NDW and MLU at 15, 24, and 36 months and 48-month EF, as well as between 6-month SES-related risk and 48-month EF (see Figure 1), while controlling for parenting sensitivity.

All analyses included a standard set of covariates (child race, sex, age, state of residence. and the length of the picture book task) and were conducted using Mplus 7.0 (Muthén & Muthén, 2012). Full information maximum likelihood (FIML, Enders & Bandalos, 2001) was used to account for missing data. Below, we use standardized regression coefficients as measures of effect size.

Results

Descriptive information for and correlations among all study variables are shown in Table 1. The analytic sample was half female (50%) and 43% African American. On average, families in our sample had an income-to-needs ratio of 1.93 ($SD = 1.74$) at child age 6 months, though there was substantial variability with a range of 0 to 16.49. Moreover, 24% of mothers in the sample had less than a high school education, a further 28% had a high school degree, 34% had some training beyond high school, and the remaining 14% had a 4-year college degree.

Descriptive statistics revealed variability in the length of the picture book task at each time point. On average, the task lasted 2.83 minutes ($SD = 1.41$) when children were 15 months, 4.41 minutes ($SD = 2.16$) when children were 24 months, and 5.19 minutes ($SD = 2.14$) when children were 36 months. Length was uncorrelated to SES-related risk at all three time points (*r*s .04 - .02, ns) and to child age at 15 and 36 months (*r*s .05 and .02, ns, respectively), and was significantly but very weakly correlated to age at 24 months ($r = .10$, $p = .003$).

SES-Related Disparities in Maternal Linguistic Input

Our first research question asked whether there were disparities in the quality of maternal language input across different levels of SES-related risk. Regressing maternal NDW on early SES-related risk and covariates, including demographic information and length of the picture book task, revealed a significant negative association between early SES-related risk and maternal NDW at 15 months ($\beta = -.30$, $SE = .03$, $p < .001$), at 24 months ($\beta = -.34$, $SE = .03$, $p < .001$), and at 36 months ($\beta = -.33$, $SE = .03$, $p < .001$). Similarly, early SES-related risk was associated with lower MLU at 15 months ($\beta = -.24$, $SE = .04$, $p < .001$), at 24 months ($\beta = -.20$, $SE = .04$, $p < .001$), and at 36 months ($\beta = -.21$, $SE = .04$, $p < .001$). Overall, these results suggest that mothers at higher socioeconomic risk tend to provide their children lower quality linguistic input than mothers who experience lower risk.

In order to graphically illustrate SES-related disparities in maternal language input, we divided the sample into quartiles based on the distribution of early SES-related risk scores. The highest quartile experienced the most risk and was at the highest disadvantage. As depicted in Figure 2, on average, mothers who experienced the most risk consistently used fewer different words and shorter sentences across the three time points than mothers in any other quartile while those who experienced the least risk used more words and longer sentences than mothers in any other quartile. A comparison of maternal NDW between the highest and lowest quartiles revealed a difference of about three quarters of a standard deviation at 15 months (27 words), four fifths of a standard deviation at 24 months (36 words), and almost an entire standard deviation at 36 months (35 words). The difference between the lowest and highest quartile in MLU was about a third to a half of a standard deviation across all three time points (.45 at 15 months, .41 at 24 months, and .38 at 36 months).

Maternal Language Input Mediates the Relation between SES-Related Risk and Child Executive Function

Our second research question aimed to uncover whether maternal language input explained the relation between early SES-related risk and child EF. To answer this question, we first regressed child EF on maternal NDW and MLU at 15, 24, and 36 months to examine direct relations from maternal language input to child EF without account for the effect of SES-related risk. We then ran a mediation model in which we regressed maternal NDW and MLU at 15, 24, and 36 months on early SES-related risk while simultaneously regressing 48-month EF on early SES-related risk and maternal language input to examine indirect relations between SES-related risk and child EF through maternal language input (see Figure 1, Model 1). In the mediational model, we included parenting sensitivity as a covariate in addition to our standard set of covariates.

Precursory analyses examining direct relations between maternal language input and child EF revealed that two measures of maternal linguistic input significantly predicted child EF: 24-month NDW ($\beta = .17$, $SE = .04$, $p < .001$) and 36-month MLU ($\beta = .09$, $SE = .04$, $p = .016$). Parenting sensitivity also predicted EF ($\beta = .23$, $SE = .04$, $p < .001$).

Results from the mediational model indicated that 24-month NDW and 36-month MLU partially mediated the relation from early SES-related risk to EF at 48 months (see Table 2 and Table 3 for full model results). Several variables showed direct effects on EF: SES-related risk ($\beta = -.11$, $SE = .04$, $p = .003$), 24-month NDW ($\beta = .16$, $SE = .04$, $p < .001$), 36-month MLU ($\beta = .09$, $SE = .04$, $p = .018$), and parenting sensitivity ($\beta = .18$, $SE = .05$, $p < .001$). No other maternal language input variables showed a direct effect. Indirect effects revealed that 24-month NDW ($\beta = -.06$, $SE = .02$, $p < .001$) and 36-month MLU ($\beta = -.02$, $SE = .01$, $p = .036$) partially mediated the relation between early SES-related risk and child EF, though effect sizes were small. These mediation results suggested that higher SES-related risk at 6 months was associated with lower maternal NDW at 24 months and lower maternal MLU at 36 months, which were in turn associated with lower child EF at 48 months. No other maternal language input variables showed an indirect effect. The mediational model accounted for 28% of the variance in EF.

Child Vocabulary Mediates the Relation between Maternal Linguistic Input and Child Executive Function

The prior analysis established that maternal language input was associated with child EF and that both maternal NDW and MLU partially mediated an association between SES-related risk at 6 months and EF at 48 months. Our final analysis aimed to uncover the role that child vocabulary might play in these associations. To address this, we first regressed child vocabulary on maternal NDW and MLU at 15, 24, and 36 months to confirm that maternal language input was directly associated with child vocabulary. Then we ran a mediation model, depicted in Figure 1, Model 2, in which we regressed maternal NDW and MLU at

15, 24, and 36 months on SES-related risk at 6 months while simultaneously regressing child receptive vocabulary at 36 months on SES-related risk at 6 months and maternal language input at 15, 24, and 36 moths, as well as regressing child EF at 48 months on SES-related risk at 6 months, MLU and NDW at 15, 24, and 36 months, and child vocabulary. In this model we included parenting sensitivity as a covariate in addition to our standard set of covariates.

Precursory analyses examining direct relations between maternal language input and child vocabulary showed that 24-month NDW (β = .21, SE = .04, p < .001) and 36-month MLU (β = .19, SE = .04, p < .001) positively predicted child vocabulary, as did parenting sensitivity (β = .21, SE = .04, p < .001). However, we found an unexpected negative relation between 36-month NDW and child vocabulary (β = −.12, SE = .04, p = .002). We suspected that the correlation between 36-month NDW and 24-month NDW (r = .55, p < .001) might be driving this negative effect; therefore, we removed 24-month NDW from the model in a follow-up analysis. Once we removed 24-month NDW, the relation between 36-month NDW and child vocabulary was greatly reduced in magnitude and was no longer significant (β = −.03, SE = .02, p = .111), suggesting that the negative relation we found in the original model may have been an artifact of the high correlation between 24-month and 36-month NDW.

Several results emerged from the mediational model (see Figure 3, Table 2, and Table 3 for full model results). First, child receptive vocabulary (β = .35, SE = .03, p < .001), 24-month NDW (β = .09, SE = .04, p = .011), and parenting sensitivity (β = .14, SE = .04, p = .002) predicted child EF. No other maternal language input variables showed a direct effect on child EF. Moreover, 24-month NDW (β = .20, SE = .04, p < .001), 36-month MLU (β = .18, SE = .04, p < .001), parenting sensitivity (β = .13, SE = .05, p = .004), and SES-related risk (β = −.19, SE = .04, p < .001) all predicted receptive vocabulary. We also observed the negative relation from 36-month NDW (β = −.11, SE = .04, p = .002) to child vocabulary that had emerged in the previous regression analyses but we had established that this was likely due to the inclusion of both 24- and 36-month NDW in the same model. No other maternal language input variables showed a direct effect on child vocabulary.

Results also showed several indirect effects. Child receptive vocabulary partially mediated the relation between 24-month NDW (β = .07 SE = .02, p < .001) and child EF. Although the effect size was small, higher maternal NDW was associated with larger child vocabulary, which was in turn associated with higher child EF. Moreover, mediation analyses suggested that there was indirect pathway through child vocabulary between 36-month MLU (β = .06, SE = .01, p < .001) and child EF. Although we cannot make any inferences about directionality given that both MLU and child vocabulary were measured concurrently, our theoretical model would support child vocabulary as the mediator. No significant mediation effects emerged with other maternal language input measures.

Mediation findings also extended to SES-related risk. That is, there was significant partial mediation of early SES-related risk on child EF through 24-month NDW and child vocabulary (β = −.02, SE = .01, p < .001), as well as significant partial mediation of early SES-related risk on child EF through 36-month MLU and child vocabulary (β = −.01, SE = .01, p = .001), though again we cannot establish temporal precedence between MLU and child vocabulary. Finally, child vocabulary partially mediated the effect from early SES-related risk to child EF ($\beta = -.06$, $SE = .01$, $p < .001$) independent of the indirect effects through maternal language. Overall, the mediational model accounted for 35% of the variance in EF and 34% of the variance in child vocabulary.

Discussion

Using data from a large, prospective longitudinal sample of children and families followed from birth, we examined associations among SES-related risk, maternal language input, child vocabulary, and child EF. We found SES-related disparities in maternal linguistic input, both in vocabulary diversity (NDW) and language complexity (MLU), when children were 15, 24, and 36 months of age. We further found that maternal NDW at child age 24 months and maternal MLU at child age 36 months partially mediated the relation between SES-related risk at 6 months of age and child EF at 48 months of age, even when controlling for parenting sensitivity. That is, generally, mothers with higher SES-related risk used less diverse vocabulary at 24 months and less complex language at 36 months, and in turn their children were more likely to demonstrate lower EF at 48 months. Lastly, we examined the role that child language, as indicated by receptive vocabulary at age 36 months, might play in associations among poverty-related risk, maternal language input, and child EF. We found that mothers of higher SES-related risk tended to use less diverse vocabulary at 24 months and less complex language at 36 months, and in turn their children tended to have lower vocabulary at 36 months and lower EF at 48 months. Moreover, we found that child vocabulary partially mediated the relation between SES-related risk and child EF above and beyond maternal language, suggesting that maternal language did not fully account for the relation between risk, child vocabulary, and EF.

These analyses build upon and extend several prior analyses of the current dataset. Prior work has established child language as a precursor to preschool EF (Kuhn et al., 2014; Kuhn et al., 2016). Separate work has also established relations between maternal language complexity and child language (Vernon-Feagans et al., 2013). The current study combined these two areas of inquiry and extended our understanding of the developmental influences on child EF prior to preschool age by examining associations between longitudinal measurements of maternal language input and child EF. By including longitudinal measurements, we arrived at a more precise understanding of the relation between maternal language and child EF as it evolves over the early childhood period, which had been lacking in prior work. Moreover, by incorporating parenting sensitivity as a covariate in our analyses we examined associations between maternal language and EF in a well-specified model. The current study also builds upon and extends the broader literature on SES-related disparities in child EF by demonstrating that SES-related disparities in maternal language account for some of the SES-related disparities in child EF prior to school entry. Notably, child vocabulary also accounts the association between SES-related risk and child EF. As such, our analyses provide insight into the precursors of child EF in the period before preschool, a critical time for EF development.

SES-Related Risk, Maternal Linguistic Input, and Child EF

Our results indicated that, on average, mothers in families experiencing greater SES-related risk used lower quality language – both in terms of vocabulary diversity and language complexity - while interacting with their children than mothers in families experiencing less risk. These findings support previous studies showing a negative association between SES and maternal language input (Hoff, 2003; Rowe, 2008). Moreover, the strength of the association between SES-related risk and maternal language input (βs = −.20 to −.34) in this analysis was similar to that reported in a previous study with a homogeneous, middle to upper class sample (Bornstein et al., 1998).

Our findings, which are the first to examine associations from both maternal NDW and MLU to child EF independently of parenting sensitivity, indicated that at approximately child age 24 months, maternal NDW was most relevant to the association between SES-related risk and child EF. In contrast, at child age 36 months, maternal MLU was most relevant. These indirect effects were small but meaningful (indirect βs range from −.02 to −.06), accounting for about a third of the total effect from SES-related risk to child EF. Moreover, the magnitude of these effects was similar to those reported by Bornstein and colleagues (1998) in analyses showing mediation from SES to child vocabulary through maternal language.

Timing of maternal language input and child EF

A unique aspect of our analyses was the longitudinal measurement of maternal language input. Although prior work has examined relations between maternal language input at different time points and child vocabulary (Rowe, 2012), no prior work had done so with child EF. By including maternal input at three time points in a single model to predict child EF at 48 months, we could test whether different aspects of maternal language input at different time points predicted child EF while controlling for prior levels of maternal language input. As such, we could test whether the pattern uncovered by Rowe in her analyses predicting child vocabulary also held in models predicting EF. And indeed, we found support for associations between 24-month NDW and 36-month MLU and child EF.

Similar to Rowe’s (2012) prior work, we also failed to find a relation between maternal vocabulary and language complexity before the second birthday and child outcomes. In Rowe’s analysis, quantity rather than vocabulary or complexity was most important at this early stage of language development. In the current study, the correlation between maternal word types and total number of words was very strong ($r > .9$ at very time point), preventing us from including both NDW and total number of words in the same model. Although this high degree of correlation between NDW and the total number of words is not unique to our sample (Hurtado, Marchman, & Fernald, 2008; Rowe, 2008), it limited our ability to test the relation between early maternal language quantity and later child EF. Regardless, however, our data suggest that variation in maternal language quality during the toddler and preschool periods, as child language development is occurring rapidly, is relevant to child EF prior to school entry.

Together, our findings regarding the relation between maternal language input and child EF lend evidence to support current interventions aiming to improve verbal communication between mothers and their young children (e.g., Guttentag et al., 2014). Specifically, our findings suggest that interventions could be effective if they focus not solely on the quantity but also on the quality of the language that mothers use with their young children. While Rowe (2012) showed that quantity may be important between the first and second birthday, both her and our data show convergent evidence that the diversity of maternal vocabulary and its complexity are most supportive of children's language and cognitive development after the second birthday.

The Role of Vocabulary

In our final analysis, we examined the role of child vocabulary at age 36 months as a possible mediator between maternal language input and child EF. That is, we hypothesized that some of the effect of maternal language on child EF would travel through child vocabulary. Building upon prior findings of this dataset (Kuhn et al., 2014; Kuhn et al., 2016), we demonstrated that child vocabulary mediated the association between maternal language and EF. Specifically, we found that child vocabulary partially mediated the association from 24-month NDW to child EF and fully mediated the association from 36-month MLU to child EF. Thus, we showed that mothers who used diverse vocabularies at 24 months and more complex language at 36-months generally had children with larger vocabularies at 36 months, who in turn tended to have better EF skills at 48 months. These findings provide novel evidence that part of the effect from maternal language input to child EF travels through child vocabulary. Moreover, they reinforce the importance of early vocabulary for EF development.

Overall, our findings raise new insights into the possible mechanisms that account for SES-related disparities in EF. Previous work using the current dataset as well as others has found that parenting sensitivity and scaffolding predict EF in early childhood (Bernier et al., 2010; Blair et al., 2011), and that child expressive language predicts EF (Kuhn et al., 2014). Our findings expand upon both of these lines of work by showing that maternal language input, above and beyond parenting sensitivity, which was used as a control variable in our models, is an independent mechanism through which caregivers support EF development. Moreover, this association was in part, but not completely, mediated by child vocabulary. This suggests that by using higher quality language with their children, caregivers provide more opportunities for young children to engage in rich conversations – enhancing the number of high quality experiences their children have to develop cognitive and linguistic skills.

Furthermore, the findings presented here support previously-advanced theoretical frameworks of EF suggesting that reflection, or the ability to process information while taking context into account, is critical to children's successful engagement of EF (Zelazo, 2015). That is, we show that as children gain more vocabulary, and likely their ability to process information becomes more efficient, EF skills are likely to improve. According to the current model, higher quality maternal language input supports this process by giving children the opportunity to learn new words.

Limitations and Future Directions

While the current study contributes to the literature on child development in several ways, it is subject to certain limitations. First, the low-income nature of the sample likely restricts the range of both independent and dependent variables and resulting estimates of effect sizes may be underestimates. This is particularly important when estimating the effect of SES-related risk on maternal language and on child EF through maternal language. Although the distribution of SES in our sample is broader than many past studies investigating associations between SES and maternal language input, the sample was drawn to represent low-income residents of the communities in which participants were located.

Second, we explored maternal language input using two measures derived from speech. While these are widely used measures in the literature and have been found to be important for child vocabulary development (Hoff, 2003), the growing literature examining the relation between maternal language and child language has identified new measures of maternal speech, such as VOCD, as well as other aspects of mother-child communicative interactions that are also important but not investigated here, such as episodes of joint attention or routines (Hirsh-Pasek et al., 2015). Future research might incorporate these other measures of mother-child communication to examine how they may be related to child EF, as well as examine how other measures of child language ability beyond receptive vocabulary may relate to child EF. For example, new evidence suggests that children's syntactic skills are concurrently associated with EF at age four (White, Alexander, & Greenfield, 2017). Given the theoretical connection between learning the rules of language and EF, this is a rich area for future research.

Finally but importantly, the model we present in this paper is correlational. Although the longitudinal design of our study and our careful consideration of covariate measures is a strength, we cannot come to causal conclusions about relations among variables. Intervention studies employing randomized designs have shown that parent training focused on parental language, specifically contingent responses to children's communicative bids, has a positive impact on children's cognitive development (Landry, Smith, Swank, & Guttentag, 2008). However, that is only one of the many pathways we test in the current model. Thus, our model provides a stepping stone for future research employing causal methodologies to non-experimental data that can more fully uncover how SES-related risk, maternal language input, child vocabulary, and child EF are related.

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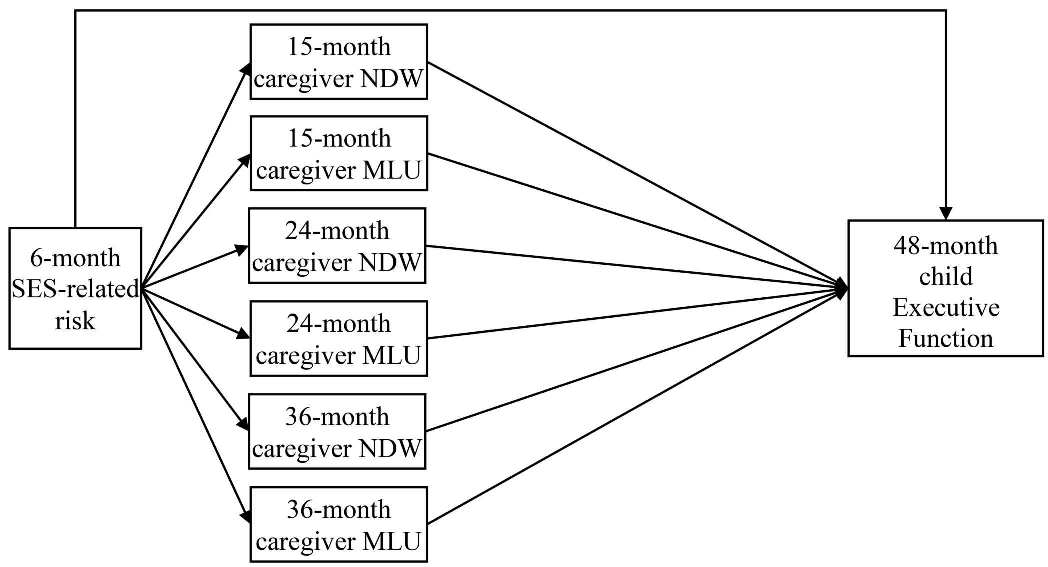
Model 1



Model 2

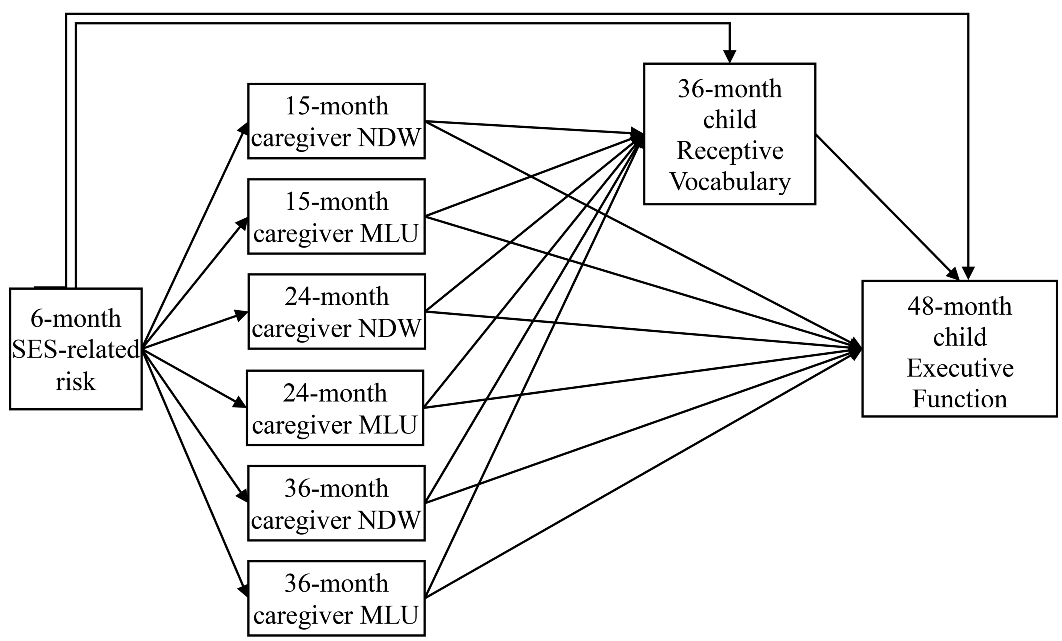


Figure 1.

Hypothesized models. Model 1 tests whether NDW and MLU at 15, 24, and 36 months mediate the association between 6-month SES-related risk and 48-month child executive function. In Model 2 we add child vocabulary as a mediator.

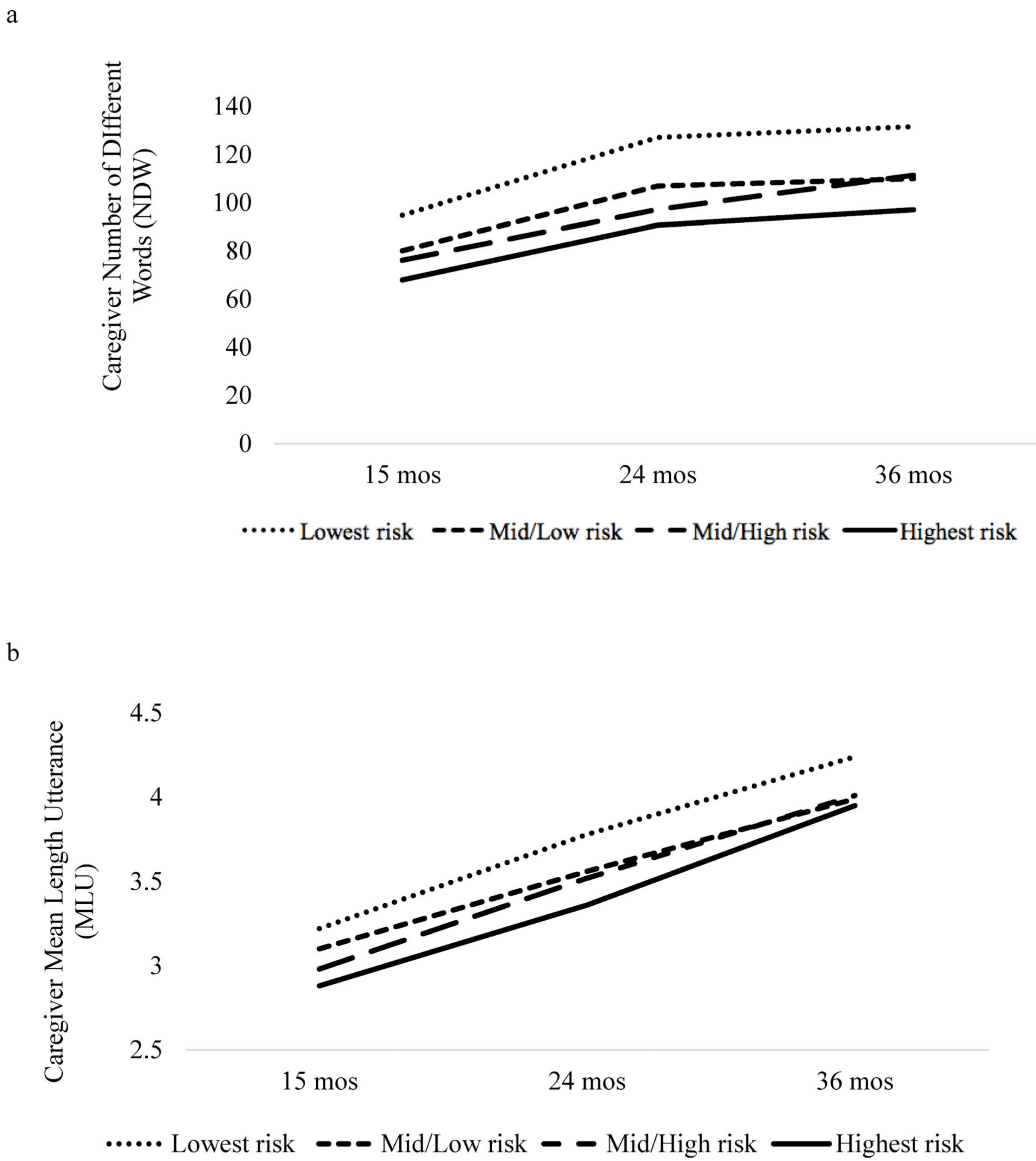


Figure 2.

Disparities in maternal NDW and maternal MLU at 15, 24, and 36 months across early SES-related risk quartiles. The top panel (a) shows maternal NDW and the bottom panel (b) shows maternal MLU.

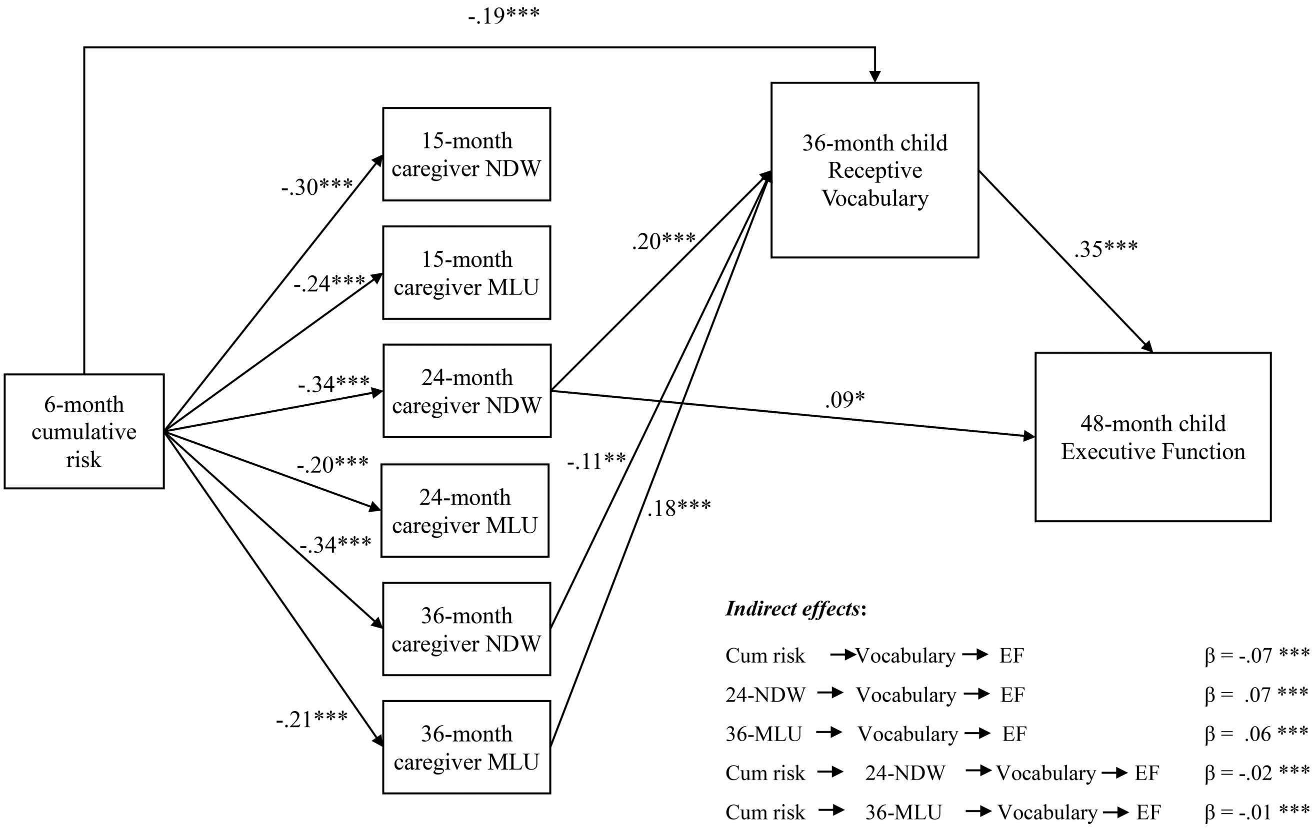


Figure 3.

Standard coefficients of the direct effects that emerged from Model 2, which examined the extent to which NDW and MLU at 15, 24, and 36 months and child vocabulary mediated the association between 6-month SES-related risk and 48-month child executive function.

Table 1

Correlations and descriptive statistics

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	SES-related Risk	-													
2	15-month NDW	**−0.28**	-												
3	15-month MLU	**−0.19**	**0.49**	-											
4	24-month NDW	**−0.31**	**0.50**	**0.29**	-										
5	24-month MLU	**−0.15**	**0.30**	**0.43**	**0.51**	-									
6	36-month NDW	**−0.30**	**0.48**	**0.32**	**0.55**	**0.31**	-								
7	36-month MLU	**−0.14**	**0.25**	**0.38**	**0.31**	**0.43**	**0.49**	-							
8	Child Vocabulary	**−0.43**	**0.23**	**0.14**	**0.35**	**0.22**	**0.22**	**0.22**	-						
9	Child EF	**−0.35**	**0.18**	**0.10**	**0.29**	**0.13**	**0.21**	**0.15**	**0.52**	-					
10	Sensitive Parenting	**−0.61**	**0.46**	**0.20**	**0.50**	**0.22**	**0.51**	**0.20**	**0.44**	**0.41**	-				
11	Male	−0.03	−0.03	−0.05	**−0.11**	**−0.09**	−0.05	**−0.11**	**−0.13**	**−0.14**	0.01	-			
12	African American	**0.45**	**−0.09**	−0.02	**−0.07**	0.01	**−0.10**	0.01	**−0.39**	**−0.34**	**−0.44**	0.01	-		
13	State (NC)	**−0.28**	0.04	−0.03	−0.05	**−0.13**	−0.03	**−0.13**	**0.31**	**0.31**	**0.32**	**0.07**	**−0.65**	-	
14	Age	**−0.07**	0.01	0.02	0.01	−0.01	0.01	0.01	0.03	**0.16**	0.05	0.01	**−0.10**	**0.08**	-
M		0.00	80.38	3.05	106.37	3.58	113.09	4.06	99.47	−0.13	2.88	0.50	0.43	0.42	48.32
SD		0.66	34.58	0.76	44.88	1.02	39.60	0.76	17.36	0.51	0.67	-	-	-	1.54

Note. NDW = number of different words; MLU = mean length utterance; EF = executive function. Bolded values indicate $p < .05$.

Table 2

Direct effects of mediation models predicting child executive function

	Model 1				Model 2			
	b	**SE**	**β**		**b**	**SE**	**β**	
Outcome								
Executive Function								
15-month NDW	−0.00	0.00	−.04		−0.01	0.00	−.04	
15-month MLU	−0.10	0.02	−.01		−0.01	0.02	−.00	
24-month NDW	0.02	0.00	.16	***	0.01	0.00	.09	*
24-month MLU	−0.01	0.02	−.01		−0.01	0.02	−.02	
36-month NDW	−0.00	0.01	−.03		0.00	0.00	.02	
36-month MLU	0.06	0.03	.09	*	0.02	0.02	.03	
Parenting Sensitivity	0.14	0.04	.18	***	0.10	0.03	.14	**
SES-Related Risk	−0.09	0.03	−.11	**	−0.04	0.03	−.04	
Child Male	−0.14	0.03	−.14	***	−0.10	0.03	−.10	***
Child African American	−0.07	0.04	−.07		−0.02	0.04	−.02	
State	0.21	0.04	.20	***	0.15	0.04	.15	***
Child Age	0.04	0.01	.12	***	0.04	0.01	.13	***
15-month Task Length	−0.00	0.01	−.01		−0.01	0.01	−.01	
24-month Task Length	0.01	0.01	.03		0.01	0.01	.04	
36-month Task Length	−0.00	0.01	−.02		−0.01	0.01	−.03	
Receptive Vocabulary					0.01	0.00	.35	***
Mediators								
15-month NDW								
SES-Related Risk	−15.98	1.81	−.30	***	−15.98	1.81	−.30	***
Child Male	−2.47	2.12	−.04		−2.49	2.12	−.03	
Child African American	2.40	2.87	.03		2.43	2.87	.03	
State	−2.14	2.80	−.03		−2.12	2.80	−.03	
Task Length	−0.59	0.73	−.02		−0.59	0.73	−.02	
15-month MLU								
SES-Related Risk	−0.27	0.04	−.24	***	−0.27	0.04	−.24	***

	Model 1				Model 2			
	b	SE	β		b	SE	β	
Child Male	−0.07	0.05	−.04		−0.07	0.05	−.04	
Child African American	0.08	0.07	.05		0.08	0.07	.05	
State	−0.10	0.06	−.06		−0.10	0.06	−.06	
Task Length	−0.01	0.02	−.02		−0.01	0.02	−.02	
24-month NDW								
SES-Related Risk	−23.21	2.46	−.34	***	−23.05	2.50	−.34	***
Child Male	8.80	2.74	−.10	**	−8.75	2.73	−.10	**
Child African American	−0.91	4.12	−.01		−0.95	4.11	−.01	
State	−11.58	3.85	−.14	**	−11.53	3.89	−.14	**
Task Length	1.07	0.78	.05		1.10	0.78	.05	
24-month MLU								
SES-Related Risk	−0.32	0.06	−.20	***	−0.32	0.06	−.20	***
Child Male	−0.16	0.06	−.08	*	−0.16	0.06	−.08	*
Child African American	−0.06	0.10	−.03		−0.06	0.10	−.02	
State	−0.41	0.08	−.19	***	−0.41	0.08	−.18	***
Task Length	−0.02	0.02	−.03		−0.02	0.02	−.03	
36-month NDW								
SES-Related Risk	−20.43	2.05	−.33	***	−20.34	2.05	−.34	***
Child Male	−3.74	2.42	−.05		−3.73	2.41	−.05	
Child African American	−2.88	3.57	−.04		−2.97	3.57	−.03	
State	−11.32	3.31	−.14	**	−11.33	3.32	−.14	**
Task Length	1.64	0.63	.09	**	1.64	0.63	.09	**
36-month MLU								
SES-Related Risk	−0.24	0.04	−.21	***	−0.24	0.04	−.21	***
Child Male	−0.14	0.05	−.09	**	−0.14	0.05	−.10	**
Child African American	−0.03	0.07	−.02		−0.03	0.07	−.02	
State	−0.31	0.07	−.20	***	−0.31	0.07	−.20	***
Task Length	0.02	0.01	.05		0.02	0.01	.05	
Receptive Vocabulary								
15-month NDW					0.00	0.02	.01	

	Model 1			Model 2		
	b	SE	β	b	SE	β
15-month MLU				−0.46	0.74	−.02
24-month NDW				0.08	0.02	.20 ***
24-month MLU				0.54	0.58	.03
36-month NDW				−0.05	0.02	−.11 **
36-month MLU				3.98	0.80	.18 ***
Parenting Sensitivity				3.33	1.16	.13 **
SES-Related Risk				−4.93	0.97	−.19 ***
Child Male				−3.28	0.91	−.10 ***
Child African American				−5.01	1.33	−.14 **
State				5.70	1.25	.16 ***
Child Age				−0.32	0.29	−.03
15-month Task Length				0.42	0.37	.04
24-month Task Length				−0.22	0.26	−.03
36-month Task Length				0.30	0.27	.04

Note. NDW = number of different words; MLU = mean length utterance;

* $p < .05$,

** $p < .01$,

*** $p < .001$

Table 3

Indirect effects of mediation models predicting Child Executive Function

	Model 1				Model 2			
	b	**SE**	**β**		**b**	**SE**	**β**	
Risk → 15-month NDW → EF	0.01	0.01	.01		0.01	0.01	.01	
Risk → 15-month MLU → EF	0.00	0.01	.00		0.00	0.01	.00	
Risk → 24-month NDW → EF	−0.04	0.01	−.06	***	−0.03	0.01	−.03	*
Risk → 24-month MLU → EF	0.00	0.01	.00		0.00	0.01	.01	
Risk → 36-month NDW → EF	0.01	0.01	.01		−0.00	0.01	−.00	
Risk → 36-month MLU → EF	−0.01	0.01	−.02	*	−0.01	0.01	−.01	
Risk → Vocabulary → EF					−0.05	0.01	−.07	***
15-month NDW → Vocabulary → EF					0.00	0.00	.00	
15-month MLU → Vocabulary → EF					−0.01	0.01	−.01	
24-month NDW → Vocabulary → EF					0.00	0.00	.07	***
24-month MLU → Vocabulary → EF					0.01	0.01	.02	
36-month NDW → Vocabulary → EF					−0.00	0.00	−.04	
36-month MLU → Vocabulary → EF					0.04	0.01	.06	***
Risk → 15-month NDW → Vocabulary → EF					−0.00	0.00	−.00	
Risk → 15-month MLU → Vocabulary → EF					0.00	0.00	.00	
Risk → 24-month NDW → Vocabulary → EF					−0.02	0.00	−.02	***
Risk → 24-month MLU → Vocabulary → EF					−0.00	0.00	−.00	
Risk → 36-month NDW → Vocabulary → EF					0.01	0.00	.01	
Risk → 36-month MLU → Vocabulary → EF					−0.01	0.00	−.01	***

Note. NDW = number of different words; MLU = mean length utterance; EF = executive function;

* $p < .05$,

** $p < .01$,

*** $p < .001$