

**Identifying Direct and Indirect Influences on Vocabulary Development of
Children from Low-Income Families from Infancy to Grade 5**

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Abstract

We explored how a constellation of factors affected vocabulary development of infants ($N=556$; 49.6% male) from families comprising the control group of the Early Head Start Research Evaluation project. Predictors assessed at age 14 months accounted for 23.5%, 25.8%, and 30.6% of variance in receptive vocabulary (Peabody Picture Vocabulary Test) at 36 months, Pre-K, and Grade 5, respectively. Joint engagement, assessed during free play (3-bags task), and infant cognitive ability (Bayley Mental Development Index) had direct associations with vocabulary knowledge. Gestational age was indirectly associated with vocabulary knowledge via infant cognitive ability. Home environment, maternal education, maternal distress, and child gender had variable direct and/or indirect effects. Latent factors were partially invariant for subgroups with Black/African American and White/European American mothers. Findings suggest a long-term impact of joint engagement on vocabulary growth at least through Grade 5, highlighting the importance of interventions to support mothers and infants living in poverty.

keywords: joint engagement; receptive vocabulary; cognitive development; measurement invariance; structural equation model

Highlights

- A constellation of factors in infancy predicts receptive vocabulary through Grade 5
- Joint engagement and infant cognitive ability had stable direct effects on vocabulary
- Gestational age had an indirect effect on vocabulary via infant cognitive ability
- Direct/indirect effects of home environment and maternal education varied with age
- Findings highlight importance of interventions to support families living in poverty

Identifying Direct and Indirect Influences on Vocabulary Development of Children from Low-Income Families from Infancy to Grade 5

Young children growing up in poverty have elevated risk of cognitive and language delays relative to children from more affluent families (Merz et al., 2019). These children may be at risk of poor developmental and academic outcomes due to differences in the quality of parent-child communication and child-directed speech in the first years of life (Hart & Risley, 1995; Hirsh-Pasek et al., 2015). In this investigation, we were interested in understanding how different factors were related within one theoretical model of risk, and how the factors would bear cross-lagged associations with later receptive vocabulary development. The overarching goal was to identify how factors associated with the developmental context contribute to a child's resilience in the face of adversity, and whether the associations differ for Black/African American and White/European American children from low-income backgrounds.

Factors that Contribute to Children's Cognitive and Communicative Development

Contextual and social-environmental factors have been shown to influence children's cognitive and communicative development, including the socio-economic status (SES) of the children's rearing context (Hoff, 2003; Letourneau et al., 2013). Social and economic deprivation puts infants at risk of compromised neurocognitive functioning (Tomalski et al., 2013; Ursache & Noble, 2016). SES is often measured as a proxy variable directly tied to parental factors including educational attainment, occupational status, and income (Ensminger & Fothergill, 2003; Farah et al., 2006). Parental education has been shown to influence children's cognitive and communicative development (Duncan & Magnuson, 2012; Hackman et al., 2015; Noble et al., 2015), such that parents with higher educational attainment are likely to spend more time

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with their children (Guryan et al., 2008), engage in higher quality parent-child interactions (Duckworth & Sabates, 2005), exhibit increased responsiveness and provision of learning materials (Magnuson et al., 2009), use more varied and complex language and speech patterns (Hoff, 2003), and have higher expectations for their child's learning and achievement (Davis-Kean, 2005). Research also suggests that parenting behaviors have a larger impact on children's school readiness (i.e., prereading skills) in low-income families than in higher income families (Hill, 2001).

Other factors that influence parental behaviors, such as parental distress and mental health, for example, have been shown to vary systematically with SES (Burchinal et al., 2008). Parental distress has been found to place children of Black/African American parents at additional risk (McLoyd, 1990), as they are often denied access to adequate support and resources to cope with poverty-related stressors. The Family Stress Model describes a process by which economic hardship affecting the family unit leads to economic pressures that contribute to psychological distress for parents and disrupted parenting practices that negatively impact children's developmental outcomes (Masarik & Conger, 2017). While much research has focused on child well-being and socio-emotional adjustment, there is evidence that parental stress and depression also influence children's later cognitive abilities and school achievement (Pearson et al., 2016). Such disparities may be rooted in developmental differences in neurocognitive functioning of children of depressed and nondepressed mothers observed as early as preschool age or approximately 2 to 5 years of age (Lebel et al., 2016).

In addition to differences in material resources associated with SES and systemic inequalities (Yeung & Conley, 2008), parenting behaviors impacting school-readiness and academic trajectories may vary as a function of culture and ethnicity (Ceballo et al., 2008; Hill,

2001; Hill & Tyson, 2008). Findings from previous research indicate that race/ethnicity may moderate associations between parenting practices (measured at child's age 12 and 24 months) and children's language development (measured at 18, 24, 30, and 36 months), such that associations between negative and intrusive parenting and children's expressive language development appear to be weaker in Black/African American families than in White/European American families (Pungello et al., 2009). While there is evidence that qualities of parent-child interactions may differ by race/ethnicity, influences of both the quantity (number of different words, number of conversational turns) and complexity (mean length of utterances, *wh*-questions, complex conjunctions) of maternal child-directed speech on children's language outcomes appear to be similar across racial/ethnic groups (Vernon-Feagans et al., 2020).

Home environment. As with parental stress and mental health, the quality of the home environment is another critical construct shown to predict children's developmental outcomes that may vary systematically with SES (Burchinal et al., 2008). The quality of the home environment is often linked to social factors such as the warmth and sensitivity exerted by the parent (Bradley et al., 2001), as well as material factors such as the number of cognitive stimulating toys and books in the home (Payne et al., 1994). Notably, past research has documented that parents of low-income status tend to report greater displays of warmth toward their children than their higher SES counterparts (Pinderhughes et al., 2008).

Child characteristics. From infancy, factors such as the child's gestational age, gender, and early emerging cognitive abilities have been shown to correlate with later cognitive and behavioral outcomes. Children born preterm (< 37 weeks) have been found to possess cognitive abilities that are directly proportional to their gestational age ($R^2 = .49, p < .001$; Bhutta et al., 2002). Such early emerging differences in children's abilities may precipitate widening

disparities over time. For instance, at approximately age 10, children who were born very preterm (< 29 weeks) were found to have cognitive and perceptual abilities approximately one standard deviation below that of age-matched peers (Stjernqvist & Svenningsen, 1999).

The child's gender has also been shown to influence cognitive and communicative development by way of differences in the social environment (Lovas, 2011). Variation in the communicative patterns of parental child-directed speech towards female and male infants is evident within the child's first months of life (Johnson et al., 2014), and persists as the infant develops and begins vocalizing (Sung et al., 2013).

Parent-infant joint engagement. Early emerging patterns of parent-infant coordinated engagement have been shown to play a critical role in early language development (Carpenter et al., 1998). The infant's ability to sustain attention while interacting with their mother has been shown to predict vocabulary learning (Çetinçelik et al., 2021; Masek et al., 2021; Yu et al., 2018), is supported by responsive parental behaviors (AUTHOR, 2018; Hirsh-Pasek et al., 2015), and occurs frequently in naturalistic contexts (Suarez-Rivera et al., 2022). Joint engagement – sometimes labeled as “triadic engagement” (E.E. Little et al., 2016) – refers to periods of parent-child interaction that involve active, sustained attending to and interest in a shared topic (Adamson, 2014). Given the emphasis on supported and coordinated activity between a child and their caregiver, which can be observed through overt behavior, joint engagement is regarded as a critical context for joint (shared) attention to objects and events of mutual interest (Adamson et al., 2019). Within the first year and a half, infants' social and communicative abilities undergo rapid development (Bakeman & Adamson, 1984), with behaviors such as shared attention to objects and events and imitation occurring on a more frequent basis (Charman et al., 2000). Language development is also dependent on child-directed

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speech, which is typically of higher quality within the context of caregiver-child joint engagement. For example, parent-child engagement in shared book-reading and other stimulating activities has been shown to influence the children's language development trajectories (Zajick-Farber, 2010). Findings from the Early Head Start Research Evaluation (EHSRE) project indicated that low-income White/European American families had higher rates of shared book-reading than low-income Black/African American or Hispanic families (Raikes et al., 2006).

Negative mother-infant interaction. Negative parenting behaviors have been found to correlate with diminished language development (Laake & Bridgett, 2018). In a prior study utilizing hierarchical linear models (Pungello et al., 2009), individual differences in language outcomes at 14, 24, 30, and 36 months were positively associated with maternal sensitivity and negatively associated with intrusiveness in parent-child interactions, with these factors moderated by race/ethnicity and SES. Scores on receptive and expressive language measures were lower for children of Black/African American parents than for children of White/European American parents, with the achievement gap increasing with age. Other research suggests that after controlling for differences in parenting practices, the achievement gap between groups narrows by 25-50% (Brooks-Gunn & Markman, 2005).

Modeling Risk with a Constellation of Factors

Complicating the developmental context even further, factors associated with increased risk of delays often co-occur and cluster together. Cumulative risk indices have been used to examine the compounding influence of environmental risks and are sometimes contrasted with approaches that examine discrete levels or categories of risk (Evans et al., 2013). There is evidence that such indices are predictive of children's developmental outcomes (Burchinal et al., 2000), beyond what is predicted by any single factor (Flouri & Kallis, 2007).

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Given the complexity of the influence of SES on children's language development, we sought to create a model of cumulative risk associated with low income based on measures derived when the child was 14 months of age. We then sought to understand how this model would predict children's later cognitive and communicative development at 36 months of age, and their vocabulary development through Grade 5. We were subsequently interested in determining whether the model would account for variation in outcomes of children regardless of the caregivers' race/ethnicity.

Research Aims

The current study is an extension of previous work using structural equation models (SEM) to explore individual differences in language outcomes of low-income toddlers in the EHSRE project (AUTHOR, 2020; Poulakos, 2013). AUTHOR (2020) presented a preliminary version of a SEM predicting Bayley MDI scores and PPVT scores at 36 months for subgroups of children in the control group of the EHSRE project who differed in race/ethnicity. Their findings indicated that the strength of associations between variables were highly similar across subgroups. We build on this earlier work by following the children from age 14 months through Grade 5. The research objectives are as follows:

1. *To test for direct and indirect influences of 14 month contextual, maternal, and child factors in predicting scores on a standardized assessment of children's receptive vocabulary knowledge at age 36 months, Pre-K (approximately 4 years) and Grade 5 (approximately 10 years).*

Our first aim was to examine how a constellation of child, maternal, and contextual factors observed in infancy might account for individual differences in receptive vocabulary knowledge over time. We tested a model of risk measured at 14 months of age, and determined

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whether various factors in the model predicted receptive vocabulary knowledge at age 36 months, Pre-K (approximate age 4 years), and Grade 5 (approximate age 10 years). We predicted that multiple factors measured at 14 months would bear direct and indirect relations to vocabulary knowledge at age 36 months, and expected the same constellation of factors to show persistent associations with vocabulary knowledge at later time points.

- 2. To determine whether latent constructs have sufficient measurement invariance across children of caregivers from different racial/ethnic subgroups. If strict invariance is not achieved, to determine which parameters vary across groups.*

Our second aim was to examine whether the proposed model of risk had invariant measurement properties between Black/African American and White/European American subgroups. To that end, we tested for psychometric invariance on the measurement models for the latent factors to ensure that the subgroup results were comparable.

- 3. To test whether the 14 month factors might differentially influence receptive vocabulary knowledge for children of Black/African American and White/European American parents.*

Our third aim was to determine whether the model was sufficient in accounting for vocabulary development trajectories of Black/African American and White/European American subgroups within the sample. Specifically, we were interested in whether model fit indices might differ substantially for Black/African American and White/European American subgroups over time.

Method

Participants

The study utilized a publicly available dataset from Early Head Start Research and

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Evaluation project (EHSRE; United States Department of Health and Human Services Administration for Children and Families, 2019a). Names and descriptions of variables used in this analysis are show in Table S1 in Supplemental Materials. All data used in this project are publicly available (see United States Department of Health and Human Services, Administration for Children and Families, 2011). The code used in this analysis has been made publicly available (see AUTHOR, 2021). The Institutional Review Board at the [...name of institution...] (where both authors were affiliated at the time of initial analysis) made the determination that the study was not human subjects research because it uses a publicly available de-identified dataset. The study was not pre-registered.

The analytic sample comprised a subset of children of low-income mothers who were in the control group of the EHSRE study (i.e., not enrolled in Early Head Start programs). The subset consisted of participants of Black/African American or White/European American caregivers who had data for the 36-month receptive vocabulary outcome measure. We excluded children in the treatment group of the EHSRE study to control for variability in Early Head Start program characteristics that might impact children's vocabulary development trajectories. Table 1 provides a summary of the demographic characteristics of the sample ($N = 556$; 280 girls and 276 boys). Child gender was coded as a binary variable (0=female, 1=male). Mothers self-identified their race/ethnicity as follows: 55.6% identified as White/European American and 44.4% as Black/African American. Race/ethnicity of the mother was re-coded as a binary variable (1=Black/African American, 0=White/European American).

Mothers reported their infant's approximate gestational age by selecting one of four choices. Most infants (84.3%) were born on time; 1.7% were born >2 months early, 11.9% were born >3 weeks early, and 2.2% were born >3 weeks late. A subset (2.8%) of mothers reported

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speaking a language other than English at home. Mothers indicated their highest educational attainment by selecting one of three possible choices: 38.2% attended some high school, 34.3% obtained a high school degree/GED, and 27.5% obtained a degree higher than high school or GED diploma. Family income was on average 59.6% (SD = 48.9) of the poverty threshold. About one-quarter (24.1%) of the sample was living in extremely impoverished circumstances, based on a household income of less than 33% of the poverty threshold for that year. As shown in the *t*-test comparison in Table 1, the subgroups did not differ with respect to child gender, gestational age, or home language, but differed in maternal education and household income.

Table 1
Sample demographics at child age 14 month

		Overall Sample (<i>N</i> = 556)	Subgroup		χ^2	<i>df</i>	<i>p</i>
			Black/African American (<i>N</i> = 247)	White/European American (<i>N</i> = 309)			
<i>Child Gender</i>		<i>N</i> = 556			.56	1	.507
<i>N</i> (%)	Boys	276 (49.6%)	48.6	48.2			
	Girls	280 (50.4%)	51.4	51.8			
<i>Child Gestational Age</i>		<i>N</i> = 464			1.38	3	.709
<i>N</i> (%)	> 2 months early	8 (1.7%)	2.3	1.2			
	2 months to 3 weeks early	55 (11.9%)	12.8	11.7			
	About on time	391 (84.3%)	83.0	85.1			
	> 3 weeks late	10 (2.2%)	1.8	1.6			
<i>Home Language</i>		<i>N</i> = 537			1.31	1	.252
<i>N</i> (%)	English	522 (97.2%)	98.3	96.3			
	Not English	15 (2.8%)	1.7	3.7			
<i>Maternal Education</i>		<i>N</i> = 545			14.76	2	<.001***
<i>N</i> (%)	< 12 years	208 (38.2%)	47.1	31.1			
	12 years or GED	187 (34.3%)	30.4	37.4			
	> 12 years	150 (27.5%)	22.5	31.5			
<i>Household Income < 33% Poverty Threshold</i>		<i>N</i> = 556			12.86	1	<.001***
<i>N</i> (%)	Yes	134 (24.1%)	31.6	18.1			
	No	422 (75.9%)	68.4	81.9			

Measures at Child Age 14 Months

In addition to the demographic variables listed above, measures of infant cognitive ability, the home environment, mother-child interaction, and maternal distress were administered at child age 14 months. Table 2 provides descriptive statistics for each measure along with *t*-tests

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comparing subgroups. Correlations between 14-month predictors and vocabulary outcomes are available in Supplemental Materials (Table S2).

Table 2
Descriptive statistics for measures at child age 14 months

14-month predictors	Overall Sample		Black/African American		White/ European American		<i>t</i>	<i>p</i>	<i>d</i>
	<i>N</i>	<i>M (SD)</i>	<i>N</i>	<i>M (SD)</i>	<i>N</i>	<i>M (SD)</i>			
Bayley MDI	426	98.5 (10.9)	173	97.3 (9.8)	253	99.3 (11.6)	-1.88	.061	-.179
HOME Inventory	473	26.6 (3.3)	201	25.4 (3.5)	272	27.5 (2.8)	-6.79	<.001***	-.653
<i>3-bag Task</i>									
Parent Supportiveness	441	4.0 (1.0)	185	3.6 (1.0)	256	4.3 (1.0)	-7.47	<.001***	-.722
Child Engagement of Parent	441	3.9 (1.1)	185	3.9 (1.2)	256	3.9 (1.0)	-.33	.741	-.033
Child Sustained Attention	441	5.0 (1.0)	185	4.7 (1.0)	256	5.2 (0.9)	-6.12	<.001***	-.598
Parent Intrusiveness	441	2.4 (1.3)	185	2.8 (1.3)	256	2.1 (1.1)	6.12	<.001***	.606
Parent Negative Regard	441	1.5 (0.8)	185	1.7 (1.0)	256	1.3 (0.6)	5.17	<.001***	.539
Child Negativity toward Parent	441	2.1 (1.1)	185	2.3 (1.2)	256	1.9 (1.0)	3.79	<.001***	.379
<i>Maternal Distress Variables</i>									
CES-D Depression Scale	496	14.0 (10.1)	218	13.7 (9.8)	278	14.2 (10.4)	-.57	.570	-.051
Parent Distress Inventory	502	27.2 (9.4)	222	28.1 (9.9)	280	26.5 (9.0)	1.82	.069	.166
Parent-Child Dysfunctional Interaction	502	17.2 (5.7)	222	17.5 (6.6)	280	16.9 (4.9)	1.51	.132	.111

Infant cognitive ability. Children completed the Bayley Scales of Infant Development (BSID; Bayley, 1993), a norm-referenced test that measures mental and motor development in infants from one to 42 months of age. BSID scores are used to describe the developmental functioning of infants and to assist in diagnosis and treatment planning for infants with developmental delays or disabilities. The Mental Development Index (MDI) measures the cognitive, language, and personal-social development of children under 3½ years of age (Bayley, 1993). We used infants’ standardized MDI scores in the model. At 14 months, scores on the MDI (*mean* = 98.5, *SD* = 10.9) approximated the population mean ($\mu = 100$, $\sigma = 15$), with no significant difference between subgroups, see Table 2.

HOME Inventory. Participants completed the Home Observation for the Measurement of the Environment (HOME) inventory (Caldwell & Bradley, 1984), which measures the quality of stimulation and support available to a child in the home environment. The infant/toddler HOME inventory is designed for use between birth and age three and consists of a combination of

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parental self-report items and interviewer-observed items. The inventory assesses the quality of the mother's speech and verbal responses to the child during the home visit (as rated by the interviewer); whether the parent encourages the child to learn shapes, colors, numbers, and the alphabet; the presence of books, toys, and games accessible to the child; and whether the parent reads to the child several times per week. A total score was derived from the infant/toddler HOME inventory and used in the model, with higher scores indicating a more stimulating and supportive home environment. As shown in Table 2, scores on the HOME inventory varied significantly between the two subgroups. After controlling for household income (income as % of poverty line for family) and maternal education (1 = Completed less than 12 years of schooling, 2 = Completed 12 years of school or a GED, 3 = Completed more than 12 years of schooling), subgroup differences in scores on the HOME inventory remained significant (see Table S3 in Supplemental Materials).

3-bag task. The 3-bag task is a semi-structured play procedure used to assess positive and negative aspects of parent-child interaction. The mother and child are given three bags of interesting toys and asked to play with the toys in sequence to facilitate parent-child interaction (United States Department of Health and Human Services, Administration for Children and Families, 2019b). Bag 1 contained the picture book *Good Dog, Carl* (Day, 1986), bag 2 contained a set of kitchen utensils, pots, pans, and a stove, and bag 3 contained a Noah's ark and animal set. The semi-structured play task was videotaped; subsequently, child and maternal behaviors were scored in accordance with the 3-bag task coding scales (NICHD Early Child Care Research Network, 1999; Ware, Brady, O'Brien, & Berlin, 2000). From this measure, we used 6 of the 7 behavioral scales: *parent supportiveness*, *child engagement of parent*, *child sustained attention*, *parent intrusiveness*, *parent negative regard*, and *child negativity toward parent*.

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The *parent supportiveness* scale assessed maternal sensitivity, positive affect, and the extent to which the mother provided cognitive stimulation while interacting with her child. The *child engagement of parent* scale assessed the extent to which the child made communicative bids to engage with their mother and whether they expressed positive regard towards her. The *child sustained attention* scale assessed the extent to which children demonstrated focused attention and engagement with the book or toy set provided. Scores reflected the extent to which the child was involved vs. disorganized in attending to the objects. The *parent intrusiveness* scale assessed the extent to which the mother attempted to control the child rather than recognizing and respecting the child's autonomy. *Parent negative regard* assessed the mother's expressed discontent with, anger toward, disapproval of, or rejection of the child. The *child negativity toward parent* scale reflected the extent to which the child engaged in negative behaviors such as aggressively rejecting a toy or hitting/throwing an object in response to their mother. Possible scores on each scale ranged from 1 to 7; intraclass correlations on coders' responses ranged from .68 to .76, with percent agreement within 1 point (range 87% to 96%; Fuligni & Brooks-Gunn, 2013). Table 2 provides *t*-test comparisons of the two subgroups. Except for the child engagement of the parent scale, all other 3-bag task scales showed significant differences between the two subgroups. Even when controlling for household and maternal education, all the subgroup differences remained significant (see Table S3 in Supplemental Materials).

Center for Epidemiological Studies-Depression Inventory (CES-D). The mothers completed the CES-D (Radloff, 1977), which measures symptoms of depression using a 20-item scale. Respondents were asked the number of days in the past week they had particular symptoms such as poor appetite, restlessness, loneliness, sadness, and lack of energy. Though the CES-D does not indicate a diagnosis of clinical depression, it does discriminate between

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depressed and not depressed patients on the number of depressive symptoms, with higher scores indicating more symptoms. Mean scores on the CES-D did not differ significantly for the two subgroups, see Table 2.

Short-form version of the Parental Stress Index (PSI-SF). The PSI-SF (Abidin, 1995) measures the degree of stress within the parent-child relationship attributable to three possible sources: the child's temperament, parental depression, and negative reinforcement. The Parental Distress Index was derived from 12-items on the PSI-SF. It served as an indicator of the level of distress the parent feels in the role of parent stemming from personal factors, including a low sense of parenting competence, stress due to the perceived restrictions associated with parenting, depression, and general lack of social support. The Parent-Child Dysfunctional Interaction Index was also derived from 12-items on the PSI-SF. It served as an indicator of whether the parent either perceives that the child is abusing or rejecting them, or feels disappointed in or alienated from the child. For each index, higher scores indicated greater maternal distress. Mean scores for the Parental Distress Index and the Parent-Child Dysfunctional Interaction Index did not differ for the two subgroups, see Table 2.

Receptive vocabulary knowledge at 36 months, Pre-K, and Grade 5

Children's receptive vocabulary knowledge was measured at three ages (36 months, pre-K, and Grade 5) using standardized age-normed scores from the Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997), an untimed verbal intelligence test of approximately 20-30 minutes duration. The examiner presents four pictures at a time to the child and the child is asked to point to the picture that matches a word spoken aloud. The test continues until the child has made errors on a set number of trials. The PPVT-III is normed for ages 2.5 to 90 years. Table 3 provides descriptive statistics for the PPVT scores on each occasion of measurement.

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Standardized scores increased over time. Whereas mean scores on the PPVT-III at age 36 months ($mean = 83.2, SD = 16.0$) were more than one SD below the population mean score ($\mu = 100, \sigma = 15$), children's scores at Grade 5 approximated the population mean ($mean = 96.5, SD = 15.5$). Subgroup differences in PPVT-III scores were statistically significant at each time point and appeared to increase over time; see Table 3 for t -test comparisons and effect-size estimates. The PPVT scores were moderately correlated across the three time points (r values = .56–.71, $ps < .001$), indicating stability in individual differences. When controlling for household and maternal education, the subgroup differences in PPVT scores remained significant (see Table S4 in Supplemental Materials).

Table 3.

Descriptive statistics for PPVT scores at child age 36 months, 4 years, and Grade 5

Age	Overall Sample		Black/African American		White/ European American		t	p	d
	N	M (SD)	N	M (SD)	N	M (SD)			
36 months	556	83.2 (16.0)	247	78.5 (14.7)	309	86.9 (16.0)	6.43	<.001***	.554
Pre-K	445	93.0 (14.8)	192	85.6 (14.1)	253	98.6 (12.7)	10.12	<.001***	.982
Grade 5	377	96.5 (15.5)	168	88.7 (14.0)	209	102.8 (13.7)	9.81	<.001***	1.02

*** $p < .001$

Results

We used structural equation modeling (SEM) to explore how a constellation of factors assessed at infancy (14 months) was associated with receptive vocabulary knowledge (PPVT-III scores) of children from low-income families at ages 36 months, Pre-K, and Grade 5. As a first step in model building, a measurement model was created using confirmatory factor analysis (CFA) to define three latent variables (joint engagement, negative interaction, maternal distress) in terms of the corresponding indicator variables. As a second step, we conducted measurement invariance on each of the latent factors, comparing a series of successively more constrained factor models. We then used SEM to determine direct and indirect effects of the various factors on receptive vocabulary knowledge at each age and whether the strength of the observed relations differed between subgroups.

Measurement Models

We used the *lavaan* (Rosseel, 2012) package in *R* to conduct CFA, which served to establish the adequacy of the indicator variables for the three latent variables. Full information robust maximum likelihood estimation was used to handle missing data (Acock, 2012). Standardized coefficients were reported and model fit was assessed using multiple indices (Hu & Bentler, 1999), including the chi-square test, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).

Joint engagement. The latent variable *joint engagement* was measured using three observed variables derived from the 3-bag task (Fulgini & Brooks-Gunn, 2013): child sustained attention, child engagement of parent, and parental supportiveness of the child. The CFA produced acceptable model fit indices, $CFI = 1.00$, $TLI = 1.00$, $RMSEA < .001$, $SRMR < .001$, with standardized loadings for all manifest variables above .50, see Figure 1 for the results for the full sample and each subgroup.

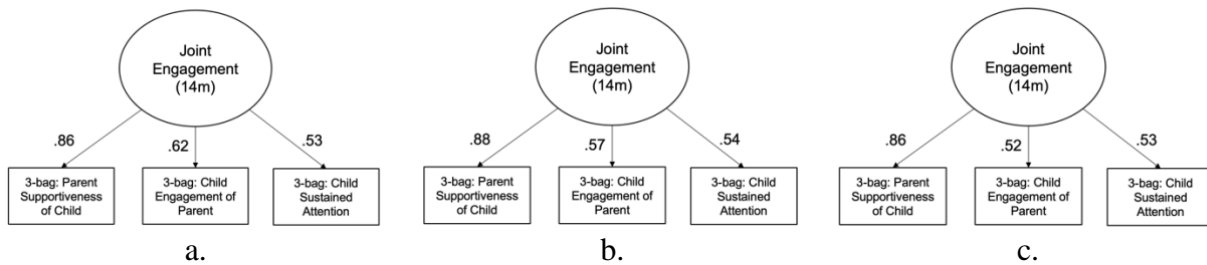


Figure 1. Latent variable for joint engagement measured at 14 months for (a) total sample ($N = 556$), (b) Black / African American sample ($N = 247$), and White / European American sample ($N = 309$)

Negative interaction. The latent variable *negative interaction* was also derived from three observed variables derived from the 3-bag task: parent negative regard of the child, parent intrusiveness, and child negativity toward parent. The CFA for negative interaction produced acceptable model fit indices, $CFI = 1.00$, $TLI = 1.00$, $RMSEA < .001$, $SRMR < .001$, with

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standardized loadings for all manifest variables above .40, see Figure 2 for the results for the full sample and each subgroup.

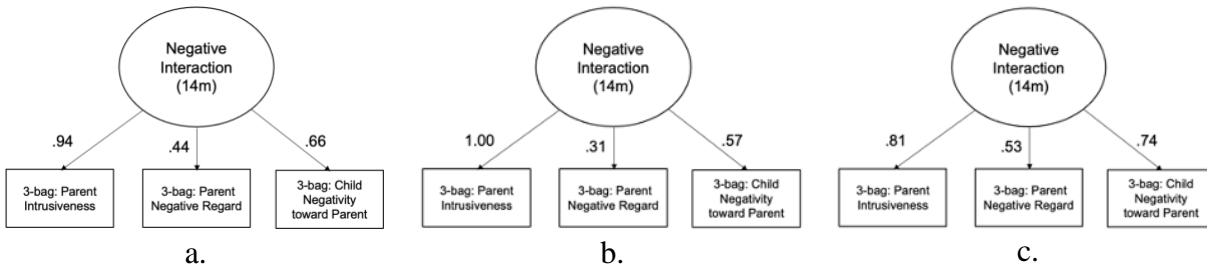


Figure 2. Latent variable for negative interaction measured at 14 months for (a) total sample ($N = 556$), (b) Black / African American sample ($N = 247$), and White / European American sample ($N = 309$)

Maternal distress. The latent variable *maternal distress* was derived from scores on the CES-D scale (Radloff, 1997), and the Parental Distress Index and Parent-Child Dysfunctional Interaction Index of the PSI-SF (Abidin, 1995). The CFA for maternal distress produced acceptable model fit indices, $CFI = 1.00$, $TLI = 1.00$, $RMSEA < .001$, $SRMR < .001$, with standardized loadings for all manifest variables above .50, see Figure 3 for the results for the full sample and each subgroup.

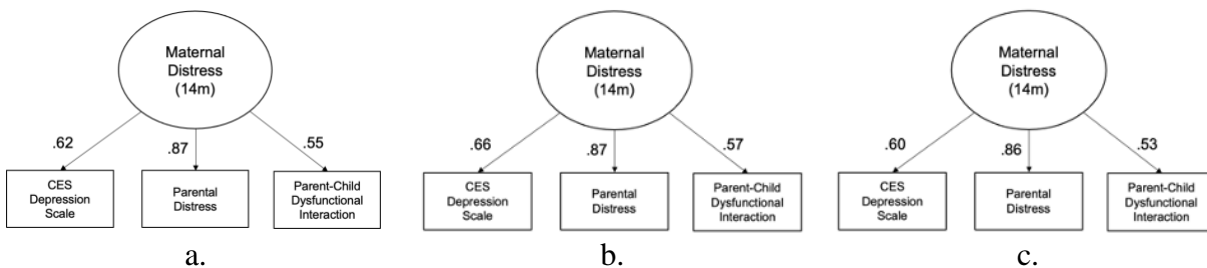


Figure 3. Latent variable for maternal distress measured at 14 months for (a) total sample ($N = 556$), (b) Black / African American sample ($N = 247$), and White / European American sample ($N = 309$)

Measurement invariance. Having confirmed good fit indices for each latent variable for the full sample using CFA, we then tested for equivalence of measurement (i.e., measurement invariance) between Black/African American and White/European American subgroups using multi-group CFA. Measurement invariance for each latent variable and for the full SEM was

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tested using the strategy proposed by Jöreskog (1971, 1993), which compares the model fit of two groups against a theoretical model using a series of models with increasingly more constrained parameters (see Milfont & Fischer, 2010; Putnick & Bornstein, 2016), see Table 4. We sought to establish, at a minimum, evidence of metric invariance (i.e., loadings constrained between groups) between the two subgroups (Guenole & Brown, 2014; Hsiao & Lai, 2018) in order to proceed with fitting the SEMs. In determining whether the assumption of invariance held at a given level of model constraint, we evaluated multiple fit indices, including the results of the χ^2 difference test, as well as the Δ CFI (Cheung & Rensvold, 2002), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values. Lower AIC and BIC values generally provide evidence of a more parsimonious factor model (Byrne et al., 1989).

Table 4
Sequence of models tested to establish measurement invariance

Model	Constraints
Configural	Same latent model structure between groups. Subgroups are tested with no additional equivalence constraints.
Metric	Same model as the “configural model,” with the addition of constraints of equivalence on factor loadings between the groups.
Scalar	Same model and constraints as the “metric model,” with the addition of constraints of equivalence on intercepts between the groups.
Strict	Same model and constraints as the “scalar model,” with the addition of constraints of equivalence on residuals between the groups.

Table 5 shows the fit indices based on robust estimation for each of the successively more constrained models that were tested in conducting the measurement invariance analysis. The findings provide evidence of adequate measurement invariance (i.e., metric invariance with the factor loadings constrained) based on the χ^2 difference test and relative decrease in AIC/BIC for each of the latent variables. For joint engagement, measurement invariance was achieved at

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the level of the metric model; for negative interaction and maternal distress, measurement invariance was achieved at the level of the scalar model.

Table 5
Comparison of model fit indices for the latent variables models comparing Black/African American and White/European American subgroups with increasing equality constraints (N = 556)

Constraints	χ^2	df	p	CFI	TLI	RMSEA	SRMR	AIC	BIC	Model Comparison					
										Δdf	p	Δdf	ΔCFI	Decision	
<i>Joint Engagement</i>															
Configural	-	-	-	1.00	1.00	<.001	<.001	3566.44	3640.04	-	-	-	-	-	-
Metric	0.10	2	0.95	1.00	1.02	<.001	0.01	3562.53	3627.96	Metric v. Configural	2	.953	2	.00	Accept
Scalar	26.23	4	<.001	0.91	0.86	0.16	0.07	3584.67	3641.92	Scalar v. Metric	2	<.001	2	.09	Reject
Strict	34.83	8	<.001	0.89	0.92	0.12	0.09	3585.27	3626.16	Strict v. Scalar	4	.055	4	.01	-
<i>Negative Interaction</i>															
Configural	-	-	-	1.00	1.00	0.00	0.00	3404.06	3477.67	-	-	-	-	-	-
Metric	2.63	2	0.27	1.00	0.99	0.04	0.02	3402.69	3468.12	Metric v. Configural	2	.538	2	.00	Accept
Scalar	10.22	4	0.04	0.98	0.97	0.08	0.05	3406.29	3463.53	Scalar v. Metric	2	.132	2	.02	Accept
Strict	99.99	8	<.001	0.67	0.75	0.23	0.25	3488.06	3528.95	Strict v. Scalar	4	<.001	4	.31	Reject
<i>Maternal Distress</i>															
Configural	-	-	-	1.00	1.00	0.00	0.00	10248.17	10324.1	-	-	-	-	-	-
Metric	2.75	2	0.25	1.00	0.99	0.04	0.03	10246.91	10314.41	Metric v. Configural	2	.430	2	.00	Accept
Scalar	8.00	4	0.09	0.99	0.98	0.06	0.04	10248.16	10307.23	Scalar v. Metric	2	.060	2	.01	Accept
Strict	33.10	8	<.001	0.92	0.94	0.11	0.12	10265.27	10307.45	Strict v. Scalar	4	.007	4	.07	Reject

Note: Bold font indicates the level at which assumptions of invariance failed.

Structural Equation Modeling

Having established measurement invariance between subgroups across all three latent constructs, we then sought to examine the direct and indirect effects of each of the predictors on receptive vocabulary development. Table S5 in Supplemental Materials shows the results of a preliminary regression model with vocabulary outcomes predicted by demographic factors. Predictors in the SEMs were measured at 14 months and included demographic variables (i.e., child gender, gestational age, maternal education) found to explain variation in receptive vocabulary at 36 months, along with the home environment (HOME Total Score), child’s cognitive ability (Bayley MDI), maternal distress, negative interaction, and joint engagement variables. Receptive vocabulary knowledge (PPVT-III scores) as an outcome was measured at 36 months (3 years), in Pre-K (approximately 4 years), and Grade 5 (approximately 10 years). For

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each successive model, the dataset was restricted to a subset of data used in the previous model. For example, data used in the model predicting variation in the children's vocabulary measured in Pre-K also contained data for the 36-month outcome. Subsequently, data used in the model predicting variation in children's vocabulary in Grade 5 also contained data points for both the 36 month and Pre-K vocabulary measurements. The generic model, with all paths tested, is shown in Figure 4.

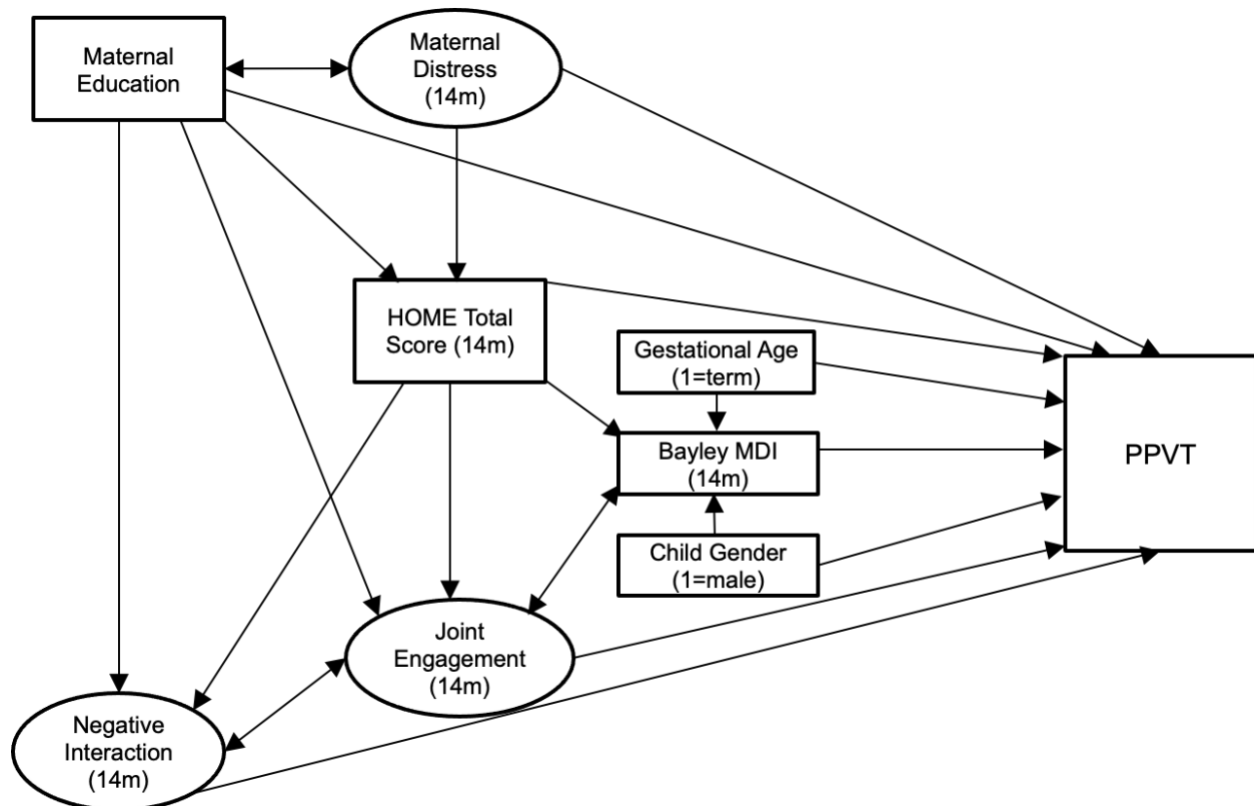


Figure 4. Generic model showing all direct effects; Indirect paths estimated include the following: HOME → Bayley MDI → PPVT; HOME → Joint engagement → PPVT; Maternal distress → HOME → PPVT; Maternal education → Joint engagement → PPVT; Maternal education → HOME → PPVT; Gestational age → Bayley MDI → PPVT; Child gender → Bayley MDI → PPVT

The predictors were examined in relation to PPVT-III scores at each age in separate SEMs using full information robust maximum likelihood estimation. First, the model was fit on the full sample. Subsequently, we conducted subgroup analysis with all three latent factors entered into the SEMs at the highest level of constraint previously achieved: factor loadings were

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constrained for joint engagement, while factor loadings and intercepts were constrained for negative interaction and maternal distress. Prior to conducting the subgroup analyses, goodness of fit indices were examined in the full model and evaluated with the same criteria mentioned previously. We expected that the model would implicate qualities of parent-child interaction in both subgroups as measured at child age 14 months on subsequent vocabulary development, while also pointing to a broader range of factors impacting outcomes (i.e., significant paths) that might differ between the Black/African American and White/European American subgroups.

36-month model. The SEM predicting variation in PPVT standardized scores for the full sample at 36 months is shown in Figure 5. The full model with unconstrained factor loadings and intercepts demonstrated good fit, $\chi^2(df = 76, n = 556) = 161.627, p < .001, CFI = 0.935, TLI = 0.910, RMSEA = 0.046 [0.036, 0.056], SRMR = 0.052$. Though the chi-square test indicated imperfect fit, the test is highly sensitive to sample size (Brown, 2015; T.D. Little, 2013), and its significance should be considered in relation to the other indices demonstrating acceptable fit. With the overall sample, approximately 23.5% of variance in the children's vocabulary scores was accounted for by the model.

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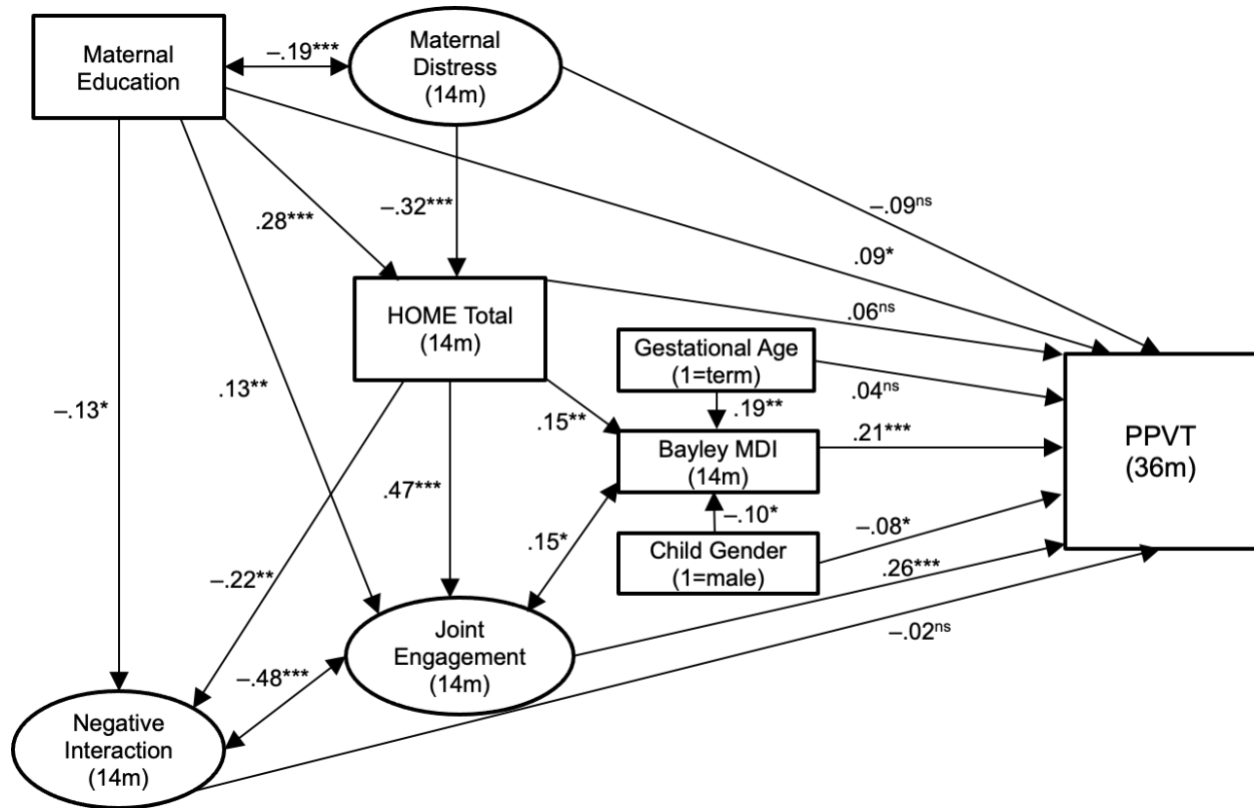


Figure 5. Standardized estimates of the model predicting PPVT scores at 36 months for the entire sample.
 Note: *** $p < .001$, ** $p < .01$, * $p < .05$, $^{ns} p \geq .05$

As shown in Figure 5, several of the 14-month variables had a significant direct effect on receptive vocabulary knowledge at 36 months. In order of magnitude, based on standardized estimates of effects, were significant direct effects of joint engagement, infant cognitive ability (Bayley MDI), maternal education, and child gender (favoring girls). Notably, although negative interaction co-varied significantly with joint engagement, it did not have a direct effect in predicting vocabulary knowledge at 36 months. Similarly, the home environment (HOME total score) was not directly associated with vocabulary knowledge, but was associated with both indicators the quality of mother-infant interaction (i.e., positively with joint engagement and negatively with negative interaction) as well as infant cognitive ability. Maternal distress was also not directly associated with vocabulary knowledge at 36 month, but accounted for

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significant variance in the quality of the home environment and covaried (negatively) with maternal education.

Table 6 provides a summary of tests of the indirect effects in the model. Joint engagement appeared to mediate the association between the quality of home environment and children's vocabulary knowledge, with evidence of a significant indirect and total effect in the absence of a direct effect. Joint engagement appeared to partially mediate the relation between maternal education and vocabulary knowledge. These findings highlight the importance of joint engagement not only as a direct contributor to later vocabulary development, but also one as a factor that influences the effect of maternal and home factors. With regard to infant cognitive ability as a possible mediator, we found some evidence of an indirect effect of the home environment on vocabulary scores by way of Bayley MDI scores, but, there was no evidence of a total effect. The same was true for gestational age: There was evidence of an indirect effect of gestational age on vocabulary scores by way of Bayley MDI scores though the total effect was not significant.

Table 6

Indirect and total effects estimated for model with 36m PPVT scores

	<i>Std. Estimate (β)</i>	<i>SE</i>	<i>95% CI (Lower)</i>	<i>95% CI (Upper)</i>	<i>z</i>	<i>p</i>
Child Gender → Bayley MDI → PPVT						
Indirect	-0.02	0.01	-0.04	0.00	-1.90	0.058 ·
Total	-0.10	0.04	-0.18	-0.03	-2.67	0.008**
Gestational Age → Bayley MDI → PPVT						
Indirect	0.04	0.02	0.01	0.07	2.57	0.010*
Total	0.08	0.04	-0.01	0.16	1.82	0.068 ·
HOME → Bayley MDI → PPVT						
Indirect	0.03	0.01	0.01	0.06	2.51	0.012*
Total	0.09	0.06	-0.03	0.22	1.52	0.128
HOME → Joint Engagement → PPVT						
Indirect	0.12	0.05	0.03	0.21	2.59	0.010*
Total	0.18	0.06	0.07	0.30	3.20	0.001**
Maternal Distress → HOME → PPVT						
Indirect	-0.02	0.02	-0.06	0.02	-1.00	0.315
Total	-0.11	0.05	-0.20	-0.02	-2.32	0.020*
Maternal Education → Joint Engagement → PPVT						
Indirect	0.03	0.02	0.00	0.07	2.04	0.042*
Total	0.12	0.04	0.04	0.21	2.90	0.004**
Maternal Education → HOME → PPVT						
Indirect	0.02	0.02	-0.02	0.05	0.99	0.322
Total	0.11	0.04	0.02	0.19	2.49	0.013*

Note: *** $p < .001$, ** $p < .01$, * $p < .05$, · $p < .10$

Subgroups. Analyses were conducted to examine differences in parameter estimates for the Black/African American ($n = 247$) and White/European American ($n = 309$) subgroups. Model fit generally appeared acceptable for both the Black/African American ($\chi^2(df = 105) = 588.67, p < .001, CFI = .931, TLI = .904, RMSEA = .043 [.025, .060], SRMR = .067$) and White/European ($\chi^2(df = 105) = 809.27, p < .001, CFI = .892, TLI = .851, RMSEA = .060 [.046, .073], SRMR = .061$) subgroups. The model accounted for 16.3% of variation in PPVT standardized scores at 36 month in the Black/African American subgroup, and 21.9% in the White/European American subgroup. For each subgroup, the strength of the regression paths shown in Figure 5 were similar to those in the full model. Table S6 in Supplemental Materials shows all standardized parameters estimates for SEM for the model fit to both subgroups separately.

Pre-K model. The SEM predicting variation in PPVT standardized scores for the full sample in Pre-K is shown in Figure 6. The model with unconstrained factor loadings and intercepts demonstrated good fit, $\chi^2(df = 76, n = 445) = 135.773, p < .001, CFI = 0.945, TLI = 0.923, RMSEA = 0.043 [0.031, 0.055], SRMR = 0.052$. The model accounted for approximately 25.8% of variance in receptive vocabulary scores at Pre-K.

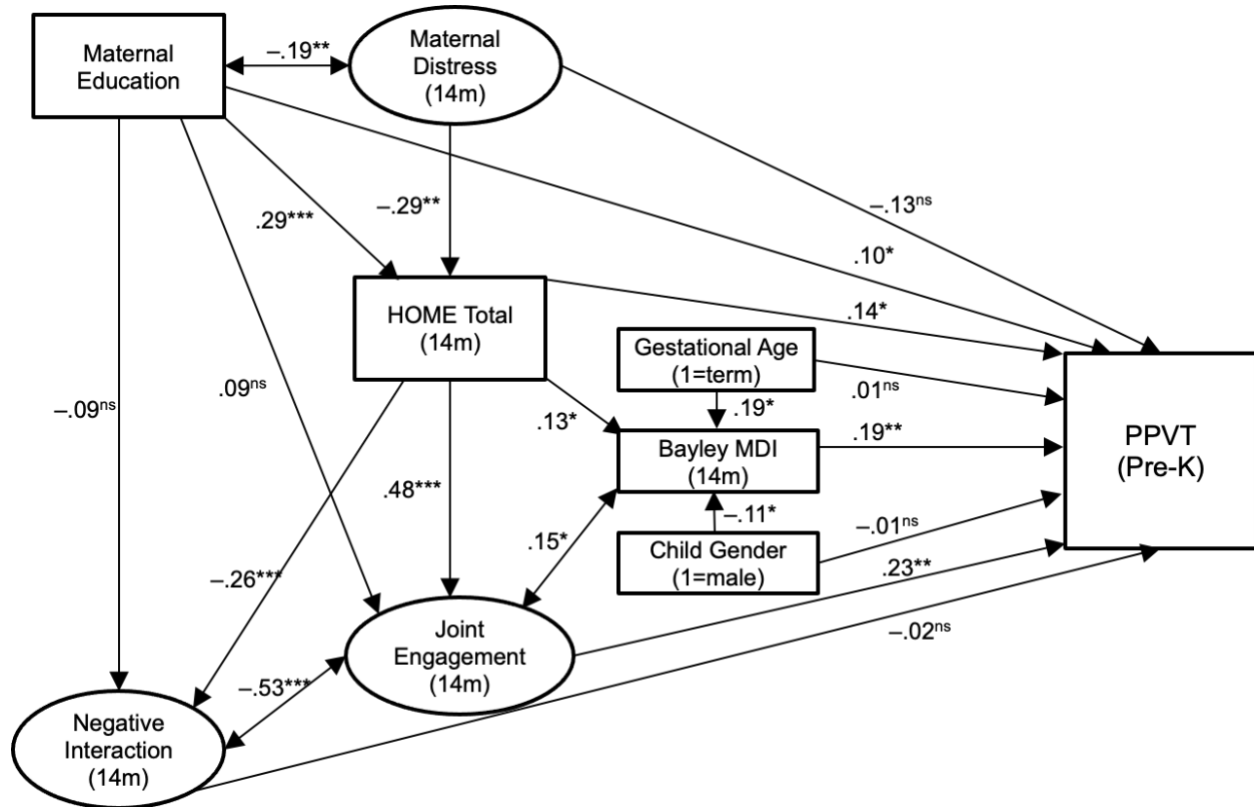


Figure 6. Standardized estimates of the model predicting PPVT scores in Pre-K. Model shows estimates for the entire sample. Note: *** $p < .001$, ** $p < .01$, * $p < .05$, ^{ns} $p \geq .05$

As shown in Figure 6, several of the 14-month variables still had significant direct effects on receptive vocabulary knowledge at Pre-K, or approximately 4 years of age. In order of magnitude, based on standardized estimates of effects, were significant direct effects of joint engagement, infant cognitive ability (Bayley MDI), home environment (HOME total score), and maternal education. The direct effects matched what was observed at 36 months, with two exceptions: home environment was significant in predicting PPVT scores at pre-K but not at 36

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months; child gender (favoring girls) was significant in predicting PPVT scores at age 36 months, but not at pre-K. As in the 36-month model, negative interaction co-varied with joint engagement, but did not have a direct effect on vocabulary knowledge. Also matching the results at 36 months, maternal distress did not have a direct effect on vocabulary knowledge, but was associated with the home environment and maternal education.

Table 7 summarizes the tests of indirect effects in the pre-K model. Joint engagement no longer appeared to mediate the association between the quality of home environment and children's vocabulary knowledge at pre-K. The home environment, in turn, mediated effects of maternal distress (as indicated by significant indirect and total effects in the absence of a direct effect) and partially mediated effects of maternal education on vocabulary knowledge (as indicated by significant direct, indirect and total effects). Taken together, the results suggest a persistent influence of the home environment on receptive vocabulary development over time, over and above its association with joint engagement. In addition, as was the case at 36 months, the indirect effect of gestational age on vocabulary scores by way of Bayley MDI scores was significant in the pre-K model, though the total effect was not significant.

Table 7

Indirect and total effects estimated for model with Pre-K PPVT scores

	<i>Std. Estimate (β)</i>	<i>SE</i>	<i>95% CI (Lower)</i>	<i>95% CI (Upper)</i>	<i>z</i>	<i>p</i>
Child Gender → Bayley MDI → PPVT						
Indirect	-0.02	0.01	-0.04	0.00	-1.87	0.062 .
Total	-0.03	0.04	-0.12	0.05	-0.74	0.457
Gestational Age → Bayley MDI → PPVT						
Indirect	0.03	0.02	0.00	0.06	2.21	0.027*
Total	0.05	0.04	-0.04	0.13	1.09	0.277
HOME → Bayley MDI → PPVT						
Indirect	0.02	0.01	0.00	0.05	1.85	0.064 .
Total	0.17	0.06	0.04	0.29	2.61	0.009**
HOME → Joint Engagement → PPVT						
Indirect	0.11	0.05	0.02	0.20	2.39	0.017*
Total	0.25	0.06	0.14	0.37	4.21	<.001***
Maternal Distress → HOME → PPVT						
Indirect	-0.04	0.02	-0.08	0.00	-2.10	0.036*
Total	-0.17	0.06	-0.28	-0.06	-2.93	0.003**
Maternal Education → Joint Engagement → PPVT						
Indirect	0.02	0.02	-0.01	0.05	1.34	0.180
Total	0.12	0.05	0.03	0.21	2.53	0.011*
Maternal Education → HOME → PPVT						
Indirect	0.04	0.02	0.00	0.08	2.15	0.031*
Total	0.14	0.05	0.05	0.23	3.06	0.002**

Note: *** $p < .001$, ** $p < .01$, * $p < .05$, · $p < .10$

Subgroups. Model fit indices remained acceptable for the Black/African American ($\chi^2(df = 105, n = 192) = 475.49, p < .001, CFI = .948, TLI = .928, RMSEA = .037 [<.001, .058], SRMR = .069$) and White/European American ($\chi^2(df = 105, n = 253) = 719.40, p < .001, CFI = .907, TLI = .871, RMSEA = .057 [.041, .072], SRMR = .063$) subgroups. The model accounted for 14.6% of variation in PPVT standardized scores at pre-K in the Black/African American subgroup, and 32.1% in the White/European American subgroup. As was the case at 36 months, the subgroups models at pre-K largely matched the results for the full sample shown in Figure 6 (see Table S7 in Supplemental Materials for standardized parameters estimates for SEMs fitted to each subgroup separately).

Grade 5 model. The SEM predicting variation in PPVT standardized scores for the full sample in Grade 5 is shown in Figure 7. The full-sample model with unconstrained factor

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loadings and intercepts demonstrated good fit, $\chi^2(df = 76, n = 322) = 108.683, p < .001, CFI = 0.960, TLI = 0.945, RMSEA = 0.052 [0.020, 0.053], SRMR = 0.052$. The model accounted for approximately 30.6% of variance in vocabulary scores in Grade 5.

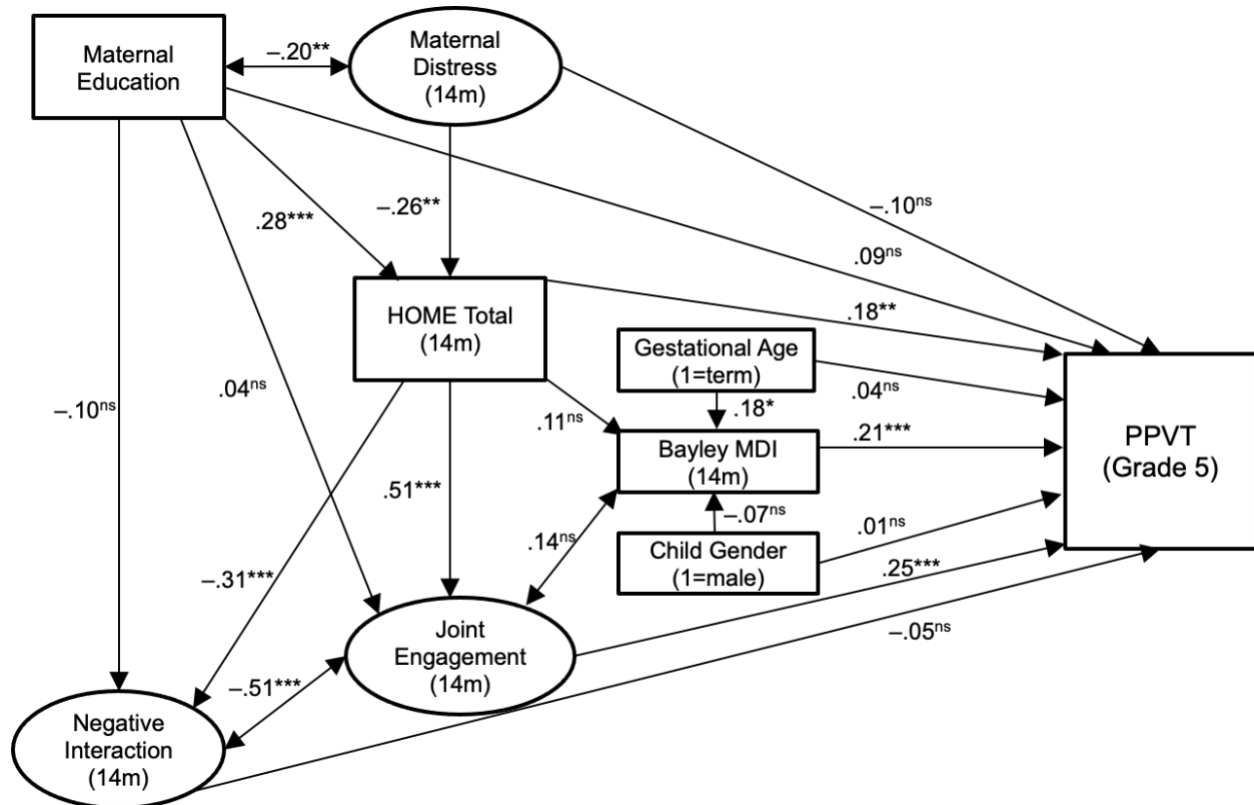


Figure 7. Standardized estimates of the model predicting PPVT scores in Grade 5. Model shows estimates for the entire sample. Note: *** $p < .001$, ** $p < .01$, * $p < .05$, ^{ns} $p \geq .05$

As shown in Figure 7, several of the 14-month variables continued to show significant direct effects on receptive vocabulary knowledge at Grade 5, or approximately 10 years of age. In order of magnitude, based on standardized estimates of effects, were significant direct effects of joint engagement, infant cognitive ability (Bayley MDI), and the home environment (HOME total score). The direct effects matched what was observed at pre-K, with one exception: the direct effect of maternal education on receptive vocabulary knowledge was significant at pre-K, but not at Grade 5. In other respects, the models at pre-K and Grade 5 were similar.

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Table 8

Indirect and total effects estimated for model with Grade 5 PPVT scores

	<i>Std. Estimate (β)</i>	<i>SE</i>	<i>95% CI (Lower)</i>	<i>95% CI (Upper)</i>	<i>z</i>	<i>p</i>
Child Gender → Bayley MDI → PPVT						
Indirect	-0.01	0.01	-0.04	0.01	-1.09	0.275
Total	0.00	0.05	-0.10	0.10	-0.04	0.968
Gestational Age → Bayley MDI → PPVT						
Indirect	0.04	0.02	0.00	0.07	2.09	0.036*
Total	0.07	0.05	-0.03	0.18	1.38	0.167
HOME → Bayley MDI → PPVT						
Indirect	0.02	0.02	-0.01	0.05	1.49	0.136
Total	0.20	0.06	0.08	0.33	3.18	0.001**
HOME → Joint Engagement → PPVT						
Indirect	0.12	0.05	0.03	0.22	2.51	0.012*
Total	0.30	0.07	0.17	0.44	4.54	<.001***
Maternal Distress → HOME → PPVT						
Indirect	-0.05	0.02	-0.09	0.00	-2.09	0.037*
Total	-0.15	0.06	-0.27	-0.02	-2.31	0.021*
Maternal Education → Joint Engagement → PPVT						
Indirect	0.01	0.02	-0.02	0.04	0.66	0.510
Total	0.10	0.05	0.01	0.20	2.08	0.037*
Maternal Education → HOME → PPVT						
Indirect	0.05	0.02	0.01	0.09	2.54	0.011*
Total	0.14	0.05	0.05	0.24	2.85	0.004***

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

Table 8 summarizes the tests of indirect effects in the Grade 5 model. As was seen in the pre-K model, joint engagement partially mediated the association between the quality of home environment and children’s vocabulary knowledge at Grade 5. Maternal education and maternal distress both continued to have an indirect effect on vocabulary knowledge, mediated by the home environment. Once again, there appeared to be an indirect effect of gestational age by way of Bayley MDI scores though the total effect was not significant.

Subgroups. Though fit indices were not as good as the models with the early outcomes, they generally had acceptable fit for the Black/African American ($\chi^2(df = 105, n = 135) = 428.99$, $p < .001$, $CFI = .890$, $TLI = .848$, $RMSEA = .059$ [.034, .081], $SRMR = .079$) and White/European American ($\chi^2(df = 105, n = 187) = 549.12$, $p < .001$, $CFI = .942$, $TLI = .920$, $RMSEA = .044$ [.018, .064], $SRMR = .062$) subgroups. The model accounted for 20.1% of

variation in PPVT standardized scores at Grade 5 in the Black/African American subgroup, and 30.0% in the White/European American subgroup. Again, the models for the two subgroups at Grade 5 were similar to that of the full sample shown in Figure 7 (see Table S8 in Supplemental Materials for standardized parameters estimates for SEMs fitted to each subgroup separately).

Discussion

For children growing up in poverty, individual differences in developmental outcomes have been linked to factors that originate in the first years of life (Ursache & Noble, 2016). The current study used SEM to tease apart direct and indirect influences of child and maternal characteristics, home environment, and parent-infant interactional dynamics in infancy in predicting receptive vocabulary of low-income Black/African American and White/European American children at ages 36 months to Grade 5 (approximately 10 years). We used CFA to test the adequacy of three latent variables serving as indices of joint engagement, negative mother-infant interaction and maternal distress. After testing the adequacy of the latent variables, we established a best-fitting SEM for the full sample. We conducted a measurement invariance analysis to determine whether the SEM showed acceptable fit indices for Black/African American and White/European American participant subgroups. Testing for measurement invariance is important especially given that Black/African American and White/European American families experience differential hardship and risk due to structural inequalities and systemic prejudice, which may affect psychometric equivalence (Brooks-Gunn & Markman, 2005; Putnick & Bornstein, 2016).

Starting with the child factors, we observed a direct effect of 14-month infant cognitive ability (Bayley MDI) on receptive vocabulary outcomes (PPVT) at 36 months of age, in Pre-K, and in Grade 5, indicating considerable stability in intellectual abilities over the first decade of

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life (Bornstein et al., 2004). Gestational age had significant indirect effects on vocabulary outcomes at each of the three time points by way of 14-month cognitive ability, indicating that children who were not born within three-weeks of term tended to have lower Bayley MDI scores, which impacted their receptive vocabulary development over time. Prior research indicates a long-term impact of prematurity on language development (Bee et al., 1982). Our findings suggest that early differences in general cognitive abilities mediate the impact of prematurity on vocabulary development. Though gender (favoring girls over boys) has also been linked with individual differences in language abilities at 2 to 5 years of age (Bornstein et al., 2004), the direct effect of gender on receptive vocabulary knowledge was significant only at 36 months. At pre-K and Grade 5, there were no direct or indirect effects of gender on PPVT scores.

With regard to maternal characteristics, maternal educational attainment had a significant direct effect and indirect effect via joint engagement in predicting children's receptive vocabulary at age 36 months and in Pre-K, but not in Grade 5. In line with previous research (Christian et al., 1998; Dollaghan et al., 1999), we found maternal educational attainment to be positively associated with children's receptive vocabulary knowledge. The indirect effect of maternal education indicates that joint engagement was enhanced for children of mothers with greater educational attainment and for children living in more emotionally supportive and cognitively stimulating homes. The latent variable maternal distress did not have a significant direct effect on receptive vocabulary scores at any age, but was indirectly associated with PPVT scores at pre-K and Grade 5 via the home environment. Previous research found that infants with mothers exhibiting depressive symptoms tended to have lower receptive vocabulary knowledge at older ages than infants of non-depressed mothers (Ahun et al., 2017; Letourneau et al., 2013); other research found a negative (concurrent) association between parenting stress (PSI-SF

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scores) and children's PPVT scores at 2 to 4 years of age (Noel et al., 2008). In our study, the two maternal variables (maternal distress, maternal education) exhibited significant negative covariance and contributed in opposite ways to the quality of the home environment, which in turn, was associated with PPVT scores. Taken together, these results indicate the importance of supporting maternal mental health and providing educational opportunities for mothers living in low-income communities as effective means of fostering their children's cognitive and academic development.

The quality of the home environment has been found to have a significant and stable association with language development, even after accounting for SES (Melvin et al., 2017). Children in developmentally stimulating environments are more likely to be exposed to learning materials such as books and toys that facilitate parent-child engagement. In the present study, we found that the direct effect of the quality of the home environment on vocabulary knowledge was significant only at Pre-K (approximately 4 years) and Grade 5 (approximately 10 years). In addition to its direct effect at select time points, the home environment indirectly influenced vocabulary knowledge via joint engagement, with a significant indirect effect at each time point. Taken together, these findings suggest that the quality of the home environment measured in infancy thus appears to have a cumulative influence on vocabulary development that extends through Grade 5. Of all the variables in the model, the latent variable joint engagement had the strongest direct effect on vocabulary development at each of the three time points. Joint engagement consisted of measures of child sustained attention, child engagement of parent, and parent supportiveness taken from the 3-bag task, an observational measure of parent-infant interaction at 14 months. As indicated by the results of the CFA, these three measures were closely linked, as was expected (Adamson et al., 2019). In the context of joint engagement,

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supportive parents aid children's cognitive and linguistic development by providing vocabulary that is relevant to the child's focus of attention (Tamis-LeMonda et al., 2001; Yu et al., 2019).

In addition to the longitudinal associations with receptive vocabulary knowledge, joint engagement exhibited a significant concurrent association with infant cognitive ability (Bayley MDI scores). Infant cognitive ability, in turn, had a direct association with vocabulary knowledge at each of the three time points. We interpreted this relation as reciprocal, given that joint engagement is thought to promote infants' cognitive, social-emotional, and communicative skills and vice versa (Adamson et al., 2019; Yu et al., 2019). Notably, joint engagement also had a significant negative covariance with the latent variable *negative interaction*, consisting of measures of parent intrusiveness, parent negative regard toward the child, and child negativity taken from the 3-bag task. Previous research indicated that parental support and responsiveness to infants were associated with advances in children's language development (Tamis-LeMonda et al., 2001) whereas parental negativity towards the child was associated with delays in language development (Laake & Bridgett, 2018). However, in our models there was no direct effect of *negative interaction* on vocabulary knowledge outcomes at any time point. Thus, intrusive parenting behaviors and negativity on the part of the parent towards the child appeared to influence later outcomes only by diminishing opportunities for joint engagement.

The observed relations were not only stable across time, but also relatively similar for both Black/African American and White/European American subgroups. The results of the measurement invariance provided some evidence of either metric invariance (for the latent variable *joint engagement*) or scalar invariance (for the latent variables *negative interaction* and *maternal distress*) between constructs. Given that assumptions of strict invariance failed, this suggests improvements could be made to ensure that measures used on a nationally

representative sample are culturally neutral. The differences in factor loadings of the negative interaction variable between groups, in particular, could point towards cultural differences that complicate the measurement of the construct (Pungello et al., 2009).

Implications

The present findings hold several important implications for improving vocabulary development of children reared in low SES contexts. Numerous past interventions have focused on improving the qualities of parent-child interactions to promote language development in children with language delays (Roberts & Kaiser, 2011; Roberts et al., 2019). Vocabulary learning interventions for children from low-income households that are administered by parents have been shown to be as effective as those administered by teachers or researchers, and more effective than those administered by non-certified or non-degreed childcare providers (Marulis & Neuman, 2013).

Other parent-child interactions have concentrated on dialogic reading among children between the ages of 3 and 5 (Troseth et al., 2020). However, such interventions tend to examine a broader range of behaviors and outcomes rather than specifically concentrating on vocabulary development during infancy and early childhood. Intervention studies designed to promote parent-child sustained attention and joint engagement behaviors associated with vocabulary development during a semi-structured play task suggest that it can be improved over time (Girolametto et al., 1994; McGillion et al., 2017; Suskind et al., 2016). Yet, whether behaviors associated with joint engagement either transfer to novel contexts (Girolametto et al., 1994) or persist over an extended period beyond several months from the initial training (McGillion et al., 2017; Suskind et al., 2016) remains undetermined. Further research should examine long-term effects of interventions designed to improve the quality of parent-child joint engagement,

particularly among parents and children from low SES households. If such behaviors are indeed malleable, the findings here suggest that the effects of the interventions could promote vocabulary development among children, including those of diverse backgrounds.

Limitations

While the findings appeared to be generally robust across both subgroups, there are several important limitations. First, even though many of the variables used in SEM were standardized measures, we were only able to establish measurement invariance of latent constructs at the metric or scalar level. Invariance at the level of the metric model was achieved for joint engagement, but at the more constrained level of the scalar model for negative interaction and maternal distress. Joint engagement and negative interaction were assessed via a single, relatively brief observation of mother-infant interaction (3-bag task). The measures might be more robust if based on observations taken more than once.

Second, examining differences in parent-child relationships as a function of population subgroups can be problematic as it may oversimplify complicated socio-cultural interactions (Dixon et al., 2008). For one, the present findings do not adequately take into consideration differences in children's dialect and how this affects the measurement of vocabulary knowledge based on standardized instruments such as the PPVT that are normed with speakers of standard American English dialects (Pearson et al., 2014). Past research has found that children with higher levels of non-standard dialect usage (i.e., African American English) tend to have more difficulty understanding words in standard American English (Edwards et al., 2014). Hence, standardized tests like the PPVT may potentially underestimate the vocabulary knowledge of Black/African American children as compared to White/European American children who speak only the standard dialect. Ideally, future studies should include multiple measures of children's

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language development that extend beyond standardized tests of receptive vocabulary knowledge. This would ideally include taking natural language samples, which provide indices of utterance length, complexity, narrative skills, perspective-taking, imitation, and other facets of communicative development.

Conclusions

This study used SEM to determine pathways through which individual differences in receptive vocabulary trajectories emerge. We found that even after accounting for the influence of developmental factors of the child, parent, and home environment, mother-infant joint engagement had robust associations with the child's subsequent receptive vocabulary development through Grade 5 (approximate age 10 years). Furthermore, we found that associations were stable across Black/African American and White/European American subgroups that differed in socioeconomic risk, despite all families being of low income. The findings indicate how the positive impact of supportive parent-child interactions and home environments during infancy persist over time, and partially mediate indirect influences of maternal distress and maternal education on vocabulary growth. Given the robustness of results across time points and subgroups, the present findings serve to identify critical targets for early intervention to support and assist low-income mothers and their infants.

References

AUTHOR. (2018).

AUTHOR. (2020).

AUTHOR. (2021). https://osf.io/8szqc/?view_only=161c0ec2cff649c88059bd499914bf5f

Abidin, R. R. (1995). *Manual for the parenting stress index*. Psychological Assessment Resources.

Acock, A. C. (2012). What to do about missing values. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, Vol. 3. Data analysis and research publication* (pp. 27–50). American Psychological Association.

Adamson, L. B. (2014). Joint attention and language development. In P. J. Brooks & V. Kempe (Eds.), *Encyclopedia of Language Development* (pp. 299–303). Sage Publications.

Adamson, L. B., Bakeman, R., Suma, K., & Robins, D. L. (2019). An expanded view of joint attention: Skill, engagement, and language in typical development and autism. *Child Development, 90*(1), e1–e18.

Ahun, M. N., Geoffroy, M. C., Herba, C. M., Brendgen, M., Séguin, J. R., Sutter-Dallay, A. L., ... & Côté, S. M. (2017). Timing and chronicity of maternal depression symptoms and children's verbal abilities. *The Journal of Pediatrics, 190*, 251–257. doi:[10.1016/j.jpeds.2017.07.007](https://doi.org/10.1016/j.jpeds.2017.07.007)

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Child Development, 55*(4), 1278-1289. doi:[10.2307/1129997](https://doi.org/10.2307/1129997)

Bayley, N. (1993). *Bayley scales of infant development (BSID-II)*. Harcourt Brace & Company.

Bee, H. L., Barnard, K. E., Eyres, S. J., Gray, C. A., Hammond, M. A., Spietz, A. L., ... & Clark, B. (1982). Prediction of IQ and language skill from perinatal status, child performance, family characteristics, and mother-infant interaction. *Child Development, 53*, 1134–1156. doi:[10.2307/1129003](https://doi.org/10.2307/1129003)

Bhutta, A. T., Cleves, M. A., Casey, P. H., Cradock, M. M., & Anand, K. J. S. (2002). Cognitive and behavioral outcomes of school-aged children who were born preterm: A meta-analysis. *JAMA, 288*(6), 728–737. doi:[10.1001/jama.288.6.728](https://doi.org/10.1001/jama.288.6.728)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

- Bornstein, M. H., Cote, L. R., Maital, S., Painter, K., Park, S. Y., Pascual, L., ... & Vyt, A. (2004). Cross-linguistic analysis of vocabulary in young children: Spanish, Dutch, French, Hebrew, Italian, Korean, and American English. *Child Development*, 75(4), 1115–1139. doi:[10.1111/j.1467-8624.2004.00729.x](https://doi.org/10.1111/j.1467-8624.2004.00729.x)
- Bradley, R. H., Corwyn, R. F., Burchinal, M., McAdoo, H. P., & García Coll, C. (2001). The home environments of children in the United States Part II: Relations with behavioral development through age thirteen. *Child Development*, 72(6), 1868–1886. doi:[10.1111/1467-8624.t01-1-00382](https://doi.org/10.1111/1467-8624.t01-1-00382)
- Brooks-Gunn, J. & Markman, L. B. (2005). The contribution of parenting to ethnic and racial gaps in school readiness. *The Future of Children*, 15(1), 139–168. <https://www.jstor.org/stable/1602666>
- Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd Edition). Guilford Press.
- Burchinal, M. R., Roberts, J. E., Hooper, S., & Zeisel, S. A. (2000). Cumulative risk and early cognitive development: a comparison of statistical risk models. *Developmental Psychology*, 36(6), 793–807. doi:[10.1037/0012-1649.36.6.793](https://doi.org/10.1037/0012-1649.36.6.793)
- Burchinal, M., Vernon-Feagans, L., Cox, M., & Key Family Life Project Investigators. (2008). Cumulative social risk, parenting, and infant development in rural low-income communities. *Parenting: Science and Practice*, 8(1), 41–69. doi:[10.1080/15295190701830672](https://doi.org/10.1080/15295190701830672)
- Byrne, B. M., Shavelson, R. J., & Muthén, B. (1989). Testing for the equivalence of factor covariance and mean structures: The issue of partial measurement invariance. *Psychological Bulletin*, 105(3), 456–466. doi:[10.1037/0033-2909.105.3.456](https://doi.org/10.1037/0033-2909.105.3.456)
- Caldwell, B. & Bradley, R. (1984). *Home Observation for Measurement of the Environment (HOME) - Revised Edition*. University of Arkansas, Little Rock.
- Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, 63(4), i-174. doi:[10.2307/1166214](https://doi.org/10.2307/1166214)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Ceballo, R., Chao, R., Hill, N. E., Le, H. N., Murry, V. M., & Pinderhughes a, E. E. (2008). Excavating culture: Summary of results. *Applied Development Science, 12*(4), 220–226.

doi:[10.1080/10888690802388110](https://doi.org/10.1080/10888690802388110)

Çetinçelik, M., Rowland, C. F., & Snijders, T. M. (2021). Do the eyes have it? A systematic review on the role of eye gaze in infant language development. *Frontiers in Psychology, 11*, 3627.

doi:[10.3389/fpsyg.2020.589096](https://doi.org/10.3389/fpsyg.2020.589096)

Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development, 15*(4), 481–498. doi:[10.1016/S0885-2014\(01\)00037-5](https://doi.org/10.1016/S0885-2014(01)00037-5)

Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling, 9*(2), 233–255. doi:[10.1207/S15328007SEM0902_5](https://doi.org/10.1207/S15328007SEM0902_5)

Christian, K., Morrison, F. J., & Bryant, F. B. (1998). Predicting kindergarten academic skills:

Interactions among child care, maternal education, and family literacy environments. *Early Childhood Research Quarterly, 13*(3), 501–521. doi:[10.1016/S0885-2006\(99\)80054-4](https://doi.org/10.1016/S0885-2006(99)80054-4)

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: the indirect role of parental expectations and the home environment. *Journal of Family Psychology, 19*(2), 294–304. doi:[10.1037/0893-3200.19.2.294](https://doi.org/10.1037/0893-3200.19.2.294)

[Day, A. \(1986\). *Good dog, Carl*. Simon & Schuster.](#)

Dixon, S. V., Graber, J. A., & Brooks-Gunn, J. (2008). The roles of respect for parental authority and parenting practices in parent-child conflict among African American, Latino, and European American families. *Journal of Family Psychology, 22*(1), 1–10. doi:[10.1037/0893-3200.22.1.1](https://doi.org/10.1037/0893-3200.22.1.1)

Dollaghan, C. A., Campbell, T. F., Paradise, J. L., Feldman, H. M., Janosky, J. E., Pitcairn, D. N., & Kurs-Lasky, M. (1999). Maternal education and measures of early speech and language. *Journal of Speech, Language, and Hearing Research, 42*(6), 1432–1443. doi:[10.1044/jslhr.4206.1432](https://doi.org/10.1044/jslhr.4206.1432)

Duckworth, K., & Sabates, R. (2005). Effects of mothers' education on parenting: an investigation across three generations. *London Review of Education, 3*(3), 239–264. doi:[10.1080/14748460500372481](https://doi.org/10.1080/14748460500372481)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

- Duncan, G. J., & Magnuson, K. (2012). Socioeconomic status and cognitive functioning: moving from correlation to causation. *Wiley Interdisciplinary Reviews: Cognitive Science*, 3(3), 377–386. doi:[10.1002/wcs.1176](https://doi.org/10.1002/wcs.1176)
- Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test* (3rd Ed.). American Guidance Service.
- Edwards, J., Gross, M., Chen, J., MacDonald, M. C., Kaplan, D., Brown, M., & Seidenberg, M. S. (2014). Dialect awareness and lexical comprehension of mainstream American English in African American English-speaking children. *Journal of Speech, Language, and Hearing Research*, 57(5), 1883–1895. doi:[10.1044/2014_JSLHR-L-13-0228](https://doi.org/10.1044/2014_JSLHR-L-13-0228)
- Ensminger, M. E., Fothergill, K. E., Bornstein, M. H., & Bradley, R. H. (2003). A decade of measuring SES: What it tells us and where to go from here. In M. H. Bornstein & R. H. Bradley (Eds.), *Socioeconomic status, parenting, and child development* (pp. 13–27). Erlbaum.
- Evans, G. W., Li, D., & Whipple, S. S. (2013). Cumulative risk and child development. *Psychological Bulletin*, 139(6), 1342–1396. doi:[10.1037/a0031808](https://doi.org/10.1037/a0031808)
- Farah, M. J., Shera, D. M., Savage, J. H., Betancourt, L., Giannetta, J. M., Brodsky, N. L., ... & Hurt, H. (2006). Childhood poverty: Specific associations with neurocognitive development. *Brain Research*, 1110(1), 166–174. doi:[10.1016/j.brainres.2006.06.072](https://doi.org/10.1016/j.brainres.2006.06.072)
- Flouri, E., & Kallis, C. (2007). Adverse life events and psychopathology and prosocial behavior in late adolescence: testing the timing, specificity, accumulation, gradient, and moderation of contextual risk. *Journal of the American Academy of Child & Adolescent Psychiatry*, 46(12), 1651–1659. doi:[10.1097/chi.0b013e318156a81a](https://doi.org/10.1097/chi.0b013e318156a81a)
- Fulgini, A. S., & Brooks-Gunn, J. (2013). Mother-child interactions in Early Head Start: Age and ethnic differences in low-income dyads. *Parenting*, 13(1), 1–26. doi:[10.1080/15295192.2013.732422](https://doi.org/10.1080/15295192.2013.732422)
- Girolametto, L., Verbey, M., & Tannock, R. (1994). Improving joint engagement in parent-child interaction: An intervention study. *Journal of Early Intervention*, 18(2), 155–167. doi:[10.1177/105381519401800204](https://doi.org/10.1177/105381519401800204)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

- Guenole, N., & Brown, A. (2014). The consequences of ignoring measurement invariance for path coefficients in structural equation models. *Frontiers in Psychology, 5*, 980.
doi:[10.3389/fpsyg.2014.00980](https://doi.org/10.3389/fpsyg.2014.00980)
- Guryan, J., Hurst, E., & Kearney, M. (2008). Parental education and parental time with children. *Journal of Economic Perspectives, 22*(3), 23–46. doi:[10.1257/jep.22.3.23](https://doi.org/10.1257/jep.22.3.23)
- Hackman, D. A., Gallop, R., Evans, G. W., & Farah, M. J. (2015). Socioeconomic status and executive function: Developmental trajectories and mediation. *Developmental Science, 18*(5), 686–702.
doi:[10.1111/desc.12246](https://doi.org/10.1111/desc.12246)
- Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experiences of young American children*. Paul H. Brookes.
- Hill, N. E. (2001). Parenting and academic socialization as they relate to school readiness: The roles of ethnicity and family income. *Journal of Educational Psychology, 93*(4), 686–697.
doi:[10.1037/0022-0663.93.4.686](https://doi.org/10.1037/0022-0663.93.4.686)
- Hill, N. E., & Tyson, D. F. (2008). Excavating culture: Ethnicity and context as predictors of parenting behavior. *Applied Development Science, 12*(4), 188–197. doi:[10.1080/10888690802388110](https://doi.org/10.1080/10888690802388110)
- Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., ... & Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science, 26*(7), 1071–1083. doi:[10.1177/0956797615581493](https://doi.org/10.1177/0956797615581493)
- Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child Development, 74*(5), 1368–1378.
doi:[10.1111/1467-8624.00612](https://doi.org/10.1111/1467-8624.00612)
- Hsiao, Y. Y., & Lai, M. H. (2018). The impact of partial measurement invariance on testing moderation for single and multi-level data. *Frontiers in Psychology, 9*, 740. doi:[10.3389/fpsyg.2018.00740](https://doi.org/10.3389/fpsyg.2018.00740)
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55.
doi:[10.1080/10705519909540118](https://doi.org/10.1080/10705519909540118)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Johnson, K., Caskey, M., Rand, K., Tucker, R., & Vohr, B. (2014). Gender differences in adult-infant communication in the first months of life. *Pediatrics*, *134*(6), e1603–e1610.

doi:[10.1542/peds.2013-4289](https://doi.org/10.1542/peds.2013-4289)

Jöreskog, K. G. (1971). Statistical analysis of sets of congeneric tests. *Psychometrika*, *36*(2), 109–133.

doi:[10.1007/BF02291393](https://doi.org/10.1007/BF02291393)

Jöreskog, K. G. (1993). Testing structural equation models. *Sage Focus Editions*, *154*, 294–294.

Laake, L. M., & Bridgett, D. J. (2018). Early language development in context: Interactions between infant temperament and parenting characteristics. *Early Education and Development*, 1–17.

doi:[10.1080/10409289.2018.1436366](https://doi.org/10.1080/10409289.2018.1436366)

Lebel, C., Walton, M., Letourneau, N., Giesbrecht, G. F., Kaplan, B. J., & Dewey, D. (2016). Prepartum and postpartum maternal depressive symptoms are related to children's brain structure in preschool. *Biological Psychiatry*, *80*(11), 859–868. doi:[10.1016/j.biopsych.2015.12.004](https://doi.org/10.1016/j.biopsych.2015.12.004)

Letourneau, N. L., Duffett-Leger, L., Levac, L., Watson, B., & Young-Morris, C. (2013). Socioeconomic status and child development: A meta-analysis. *Journal of Emotional and Behavioral Disorders*, *21*(3), 211–224. doi:[10.1177/1063426611421007](https://doi.org/10.1177/1063426611421007)

Letourneau, N. L., Tramonte, L., & Willms, J. D. (2013). Maternal depression, family functioning and children's longitudinal development. *Journal of Pediatric Nursing*, *28*(3), 223–234.

doi:[10.1016/j.pedn.2012.07.014](https://doi.org/10.1016/j.pedn.2012.07.014)

Little, T. D. (2013). *Longitudinal structural equation modeling*. Guilford Press.

Little, E. E., Carver, L. J., & Legare, C. H. (2016). Cultural variation in triadic infant–caregiver object exploration. *Child Development*, *87*(4), 1130–1145. doi:[10.1111/cdev.12513](https://doi.org/10.1111/cdev.12513)

Lovas, G. S. (2011). Gender and patterns of language development in mother-toddler and father-toddler dyads. *First Language*, *31*(1), 83–108. doi:[10.1177/0142723709359241](https://doi.org/10.1177/0142723709359241)

Love, J. M., Kisker, E. E., Ross, C., Raikes, H., Constantine, J., Boller, K., ... & Fuligni, A. S. (2005). The effectiveness of early head start for 3-year-old children and their parents: Lessons for policy and programs. *Developmental Psychology*, *41*(6), 885–901. doi:[10.1037/0012-1649.41.6.88](https://doi.org/10.1037/0012-1649.41.6.88)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

- Magnuson, K. A., Sexton, H. R., Davis-Kean, P. E., & Huston, A. C. (2009). Increases in maternal education and young children's language skills. *Merrill-Palmer Quarterly*, 319–350. Retrieved from: <https://www.jstor.org/stable/23096260>
- Marulis, L. M., & Neuman, S. B. (2013). How vocabulary interventions affect young children at risk: A meta-analytic review. *Journal of Research on Educational Effectiveness*, 6(3), 223–262. doi:[10.1080/19345747.2012.755591](https://doi.org/10.1080/19345747.2012.755591)
- Masarik, A. S., & Conger, R. D. (2017). Stress and child development: A review of the Family Stress Model. *Current Opinion in Psychology*, 13, 85–90. doi:[10.1016/j.copsyc.2016.05.008](https://doi.org/10.1016/j.copsyc.2016.05.008)
- Masek, L. R., McMillan, B. T., Paterson, S. J., Tamis-LeMonda, C. S., Golinkoff, R. M., & Hirsh-Pasek, K. (2021). Where language meets attention: How contingent interactions promote learning. *Developmental Review*, 60, 100961. doi:[10.1016/j.dr.2021.100961](https://doi.org/10.1016/j.dr.2021.100961)
- McGillion, M., Pine, J. M., Herbert, J. S., & Matthews, D. (2017). A randomised controlled trial to test the effect of promoting caregiver contingent talk on language development in infants from diverse socioeconomic status backgrounds. *Journal of Child Psychology and Psychiatry*, 58(10), 1122–1131. doi:[10.1111/jcpp.12725](https://doi.org/10.1111/jcpp.12725)
- McLoyd, V. C. (1990). The impact of economic hardship on Black families and children: Psychological distress, parenting, and socioemotional development. *Child Development*, 61(2), 311–346. doi:[10.1111/j.1467-8624.1990.tb02781.x](https://doi.org/10.1111/j.1467-8624.1990.tb02781.x)
- Melvin, S. A., Brito, N. H., Mack, L. J., Engelhardt, L. E., Fifer, W. P., Elliott, A. J., & Noble, K. G. (2017). Home environment, but not socioeconomic status, is linked to differences in early phonetic perception ability. *Infancy*, 22(1), 42–55. doi:[10.1111/infa.12145](https://doi.org/10.1111/infa.12145)
- Merz, E. C., Wiltshire, C. A., & Noble, K. G. (2019). Socioeconomic inequality and the developing brain: Spotlight on language and executive function. *Child Development Perspectives*, 13(1), 15–20. doi:[10.1111/cdep.12305](https://doi.org/10.1111/cdep.12305)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Milfont, T. L., & Fischer, R. (2010). Testing measurement invariance across groups: Applications in cross-cultural research. *International Journal of Psychological Research*, 3(1), 111–130.

doi:[10.21500/20112084.857](https://doi.org/10.21500/20112084.857)

NICHD Early Child Care Research Network. (1999). Child care and mother–child interaction in the first three years of life. *Developmental Psychology*, 35(6), 1399–1413. doi:[10.1037/0012-](https://doi.org/10.1037/0012-1649.35.6.1399)

[1649.35.6.1399](https://doi.org/10.1037/0012-1649.35.6.1399)

Noble, K. G., Houston, S. M., Brito, N. H., Bartsch, H., Kan, E., Kuperman, J. M., ... & Schork, N. J. (2015). Family income, parental education and brain structure in children and adolescents. *Nature Neuroscience*, 18(5), 773–778. doi:[10.1038/nn.3983](https://doi.org/10.1038/nn.3983)

Noel, M., Peterson, C., & Jesso, B. (2008). The relationship of parenting stress and child temperament to language development among economically disadvantaged preschoolers. *Journal of Child*

Language, 35(4), 823–843. doi:[10.1017/S0305000908008805](https://doi.org/10.1017/S0305000908008805)

Payne, A. C., Whitehurst, G. J., & Angell, A. L. (1994). The role of home literacy environment in the development of language ability in preschool children from low-income families. *Early*

Childhood Research Quarterly, 9(3-4), 427–440. doi:[10.1016/0885-2006\(94\)90018-3](https://doi.org/10.1016/0885-2006(94)90018-3)

Pearson, B. Z., Jackson, J. E., & Wu, H. (2014). Seeking a valid gold standard for an innovative, dialect-neutral language test. *Journal of Speech, Language, and Hearing Research*, 57(2), 495–508.

doi:[10.1044/2013_JSLHR-L-12-0126](https://doi.org/10.1044/2013_JSLHR-L-12-0126)

Pearson, R. M., Bornstein, M. H., Cordero, M., Scerif, G., Mahedy, L., Evans, J., ... & Stein, A. (2016).

Maternal perinatal mental health and offspring academic achievement at age 16: The mediating role of childhood executive function. *Journal of Child Psychology and Psychiatry*, 57(4), 491–

501. doi:[10.1111/jcpp.12483](https://doi.org/10.1111/jcpp.12483)

Pinderhughes, E. E., Hurley, S., & Conduct Problems Prevention Research Group. (2008). Disentangling ethnic and contextual influences among parents raising youth in high-risk communities. *Applied*

Development Science, 12(4), 211–219. doi:[10.1080/10888690802388151](https://doi.org/10.1080/10888690802388151)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

- Poulakos, A. (2013). Language development in context: Influences of perinatal risk and environmental characteristics on outcomes at 14 to 36 months (Doctoral Dissertation). Order No. 3601689. Available from ProQuest Dissertations & Theses Global (1467526239).
- Pungello, E. P., Iruka, I. U., Dotterer, A. M., Mills-Koonce, R., & Reznick, J. S. (2009). The effects of socioeconomic status, race, and parenting on language development in early childhood. *Developmental Psychology*, 45(2), 544–557. doi:[10.1037/a0013917](https://doi.org/10.1037/a0013917)
- Putnick, D. L., & Bornstein, M. H. (2016). Measurement invariance conventions and reporting: The state of the art and future directions for psychological research. *Developmental Review*, 41, 71–90. doi:[10.1016/j.dr.2016.06.004](https://doi.org/10.1016/j.dr.2016.06.004)
- R Core Team. (2019). A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from: <https://www.R-project.org>.
- Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1(3), 385–401. doi:[10.1177/014662167700100306](https://doi.org/10.1177/014662167700100306)
- Raikes, H., Alexander Pan, B., Luze, G., Tamis-LeMonda, C. S., Brooks-Gunn, J., Constantine, J., ... & Rodriguez, E. T. (2006). Mother–child bookreading in low-income families: Correlates and outcomes during the first three years of life. *Child Development*, 77(4), 924–953. doi:[10.1111/j.1467-8624.2006.00911.x](https://doi.org/10.1111/j.1467-8624.2006.00911.x)
- Roberts, M. Y., Curtis, P. R., Sone, B. J., & Hampton, L. H. (2019). Association of parent training with child language development: A systematic review and meta-analysis. *JAMA Pediatrics*, 173(7), 671–680. doi:[10.1001/jamapediatrics.2019.1197](https://doi.org/10.1001/jamapediatrics.2019.1197)
- Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling and more. Version 0.5–12 (BETA). *Journal of Statistical Software*, 48(2), 1–36.
- Stjernqvist, K., & Svenningsen, N. W. (1999). Ten-year follow-up of children born before 29 gestational weeks: health, cognitive development, behaviour and school achievement. *Acta Paediatrica*, 88(5), 557–562. doi:[10.1111/j.1651-2227.1999.tb00175.x](https://doi.org/10.1111/j.1651-2227.1999.tb00175.x)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Suarez-Rivera, C., Schatz, J. L., Herzberg, O., & Tamis-LeMonda, C. S. (2022). Joint engagement in the home environment is frequent, multimodal, timely, and structured. *Infancy*.

doi:[10.1111/infa.12446](https://doi.org/10.1111/infa.12446)

Sung, J., Fausto-Sterling, A., García Coll, C., & Seifer, R. (2013). The dynamics of age and sex in the development of mother–infant vocal communication between 3 and 11 months. *Infancy*, 18(6), 1135–1158. doi:[10.1111/infa.12019](https://doi.org/10.1111/infa.12019)

Suskind, D. L., Leffel, K. R., Graf, E., Hernandez, M. W., Gunderson, E. A., Sapolich, S. G., ... & Levine, S. C. (2016). A parent-directed language intervention for children of low socioeconomic status: A randomized controlled pilot study. *Journal of Child Language*, 43(2), 366–406.

doi:[10.1017/S0305000915000033](https://doi.org/10.1017/S0305000915000033)

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development*, 72(3), 748–767.

doi:[10.1111/1467-8624.00313](https://doi.org/10.1111/1467-8624.00313)

Tomalski, P., Moore, D. G., Ribeiro, H., Axelsson, E. L., Murphy, E., Karmiloff-Smith, A., ... & Kushnerenko, E. (2013). Socioeconomic status and functional brain development—associations in early infancy. *Developmental Science*, 16(5), 676–687. doi:[10.1111/desc.12079](https://doi.org/10.1111/desc.12079)

Troseth, G. L., Strouse, G. A., Flores, I., Stuckelman, Z. D., & Johnson, C. R. (2020). An enhanced eBook facilitates parent–child talk during shared reading by families of low socioeconomic status. *Early Childhood Research Quarterly*, 50, 45–58. doi:[10.1016/j.ecresq.2019.02.009](https://doi.org/10.1016/j.ecresq.2019.02.009)

United States Department of Health and Human Services, Administration for Children and Families.

(2011). Administration for Children and Families. (2011). Early Head Start Research and Evaluation (EHSRE) Study, 1996-2010: [United States]. ICPSR03804-v5. *Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor]*, 09-22.

<https://www.icpsr.umich.edu/web/ICPSR/studies/3804/>

United States Department of Health and Human Services, Administration for Children and Families.

(2019a). *Early Head Start Research and Evaluation Project (EHSRE), 1996-2010: Project*

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

overview. U.S. Department of Health and Human Services.

<https://www.acf.hhs.gov/opre/research/project/early-head-start-research-and-evaluation-project-ehsre-1996-2010>

United States Department of Health and Human Services, Administration for Children and Families.

(2019b). *EHSRE Videotaped Protocol Booklet – 14 Months*. U.S. Department of Health and Human Services. [Last reviewed 29 April 2019]. Retrieved from

<https://www.acf.hhs.gov/opre/resource/videotaped-protocol-booklet-14-months>

Ursache, A., & Noble, K. G. for the Pediatric Imaging, Neurocognition and Genetics Study. (2016).

Socioeconomic status, white matter, and executive function in children. *Brain and Behavior*, 6(10), e00531. doi:[10.1002/brb3.531](https://doi.org/10.1002/brb3.531)

Van Buuren, S. & Groothuis-Oudshoorn, K. (2011). mice: Multivariate Imputation by Chained

Equations in R. *Journal of Statistical Software*, 45(3), 1–67. Retrieved from:

<https://www.jstatsoft.org/v45/i03/>.

Vernon-Feagans, L., Bratsch-Hines, M., Reynolds, E., & Willoughby, M. (2020). How early maternal

language input varies by race and education and predicts later child language. *Child*

Development, 91(4), 1098–1115. doi:[10.1111/cdev.13281](https://doi.org/10.1111/cdev.13281)

Ware, A., Brady, C., O'Brien, C., & Berlin, L. J. (2000). *EHSRE 14-Month child-parent interaction*

rating scales for the Three Bag Assessment. National Center for Children and Families, Teachers

College, Columbia University. Retrieved from: [http://policyforchildren.org/wp-](http://policyforchildren.org/wp-content/uploads/2013/08/14mos_3bscales_final_62805.pdf)

[content/uploads/2013/08/14mos_3bscales_final_62805.pdf](http://policyforchildren.org/wp-content/uploads/2013/08/14mos_3bscales_final_62805.pdf)

Yeung, W. J., & Conley, D. (2008). Black-White achievement gap and family wealth. *Child*

Development, 79, 303–324. doi:[10.1111/j.1467-8624.2007.01127.x](https://doi.org/10.1111/j.1467-8624.2007.01127.x)

Yu, C., Suanda, S. H., & Smith, L. B. (2018). Infant sustained attention but not joint attention to objects

at 9 months predicts vocabulary at 12 and 15 months. *Developmental Science*, 22(1), e12735.

doi:[10.1111/desc.12735](https://doi.org/10.1111/desc.12735)

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Zajicek-Farber, M. L. (2010). The contributions of parenting and postnatal depression on emergent language of children in low-income families. *Journal of Child and Family Studies, 19*(3), 257–269. doi:[10.1007/s10826-009-9293-7](https://doi.org/10.1007/s10826-009-9293-7)

Supplemental Materials

Table S1
List of variables used

Age	Domain (as referenced in manuscript)	Variable Label (from EHSRE data set)	Variable Name (as referenced in manuscript)	Measure	Variable Derivation (from EHSRE codebook)
14 months	Demographics	C_MALE	Focal child's gender	Parental self-report administered at baseline	(0) Female (1) Male -5 -5/.E=missing item
		FC_BRN (recoded*)	Focal child gestational length (recoded to indicate if focal child was born premature or not.)	Parental self-report administered at baseline	(1) More than 2 months early (2) 2 months to 3 weeks early (3) About on time (4) More than 3 weeks late -6 -6/.F=missingSectn -5 -5/.E=missing item -1 -1/.A=DK *Recoded such that if the child was born premature (1) or not (0)
		ENGLISH	Primary caregiver's primary language is English	Parental self-report administered at baseline	0 (0) Not English 1 (1) English -6 -6/.F=missingSectn -5 -5/.E=missing item
		HGCG	Primary caregiver's educational attainment	Parental self-report administered at baseline	(1) Completed less than 12 years of schooling (2) Completed 12 years of school or a GED (3) Completed more than 12 years of schooling -6 -6/.F=missingSectn -5 -5/.E=missing item
		POVRATIO	Income as % of Poverty line for family	Parental self-report administered at baseline	Use year, household size and number of children in household to determine the poverty line income (povline). If there is insufficient information to determine povline or household income is missing, then set povratio to missing. Otherwise, set povratio=household income multiplied by 100/povline. If povratio is missing, then set povgroup to missing. Otherwise, if 0<=povratio<33, then set povgroup=1. Otherwise, if 33<= povratio<67, then set povgroup=2. Otherwise, if 67<=povratio<100, then set povgroup
	Infant Cognition	BIB_MDI	Infant Cognition	Bayley MDI Score	The Bayley MDI was normed on a nationally representative sample of children of various ages so that raw scores can be converted to age-adjusted, standardized scores with a mean of 100 and a standard deviation of 15. BnB_MDI (where n=1,2,3 is a birthday-related time period).
	Home Environment	B1P_HOME	Home Environment	HOME Environment Total Score	Measures the cognitive stimulation and emotional support provided by the parent in the home environment. Information needed to score the inventory is obtained through a combination of interview and observation conducted in the home with the child's parent while the child is present. The total includes all of the 31 items included in 5 subscales (including one that was dropped) out of the original 45 items. The maximum potential score is 31.

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Age	Domain (as referenced in manuscript)	Variable Label (from EHSRE data set)	Variable Name (as referenced in manuscript)	Measure	Variable Derivation (from EHSRE codebook)
14 months	Joint Engagement	B1V3_SUP	Parent Supportiveness	3-bag	Parent Behavior during Parent-Child Semistructured Play - measures the parents behavior with the child during a semistructured play task. The parent and child were given three bags of interesting toys and asked to play with the toys in sequence. The semistructured play task was videotaped, and child and parent behaviors were coded by child development researchers according to strict protocols
		B1V3CENG	Child Engagement of Parent	3-bag	-
		B1V3CATN	Child Sustained Attention with Objects	3-bag	-
	Negative	BnV3PINT	Parent Intrusiveness	3-bag	-
		B1V3PNEG	Parent Negative Regard toward Child	3-bag	-
		B1V3CNEG	Child Negativity Toward Parent	3-bag	-
	Maternal Distress	B1P_PD	Parental Distress	Parental Distress Scale (Abidin, 1995)	Parenting Stress Index -- Short Form (PSI-SF) -- measures the degree of stress in parent-child relationships stemming from three possible sources: the child's challenging temperament, parental depression, and negatively reinforcing parent-child interactions (Abidin 1995). Parental Distress measures the level of distress the parent is feeling in his or her role as a parent stemming from personal factors, including a low sense of competence as a parent, stress because of perceived restrictions stemming from parenting, depression, and lack of social support. The parent answers whether he or she agrees or disagrees with statements such as, "You often have the feeling that you cannot handle things very well," and "You feel trapped by your responsibilities as a parent," and "You feel alone and without friends." Item responses were coded on a 5-point scale (initially, 1 = SA, 2 = A, 3= DK, 4 =D, 5 = SD, recoded to 5 = Strongly Agree, 4 = Agree, 3= DK, 2 =Disagree, 1 = Strongly Disagree), so that 5 indicates high levels of [TYPE]. Define BnP_[TYPE] as the sum of the 12 recoded items, [LIST], using imputed values if one or two of the items were missing. Scores on the 12-item subscale can range from 12 to 60.
		B1P_PCDI	Parent-Child Dysfunctional Interaction	Parental Distress Scale (Abidin, 1995)	Parenting Stress Index -- Short Form (PSI-SF) -- measures the degree of stress in parent-child relationships stemming from three possible sources: the child's challenging temperament, parental depression, and negatively reinforcing parent-child interactions (Abidin 1995). The parent may perceive that the child is abusing or rejecting the parent or that the parent feels disappointed in or alienated from the child. The parent answers whether he or she agrees or disagrees with statements such as, "Your child rarely does things for you that make you feel good," and "Most times you feel that your child does not like you and does not want to be close to you," and "Your child seems to smile less than most children." Item responses were coded on a 5-point scale (initially, 1 = SA, 2 = A, 3= DK, 4 =D, 5 = SD, recoded to 5 = Strongly Agree, 4 = Agree, 3= DK, 2 =Disagree, 1 = Strongly Disagree), so that 5 indicates high levels of [TYPE]. Define BnP_[TYPE] as the sum of the 12 recoded items, [LIST], using imputed values if one or two of the items were missing. Scores on the 12-item subscale can range from 12 to 60.
		B1P_CESD	Parental Depressive Symptoms	CES-Depression Scale Total Score	The Long Form (20 items) CES-D was administered at 14 months. "Long form" scores were computed from all 20 items at baseline and 14 months.

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Age	Domain (as referenced in manuscript)	Variable Label (from EHSRE data set)	Variable Name (as referenced in manuscript)	Measure	Variable Derivation (from EHSRE codebook)
14 months	Vocabulary Knowledge	B1P_VPRD	Vocabulary Knowledge	MacArthur CDI Vocabulary Production Score	The MacArthur CDI measure was either completed by an interviewer with the parent or by the parent themselves. A sum score was derived reflecting the total number of words the child had produced at age 14 months.
36 months	Vocabulary Knowledge	B3RPPVTS	Vocabulary Knowledge	PPVT-III Standard Score	The child is presented with four pictures and is asked to point to the picture that matches the word spoken by the interviewer. The PPVT-III was normed on a nationally representative sample of children and adults of various ages so that raw scores can be converted to age-adjusted, standardized scores with a mean of 100 and a standard deviation of 15.
Pre K	Vocabulary Knowledge	C4PPVT3S	Vocabulary Knowledge	PPVT-III Standard Score	-
Grade 5	Vocabulary Knowledge	C5PPVT3S	Vocabulary Knowledge	PPVT-III Standard Score	-

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Table S2
Correlations between 14-month predictors and vocabulary outcomes

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Bayley MDI	-	0.002	<.001	<.001	<.001	0.001	0.026	0.042	0.898	0.732	0.085	<.001	<.001	<.001
2. HOME Inventory	0.15	-	<.001	<.001	<.001	<.001	<.001	0.010	<.001	<.001	<.001	<.001	<.001	<.001
<i>3-bag Task</i>														
3. Parent Supportiveness	0.18	0.48	-	<.001	<.001	<.001	<.001	<.001	0.046	0.058	<.001	<.001	<.001	<.001
4. Child Engagement of Parent	0.18	0.19	0.49	-	<.001	0.001	<.001	<.001	0.780	0.760	0.008	<.001	0.003	0.003
5. Child Sustained Attention	0.22	0.24	0.51	0.31	-	<.001	<.001	<.001	0.678	0.096	0.002	<.001	<.001	<.001
6. Parent Intrusiveness	-0.17	-0.22	-0.37	-0.15	-0.40	-	<.001	<.001	0.338	0.591	0.035	<.001	<.001	<.001
7. Parent Negative Regard	-0.11	-0.24	-0.38	-0.17	-0.31	0.42	-	<.001	0.989	0.363	0.001	<.001	<.001	0.012
8. Child Negativity toward Parent	-0.10	-0.12	-0.30	-0.19	-0.38	0.63	0.29	-	0.805	0.705	0.166	0.002	0.029	0.002
<i>Maternal Distress Variables</i>														
9. CES-D Depression Scale	-0.01	-0.21	-0.10	-0.01	-0.02	0.05	0.00	0.01	-	<.001	<.001	0.133	0.012	0.010
10. Parent Distress Inventory	0.02	-0.28	-0.09	-0.01	-0.08	0.03	0.04	0.02	0.53	-	<.001	0.001	<.001	0.016
11. Parent-Child Dysfunctional Interaction	-0.08	-0.32	-0.18	-0.13	-0.15	0.10	0.16	0.07	0.34	0.47	-	0.001	<.001	0.001
<i>PPVT</i>														
12. 36 months	0.31	0.30	0.33	0.21	0.35	-0.21	-0.19	-0.15	-0.07	-0.15	-0.15	-	<.001	<.001
13. Pre-K	0.26	0.37	0.35	0.15	0.36	-0.25	-0.22	-0.12	-0.13	-0.18	-0.18	0.60	-	<.001
14. Grade 5	0.29	0.40	0.40	0.17	0.35	-0.31	-0.14	-0.18	-0.14	-0.13	-0.17	0.57	0.71	-

Note: Values below the diagonal reflect Pearson correlation coefficients. Values above the diagonal reflect corresponding p-values.

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Table S3

Estimated marginal means (EMM) for measures at child age 14 months controlling for household income (POVRATIO) and maternal educational attainment (HGCG)

14-month predictors	Black/African American		White/ European American		<i>t</i>	<i>p</i>	<i>d</i>
	<i>N</i>	<i>EMM (SD)</i>	<i>N</i>	<i>EMM (SD)</i>			
Bayley MDI	173	97.8 (9.8)	253	99.2 (16.6)	-1.03	.305	-.119
HOME Inventory	201	26.0 (3.5)	272	27.3 (3.1)	-4.45	<.001***	-.480
<i>3-bag Task</i>							
Parent Supportiveness	185	3.7 (1.1)	256	4.2 (1.0)	-5.17	<.001***	-.578
Child Engagement of Parent	185	3.9 (1.3)	256	3.9 (1.2)	-.11	.916	-.012
Child Sustained Attention	185	4.7 (1.2)	256	5.2 (1.0)	-4.61	<.001***	-.514
Parent Intrusiveness	185	2.8 (1.4)	256	2.1 (1.2)	5.11	<.001***	.571
Parent Negative Regard	185	1.6 (0.8)	256	1.3 (0.7)	4.33	<.001***	.483
Child Negativity toward Parent	185	2.3 (1.3)	256	1.9 (1.1)	3.46	<.001***	.386
<i>Maternal Distress Variables</i>							
CES-D Depression Scale	218	12.6 (11.4)	278	14.2 (10.1)	-1.57	.117	-.051
Parent Distress Inventory	222	27.6 (11.5)	280	26.6 (10.2)	1.01	.315	.104
Parent-Child Dysfunctional Interaction	222	17.4 (6.9)	280	17.0 (6.1)	.66	.511	.068

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Table S4

Estimated marginal means (EMM) for PPVT scores at child age 36 months, 4 years, and Grade 5 controlling for household income (POVRATIO) and maternal educational attainment (HGCG)

Age	Black/African American		White/ European American		<i>t</i>	<i>p</i>	<i>d</i>
	<i>N</i>	<i>EMM (SD)</i>	<i>N</i>	<i>EMM (SD)</i>			
	<i>36 months</i>	247	79.6 (18.5)	309			
<i>Pre-K</i>	192	86.2 (15.6)	253	98.2 (13.7)	-8.43	<.001	-.931
<i>Grade 5</i>	168	89.0 (15.9)	209	102.0 (14.1)	-8.03	<.001	-.956

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Table S5

Standardized regression coefficients and predictors of children's receptive vocabulary knowledge (PPVT) at age 36 months, Pre-K (48 months), and grade 5 (approx. ~120– months)

	36m (N = 357)	Pre-K (N = 292)	Grade 5 (N = 251)
Child Gender (1 = Male)	-.17 **	-.08	.01
Child Gestational Age	.09 ·	.07	.06
Home Language (1 = English)	-.01	-.08	-.04
Maternal Education	.19 ***	.18 **	.20 **
Poverty Ratio	.01	.14 *	.05
R^2 total (Adjusted R^2)	.07 (.05)	.08 (.07)	.05 (.04)
Model $F(5, N-8)$	5.13 ***	5.10 ***	2.83 *

*** $p < .001$, ** $p < .01$, * $p < .05$, · $p < .10$

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Table S6

Standardized estimates for SEM predicting variation in children’s receptive vocabulary knowledge (PPVT) at 36m based on predictors measured at 14m.

	Black/African American						White/European American					
	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p
Latent Variables												
Joint Attention =~												
Child Attention	0.59	0.07	0.45	0.73	8.18	<.001	0.52	0.08	0.36	0.69	6.26	<.001
Parental Supportiveness	0.82	0.08	0.67	0.97	10.61	<.001	0.90	0.07	0.76	1.03	12.82	<.001
Child Engagement of Parent	0.57	0.07	0.42	0.71	7.82	<.001	0.58	0.06	0.46	0.69	9.87	<.001
Negative Interaction =~												
Parental Intrusiveness	0.93	0.09	0.76	1.10	10.83	<.001	0.78	0.08	0.62	0.94	9.64	<.001
Parental Negative Regard	0.37	0.08	0.21	0.53	4.50	<.001	0.54	0.08	0.38	0.69	6.76	<.001
Child Negativity to Parent	0.66	0.09	0.50	0.83	7.73	<.001	0.76	0.08	0.60	0.92	9.58	<.001
Maternal Distress =~												
Maternal Distress	0.84	0.07	0.70	0.98	11.65	<.001	0.77	0.06	0.66	0.88	13.49	<.001
Parent-Child Dysfunction	0.59	0.07	0.46	0.71	8.94	<.001	0.60	0.07	0.46	0.74	8.38	<.001
Parental Dep. Symptoms	0.67	0.07	0.53	0.81	9.48	<.001	0.63	0.06	0.51	0.74	10.74	<.001
Regressions												
HOME ~												
Maternal Distress	-0.22	0.08	-0.39	-0.06	-2.73	0.006	-0.46	0.09	-0.63	-0.29	-5.37	<.001
Maternal Education	0.29	0.06	0.19	0.40	5.29	<.001	0.18	0.06	0.06	0.30	2.85	0.004
Negative Interaction ~												
Maternal Education	-0.02	0.10	-0.21	0.18	-0.18	0.857	-0.17	0.07	-0.30	-0.03	-2.38	0.017
HOME	-0.16	0.11	-0.36	0.05	-1.49	0.136	-0.09	0.10	-0.30	0.11	-0.92	0.355
Joint Attention ~												
Maternal Education	0.12	0.09	-0.05	0.30	1.40	0.163	0.12	0.06	-0.01	0.24	1.85	0.065
HOME	0.41	0.12	0.17	0.65	3.33	0.001	0.42	0.11	0.20	0.65	3.70	<.001
Child Cognition ~												
Gestational Age	0.27	0.09	0.10	0.44	3.14	0.002	0.13	0.07	-0.01	0.27	1.81	0.071
Gender (1=male)	-0.09	0.07	-0.23	0.05	-1.28	0.201	-0.10	0.06	-0.22	0.03	-1.55	0.121
HOME	0.13	0.08	-0.03	0.29	1.54	0.124	0.14	0.06	0.03	0.25	2.51	0.012
Child Vocabulary (36m) ~												
Gestational Age	0.08	0.07	-0.05	0.22	1.22	0.221	-0.01	0.05	-0.11	0.08	-0.27	0.786
HOME	0.06	0.10	-0.14	0.26	0.58	0.562	0.04	0.07	-0.10	0.18	0.55	0.580
Gender (1=male)	-0.09	0.06	-0.21	0.03	-1.54	0.124	-0.08	0.05	-0.19	0.02	-1.62	0.105
Maternal Distress	-0.05	0.08	-0.20	0.10	-0.62	0.533	-0.12	0.08	-0.27	0.03	-1.54	0.123
Maternal Education	0.11	0.07	-0.02	0.24	1.64	0.101	0.08	0.05	-0.02	0.19	1.53	0.127
Child Cognition	0.18	0.09	0.01	0.35	2.12	0.034	0.25	0.06	0.13	0.37	4.02	<.001
Joint Attention	0.20	0.14	-0.07	0.47	1.43	0.151	0.23	0.10	0.04	0.42	2.38	0.017
Negative Interaction	0.02	0.09	-0.16	0.19	0.19	0.848	-0.01	0.10	-0.20	0.18	-0.07	0.945
Covariances												
Joint Attention ~												
Negative Interaction	-0.42	0.12	-0.65	-0.19	-3.57	<.001	-0.46	0.10	-0.65	-0.27	-4.75	<.001

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

	Black/African American						White/European American					
	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>
Child Cognition	0.17	0.09	0.00	0.35	1.92	0.055	0.11	0.09	-0.06	0.29	1.25	0.210
Parental Mental Health ~ Maternal Education	-0.12	0.08	-0.28	0.04	-1.42	0.154	-0.25	0.06	-0.37	-0.12	-3.91	<.001
Indirect and Total Effect												
Child Gender → Bayley MDI → PPVT												
Indirect	-0.02	0.02	-0.05	0.01	-1.07	0.284	-0.02	0.02	-0.06	0.01	-1.47	0.141
Total	-0.11	0.06	-0.22	0.01	-1.81	0.071	-0.11	0.05	-0.21	0.00	-2.03	0.043
Gestational Age → Bayley MDI → PPVT												
Indirect	0.05	0.03	-0.01	0.11	1.65	0.099	0.03	0.02	-0.01	0.07	1.63	0.102
Total	0.13	0.07	0.00	0.27	1.92	0.055	0.02	0.05	-0.09	0.13	0.33	0.741
HOME → Bayley MDI → PPVT												
Indirect	0.02	0.02	-0.01	0.06	1.24	0.216	0.04	0.02	0.00	0.07	2.07	0.038
Total	0.08	0.10	-0.12	0.28	0.80	0.424	0.08	0.07	-0.07	0.22	1.04	0.298
HOME → Joint Attention → PPVT												
Indirect	0.08	0.06	-0.04	0.20	1.29	0.198	0.10	0.05	0.00	0.20	1.94	0.052
Total	0.14	0.09	-0.03	0.31	1.60	0.110	0.14	0.07	0.00	0.27	2.00	0.045
Maternal Distress → HOME → PPVT												
Indirect	-0.01	0.02	-0.06	0.03	-0.57	0.567	-0.02	0.03	-0.08	0.05	-0.55	0.579
Total	-0.06	0.07	-0.21	0.08	-0.84	0.402	-0.14	0.07	-0.27	0.00	-2.02	0.044
Maternal Education → Joint Attention → PPVT												
Indirect	0.02	0.02	-0.02	0.07	1.10	0.271	0.03	0.02	-0.01	0.06	1.44	0.150
Total	0.13	0.07	0.00	0.27	1.95	0.051	0.11	0.05	0.00	0.22	2.02	0.043
Maternal Education → HOME → PPVT												
Indirect	0.02	0.03	-0.04	0.08	0.57	0.567	0.01	0.01	-0.02	0.03	0.55	0.580
Total	0.13	0.07	-0.01	0.26	1.80	0.072	0.09	0.05	-0.02	0.20	1.66	0.096
Intercepts												
Child Attention	0.65	0.09	0.48	0.82	7.61	<.001	1.00	0.00	1.00	1.00	-	-
Parental Supportiveness	0.33	0.13	0.08	0.57	2.57	0.010	3.32	0.53	2.28	4.36	6.25	<.001
Child Engagement of Parent	0.68	0.08	0.52	0.84	8.25	<.001	0.48	0.60	-0.70	1.66	0.79	0.427
Parental Intrusiveness	0.14	0.16	-0.17	0.45	0.88	0.379	1.21	0.42	0.39	2.03	2.90	0.004
Parental Negative Regard	0.86	0.06	0.75	0.98	14.29	<.001	2.94	0.67	1.62	4.25	4.38	<.001
Child Negativity to Parent	0.56	0.11	0.34	0.78	4.91	<.001	2.97	0.57	1.86	4.08	5.23	<.001
Maternal Distress	0.29	0.12	0.05	0.53	2.41	0.016	2.99	0.60	1.82	4.16	5.01	<.001
Parent-Child Dysfunction	0.66	0.08	0.51	0.81	8.54	<.001	2.95	0.11	2.73	3.17	26.76	<.001
Parental Dep. Symptoms	0.55	0.09	0.37	0.74	5.83	<.001	3.48	0.23	3.03	3.93	15.12	<.001
HOME	0.84	0.06	0.72	0.95	14.34	<.001	1.38	0.05	1.28	1.48	26.05	<.001
Child Cognition (14m)	1.00	0.00	1.00	1.00	-	-	9.35	0.65	8.07	10.63	14.31	<.001
Child Vocabulary (36m)	1.00	0.00	1.00	1.00	-	-	6.98	0.77	5.47	8.49	9.06	<.001
Maternal Education	0.90	0.05	0.80	1.00	17.56	<.001	1.78	0.72	0.38	3.19	2.49	0.013
Gestational Age	1.00	0.00	1.00	1.00	-	-	2.53	0.08	2.38	2.69	31.45	<.001
Gender (1=male)	0.85	0.05	0.75	0.95	16.89	<.001	2.42	0.26	1.92	2.92	9.46	<.001
Joint Attention	.00		.00	.00	-	-	.00		.00	.00	-	-
Negative Interaction	.00		.00	.00	-	-	.00		.00	.00	-	-
Maternal Distress	.00		.00	.00	-	-	.00		.00	.00	-	-

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

	Black/African American						White/European American					
	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>
Variances												
Child Attention	0.65	0.09	0.48	0.82	7.61	<.001	0.72	0.09	0.55	0.90	8.24	<.001
Parental Supportiveness	0.33	0.13	0.08	0.57	2.57	0.010	0.20	0.13	-0.05	0.44	1.58	0.114
Child Engagement of Parent	0.68	0.08	0.52	0.84	8.25	<.001	0.67	0.07	0.53	0.80	9.87	<.001
Parental Intrusiveness	0.14	0.16	-0.17	0.45	0.88	0.379	0.39	0.13	0.14	0.64	3.09	0.002
Parental Negative Regard	0.86	0.06	0.75	0.98	14.29	<.001	0.71	0.09	0.54	0.88	8.27	<.001
Child Negativity to Parent	0.56	0.11	0.34	0.78	4.91	<.001	0.42	0.12	0.18	0.66	3.49	<.001
Maternal Distress	0.29	0.12	0.05	0.53	2.41	0.016	0.41	0.09	0.24	0.58	4.72	<.001
Parent-Child Dysfunction	0.66	0.08	0.51	0.81	8.54	<.001	0.64	0.09	0.47	0.81	7.46	<.001
Parental Dep. Symptoms	0.55	0.09	0.37	0.74	5.83	<.001	0.61	0.07	0.46	0.75	8.31	<.001
Child Vocabulary (36m)	0.84	0.06	0.72	0.95	14.34	<.001	0.78	0.05	0.67	0.89	14.43	<.001
Gender (1=male)	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
Maternal Education	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
Child Cognition	0.90	0.05	0.80	1.00	17.56	<.001	0.95	0.03	0.90	1.01	34.67	<.001
Gestational Age	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
HOME	0.85	0.05	0.75	0.95	16.89	<.001	0.72	0.07	0.57	0.86	9.85	<.001
Joint Attention	0.79	0.11	0.58	1.00	7.42	<.001	0.78	0.10	0.57	0.98	7.48	<.001
Negative Interaction	0.97	0.04	0.90	1.04	27.76	<.001	0.95	0.04	0.88	1.03	23.79	<.001
Maternal Distress	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-

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

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Table S7

Standardized estimates for SEM predicting variation in children’s receptive vocabulary knowledge (PPVT) at Pre–K (approximately 48m) based on predictors measured at 14m.

	Black/African American						White/European American					
	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p
Latent Variables												
Joint Attention =~												
Child Attention	0.63	0.07	0.49	0.78	8.48	<.001	0.63	0.08	0.48	0.77	8.33	<.001
Parental Supportiveness	0.79	0.07	0.65	0.94	10.69	<.001	0.88	0.06	0.76	1.00	13.97	<.001
Child Engagement of Parent	0.57	0.08	0.41	0.73	6.96	<.001	0.62	0.05	0.52	0.72	12.23	<.001
Negative Interaction =~												
Parental Intrusiveness	0.90	0.09	0.73	1.07	10.25	<.001	0.76	0.09	0.58	0.94	8.06	<.001
Parental Negative Regard	0.43	0.09	0.25	0.61	4.64	<.001	0.55	0.08	0.39	0.71	6.65	<.001
Child Negativity to Parent	0.64	0.09	0.46	0.83	6.78	<.001	0.79	0.09	0.62	0.96	9.06	<.001
Maternal Distress =~												
Maternal Distress	0.84	0.09	0.67	1.00	9.64	<.001	0.75	0.07	0.62	0.88	11.25	<.001
Parent–Child Dysfunction	0.59	0.07	0.45	0.72	8.52	<.001	0.51	0.07	0.37	0.64	7.55	<.001
Parental Dep. Symptoms	0.64	0.08	0.48	0.80	7.89	<.001	0.63	0.07	0.50	0.77	9.17	<.001
Regressions												
HOME ~												
Maternal Distress	-0.24	0.10	-0.43	-0.05	-2.49	0.013	-0.33	0.08	-0.49	-0.17	-4.09	<.001
Maternal Education	0.30	0.06	0.17	0.42	4.71	<.001	0.25	0.06	0.12	0.38	3.85	<.001
Negative Interaction ~												
Maternal Education	0.05	0.11	-0.16	0.26	0.46	0.645	-0.17	0.07	-0.31	-0.02	-2.23	0.025
HOME	-0.23	0.12	-0.47	0.01	-1.89	0.058	-0.07	0.11	-0.28	0.14	-0.64	0.522
Joint Attention ~												
Maternal Education	0.02	0.10	-0.17	0.22	0.21	0.833	0.13	0.07	-0.01	0.27	1.77	0.078
HOME	0.48	0.13	0.23	0.73	3.77	<.001	0.37	0.09	0.19	0.55	3.99	<.001
Child Cognition ~												
Gestational Age	0.28	0.09	0.09	0.46	2.90	0.004	0.14	0.08	-0.01	0.29	1.77	0.077
Gender (1=male)	-0.09	0.08	-0.25	0.07	-1.16	0.246	-0.12	0.07	-0.25	0.01	-1.74	0.082
HOME	0.07	0.10	-0.12	0.26	0.77	0.442	0.15	0.06	0.02	0.27	2.31	0.021
Child Vocabulary (36m) ~												
Gestational Age	0.03	0.08	-0.13	0.18	0.35	0.728	0.05	0.06	-0.06	0.16	0.88	0.380
HOME	-0.03	0.11	-0.25	0.19	-0.29	0.768	0.17	0.07	0.03	0.31	2.43	0.015
Gender (1=male)	-0.02	0.07	-0.15	0.12	-0.29	0.774	-0.01	0.05	-0.12	0.09	-0.25	0.799
Maternal Distress	-0.01	0.10	-0.21	0.18	-0.12	0.904	-0.30	0.08	-0.45	-0.15	-3.84	<.001
Maternal Education	0.25	0.08	0.10	0.40	3.27	0.001	0.00	0.06	-0.11	0.11	-0.07	0.943
Child Cognition	0.08	0.09	-0.11	0.26	0.83	0.408	0.29	0.07	0.15	0.42	4.25	<.001
Joint Attention	0.26	0.16	-0.05	0.58	1.64	0.100	0.13	0.10	-0.06	0.32	1.34	0.180
Negative Interaction	0.09	0.11	-0.13	0.31	0.79	0.428	0.03	0.09	-0.14	0.20	0.34	0.731
Covariances												
Joint Attention ~												
Negative Interaction	-0.50	0.13	-0.74	-0.25	-3.94	<.001	-0.52	0.09	-0.69	-0.35	-6.05	<.001

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

	Black/African American						White/European American					
	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p
Child Cognition	0.21	0.10	0.02	0.40	2.13	0.033	0.10	0.09	-0.07	0.28	1.19	0.236
Parental Mental Health ~ Maternal Education	-0.15	0.09	-0.33	0.03	-1.67	0.094	-0.22	0.08	-0.38	-0.06	-2.72	0.006
Indirect and Total Effect												
Child Gender → Bayley MDI → PPVT												
Indirect	-0.01	0.01	-0.03	0.01	-0.75	0.454	-0.03	0.02	-0.07	0.01	-1.69	0.092
Total	-0.03	0.07	-0.16	0.11	-0.39	0.694	-0.05	0.06	-0.16	0.06	-0.84	0.398
Gestational Age → Bayley MDI → PPVT												
Indirect	0.02	0.03	-0.03	0.08	0.75	0.452	0.04	0.02	-0.01	0.08	1.67	0.094
Total	0.05	0.07	-0.10	0.19	0.66	0.508	0.09	0.05	-0.02	0.19	1.62	0.106
HOME → Bayley MDI → PPVT												
Indirect	0.01	0.01	-0.02	0.03	0.52	0.602	0.04	0.02	0.00	0.08	2.15	0.031
Total	-0.03	0.11	-0.25	0.20	-0.24	0.813	0.21	0.07	0.08	0.35	3.04	0.002
HOME → Joint Attention → PPVT												
Indirect	0.13	0.09	-0.05	0.30	1.44	0.149	0.05	0.04	-0.02	0.12	1.30	0.194
Total	0.09	0.10	-0.10	0.29	0.95	0.341	0.22	0.07	0.08	0.35	3.21	0.001
Maternal Distress → HOME → PPVT												
Indirect	0.01	0.03	-0.05	0.06	0.29	0.770	-0.06	0.03	-0.11	-0.01	-2.25	0.024
Total	0.00	0.10	-0.19	0.18	-0.04	0.965	-0.35	0.07	-0.49	-0.21	-4.99	<.001
Maternal Education → Joint Attention → PPVT												
Indirect	0.01	0.03	-0.05	0.06	0.21	0.830	0.02	0.02	-0.02	0.05	1.01	0.311
Total	0.26	0.08	0.10	0.41	3.32	0.001	0.01	0.06	-0.10	0.12	0.21	0.831
Maternal Education → HOME → PPVT												
Indirect	-0.01	0.03	-0.07	0.05	-0.29	0.769	0.04	0.02	0.00	0.08	2.03	0.043
Total	0.24	0.07	0.09	0.39	3.22	0.001	0.04	0.06	-0.08	0.15	0.66	0.507
Intercepts												
Child Attention	2.50	0.55	1.42	3.58	4.54	<.001	2.93	0.56	1.84	4.02	5.27	<.001
Parental Supportiveness	0.85	0.62	-0.36	2.06	1.37	0.169	0.63	0.78	-0.90	2.16	0.81	0.420
Child Engagement of Parent	1.17	0.47	0.26	2.09	2.51	0.012	1.11	0.52	0.09	2.14	2.14	0.032
Parental Intrusiveness	3.59	0.61	2.40	4.79	5.91	<.001	2.76	0.90	0.99	4.53	3.05	0.002
Parental Negative Regard	2.45	0.36	1.75	3.14	6.88	<.001	2.85	0.77	1.34	4.35	3.71	<.001
Child Negativity to Parent	2.96	0.54	1.90	4.02	5.47	<.001	2.83	0.87	1.12	4.55	3.24	0.001
Maternal Distress	2.89	0.14	2.61	3.16	20.71	<.001	2.99	0.12	2.75	3.22	24.91	<.001
Parent-Child Dysfunction	2.67	0.25	2.17	3.16	10.55	<.001	3.71	0.25	3.22	4.20	14.73	<.001
Parental Dep. Symptoms	1.42	0.09	1.24	1.59	15.97	<.001	1.42	0.06	1.30	1.54	23.22	<.001
HOME	6.79	0.60	5.61	7.97	11.31	<.001	10.31	0.71	8.93	11.69	14.61	<.001
Child Cognition (14m)	8.99	1.24	6.56	11.41	7.27	<.001	6.64	0.88	4.92	8.37	7.54	<.001
Child Vocabulary (36m)	4.11	1.08	1.99	6.24	3.80	<.001	2.82	0.82	1.23	4.42	3.46	0.001
Maternal Education	2.23	0.07	2.09	2.37	31.07	<.001	2.52	0.09	2.34	2.69	28.70	<.001
Gestational Age	2.42	0.30	1.84	3.00	8.14	<.001	2.35	0.25	1.87	2.83	9.61	<.001
Gender (1=male)	1.11	0.09	0.93	1.29	11.88	<.001	1.00	0.07	0.86	1.13	14.31	<.001
Joint Attention	.00		.00	.00	-	-	.00		.00	.00	-	-
Negative Interaction	.00		.00	.00	-	-	.00		.00	.00	-	-
Maternal Distress	.00		.00	.00	-	-	.00		.00	.00	-	-

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

	Black/African American						White/European American					
	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>
Variances												
Child Attention	0.60	0.09	0.41	0.78	6.31	<.001	0.61	0.09	0.42	0.79	6.46	<.001
Parental Supportiveness	0.37	0.12	0.14	0.60	3.15	0.002	0.23	0.11	0.01	0.44	2.04	0.042
Child Engagement of Parent	0.67	0.09	0.49	0.86	7.12	<.001	0.61	0.06	0.49	0.74	9.61	<.001
Parental Intrusiveness	0.19	0.16	-0.12	0.50	1.20	0.231	0.42	0.14	0.14	0.70	2.95	0.003
Parental Negative Regard	0.82	0.08	0.66	0.97	10.31	<.001	0.70	0.09	0.52	0.88	7.62	<.001
Child Negativity to Parent	0.59	0.12	0.35	0.83	4.87	<.001	0.38	0.14	0.11	0.65	2.73	0.006
Maternal Distress	0.30	0.14	0.02	0.59	2.09	0.037	0.44	0.10	0.25	0.64	4.45	<.001
Parent-Child Dysfunction	0.65	0.08	0.49	0.81	8.06	<.001	0.74	0.07	0.61	0.88	10.98	<.001
Parental Dep. Symptoms	0.59	0.10	0.39	0.79	5.67	<.001	0.60	0.09	0.43	0.77	6.95	<.001
Child Vocabulary (36m)	0.85	0.06	0.73	0.98	13.68	<.001	0.68	0.05	0.57	0.78	12.83	<.001
Gender (1=male)	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
Maternal Education	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
Child Cognition	0.91	0.06	0.80	1.02	16.13	<.001	0.95	0.03	0.88	1.01	27.52	<.001
Gestational Age	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
HOME	0.83	0.06	0.71	0.95	13.73	<.001	0.79	0.06	0.68	0.91	13.47	<.001
Joint Attention	0.76	0.12	0.52	1.00	6.27	<.001	0.82	0.07	0.68	0.96	11.15	<.001
Negative Interaction	0.95	0.05	0.85	1.05	18.85	<.001	0.96	0.04	0.88	1.04	24.41	<.001
Maternal Distress	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-

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

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

Table S8

Standardized estimates for SEM predicting variation in children’s receptive vocabulary knowledge (PPVT) at Grade 5 (approximately 120m) based on predictors measured at 14m.

	Black/African American						White/European American					
	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p	Std. Estimate (β)	SE	95% CI (Lower)	95% CI (Upper)	z	p
Latent Variables												
Joint Attention =~												
Child Attention	0.67	0.09	0.49	0.85	7.15	<.001	0.64	0.09	0.47	0.80	7.37	<.001
Parental Supportiveness	0.80	0.08	0.64	0.96	9.86	<.001	0.87	0.07	0.74	1.00	13.00	<.001
Child Engagement of Parent	0.62	0.08	0.45	0.79	7.29	<.001	0.64	0.06	0.54	0.75	11.67	<.001
Negative Interaction =~												
Parental Intrusiveness	0.91	0.13	0.67	1.16	7.28	<.001	0.68	0.11	0.46	0.90	6.14	<.001
Parental Negative Regard	0.42	0.12	0.19	0.65	3.56	<.001	0.61	0.10	0.42	0.79	6.38	<.001
Child Negativity to Parent	0.63	0.11	0.41	0.85	5.56	<.001	0.84	0.09	0.66	1.02	9.16	<.001
Maternal Distress =~												
Maternal Distress	0.91	0.14	0.64	1.18	6.61	<.001	0.69	0.08	0.54	0.84	9.04	<.001
Parent–Child Dysfunction	0.53	0.09	0.36	0.71	5.96	<.001	0.55	0.09	0.37	0.74	5.89	<.001
Parental Dep. Symptoms	0.60	0.11	0.39	0.81	5.64	<.001	0.59	0.10	0.40	0.78	6.17	<.001
Regressions												
HOME ~												
Maternal Distress	-0.14	0.15	-0.44	0.16	-0.91	0.362	-0.40	0.10	-0.59	-0.20	-3.95	<.001
Maternal Education	0.32	0.08	0.18	0.47	4.32	<.001	0.19	0.08	0.04	0.33	2.43	0.015
Negative Interaction ~												
Maternal Education	-0.01	0.11	-0.23	0.21	-0.11	0.916	-0.11	0.08	-0.28	0.05	-1.32	0.186
HOME	-0.27	0.18	-0.62	0.08	-1.54	0.125	-0.07	0.13	-0.32	0.18	-0.54	0.592
Joint Attention ~												
Maternal Education	-0.08	0.12	-0.30	0.15	-0.65	0.518	0.12	0.08	-0.04	0.28	1.41	0.159
HOME	0.59	0.17	0.26	0.92	3.47	0.001	0.33	0.11	0.11	0.54	3.01	0.003
Child Cognition ~												
Gestational Age	0.39	0.12	0.16	0.63	3.28	0.001	0.09	0.08	-0.07	0.25	1.07	0.283
Gender (1=male)	-0.08	0.10	-0.27	0.11	-0.84	0.402	-0.07	0.08	-0.22	0.09	-0.83	0.408
HOME	0.00	0.12	-0.23	0.23	0.00	0.998	0.16	0.07	0.02	0.30	2.28	0.023
Child Vocabulary (36m) ~												
Gestational Age	0.01	0.09	-0.17	0.18	0.05	0.956	0.08	0.08	-0.07	0.23	1.08	0.279
HOME	0.01	0.12	-0.23	0.25	0.09	0.930	0.17	0.08	0.00	0.33	1.96	0.050
Gender (1=male)	-0.06	0.08	-0.22	0.10	-0.77	0.441	0.09	0.07	-0.04	0.22	1.34	0.180
Maternal Distress	-0.07	0.10	-0.27	0.12	-0.72	0.472	-0.16	0.10	-0.36	0.04	-1.57	0.116
Maternal Education	0.18	0.09	0.00	0.36	2.00	0.046	0.06	0.06	-0.06	0.18	0.97	0.332
Child Cognition	0.15	0.11	-0.07	0.37	1.32	0.185	0.29	0.08	0.14	0.43	3.81	<.001
Joint Attention	0.32	0.17	-0.02	0.66	1.85	0.064	0.23	0.11	0.02	0.44	2.11	0.035
Negative Interaction	0.05	0.14	-0.22	0.32	0.34	0.736	0.11	0.12	-0.13	0.34	0.90	0.370
Covariances												
Joint Attention ~												
Negative Interaction	-0.45	0.15	-0.75	-0.16	-3.02	0.003	-0.56	0.09	-0.74	-0.39	-6.28	<.001

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

	Black/African American						White/European American					
	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>
Child Cognition	0.29	0.12	0.06	0.52	2.44	0.015	0.06	0.10	-0.13	0.25	0.60	0.549
Parental Mental Health ~ Maternal Education	-0.13	0.10	-0.33	0.07	-1.28	0.201	-0.26	0.09	-0.44	-0.09	-2.97	0.003
Indirect and Total Effect												
Child Gender → Bayley MDI → PPVT												
Indirect	0.16	0.09	-0.01	0.33	1.79	0.073	0.09	0.06	-0.04	0.21	1.38	0.168
Total	0.19	0.09	0.01	0.36	2.08	0.037	0.09	0.07	-0.04	0.22	1.34	0.180
Gestational Age → Bayley MDI → PPVT												
Indirect	0.06	0.09	-0.10	0.23	0.75	0.456	0.11	0.07	-0.03	0.25	1.50	0.135
Total	-0.07	0.08	-0.23	0.09	-0.91	0.365	0.07	0.07	-0.07	0.20	1.00	0.317
HOME → Bayley MDI → PPVT												
Indirect	-0.01	0.02	-0.05	0.02	-0.70	0.486	-0.02	0.02	-0.07	0.03	-0.81	0.417
Total	0.01	0.12	-0.22	0.24	0.09	0.928	0.21	0.09	0.04	0.38	2.48	0.013
HOME → Joint Attention → PPVT												
Indirect	0.20	0.12	-0.04	0.43	1.65	0.100	0.24	0.08	0.08	0.40	2.97	0.003
Total	-0.07	0.10	-0.27	0.12	-0.74	0.459	-0.23	0.09	-0.40	-0.05	-2.58	0.010
Maternal Distress → HOME → PPVT												
Indirect	0.06	0.05	-0.04	0.16	1.17	0.243	0.03	0.02	-0.02	0.07	1.09	0.275
Total	0.00	0.04	-0.07	0.08	0.09	0.930	0.03	0.02	-0.01	0.07	1.51	0.132
Maternal Education → Joint Attention → PPVT												
Indirect	0.00	0.02	-0.03	0.03	0.00	0.998	0.05	0.02	0.00	0.09	1.98	0.048
Total	0.19	0.12	-0.05	0.43	1.55	0.122	0.07	0.04	-0.01	0.16	1.76	0.078
Maternal Education → HOME → PPVT												
Indirect	-0.02	0.04	-0.10	0.05	-0.65	0.516	0.03	0.02	-0.02	0.07	1.20	0.231
Total	0.00	0.02	-0.03	0.03	-0.09	0.931	-0.07	0.04	-0.14	0.01	-1.82	0.069
Intercepts												
Child Attention	2.00	0.60	0.82	3.19	3.32	0.001	3.24	0.67	1.93	4.55	4.84	<.001
Parental Supportiveness	0.14	0.62	-1.07	1.36	0.23	0.815	0.82	0.89	-0.93	2.57	0.92	0.359
Child Engagement of Parent	0.50	0.49	-0.45	1.46	1.03	0.301	1.01	0.63	-0.23	2.25	1.59	0.111
Parental Intrusiveness	4.13	0.75	2.65	5.60	5.49	<.001	2.58	0.98	0.65	4.51	2.62	0.009
Parental Negative Regard	2.57	0.53	1.53	3.60	4.85	<.001	2.74	0.97	0.84	4.63	2.83	0.005
Child Negativity to Parent	3.30	0.79	1.74	4.86	4.15	<.001	2.80	1.13	0.58	5.02	2.47	0.014
Maternal Distress	2.79	0.15	2.50	3.08	18.81	<.001	3.04	0.14	2.77	3.32	21.57	<.001
Parent-Child Dysfunction	2.51	0.28	1.96	3.06	8.92	<.001	3.70	0.30	3.10	4.29	12.22	<.001
Parental Dep. Symptoms	1.45	0.12	1.21	1.69	12.04	<.001	1.43	0.07	1.29	1.57	19.94	<.001
HOME	6.79	0.66	5.50	8.09	10.27	<.001	10.98	0.86	9.29	12.67	12.73	<.001
Child Cognition (14m)	8.89	1.51	5.94	11.84	5.91	<.001	6.41	0.96	4.53	8.30	6.67	<.001
Child Vocabulary (36m)	3.09	1.18	0.78	5.40	2.62	0.009	1.92	1.00	-0.03	3.87	1.93	0.054
Maternal Education	2.29	0.11	2.08	2.50	21.68	<.001	2.59	0.11	2.38	2.81	23.70	<.001
Gestational Age	2.40	0.45	1.53	3.27	5.39	<.001	2.46	0.31	1.85	3.07	7.90	<.001
Gender (1=male)	1.17	0.14	0.89	1.45	8.12	<.001	0.99	0.08	0.83	1.15	12.17	<.001
Joint Attention	.00		.00	.00	-	-	.00		.00	.00	-	-
Negative Interaction	.00		.00	.00	-	-	.00		.00	.00	-	-
Maternal Distress	.00		.00	.00	-	-	.00		.00	.00	-	-

DIRECT INDIRECT INFLUENCES VOCABULARY DEVELOPMENT

	Black/African American						White/European American					
	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>	<i>Std. Estimate</i> (β)	<i>SE</i>	<i>95% CI</i> (Lower)	<i>95% CI</i> (Upper)	<i>z</i>	<i>p</i>
Variances												
Child Attention	0.55	0.13	0.30	0.80	4.38	<.001	0.60	0.11	0.38	0.81	5.43	<.001
Parental Supportiveness	0.36	0.13	0.11	0.62	2.82	0.005	0.24	0.12	0.01	0.47	2.04	0.041
Child Engagement of Parent	0.62	0.11	0.41	0.82	5.87	<.001	0.59	0.07	0.45	0.73	8.27	<.001
Parental Intrusiveness	0.16	0.23	-0.29	0.61	0.71	0.479	0.53	0.15	0.24	0.83	3.52	<.001
Parental Negative Regard	0.82	0.10	0.63	1.02	8.32	<.001	0.63	0.12	0.40	0.86	5.45	<.001
Child Negativity to Parent	0.60	0.14	0.33	0.88	4.26	<.001	0.30	0.15	0.00	0.60	1.96	0.050
Maternal Distress	0.17	0.25	-0.33	0.66	0.65	0.513	0.52	0.11	0.31	0.73	4.89	<.001
Parent-Child Dysfunction	0.72	0.10	0.53	0.90	7.48	<.001	0.69	0.10	0.49	0.90	6.64	<.001
Parental Dep. Symptoms	0.64	0.13	0.38	0.89	4.91	<.001	0.65	0.11	0.43	0.87	5.72	<.001
Child Vocabulary (36m)	0.80	0.08	0.64	0.95	10.02	<.001	0.70	0.06	0.58	0.82	11.85	<.001
Gender (1=male)	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
Maternal Education	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
Child Cognition	0.84	0.09	0.65	1.02	8.90	<.001	0.96	0.03	0.90	1.02	30.49	<.001
Gestational Age	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-
HOME	0.86	0.07	0.73	1.00	12.67	<.001	0.77	0.07	0.63	0.91	10.55	<.001
Joint Attention	0.68	0.19	0.30	1.05	3.55	<.001	0.86	0.08	0.70	1.01	10.95	<.001
Negative Interaction	0.92	0.10	0.73	1.12	9.28	<.001	0.98	0.04	0.91	1.05	27.49	<.001
Maternal Distress	1.00	0.00	1.00	1.00	-	-	1.00	0.00	1.00	1.00	-	-

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