Temperament Predicts Vocabulary Development of Infants from Low-Income Families: A Longitudinal Structural Equation Model Analysis

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Abstract

This study aimed to elucidate the influence of temperament on vocabulary development of infants from low-income families, using data from the Early Head Start Research Evaluation Study (N = 970). Longitudinal structural equation modeling was used to evaluate contributions of latent temperament, with sustained attention, engagement of parent, and negativity (reverse-scored) as indicators, and emotion regulation as predictors of vocabulary knowledge at ages 14, 24, and 36 months. Latent temperament predicted both vocabulary knowledge and emotion regulation skills at subsequent time points, whereas emotion regulation was non-significant in predicting vocabulary knowledge after controlling for temperament. Although descriptive analyses indicated greater vulnerability of boys than girls across measures (e.g., lower vocabulary scores), structural relations appeared to be invariant across genders. Modeling temperament as a latent variable accounts for the common variance shared across constructs. Future research should aim to uncover how distinct facets of temperament influence vocabulary development trajectories.

Keywords: temperament**;** vocabulary; emotion regulation; infancy; sustained attention; longitudinal modeling

Introduction

Infants vary in temperamental characteristics, often described using adjectives like *easy* or *colicky* (Thomas & Chess, 1977). Temperament comprises basic dispositions that moderate infants' activity, reactivity, emotionality, and sociability (Goldsmith et al., 1987; Shiner et al., 2012). Such dispositions influence how infants interact and learn from their physical and social environments (Ollas-Skogster et al, 2025; Rothbart & Bates, 2006), which, in turn, may contribute to individual differences in language and communicative development trajectories (Kuhl, 2007).

As a multifactorial construct, temperament encompasses early emerging differences in emotionality (e.g., negativity), sociability, attentional control, and activity level (Buss & Pérez-Edgar, 2025; Rothbart, 2007, 2011). Additional facets of temperament, such as effortful control and self-regulation, emerge over time (Buss & Pérez-Edgar, 2025; Shiner et al., 2012). The link between temperament and language development may be interpreted through a transactional model of development (Sameroff, 2009), with infant temperament interacting with environmental factors (parental input, social opportunities) to either facilitate or hinder language acquisition (Conture et al., 2013).

Research linking infant temperament with language and communicative development has yielded mixed findings (e.g., Dixon & Smith, 2000; Karrass & Braungart-Rieker, 2003; Ollas-Skogster et al., 2025). Our prior work (Che et al., 2025) found bi-directional associations between children's emotion regulation (indexed via parental report of their child's task persistence, tolerance of frustration, and adaptability) and vocabulary knowledge from 14 months (m) to pre-K, which suggested that effortful control and language skills develop in tandem. This study utilized data from the Early Head Start Research and Evaluation (EHSRE) project—a longitudinal study of infants in low-income families (US Department of Health and Human Services Administration for Children and Families, 2011).

Growing up in poverty places children at elevated risk of language delays as well as difficulties in social-emotional adjustment and school readiness (Lacour & Tissington, 2011; Vernon-Feagans et al., 2012). Boys from low-income families may have greater vulnerability than girls, with heightened risks of engaging in antisocial behavior and poor educational outcomes (Odgers, 2015). For the present study, we included observational measures of infant temperament as predictors of vocabulary outcomes in the EHSRE sample. We constructed a latent variable comprising sustained attention, engagement with parent, and emotional negativity, and used longitudinal equation modeling (SEM) to examine whether infant temperament and emotion regulation uniquely predicted vocabulary development trajectories. We further tested for model invariance by gender.

Research Objectives and Hypotheses

SEM was used to examine longitudinal relations between infant temperament, emotion regulation, and vocabulary development of children growing up in low-income families in the United States. We hypothesized positive associations between temperament, emotion regulation, and vocabulary knowledge across time points. Given findings indicating a stronger association between social/emotional regulation and language skills in boys than girls (Chaplin & Aldao, 2013; Slot et al., 2020), we hypothesized that the pattern of structural relations might vary across gender subgroups.

Method

We used publicly available data from the EHSRE project housed at the Inter-university Consortum for Political and

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Social Research. The EHSRE project ran from 1996 to 2010 and involved data collection at 17 urban and rural sites across the United States. Participants were randomly assigned to receive services through Early Head Start or to control group. We included both after confirming minimal group differences across measures.

Analytic Sample. The analytic sample ($N = 970$) comprised children from the original EHSRE sample who had completed the three-bags task at ages 14m and 36m, and had measures of vocabulary knowledge at ages 14m, 24m, and 36m. The three-bags task was missing 13.9% of values for each subscale at 24m. Additionally, for the measure of emotion regulation, 2.8% of scores were missing at 14m, 11.2% at 24m, and 1.1% at 36m. Missing data were replaced using multiple imputation in SPSS 29. Sample demographics are provided in Table 1.

Table 1. Demographics for the analytic sample ($N = 970$).

Demographic Variables	Overall Sample	Percent
Child Gender		
Boys	481	49.6%
Girls	489	50.4%
Maternal Race/Ethnicity		
White/European-American	452	46.6%
Black/African-American	344	35.5%
Hispanic/Latina	123	12.7%
Other	40	4.1%
Not Reported / Missing	11	1.1%
Maternal Age		
≤ 19 years	384	39.6%
> 20 years	584	60.2%
Not Reported / Missing	2	.2%
Maternal Education		
< 12 years of schooling	364	37.5%
12 years of school or a GED	308	31.8%
> 12 years of school	267	27.5%
Not Reported / Missing	31	3.2%
Home Language		
English	853	87.9%
Not English	89	9.2%
Not Reported / Missing	28	2.9%

Description of Measures

Three Bags Task. The three-bags task (Ware et al., 1998) is an observational measure of parent-child interaction. Mother-infant dyads were asked to engage naturally in three semi-structured playtasks involving a board book (*Good Dog Carl*; Day, 1985), a kitchen stovetop with pots and pans, and a Noah's Ark toyset with animals. Assessments of child temperament were taken at ages 14, 24, and 36 months using video-recordings of the three-bags task. The analyses reported here used the original three-bags coding provided for the EHSRE dataset (see Box C2.A in Love et al., 2002).

Children at each time point were rated on their sustained attention, engagement with parent,, and negativity using a seven-point scale, with "1" indicating a very low incidence of the behavior and "7" indicating a very high incidence; see Table 2 for descriptives. The sustained attention scale assessed the extent to which the child demonstrated focused vs. disorganized attention while engaging with the book and toy sets. The child engagement with parent scale assessed the extent to which the child solicited attention and made bids to elicit engagement from their mother and expressed positive feelings towards her. The negativity scale assessed the degree to which the child overtly expressed hostility, rejection, resistance, or anger toward their mother.

All scoring was quantitative and reflected the frequency of each of the coded behaviors. EHSRE coders were trained to a reliability criterion of 85% inter-rater agreement (exact or within 1 point) on all scales before coding began. Prior work using this measure reported intra-class correlations on coders' responses ranging from .68 to .76 (Fuligni & Brooks-Gunn, 2013). In our analytic sample, girls were reported to have higher sustained attention than boys at ages 24m and 36m, $ts(968) \geq 2.31$, $ps \leq .021$, and higher engagement of their mother at ages 14m and 24m, $ts(968) \geq 2.39$, $ps \leq .017$. Negativity did not vary by gender.

Table 2. Descriptive statistics for child-temperament indicators from the three-bags task.

Index	Age	Full ($N = 970$) *M (SD)* [*range*]	Boys ($n = 481$) *M (SD)* [*range*]	Girls ($n = 489$) *M (SD)* [*range*]
Sustained Attention				
	14m	5.01 (1.00) [1–7]	4.97 (1.01) [1–7]	5.06 (0.98) [2–7]
	24m	5.09 (1.05) [2–7]	5.01 (1.04) [2–7]	5.17 (1.05) [2–7]
	36m	4.93 (0.93) [2–7]	4.85 (0.95) [2–7]	5.00 (0.90) [2–7]
Child Engagement with Parent				
	14m	3.94 (1.12) [1–7]	3.81 (1.13) [1–7]	4.06 (1.10) [1–7]
	24m	4.39 (1.32) [1–7]	4.29 (1.29) [1–7]	4.49 (1.34) [1–7]
	36m	4.74 (0.99) [2–7]	4.70 (0.98) [2–7]	4.79 (1.00) [2–7]
Negativity				
	14m	2.08 (1.12) [1–7]	2.15 (1.13) [1–6]	2.02 (1.10) [1–7]
	24m	2.02 (1.38) [1–7]	2.08 (1.38) [1–7]	1.96 (1.38) [1–7]
	36m	1.29 (0.58) [1–7]	1.32 (0.63) [1–7]	1.26 (0.53) [1–5]

Bayley Behavioral Rating Scale. Emotion regulation was assessed at each of the three time points using the Emotion Regulation factor from the Bayley Behavior Rating Scale (BBRS; Bayley, 1993). The BBRS required the caregiver to

rate their child based on observations of developmental functioning in terms of task persistence, ability to tolerate frustration, and adapt to change. On each of these dimensions, the parent was asked to rate their child from 0 to 2, with 2 indicating mastery, 1 indicating emerging ability, and 0 indicating absence. Scores were summed to create composite scores; see Table 3. At all three ages, girls were reported to have higher emotional self-regulation than boys, ts(968) ≥ 3.48, ps < .001.

Table 3. Descriptive statistics for the Bayley Behavioral Rating Scale.

Age	Full (N = 970) *M (SD)* [*range*]	Boys (n = 481) *M (SD)* [*range*]	Girls (n = 489) *M (SD)* [*range*]
14m	3.70 (0.65) [1.29–5.00]	3.63 (0.64) [1.29–5.00]	3.78 (0.65) [1.57–5.00]
24m	3.61 (0.80) [0.93–5.83]	3.50 (0.80) [0.93–5.00]	3.71 (0.79) [1.00–5.83]
36m	3.99 (0.72) [1.43–5.29]	3.88 (0.75) [1.43–5.29]	4.10 (0.68) [1.57–5.26]

Table 4. Descriptive statistics for vocabulary knowledge measures (Comp = comprehension; Prod = production).

Index	Age	Full (N = 970) *M (SD)* [*range*]	Boys (n = 481) *M (SD)* [*range*]	Girls (n = 489) *M (SD)* [*range*]
Macarthur-Bates Communicative Development Inventories				
Comp	14m	47.60 (19.12) [0–89]	45.00 (19.68) [0–89]	50.16 (18.21) [2–89]
Prod	14m	11.91 (11.25) [0–83]	11.17 (11.12) [0–77]	12.63 (11.33) [0–83]
Prod	24m	55.82 (21.49) [1–100]	53.50 (21.07) [1–100]	58.11 (21.67) [6–100]
Peabody Picture Vocabulary Test				
Comp	36m	83.06 (15.58) [40–123]	81.75 (15.62) [40–116]	84.35 (15.45) [40–123]

MacArthur-Bates Communicative Development Inventories. Vocabulary at 14m and 24m was measured using the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 1994), a parental checklist of child vocabulary knowledge. Parents completed the Words and Gestures form at 14m, which provided separate scores for vocabulary comprehension and production, and the Words and Sentences form at 24m, which provided a score for vocabulary production. Raw CDI scores are reported in Table 4. Across ages and CDI measures, girls were reported to have higher vocabulary knowledge than boys, ts(968) ≥ 2.04, ps ≤ .042.

Peabody Picture Vocabulary Test. Receptive vocabulary knowledge was measured at 36m using the norm-referenced Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997). On each trial, the child was asked to point to the picture (out of 4 options) that matched a word spoken aloud. The test continued until the child made a set number of errors. Norm-referenced PPVT scores are reported in Table 4. The mean scores are markedly below the population norms (μ = 100, σ = 15) indicating delays in vocabulary acquisition in this low-income sample. Girls had higher PPVT scores than boys, t(968) ≥ 2.61, p = .009.

Results

To facilitate interpretation of coefficients, we standardized all scores in the models reported below. Following Grace and Bollen (2005), prior to standardization, we used unstandardized solutions to test for invariance across time points (14m, 24m, 36m) and groups (boys, girls). The analytic dataset along with the R script for analysis is available in Supplemental Materials (Zapparrata et al., 2026).

Measurement Model for Child Temperament

Latent temperament was modeled at each time point using indicator variables from the three-bags task: sustained attention, engagement with parent, and negativity. Note here that scores for negativity were flipped (reverse-coded) so that higher scores would consistently indicate more adaptive temperamental characteristics. Correlated residuals between indicators were estimated across the three time points to account for the repeated measures (Cole & Preacher, 2014; Kenny et al., 1998). A confirmatory factor analysis conducted on the unstandardized scores indicated adequate fit at the global level, *Chi-Square* [15, 970] = 57.29, p < .001; *CFI* = .970; *SRMR* = .031; *RMSEA* = .054 [*90% CI* = .040; .069]. Although the model failed the global chi-square test of significance, correlated residuals indicated adequate fit (i.e., none exceeded .10 in absolute value; see Supplemental Table S1).

To assess whether the temperament indicators were invariant over time, equality constraints were imposed on each indicator across the three time points. Model fit comparisons indicated that sustained attention behaved invariantly across time points, whereas engagement with parent and negativity did not show invariance over time; see Supplemental Table S2. The measurement model with no equality constraints was retained as the final model, shown in Figure 1 with standardized coefficients. The full model with the unstandardized coefficients is reported in Supplemental Table S3. Note that we also tested for invariance across participant subgroups (boys, girls) and found no differences, see Supplemental Table S4.

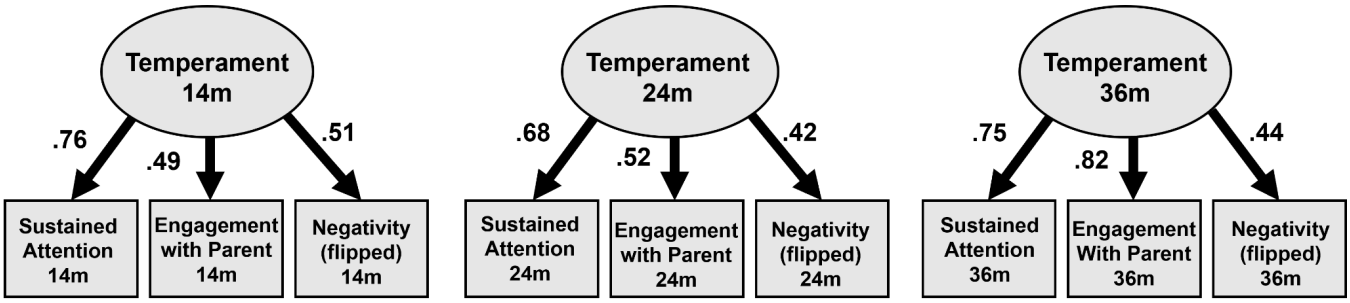

Figure 1. Measurement model for indicators of temperament across three time points (14m, 24m, and 36m). Note that the figure does not show the covariances between the latent variables and the correlated errors across each of the repeated-measures, which were estimated as parameters in the model. All coefficients are standardized.

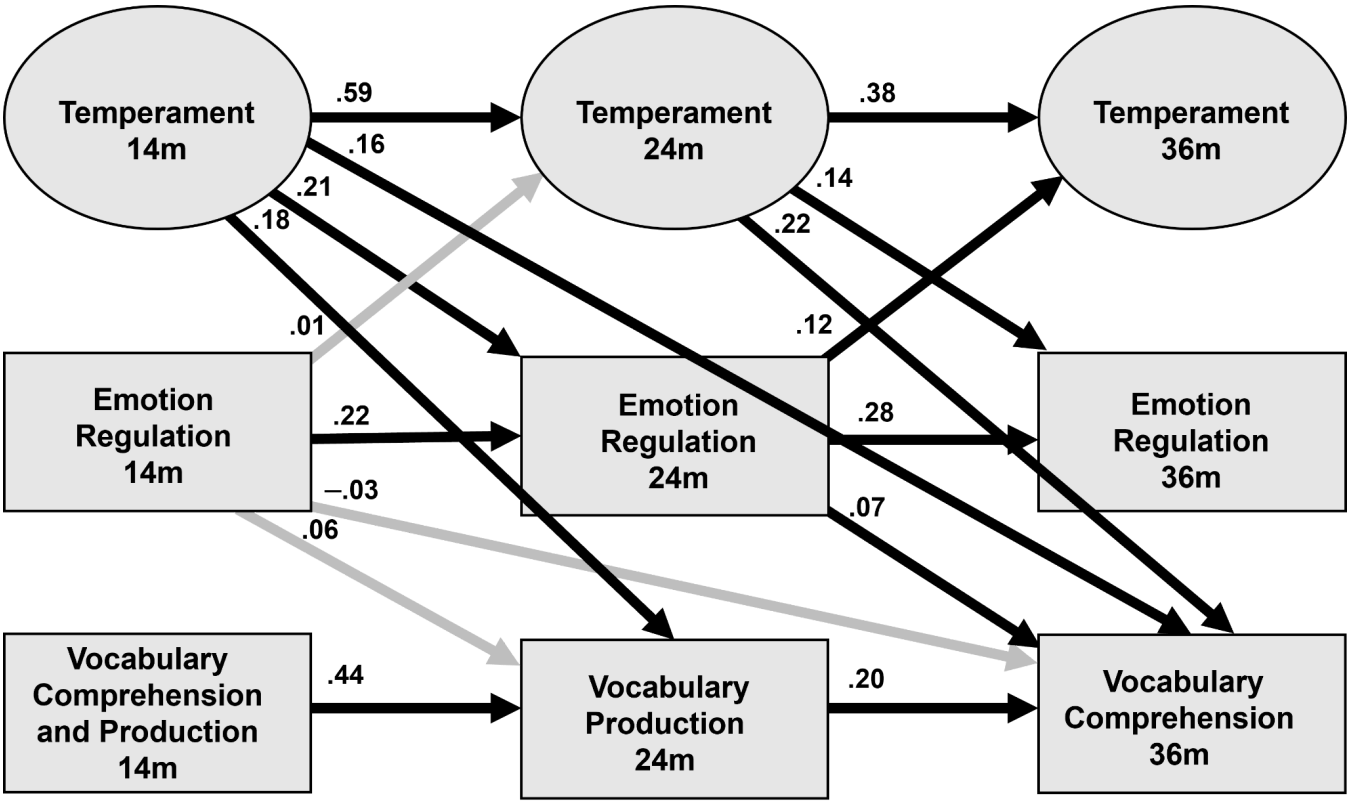

Figure 2. Structural longitudinal equation model demonstrating relationships between temperament, emotion regulation, and vocabulary knowledge across the three time points (14m, 24m, and 36m). Black paths indicate significant direct effects, gray paths indicate nonsignificant effects. Note that the figure does not show the covariances between the 14m measures and the correlated errors at 24m and 36m, which were estimated in the model. All coefficients are standardized.

Structural Model for Vocabulary Development

SEM was conducted in RStudio using the *lavaan* package (Rosseel, 2012). Figure 2 presents the final structural model. Note that the CDI scores for vocabulary comprehension and production at 14m were merged via dimension reduction to create a composite vocabulary score. Vocabulary outcomes were estimated longitudinally at 24 and 36m with both cross-lagged and autoregressive effects. Cross-lagged effects estimated vocabulary outcomes using temperament and emotion regulation at earlier time points as predictors. Autoregressive effects predicted each measure at 24m and 36m, using the same construct at the prior time point as a predictor. Concurrent associations between variables (e.g., temperament and emotion regulation at 14m) were accounted for by specifying covariances across measures at each age. The hypothesized SEM exhibited adequate fit at the global level, *Chi-Square* [62, 970] = 159.8, $p < .001$; *CFI* = .960; *SRMR* = .033; *RMSEA* = .040 [*90% CI* = .033; .048]. Although the model failed the global chi-square test of significance ($p < .001$), correlated residuals, inspected at the local level, indicated adequate fit (i.e., none exceeded .10 in absolute value; see Supplemental Table S5).

Table 5. Standardized coefficients for cross-lagged and autoregressive effects in the longitudinal SEM.

Regressions		Estimate	SE	*p*-value
*Temperament	24m			
Temperament	14m	.59	.08	< .001
Emotion regulation	14m	.01	.05	.813
*Emotion Regulation	24m			
Emotion Regulation	14m	.22	.03	< .001
Temperament	14m	.21	.04	< .001
*Vocabulary Production	24m			
Vocabulary Comp+Prod	14m	.44	.03	< .001
Emotion Regulation	14m	.06	.03	.060
Temperament	14m	.18	.04	< .001
*Temperament	36m			
Temperament	24m	.38	.06	< .001
Emotion regulation	24m	.12	.05	.010
*Emotion Regulation	36m			
Emotion Regulation	24m	.28	.03	< .001
Temperament	24m	.14	.04	< .001
*Vocabulary Comp	36m			
Vocabulary Prod	24m	.20	.03	< .001
Emotion Regulation	14m	–.03	.03	.251
Emotion Regulation	24m	.07	.03	.032
Temperament	14m	.16	.05	.001
Temperament	24m	.22	.05	< .001

Note. * indicates the outcome variable

Table 5 provides the direct path estimates for the final SEM, with * indicating the outcome measures at each time point. Table 6 provides the covariances and error covariances for the same model.

Starting with the autoregressive effects, measures of temperament, emotion regulation, and vocabulary knowledge showed stability across the three time points. For each of these constructs, scores at earlier time points predicted scores for the same construct at each subsequent time point. With respect to the cross-lagged effects shown in Table 5, latent temperament predicted vocabulary knowledge and emotion regulation at each subsequent time point. In contrast, influences of emotion regulation on vocabulary knowledge did not reach significance until age 36m. Note here that the relation between temperament and emotion regulation appeared to be bidirectional from 24m to 36m, with emotion regulation predicting temperament and vice versa. A similar pattern is evident in the covariances shown in Table 6. At 14m, infant temperament was associated with both emotion regulation and vocabulary knowledge, whereas emotion regulation was unassociated with vocabulary knowledge. At 24 and 36m, the three constructs (latent temperament, emotion regulation, and vocabulary knowledge) all appear to be interrelated. With respect to explained variance, the SEM accounted for 24.6% of variance in vocabulary comprehension, 20.0% of variance in temperament, and 14.1% of variance in emotion regulation at 36m.

Table 6. Standardized covariances and error covariances of measures taken at each time point.

Covariances 14m	Estimate	SE	*p*-value
Temperament ~~			
Vocabulary Comp+Prod	.16	.03	< .001
Emotion Regulation	.25	.04	< .001
Emotion Regulation ~~			
Vocabulary Comp+Prod	–.002	.03	.950
Error Covariances 24m	**Estimate**	**SE**	***p*-value**
Temperament ~~			
Vocabulary Prod	.18	.04	< .001
Emotion Regulation	.29	.05	< .001
Emotion Regulation ~~			
Vocabulary Prod	.15	.03	< .001
Error Covariances 36m	**Estimate**	**SE**	***p*-value**
Temperament ~~			
Vocabulary Comp	.15	.04	< .001
Emotion Regulation	.15	.04	< .001
Emotion Regulation ~~			
Vocabulary Comp	.20	.03	< .001

Given the observed gender differences in temperament, emotion regulation, and vocabulary knowledge of the children in the EHSRE dataset (indicating higher vulnerability of boys), we conducted an analysis of invariance to assess whether the structural relations between constructs were similar for boys and girls. We first fit a model with no constraints imposed on regressions (i.e., all regression coefficients were allowed to freely vary between groups) and compared it to a model with constraints imposed on all regressions (i.e., all regression coefficients were constrained to be equal across groups) and found no differences in model fit; see Supplemental Tables S6 and S7. From this result, we can conclude that the structural relations between variables were similar for boys and girls. To confirm adequate model fit, we conducted subgroup analyses, i.e., rerunning the full SEM on data for boys only and for girls only. For boys: *Chi-Square* [62, 481] = 142.7, $p < .001$; *CFI* = .936; *SRMR* = .042; *RMSEA* = .052 [*90% CI* = .041; .063], with the SEM explaining 26.1% of the variance in vocabulary comprehension, 23.3% of the variance in temperament, and 10.5% of the variance in emotion regulation at 36m. For girls: *Chi-Square* [62, 489] = 81.78, $p = .047$; *CFI* = .982; *SRMR* = .035; *RMSEA* = .026 [*90% CI* = .003; .040], with the SEM explaining 23.1% of the variance in vocabulary comprehension, 17.1% of the variance in temperament, and 11.7% of the variance in emotion regulation at 36m.

Discussion

Children growing up in poverty are at heightened risk of language delays (Horwitz et al. 2003; Vernon-Feagans et al., 2012) and social-emotional difficulties (Lee & Zhang, 2022). Yet, even among children growing up under

extreme adversity, there are enormous individual differences in outcomes. The present study aimed to measure influences of infant temperament on early language development trajectories with a focus on vocabulary knowledge. Using longitudinal data from the EHSRE project (United States Department of Health and Human Services Administration for Children and Families, 2011) we investigated structural relations between temperament, emotion regulation, and vocabulary knowledge from 14 to 36m. We built on our previous research that identified bi-directional relations between emotion regulation and vocabulary knowledge (Che et al., 2025), by including an additional latent factor for temperament in our longitudinal model.

Latent temperament proved to be a key predictor of children's emotion regulation and vocabulary knowledge at each time point. In contrast, emotion regulation did not explain significant variance in vocabulary knowledge over and above the influence of temperament. Emotion regulation and self control undergo considerable development from early to middle childhood (Rothbart et al., 2004), and are likely to have increasing influence on school readiness and academic outcomes, such as literacy, at ages beyond infancy (Blair & Raver, 2015; Roben et al., 2013). In the present study, we assessed temperament using experimenter ratings of the child's behavior while engaged in toy play with a parent (Ware et al., 1998) whereas emotion regulation was assessed via parental report (Bayley, 1993). We cannot rule out the possibility that the trained coders had greater sensitivity to variation in infant behavior than the parents, resulting in more reliable evaluations of child characteristics.

Notably the SEM predicted close to 25% of the variance in vocabulary comprehension at 36m (PPVT scores, Dunn & Dunn, 1997), indicating that the influence of temperament on vocabulary development was not small in magnitude. That said, our SEM did not include parental influences on vocabulary knowledge, which are likely to be substantial given the importance of sensitive, responsive caregiving and high quality child-directed speech in early language development (Hirsh-Pasek et al., 2015; Rowe, 2008; Tamis-LeMonda et al., 2014). As a further test of the transactional model (Sameroff, 2009), we plan to include parental measures from the three-bags task (e.g., parental supportiveness, negativity, detachment, intrusiveness) to assess bidirectional relations.

We also did not include maternal characteristics (age, educational attainment) in SEM, which also influence children's language and cognitive development (Justice et al., 2020; Keown et al., 2001). In the present study, 39.6% of mothers were teenagers at the time of their child's birth and 37.5% had not yet finished high school. The mean PPVT scores of the EHSRE sample at 36m (M = 83.1) was more than one SD below population norms ($\mu = 100$, $\sigma = 15$), underscoring the heightened susceptibility of children from low-income families to language difficulties and disorders.

Our use of a latent variable for infant temperament was motivated by non-trivial correlations between sustained attention, engagement with parent, and negativity (reverse-scored) variables drawn from the same video-recorded observations. Future modeling efforts should aim to disentangle influences of different facets of temperament on vocabulary development to improve alignment with core frameworks (Buss & Pérez-Edgar, 2025; Shiner et al., 2012). Based on other research linking infant sustained attention (Yu et al., 2018) and sociability (aka surgency; Balázs et al., 2024) with early vocabulary development, and null findings for negative emotionality (Ollas-Skogster et al., 2025), we would expect different facets of temperament to have unique effects.

The adverse effects of poverty on child development may be more pronounced for boys than girls (Odgers, 2015). In the present study, significant gender differences, favoring girls, were found at each time point for vocabulary development and emotion regulation, in keeping with prior work (Bierman et al., 2009; Mathews et al., 2009). With regard to temperament, girls scored higher on sustained attention and engagement with parent at two of the three time points, but did not differ from boys on negativity. While the direction of gender effects consistently placed girls at an advantage, the observed differences tended to be small in magnitude (*Cohen's d* $\leq$ .31) and the distributions of scores were largely overlapping. Further, we found no evidence that the structural relations between temperament, emotion regulation, and vocabulary development differed by gender. This contrasts with other work (Slot et al., 2020) reporting stronger influences of social-emotional regulation of language outcomes of boys than girls. Future analyses should investigate potential subgroup differences in effects by setting constraints between measures as part of a larger SEM model building process.

Our findings elucidate the contributions of child-level factors (temperament, emotion regulation) in accounting for individual differences in language development trajectories of children growing up in low-income families, providing a complement to research emphasizing influences of parenting practices and the home environment (Brito, 2017; Tamis-LeMonda et al., 2014). Future studies should model child and parental influences in a unified framework to better understand language trajectories of children at risk (Conture et al., 2013). Caring for an infant with a difficult temperament compounds parenting stress (McQuillan & Bates, 2017), especially for families experiencing poverty-related insecurity. As of 2022, 16% of US children were growing in poverty, with even higher rates for Black and Hispanic racial-ethnic minorities (Benson, 2023; Shrider, 2024). To translate research findings into meaningful practice requires greater investment in early childhood programs and other supports for young families, especially for children with difficult temperaments who may be at elevated risk of language delays.

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