Infant Temperament and Parental Aggravation Predict Vocabulary Growth through Age Nine

Zachary Bergson and Patricia J. Brooks

1. Introduction

Infants vary in temperament—a constellation of traits encompassing emotionality/affectivity, activity level, shyness, extraversion/sociability, and attentional control (Buss & Plomin, 1984; Derryberry & Rothbart, 1988; Rothbart, 1981) that influence how infants explore their surroundings and the quality of their social interactions with caregivers and others (Thomas & Chess, 1977). Temperament may be viewed as an early indicator of the infant's emerging regulatory capacities and emotional expression. As a psychobiological construct, temperament has proven to be an important factor associated with parental stress, aggravation, and involvement in child care (Calkins et al., 2004; Mäntymaa et al. 2006; McBride et al., 2004). While having an easy temperament appears to be a protective factor in the context of a negative home environment (Derauf et al., 2012), difficult temperament and negative emotionality increase infants' susceptibility to negative parenting (Slagt et al., 2016).

Parental reports of infant temperament correlate with infants' ability to follow their mother's direction of gaze and establish joint attention at age 6 months and are predictive of infants' receptive vocabulary knowledge at age 12 months (Morales et al., 2000). As parent-child joint attention provides a critical context for word learning (Carpenter et al., 1998; Hirsh-Pasek et al., 2015), individual differences in temperament may have long-term impact on language development trajectories. Consistent with this hypothesis, research has documented longitudinal associations between various indices of temperament and early language development outcomes. For example, Dixon and Shore (1997) linked duration of orienting and soothability at age 13 months with noun vocabulary at 20 months and Dixon and Smith (2000) linked attentional control and positive affectivity at 13 months with receptive and expressive language at 20 months. Pérez-Pereira et al. (2015) similarly found extroversion and positive affectivity at age 10 months to predict expressive language development at 30 months in a sample of healthy preterm and full-term infants. Extending results into middle childhood, Slomkowski et al. (1992) found that extraversion and affectivity assessed at age 2 predicted expressive and receptive language at age 3

* Zachary Bergson is at Yeshiva University; Patricia J. Brooks is at the College of Staten Island and The Graduate Center, CUNY. Please direct correspondence to Zachary Bergson at zach.bergson@gmail.com.

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and receptive language ability at age 7 years after controlling for other factors. The current study builds on this work using a longitudinal mixed-effects model to explore links between infant temperament assessed at age 1 year and receptive vocabulary knowledge through age 9 years.

In addition to using parental reports of infant temperament as predictors of vocabulary growth, we included mothers' self-reported aggravation in parenting as an additional factor in our models. Previous research has reported longitudinal associations between self-reported parenting stress at 1 year of age and children's expressive language abilities at 4 years of age (Magill-Evans & Harrison, 2001). More recently, Ober and Brooks (2020) used structural equation models (SEM) to explore individual differences in language outcomes of children from the Early Head Start Research Evaluation Study (United States Department of Health and Human Services Administration for Children and Families, 2011). The authors found a significant direct effect of maternal distress at age 14 months on children's receptive vocabulary knowledge at age 36 months after controlling for various factors including the quality of the home environment, joint attention, and negative parent-child interaction. In addition to its direct effect on receptive vocabulary, maternal distress also appeared to have an indirect effect on vocabulary development via its negative association with the home environment.

To date, only a few studies have considered influences of both infant temperament and parenting stress on children's language development within the same statistical models. Molfese et al. (2010) used SEM to explore transactional relations between infant temperament, parenting stress, and positive maternal personality on infants' vocabulary development, assessed using the MacArthur-Bates Communicative Development Inventories (a parental report form; Fenson et al., 2007). In a concurrent model (all measures taken at age 12 months), infant negative emotionality (difficult temperament) was linked to heightened parental stress, and both negative emotionality and parental stress accounted for variance in vocabulary scores. While positive maternal personality was negatively associated with parenting stress, it did not have a direct effect on language outcomes. In a cross-sectional study of preschool-age children (age 2;8 to 4;10), Noel et al. (2008) examined concurrent relations between child temperament, parenting stress, and expressive and receptive vocabulary knowledge. As in Molfese et al. (2010), children's negative emotionality was associated with increased parenting stress. While both variables were negatively associated with receptive vocabulary knowledge, only parental stress was associated with expressive vocabulary knowledge.

For the current study, we used data from the Fragile Families and Child Wellbeing Study (FFWCS)—a large-scale longitudinal dataset suitable for exploring long-term effects of infant temperament and aggravation in parenting on language development (receptive vocabulary) from early to middle childhood. The FFWCS recruited families from 75 hospitals in 20 cities across the U.S., with intentional oversampling of low-income families and non-marital births (Reichman et al., 2001). Starting at birth, the FFWCS measured factors associated with children's behavior and cognition, mental and physical health, parenting,

income, and neighborhood and school environments. In year 1, the FFWCS had mothers complete portions of the Emotionality, Activity, Shyness (EAS) Temperament Survey (Buss & Plomin, 1984) and an assessment of aggravation in parenting adapted in part from the Parent Stress Inventory (Abidin, 1995). At ages 3, 5, and 9 years, children were given the Peabody Picture Vocabulary Test (PPVT) to assess their receptive vocabulary knowledge.

To determine if infant temperament and aggravation in parenting impacted vocabulary development through middle childhood, we subjected the children's PPVT scores to a longitudinal mixed-effects model, with PPVT raw scores treated as a repeated measure. In addition to our main variables of interest, we entered various demographic factors (i.e., child gender, maternal education, household income, race/ethnicity) as control variables, as each of these factors has been shown to be associated with individual differences in children's PPVT scores (Brooks et al., 2018; Brooks-Gunn et al., 1996; Rowe, 2008). Hence our aim was to determine if the infant temperament and aggravation in parenting measures would explain variance in vocabulary knowledge up to age 9 years after controlling for other factors.

2. Methods

2.1. Participants

Archival data came from the Fragile Families and Child Wellbeing study (FFWCS), a longitudinal study of cohorts of U.S. parents and their children from birth into adulthood (Reichman et al., 2001). For the analyses reported here, we excluded participants who were missing data on any of the variables of interest to avoid problems associated with imputation. Criteria for inclusion were available data for the following measures: baseline demographic variables of child gender, maternal education, household income, and race/ethnicity; infant temperament (emotionality, shyness) and aggravation in parenting at year 1; and PPVT scores at years 3, 5, 9. Our sample comprised 1,399 children out of the approximately 5,000 children enrolled in the FFWCS study.

Demographic information was collected at birth from maternal report; see Table 1 for descriptive statistics. Mothers indicated their level of education using a four-point scale: 1 = "less than high school" to 4 = "a college education and above." We recoded maternal education into three bins: 1 = "less than high school", 2 = "high school", and 3 = "some college and above" to have roughly equal numbers of participants per category. We also recoded household income into five bins: "$0 to $10,000", "$10,000 to $20,000", "$20,000 to $30,000", "$30,000 to $60,000", and "$60,000 and above" to ensure that the numbers of participants in each category were roughly equivalent. Race/ethnicity was originally coded into four categories, which we recoded into two bins: "White" and "minority" as prior literature indicates lower risk of language delays for low-income children growing up in White families in the U.S. (Brooks et al., 2018; Brooks-Gunn et al., 1996).

Table 1. Descriptive statistics for demographic variables serving as baseline factors (*N* = 1399).

Demographic Variable	Subgroup	n (%)
Child Gender		
	Boys	716 (51.0%)
	Girls	683 (49.0%)
Maternal Education		
	Less than high school	422 (30.7%)
	High school	456 (32.6%)
	Some college	373 (26.6%)
	College education and above	148 (10.5%)
*Household Income**		
	$0 to $10,000	330 (23.5%)
	$10,000 to $20,000	281 (20.0%)
	$20,000 to $30,000	316 (22.5%)
	$30,000 to $60,000	207 (14.7%)
	$60,000 and above	265 (19.0%)
Race/Ethnicity		
	White	304 (21.7%)
	Black	787 (56.2%)
	Latino/a	265 (18.9%)
	Asian	43 (3.0%)

* Overall Mean = $32,890

2.2. Measures

Infant temperament and aggravation in parenting were assessed during the year 1 interviews with the mothers (i.e., when the children were between 12 and 18 months of age). Measures were scored based on guidelines provided in the FFWCS user's guide (Bendheim-Thoman Center for Research on Child Wellbeing, 2018). Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test (PPVT-III; Dunn & Dunn, 1997) at child age 3, 5, and 9 years.

2.2.1. Emotionality and Shyness

Emotionality and shyness were measured using a subset of items from the EAS Temperament Survey for Children: Parental Ratings (Buss & Plomin, 1984). Three questions from the emotionality and shyness measures were administered to mothers at year 1. Each question was rated on a 1 to 5 scale: 1 = "not at all like my child" and 5 = "very much like my child". Emotionality was defined as the infant's tendency to become aroused easily and intensely. The three descriptions

mothers reacted to for emotionality were “often cries and fusses,” “gets upset easily,” and “reacts strongly when upset”. Shyness was defined as the infant’s tendency to be inhibited and awkward in new social situations. The descriptions for shyness were “tends to be shy,” “is very sociable,” and “is very friendly with strangers”; note that two of the shyness items were reverse-scored. The three items for each temperament indicator were averaged to create overall scores. Higher scores (closer to 5) indicated greater emotionality and shyness.

2.2.2. Aggravation in Parenting

Aggravation in parenting at year 1 was assessed using a measure taken from the Child Development Supplement of the Panel Study of Income Dynamics (Hofferth et al., 1997), which included items from the Parent Stress Inventory (Abidin, 1995). Four items measured stress associated with changes in the parent’s life: “Being a parent is harder than I thought it would be,” “I feel trapped by my responsibilities as a parent,” “I find that taking care of my child(ren) is much more work than pleasure,” and “I often feel tired, worn out, or exhausted from raising a family.” Mothers responded to each descriptive statement using a four point Likert scale, with 1 = “strongly agree” and 4 = “strongly disagree”. The four items were averaged to create an overall score, with lower scores (closer to 1) indicating a higher degree of parental aggravation.

2.2.3. Peabody Picture Vocabulary Test

The Peabody Picture Vocabulary Test, Version 3 (PPVT-III; Dunn & Dunn, 1997) was administered by examiners in the child’s home at ages 3, 5, and 9. The PPVT as a norm-referenced, untimed assessment of receptive vocabulary knowledge suitable for individuals of age 2.5 years and above. On each trial, the child is shown four pictures and instructed to pick the one that matches a vocabulary word spoken aloud by the examiner. Trials are arranged in sets of items of increasing difficulty. The first set is determined by the child’s age and adjusted downward if the child makes 2 or more errors on that set. This serves to establish the basal score (i.e., the first set with fewer than 2 errors). Additional sets are presented until the child makes eight or more errors in a set. This serves to establish the ceiling score. Raw scores are computed by adding the number of correct responses between the basal and ceiling to the basal score. Standardized scores for the PPVT were derived for each participant based on population norms, $\mu = 100$, $\sigma = 15$. Because we were interested in PPVT growth over time, we used raw scores rather than standardized scores in the analyses.

3. Results

3.1. Descriptive Statistics

Table 2 presents the descriptive statistics for measures of infant temperament and aggravation in parenting at age 1 year. Univariate correlations between

measures of infant temperament and aggravation in parenting confirmed a link between emotionality and parental aggravation, $r(1397) = –.17$, $p < .001$, with higher negativity associated with greater aggravation in parenting. Although shyness was unrelated to aggravation in parenting, $r(1397) = –.04$, $p = .143$, it was unexpectedly associated with emotionality, $r(1397) = .15$, $p < .001$, suggesting that parents tended to rate shy infants as higher in negative emotional expression.

Table 2 also presents raw and standardized PPVT scores at each age. Children's receptive vocabulary knowledge varied widely. At each age, mean standardized scores were below the normed population average ($\mu = 100$), as would be expected in a predominantly low-income sample (Brooks et al., 2018).

Table 2. Descriptive statistics for measures of infant temperament, parental stress, and receptive vocabulary (PPVT raw and standardized scores) (*N* = 1399).

		Raw Scores		Standardized Scores	
	Age	*M* (*SD*)	Range	*M* (*SD*)	Range
EAS Temperament					
Emotionality	1 year	2.8 (1.1)	1–5	n/a	
Shyness	1 year	2.4 (0.9)	1–5	n/a	
Parenting Aggravation	1 year	2.8 (0.6)	1–4	n/a	
PPVT					
Time 1	3 years	27.0 (14.3)	1-80	90.2 (12.1)	40-131
Time 2	5 years	63.1 (18.4)	4-119	87.6 (10.0)	51-153
Time 3	9 years	110.4 (19.1)	123-164	93.0 (14.2)	48-139

3.2. Linear Regression Analysis

Prior to running a longitudinal mixed-effects model spanning ages 3 to 9 years, we ran separate multivariate linear regression models at ages 3, 5, and 9 to investigate relations between PPVT scores and the various factors. In the models for ages 5 and 9, we entered raw PPVT scores at the previous time point as an additional predictor variable. Across all models, variance inflation factors < 2, indicating inconsequential collinearity.

The linear regression models clearly show the importance of demographic variables in predicting PPVT scores at each age; see Table 3 for results. Whereas girls had significantly higher PPVT scores than boys at age 5, the effect of child gender reversed at age 9. As expected, socioeconomic factors predicted significant variance in PPVT scores at all ages. Specifically, maternal education (some college and above), household income ($30,000 and above), and White race/ethnicity were associated with children having higher PPVT scores. Infant temperament and aggravation in parenting were not significant predictors of

PPVT scores in the age 3 model. Aggravation in parenting became significant in the age 5 model and infant temperament (emotionality and shyness) became significant in the age 9 model. Note that in the models at ages 5 and 9 years, PPVT scores at the previous time point were significant predictors of later scores, which would reflect stability in individual differences in receptive vocabulary knowledge over time.

Table 3. Unstandardized coefficients for regression models with raw scores on the Peabody Picture Vocabulary Test at ages 3, 5, and 9 years as the dependent variable (*N* = 1399).

Predictors	3 years	5 years	9 years
Constant	29.06***	44.06***	84.69***
Child Gender (0 = boy; 1 = girl)	1.27†	2.21**	–1.79*
Maternal Education			
High school	–0.33	1.74†	0.48
Some college and above	4.57***	6.31***	3.34**
Household Income			
$10,000 to $20,000	0.45	3.71**	1.33
$20,000 to $30,000	1.44	1.85	2.05†
$30,000 to $60,000	3.15**	4.20**	1.83
$60,000 and higher	5.56***	6.58***	5.32***
Race/Ethnicity (0 = White; 1 = minority)	–8.50***	–6.22***	–5.47***
EAS Temperament Survey			
Emotionality	–0.50	–0.37	–1.17**
Shyness	–0.24	–0.03	–0.81*
Aggravation in Parenting	0.86	1.95**	–0.65
Vocabulary at Previous Age			
PPVT raw score at age 3	n/a	0.46***	n/a
PPVT raw score at age 5	n/a	n/a	0.55***
R-squared total	18.3%	33.3%	44.1%
Residual Std Error	12.94	15.07	14.37
F-statistic	28.16***	57.54***	91.10***
F-statistic (DF)	(11, 1387)	(12, 1386)	(12, 1386)

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

3.3. Longitudinal Mixed-Effects Model

We subsequently adopted a mixed-effects approach to analyze the data longitudinally. We chose to view the data as repeated measures for practical and

conceptual reasons. Conceptually, a repeated-measures approach that takes into account both the random effects of participants and time made the most sense to us. Ultimately, there is not much of a difference between a longitudinal mixed-effects model and a latent growth curve model as they reach nearly the same conclusions in most analyses (Clark, 2017). Note that the random effects in the longitudinal mixed-effects model are essentially the latent variables in a growth curve model.

Figure 1 provides a conceptual overview of the longitudinal mixed-effects model, when the variables were measured, and how they related to the time-varying dependent variable, PPVT raw scores. Unlike a traditional linear model that generates a uniform slope and intercept for all participants (i.e., the slope and y-intercept for each participant's outcome are averaged to be nearly identical), the mixed-effects model allows each participant's slope and y-intercept to vary randomly. This allows us to determine with greater accuracy how much variance in PPVT scores is a result of fixed effects vs. random effects. The fixed effects in the model were the baseline factors (child gender, maternal education, household income, race/ethnicity) and age 1 factors (emotionality, shyness, and aggravation in parenting). The random effects refer to variance seen in the model based on participant by time, with time represented by three levels and each participant representing a group or level as well.

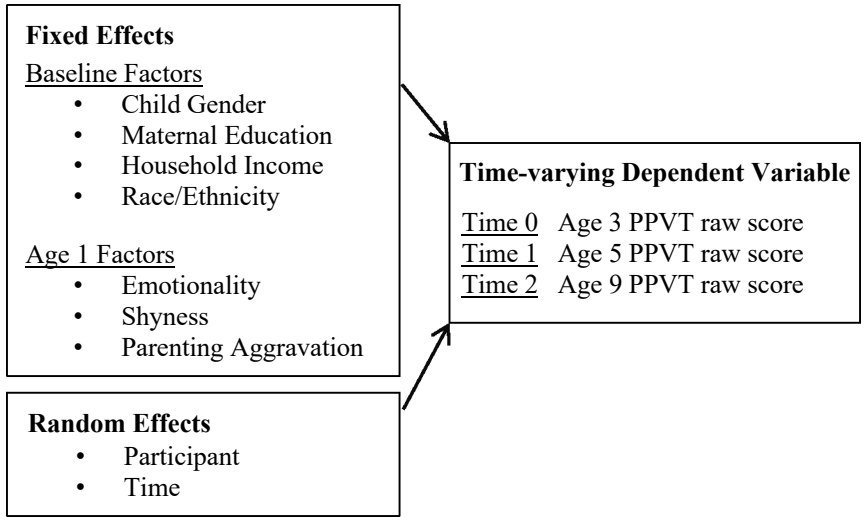

Fig. 1. Conceptual overview of the longitudinal mixed-effects model

We used the *lme4* package in R to analyze the longitudinal data, with PPVT raw scores at age 3 corresponding to time 0 in the model. We built the mixed-effects model in a series of steps, starting with just the baseline factors (child

gender, maternal education, household income, and race/ethnicity) and then adding in age 1 factors for infant temperament (emotionality and shyness) and aggravation in parenting. We then added in two-way interactions between time and age 1 factors to determine whether any influences of infant temperament and aggravation in parenting varied as a function of child age. These interactions were included in the mixed-effects model based on the results of the linear regression models, summarized in Table 3, which suggested that infant temperament and aggravation in parenting may have a greater influence on language outcomes at older ages (5 and 9 years).

Table 4. Longitudinal mixed-effects model predicting raw scores on the Peabody Picture Vocabulary Test at ages 3, 5, and 9 (*N* = 1399).

Predictors	Estimate	Confidence Interval	*p*-value
Intercept	26.05	20.50; 31.59	< .001
Time (centered at 0)	44.61	41.86; 47.35	< .001
Child Gender (0 = boy; 1 = girl)	1.70	0.48; 2.92	.006
Maternal education (bin)	3.18	2.34; 4.01	< .001
Household Income (bin)	1.79	1.30; 2.28	< .001
Race/Ethnicity (0 = White; 1 = minority)	–9.77	–11.32; –8.22	< .001
EAS Temperament Survey			
Emotionality	–0.05	–0.73; 0.62	.880
Shyness	0.16	–0.57; 0.90	.664
Aggravation in Parenting	1.35	0.30; 2.40	.012
*Age 5 * Emotionality*	–1.39	–2.15; –0.64	< .001
*Age 9 * Emotionality*	–1.26	–2.15; –0.37	.006
*Age 5 * Shyness*	–0.97	–1.83; –0.11	.027
*Age 9 * Shyness*	–1.08	–2.03; –0.12	.028
*Age 5 * Aggravation*	–0.70	–1.67; 0.27	.157
*Age 9 * Aggravation*	0.08	–1.33; 1.50	.991
Marginal R-squared	83.4%		
Conditional R-squared	91.0%		

The final mixed-effects model, summarized in Table 4, indicated significant relations between infant temperament, aggravation in parenting, and receptive vocabulary knowledge. After controlling for the baseline effects of child gender (favoring girls), maternal education, household income, and race/ethnicity (favoring White families), aggravation in parenting predicted growth in PPVT scores over time. Higher levels of parenting aggravation were associated with lower receptive vocabulary knowledge, with no evidence that the effect varied

significantly as a function of time (i.e., all interactions of age and aggravation were not significant). Note that the positive coefficient in Table 4 reflects the scoring of the measure, where lower scores indicated a higher degree of parental aggravation.

In contrast, the infant temperament measures were not associated with PPVT scores in a time-invariant fashion. Rather, both emotionality and shyness became significant over time, as indicated by the significant interactions at age 5 and age 9. The mixed-effect model thus confirmed the results of the linear regression models, indicating that parental reports of infants' negative emotionality and shyness at age 1 were associated with lower receptive vocabulary knowledge at age 9, after controlling for children's vocabulary knowledge at the previous time points. These results underscore the importance of setting slopes and intercepts randomly on participant and time-related levels, as the formula for predicting PPVT scores has a certain degree of heterogeneity. The random effects from participants and participants crossed with time accounted for a large amount of variance in the model (approximately 32%). This suggests that there is a much wider range of potential PPVT scores for any given factor than the fixed effects model can predict on its own.

4. Discussion

The current study aimed to find out whether infant temperament and aggravation in parenting have long-term impact on children's language development through age 9 years. Using a mixed-effects longitudinal model, we found significant effects of infant temperament and aggravation in parenting (assessed in year 1) on receptive vocabulary knowledge after accounting for important demographic factors (child sex, maternal education, household income, race/ethnicity). The effect of parenting aggravation on vocabulary growth appeared to be time invariant, i.e., it did not vary significantly as a function of child age. In contrast, the effects of infant temperament (negative emotionality and shyness) increased with age and, unexpectedly, were most evident at age 9 years. Notably, our initial linear regression models explained a much larger percentage of the variance in PPVT scores at ages 5 (R^2 = 33%) and 9 (R^2 = 44%) than at age 3 (R^2 =18%)—a consequence of including PPVT scores at the previous time point as a predictor of scores at the next time point. It is possible that this analytic strategy made our analyses more sensitive to weak effects of temperament on vocabulary growth at the older ages by reducing unexplained variance.

While extending finding to middle childhood, several of our findings resonate with prior research. In particular, research has linked difficult temperament (or negative emotionality) with parenting stress (e.g., McBride et al.., 2002; Östberg & Hagekull, 2000), an association confirmed in the FFCWS dataset using parent-report measures of infant emotionality and aggravation in parenting. One of the limitations of our longitudinal modeling was that we did not test for indirect effects of infant temperament on receptive vocabulary knowledge mediated by parenting aggravation. Molfese et al. (2010) found evidence of both direct and indirect effects of difficult temperament on language outcomes at 12 months of age, with indirect

effects mediated by parenting stress. Other related work (Karrass & Braungart-Rieker, 2003; Laake & Bridgett, 2018) suggests that the beneficial influence of responsive, supportive parenting on early language outcomes may vary as a function of infant temperament. Such findings underscore the need for further work to elucidate both direct and indirect effects of infant temperament and parenting behaviors on language outcomes from infancy through middle childhood. Ideally, future studies would also include measures of joint engagement and child-directed speech as both are key factors influencing early language development trajectories (Hirsh-Pasek et al., 2015; Hoff, 2006; Rowe, 2008) and may vary as a function of infant temperament (Smolak, 1987; Spinelli et al., 2018).

The infant temperament measures available in the FFCWS dataset were limited to emotionality and shyness, and did not include EAS measures of activity level or sociability. According to FFCWS documentation (Bendheim-Thoman Center for Research on Child Wellbeing, 2018), emotionality and shyness were selected as measures of temperament because they are heritable personality traits (Buss & Plomin, 1984; Plomin et al., 1988) and because shyness is associated with increased risk of anxiety disorders (Biederman et al., 1990). While there is some prior evidence that shy children lag behind their peers in language development (Spere & Evans, 2009), other research indicates minimal associations between shyness or behavior inhibition and receptive language abilities (Smith Watts et al., 2014). Moreover, while studies linking extraversion (sociability) with language development suggest advantages for children who are outgoing and talkative (Pérez-Pereira et al., 2010; Slomkowski et al., 1992), several items on the EAS sociability scale are more closely related to activity level than with shyness (Boer & Westenberg, 1994). Additionally, even though the EAS measures had previously been shown to have acceptable internal consistency at child age 18 months (Mathiesen & Tambs, 1999), the reliability of the FFCWS's abbreviated 3-item shyness scale was somewhat lower than that of the original scale, indicating that caution should be taken in interpreting results using this measure (Bendheim-Thoman Center for Research on Child Wellbeing, 2018). In light of this, we would argue for additional longitudinal research to confirm an effect of shyness on receptive vocabulary in middle childhood.

We would also suggest including attentional control (i.e., sustained attention) as a measure of infant temperament (Derryberry & Rothbart, 1988), as it has been linked to self-regulatory capabilities (Brandes-Aitken et al., 2019) and vocabulary development in recent studies (Brooks et al., 2018; Yu et al., 2019). Research on infant temperament and parenting behaviors may also help to elucidate paths of resiliency of children growing up in low-income families. For example, easy temperament has been shown to be predictive of first-grade readiness (Schoen et al., 1994), and with emotional regulatory skills like effortful control and inhibition (Kochanska et al., 2000) that foster children's academic success. Such research may inform efforts to provide socio-emotional support for families with young infants and evidence-based intervention programs to improve the quality of child-parent interactions with implications for language development.

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