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Sequences of toddler negative emotion and parent–toddler verbal communication during a waking day

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Abstract

Although the second year of life is characterized by dramatic changes in expressive language and by increases in negative emotion expression, verbal communication and emotional communication are often studied separately. With a sample of twenty-five one-year-olds (12–23 months), we used Language Environment Analysis (LENA; Xu, Yapanel, & Gray, 2009, *Reliability of the LENA™ language environment analysis system in young children's natural home environment*. LENA Foundation) to audio-record and quantify parent–toddler communication, including toddlers' vocal negative emotion expressions, across a full waking day. Using a multilevel extension of lag-sequential analysis, we investigated whether parents are differentially responsive to toddlers' negative emotion expressions compared to their verbal or preverbal vocalizations, and we examined the effects of parents' verbal responses on toddlers' subsequent communicative behavior. Toddlers' negative emotions were less likely than their vocalizations to be followed by parent speech. However, when negative emotions were followed by parent speech, toddlers were most likely to vocalize next. Post hoc analyses suggest that older toddlers and toddlers with higher language abilities were more likely to shift from negative emotion to verbal or preverbal vocalization following parent response. Implications of the results for understanding the parent–toddler communication processes that support both emotional development and verbal development are discussed.

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1 | INTRODUCTION

Although emotional development and language development are believed to be intricately related, they are historically studied as separate domains (Bloom, Tinker, & Scholnick, 2001; Cole, Armstrong, & Pemberton, 2010). For most children, these two domains change markedly in the second year of life; there is both the onset and rapid expansion of expressive language (Camaioni, 2001) and an increase in the frequency and intensity of negative emotion expressions (Karraker, Lake, & Parry, 1994; Lewis, Zimmerman, Hollenstein, & Lamey, 2004). Correlational evidence generally suggests that young toddlers' negative emotions are associated with lower language abilities both concurrently and longitudinally (Dixon & Smith, 2000; Kubicek & Emde, 2012; Nozadi et al., 2013; Salley & Dixon, 2007). Yet the specific processes by which these two communication systems co-develop are understudied.

It is well-understood that early emotional and verbal capacities emerge largely in the context of parent–child communication (Hoff, 2006; Laible & Thompson, 2007). What is less well-understood is how toddler emotion and speech influence and are influenced by interactions with parents. Investigation of the spontaneous, naturally occurring dynamics of emotion-communication interplay can yield a more nuanced understanding of whether and in what patterns toddler negative emotions elicit or disrupt language interactions with caregivers, as well as how parental reactions to toddlers' emotional and verbal communicative behavior shape toddlers' subsequent communication. Such knowledge may eventually contribute to more sophisticated ways of assessing and intervening with young children and their parents.

Two separate lines of research consistently show that that parental responsiveness to child cues is critical for both language development and emotional development (Brophy-Herb et al., 2011; Leerkes, Blankson, & O'Brien, 2009; Tamis-LeMonda, Kuchirko, & Song, 2014). However, there are three gaps in the evidence that must be addressed to understand the dynamic relations between language and emotion in daily discourse in families of young children. First, few studies assess parents' responses to both toddlers' verbalization attempts *and* their emotional cues. It is therefore largely unknown whether parents respond differentially to toddlers' emotional and verbal cues. Second, although parent responsiveness is linked to children's later outcomes, few studies investigate proximal effects of the interaction, for example, how parent responses to toddlers' verbal and emotional cues influence the nature of children's next communicative behavior. Third, parent–toddler communicative interactions, whether assessed in terms of toddler verbalizations or emotional expression, are often assessed in brief semi-structured or quasi-naturalistic observations that may not closely resemble the everyday interactions of toddlers and parents. These methods may inflate or distort estimates of parental responsiveness or child emotional or verbal cues (Crockenberg & Leerkes, 2003; McHale, Kavanaugh, & Berkman, 2003; Tamis-LeMonda, Kuchirko, Luo, Escobar, & Bornstein, 2017). Thus, the study of emotional and verbal toddler-parent communication is often decontextualized, isolating emotional and verbal communicative cues, and neglecting the moment-to-moment sequences of interaction that capture more ecologically valid patterns. Yet emotional and verbal expressions occur in concert, within in real-time, continuous interactions in toddlers' everyday experiences (Bloom et al., 2001).

We examined naturally occurring sequences of parent speech, toddler verbal or preverbal vocalizations, and toddler nonverbal negative vocalizations during one day in 1-year-olds' lives. We used an automated audio recording and processing system, Language Environment Analysis (LENA; Xu, Yapanel, & Gray, 2009), which records and quantifies continuous samples of family communication across a waking day. To our knowledge, no published study has capitalized on LENA's ability to automatically identify children's nonverbal vocal negative emotion expressions, which LENA refers to as cries. We investigated whether toddlers' nonverbal expressions of negative emotion, relative to

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their verbal or preverbal vocalizations, elicit parent verbal responses. Moreover, we investigated the extent to which parental responses to toddler cues—both verbalizations and cries—predicted toddlers' subsequent communicative behavior.

1.1 | Studying emotional and verbal communication in the second year

The second year of life is marked by rapid and dramatic changes in how young toddlers and their parents communicate. During the first year, infants communicate primarily via emotional expressions (Papousek, Jürgens, & Papoušek, 1992; Tronick, 1989); during the second year, the onset and rapid expansion of expressive language provides toddlers with more precise ways to communicate. Yet verbal expressions do not replace emotional expressions; in fact, during the second year, negative emotion expressions peak in frequency and intensity (Barry & Kochanska, 2010; Karraker et al., 1994; Lewis et al., 2004; Raikes, Robinson, Bradley, Raikes, & Ayoub, 2007).

Notably, in the first year, infants who more frequently express negative emotion develop better language skills (Beckwith & Rodning, 1996; Moreno & Robinson, 2005; Robinson & Acevedo, 2001). However, in the second year, a different pattern emerges; toddler negative emotion, often conceptualized and assessed as a temperamental trait, is generally associated with poorer language skills (Dixon & Smith, 2000; Kubicek & Emde, 2012; Nozadi et al., 2013; Salley & Dixon, 2007). This latter evidence led to the hypothesis that toddler negative emotions discourage parent responsiveness or disrupt parent–toddler communication (Kubicek & Emde, 2012). For example, because parents aim to promote the development of both verbal communication and emotional self-regulation (Brownell & Kopp, 2010), they may begin to ignore toddler negative emotion, waiting to see whether a toddler gains control autonomously or uses words. One the other hand, parents might use language to respond to negative emotion, discouraging negative emotion, helping to regulate emotions, or possibly stimulating toddler verbalizations. It is also possible that parents' verbal responses exacerbate negative emotions. None of these possibilities has been tested directly using continuous, real-time measurement of both emotional and verbal communication. Next, we integrate findings from two largely separate empirical literatures—on emotional and language development—to explore these issues and formulate this study's hypotheses.

1.1.1 | Parent responses to toddler verbal and emotional cues

Many studies of early language development either exclude toddler negative emotion (Goldstein, Schwade, & Bornstein, 2009; Tamis-Lemonda, Bornstein, Baumwell, & Damast, 1996) or focus on a variety of child communicative behaviors without distinguishing among types (Landry, Smith, Swank, Assel, & Vellet, 2001; Masur, Flynn, & Eichorst, 2005). These studies suggest that parents become increasingly responsive to more sophisticated communicative behaviors (e.g., speech, gestures) and less responsive to more rudimentary forms of communication (Bornstein, Tamis-LeMonda, Hahn, & Haynes, 2008; Gros-Louis, West, & King, 2015; Tamis-LeMonda et al., 2014; Warlaumont, Richards, Gilkerson, & Oller, 2014). It follows that negative emotions may become viewed as less advanced or acceptable once toddler expressive language emerges; however, the evidence, drawn largely from research on emotional development, is mixed. Some evidence suggests that parents become relatively less responsive to negative compared to non-distressed cues in the second year (Bornstein et al., 1992; Kochanska & Aksan, 2004). Other evidence suggests that parents increase the extent to which they respond verbally to toddlers' emotion expressions, responding *more* often to toddlers' negative emotions. These verbal responses are often intended to discourage negative emotion or aid its regulation (Capatides & Bloom, 1993; Grolnick, Kurowski, McMenamy, Rivkin, & Bridges, 1998; Spinrad,

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Stifter, Donelan-McCall, & Turner, 2004). However, the evidence is not based on investigation of the moment-to-moment proximal effects of parent responses to negative emotions.

1.1.2 | Effects of parent verbal responses to toddler cues

Parental responsiveness, parent–child communication, and parent emotion socialization are often measured by assessing the temporal and sequential contingencies of parent behaviors and child cues. Many studies examine specific two-event sequences (e.g., child behavior, parental response) and link these sequences with long-term language or socioemotional outcomes (Bell & Ainsworth, 1972; Leerkes et al., 2009; Nicely, Tamis-LeMonda, & Bornstein, 1999; Spinrad et al., 2004; Tamis-LeMonda et al., 2014). However, surprisingly few studies have directly examined the proximal effects of parent responses to toddler cues on the next step in the sequence—toddlers' subsequent communicative behaviors. This three-event sequence (child cue, parent response, child communicative behavior) is critical for understanding the mechanisms by which parents support children's verbal and emotional development (Bornstein, 2012; Bornstein et al., 2008).

Parents' responsiveness to young children's cues support reciprocal communicative routines and shape and encourage infant or toddler vocalizations (Bornstein, 2012; Tamis-LeMonda et al., 2014). During infancy, these cues are primarily emotional; parents speak in response to infants' emotional signals such that verbal and emotional information interact in conversational turns (Casillas, 2014; Lester & Boukydis, 1992), which appears to contribute to early language acquisition (Bell & Ainsworth, 1972; Nicely et al., 1999). In the toddler period, children begin to use words but still communicate via emotion. Parents' responsiveness to toddlers' preverbal or verbal signals supports language acquisition (Tamis-Lemonda et al., 1996) yet examination of the immediate effects of parents' responses to these signals in the interactional sequence is limited. Moreover, it is unknown how parents' responses to toddlers' *emotional* signals influence the toddler's next communicative behavior. Do parents continue to respond to negative emotions as conversational turns? Might they respond in ways that exacerbate or reinforce negative expression, or do they respond in ways that facilitate verbal communication?

One study used LENA to naturalistically sample parent–child communication and examine the proximal effects of parental verbal responses to various toddler cues (Warlaumont et al., 2014). It reported that parents are more verbally responsive to young children's preverbal vocalizations than to noises such as grunts, burps, sighs, and cries. Moreover, parents' responses to child preverbal vocalizations predicted children's subsequent expressive behavior, such that the child's next vocalization was also likely to be preverbal. Yet toddler vocal negative emotion was treated as a noise and not a communicative behavior. Moreover, this cross-sectional study included children from wide age range (8–48 months). Thus, the specific pattern of parental responses to *toddler* negative emotion expressions, and their effect on toddlers' subsequent expression, was not assessed.

1.2 | Facilitating naturalistic sampling of communication with automated measurement

Capturing complex moment-to-moment processes in parent–child interactions and verbal communication requires labor and time-intensive coding or transcription; automated methods can reduce this burden to facilitate the study of real-time interaction dynamics (Messinger et al., 2014). LENA (Xu et al., 2009) records 10–16 hr of young children's lives. Its automated speech processing provides nearly instantaneous estimates of parent and child speech and conversational turns. Most studies using LENA use aggregated estimates of daily language input and output. Only a few have capitalized on

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the continuous record of adult speech and child vocalizations to examine dynamics of parent–child communication (see Ko, Seidl, Cristia, Reimchen, & Soderstrom, 2016; Warlaumont et al., 2014). Moreover, no known study has capitalized on LENA's ability to identify non-verbal vocal negative emotion (e.g., cries, fusses, whines).

In addition to efficiently measuring parent–toddler communication dynamics, LENA may better capture the natural variability in these patterns than do assessments during brief, semi-structured laboratory tasks or quasi-naturalistic home observations. These observation methods may pull for verbal interactions, parental responsiveness, or specific emotions, resulting in distorted estimates and constrained variability in interaction patterns (Crockenberg & Leerkes, 2003; McHale et al., 2003; Tamis-LeMonda et al., 2017). However, because LENA's recorder is worn by the child across a full day, LENA may provide more valid estimates of—and capture greater variability in—parent–child communication dynamics (Tamis-LeMonda et al., 2017; Zauche, Thul, Mahoney, & Stapel-Wax, 2016). Thus, LENA provides an efficient, ecologically valid method for sampling moment-to-moment emotional and verbal parent–toddler communication patterns.

1.3 | Current study

We used LENA to analyze patterns of parent–toddler communication in a sample of one-year-olds. We examine the predominant sequential patterns of toddler non-verbal vocal negative emotion (which we refer to as cries), toddler speech-related vocalizations, and adult speech. We investigate (a) whether parents are more or less likely respond to toddlers' cries relative to their vocalizations and (b) how parental responses to cries and vocalizations predict toddlers' subsequent communicative behavior (e.g., whether toddlers are more likely to cry or vocalize next). Although individual differences are not of primary interest in the present study, we employ statistical methods that account for heterogeneity in sequential patterns. Given rapid growth in language abilities in the second year, in post hoc analyses, we also examine whether toddlers' age or concurrent language abilities are associated with variability in sequential patterns.

We hypothesized that parents would be less likely to respond to cries than to vocalizations. However, we predicted that, when adult speech followed toddler cries, toddlers would be most likely to vocalize next. We expected that the predicted patterns may be stronger for toddlers with more advanced language abilities, given that parents may be less responsive to negative emotions in toddlers who are more competent verbal communicators, and that parental responses to these toddlers' negative emotions may be more successful at eliciting verbal communication.

2 | METHODS

Data were drawn from the Toddler Daily Language Environment (TodDLE) Project, a study of the communication patterns of 25 1-year-olds (whom we refer to as toddlers) and their parents. Families audio-recorded a full waking day (at least 10 hr) in their homes using LENA and participated in two home visits during which toddlers' language abilities were assessed and semi-structured parent–child interaction tasks were administered. The present study was conducted according to guidelines outlined in the Declaration of Helsinki, with written informed consent obtained from a parent or guardian for each child before any assessment or data collection. All procedures in this study were approved by the Institutional Review Board at the Pennsylvania State University Office for Research Protections.

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2.1 | Participants

Twenty-six families with a toddler between 12 and 23 months of age were recruited from a small university town and surrounding area. Families with a child in the target age range were identified through a database of birth records and were contacted via mailings and phone calls. Families were also recruited through flyers posted at daycares, public places, and events, and through word of mouth. One family's data were unusable because they recorded less than 10 hr, resulting in a final sample of 25 families. LENA was purchased at discounted rate available to graduate students, with the stipulation that the sample size was limited to 25 participants.

Families were eligible to participate if (a) there were two caregivers living in the home, (b) English was the primary language spoken, and (c) they had only one child. We studied only-children given the associations between birth order or sibling presence with language acquisition and parent–child communication (Hoff, 2006). Toddlers born earlier than 36 weeks of gestation, or whose parents had significant concerns about their health or development, were not eligible to participate. Finally, participating toddlers were required to be walking, given that walking onset is associated with transitions in language acquisition and in the affective quality of parent–child interactions (Biringen, Emde, Campos, & Appelbaum, 1995; Walle & Campos, 2014).

Twenty-four heterosexual couples and one same-sex couple (female) participated in the study. The average total household income was $84,057 (range: 0–$150,000). Families were predominantly two-income households; 80% of parents worked full time and 14% worked part time. Overall, the sample was highly educated. On average, parents had completed 17.80 years of education; 84% of parents had completed college or above, and many had completed advanced degrees. The sample was predominantly White/Caucasian (92% of toddlers). Toddlers (60% female) ranged from aged 12.58 to 23.52 months (mean: 16.60, *SD*: 3.58).

2.2 | Procedures

The study involved one recording day using LENA and two home visits. For the recording day, families were asked to choose a single day (usually a Saturday or Sunday), during which they planned to stay at home for most of the day and were not anticipating visitors. The toddler wore a small audio recorder (LENA Digital Language Processor) in a vest from the time the toddler woke up until bedtime. During activities such as bathing or naptime, families removed the vest, but kept the recorder running nearby. Families were asked to limit outings to public places and to pause the recorder if leaving home. If a visitor came to the house, families were given the option to inform visitors of their participation. If visitors agreed, they signed a visitor consent form, and recording continued. If visitor consent was not obtained, families paused the recorder until the visitors left. All outings and visitors were documented via questionnaire.

During the home visits, an assessment of the toddlers' cognitive, receptive, and expressive language was administered. The primary caregiver filled out questionnaires about family demographic information and their child's language development. Families were compensated $20 for study completion.

2.3 | Measures

2.3.1 | Language Environment Analysis

The LENA software processed recordings, segmenting the audio files based on sound source. We focus on three segment types: toddler cries, toddler vocalizations, and adult speech. Any non-verbal vocal expressions of negative emotions, which included fusses, whines, and whimpers, in addition to cries, were

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identified by LENA as a cry. For the sake of clarity and brevity, we will refer to these sounds as cries in the methods and results. Toddler vocalizations were defined as verbal or preverbal speech-related sounds, which could include speech but also included babbling and attempts at verbal communication. Adult speech referred to any utterance spoken by an adult within the vicinity of the toddler, whether or not the speech was directed at the toddler. All other sounds (e.g., silences, ambient noise, other non-speech sounds) were re-categorized as "No Vocal Communication," resulting in four mutually exclusive categories.

LENA's agreement with human coders

Previous studies have demonstrated adequate agreement between LENA and human coders (82% agreement for adult speech, 75% for target child vocalizations, and 84% for vegetative or fixed signals; Oller et al., 2010; Xu et al., 2009). Though the vegetative and fixed signal category includes cries, LENA's agreement with human coders for identifying cries specifically has not been previously assessed. We assessed human agreement with LENA classification for 30% of the participants. Consistent with the procedures outlined by LENA, for each of these participants, three 10-min sections, identified by LENA as being in the top 10th percentile, middle 20th percentile, and bottom 10th percentile for cry frequency, were chosen. A human coder (a trained undergraduate research assistant) listened to these 10-min sections and identified the onsets and offsets of cries. Cries were defined as vocal, nonverbal *negative* emotion expressions (e.g., cries, fusses, whines); non-negative expressions of emotions (e.g., a laugh, a happy squeal) were not included in this definition. Agreement between human and LENA identification of cries was 79.3% (Cohen's Kappa = .67).[1]

Data preparation

To prepare for analyses, data files were cleaned to isolate the four segment types of interest. LENA uses Hart and Risley's (1995) 5-s criterion to distinguish fleeting pauses from true breaks in communication. If five seconds or more passed without toddler cries, vocalizations, or adult speech, this was classified as "No Vocal Communication." On the other hand, brief pauses in vocal communication (<5 s) were excluded from analyses. For example, if a toddler vocalized and there was a pause of less than 5 s before adult speech, this was considered a transition from vocalization to adult speech. In addition, because we were interested primarily in the *transitions* between speakers and segment types, we conducted analyses such that segments could not repeat. As such, if an adult was speaking, paused briefly (<5 s), then spoke again, we considered this one adult speech event.

Thus, the data were prepared based on the above criteria such that each participant's file reflected a continuous stream of four mutually exclusive and exhaustive categories: toddler cry (CRY), toddler verbal or preverbal vocalization (VOC), adult speech (ADT), and no vocal communication (NVC).

2.3.2 | Toddler language ability

Toddlers' language abilities were assessed using parent report and an objective assessment administered in the home. A language composite score was calculated for post hoc analyses. Descriptive statistics and intercorrelations of these measures are found in Table 1.

[1]LENA's algorithm classifies audio signals into mutually exclusive categories. Therefore, LENA could not, for example, identify speech that contained negative emotion. To investigate how often toddlers' verbal or preverbal vocalizations co-occurred with nonverbal vocal negative emotion, the human coder was allowed to classify such sounds as a vocalization/cry. However, only 9% of the segments identified by LENA as cries, and only 5% of the segments identified by LENA as vocalizations, were identified by the human coder as a vocalization/cry. Thus, the majority (93%) of cries and vocalizations identified by LENA were truly mutually exclusive; speech-like vocalizations were predominantly non-negative and cries rarely contained speech.

TABLE 1 Descriptive statistics and intercorrelations of toddler language measures

	Mean (*SD*)	Range	1.	2.	3.
1. MCDI productive vocabulary	63.16 (78.655)	0–270	–		
2. Bayley expressive language	15.24 (3.257)	11–22	.911**	–	
3. Bayley receptive language	15.40 (3.452)	11–24	.736***	.740***	–

**$p < .01$.
***$p < .001$.

MacArthur communicative development inventory

The toddler's primary caregiver completed the MacArthur communicative development inventory (MCDI; Fenson et al., 2007), a parent-reported questionnaire on young children's language development. Two versions, *Words and Gestures* (for 12- to 16-month-olds) and *Words and Sentences* (for 17- to 23-month-olds) were used. Both versions include a vocabulary checklist and provide an estimate of a child's productive vocabulary (# of words used).

Bayley scales of infant and toddler development screening test, third edition (Bayley-III screening test)

The first author administered three subtests (Cognitive, Receptive Language, and Expressive Language) of the Bayley-III Screening Test (Bayley, 2006), which briefly assess a brief assessment of young children's cognitive, language, and motor abilities. The Bayley-III Screening Test yields raw scores (# items correct), rather than standard scores, with cut points to determine whether the child is at risk for developmental delay.

Language composite

A language composite was derived by z-transforming and then summing the raw scores of the MCDI productive vocabulary scale, the Bayley-III expressive language scale, and the Bayley-III receptive language scale.

2.4 | Data analytic plan

We employed a multilevel extension of lag-sequential analysis—multilevel log-linear modeling (Howe, Dagne, & Brown, 2005)—for the majority of analyses. Traditional lag-sequential analysis (Bakeman & Quera, 2011) involves generating a contingency table, in which rows represent all possible behaviors of interest at Lag0, and columns represent all possible behaviors that follow (Lag1). The values in each cell represent joint frequencies, or the frequency at which a specific behavior at Lag0 (e.g., toddler cry) is followed by at specific behavior at Lag1 (e.g., adult speech).

Traditional lag-sequential analysis pools data across participants, creating one contingency table for the entire sample. Multilevel log-linear modeling, however, involves generating a contingency table for each participant (for a thorough summary of the method and sample syntax, see Howe et al., 2005). Next, each cell of the table is incorporated in its own line of data as a set of contrasts. The log of each cell count is modeled as a linear function of its row and its column, allowing the comparison of specific sequences of interest while accounting for the relative frequency of all target behaviors and for the non-independence of rows and columns. The row and column counts, and the associations among them, are modeled as random effects and allowed to vary across participants. Estimates for the row and column contrasts reflect the average size and direction of differences between frequencies of behaviors,

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accounting for all other effects. Estimates for the association contrasts reflect the average size and direction of differences in log counts of specific sequences of interest (e.g., CRY → ADT vs. VOC → ADT), accounting for all other effects. This can be interpreted as statistically comparing the likelihood of the two sequences occurring (Howe et al., 2005). This statistical approach allows researchers to account for the nestedness of sequential data within participants, and to test for significant heterogeneity in sequential patterns. Multilevel log-linear modeling has several additional advantages, including the ability to account for differences in communication length or frequency, and to include sources of heterogeneity as level 2 predictors (Dagne, Howe, Brown, & Muthén, 2002; Howe et al., 2005).

We used the Generalized Sequential Querier (GSEQ; Bakeman & Quera, 2011) to generate 2-event and 3-event joint frequency tables for each participant. For the purposes of multilevel modeling, rather than conduct analyses on the full (4×4 or $4 \times 4 \times 4$) tables, it was necessary to collapse categories that were not of interest into an "Other" category. For example, we compared the Lag0 categories of interest, CRY and VOC, with each other and collapsed ADT and NVC into an "Other" category. Collapsing the tables allowed us to isolate hypotheses of interest, increase statistical power, and eliminate structural zeroes. Aim 2 involved examining a three-event ($3 \times 2 \times 3$, 18 cell) table. Due to limited statistical power, the full three-event table could not be included in a single multilevel model. Instead, we generated three 2×3 tables and ran three separate multilevel models: one each for sequences beginning with toddler cry, with toddler vocalizations, or with "Other" communication variables (ADT or NVC).

Once the data were prepared, we used MPLUS (Muthén & Muthén, 1998) to conduct multilevel log-linear modeling. We included covariances among row, column, and association effects as Level 2 parameters to account for heterogeneity in sequential patterns.

Although the sample size did not provide enough statistical power to include covariates in the multilevel models, we conducted post hoc analyses to examine the association between toddler language or toddler age and the likelihood of specific sequences occurring. For these analyses, we used GSEQ to calculate transitional probabilities and adjusted residuals (Bakeman & Quera, 2011) for the sequences of interest from each aim. Then, we examined the correlations of these statistics with toddler language ability and toddler age.

3 | RESULTS

3.1 | Descriptive statistics

Descriptive statistics and intercorrelations of LENA's full-day estimates of communication variables, and of the toddler language composite, are found in Table 2. A repeated-measures ANOVA indicated that the frequencies of the communication variables significantly differed from one another, $F(2, 48) = 48.802$, $p < .001$. Specifically, toddler cries were significantly less frequent than toddler vocalizations (mean difference = −1,475.316, $p < .001$) and adult speech (mean difference = −1,931.075, $p < .001$). However, toddlers' vocalization frequency did not differ significantly from adult speech frequency (mean difference = −455.759, $p = .172$). Toddlers' cry frequency was significantly correlated with vocalization frequency, $r(23) = .480$, $p = .015$, but not with adult speech frequency or toddler language ability.

3.2 | Aim 1: Parent verbal responses to toddler cries and vocalizations

The overall transitional probabilities of adult speech following toddler cries compared to vocalizations are presented in Table 3. Across the sample, the probability that adult speech followed a toddler cry was 37%, whereas the probability that adult speech followed a toddler vocalization was 53%. The

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TABLE 2 Descriptive statistics and intercorrelations of LENA-estimated communication variables and toddler language composite

	Mean (*SD*)	Range	1.	2.	3.	4.
1. Toddler cry frequency[a]	805.001 (471.531)	343.446 to 2,297.134	–			
2. Toddler vocalization frequency[a]	2,280.318 (1,096.675)	614.594 to 5,012.033	.480*	–		
3. Adult speech frequency[a]	2,736.077 (982.077)	1,385.924 to 5,048.747	.310	.401*	–	
4. Language composite	0.000 (2.788)	−3.03 to 5.73	.268	.755***	.173	–

[a]Given the range in recording lengths for each participant, these estimates reflect 12-hr projections.
*$p < .05$.
***$p < .001$.

TABLE 3 Transitional probabilities for Aim 1

	Target (Lag1) transitional probabilities	
Given (Lag0)	**Parent speech (ADT)**	**OTHER$_{(cry, voc, nvc)}$**
Toddler CRY	.37	.63
Toddler VOC	.53	.47
OTHER$_{(adt, nvc)}$	.22	.78

results of the multilevel model are presented in Table 4, and the covariance estimates are presented in Table 5. The significant Association 1 contrast ($\beta_4 = 1.026$, $p < .001$) indicates that, once accounting for other model effects, toddler cries were significantly more likely to be followed by adult speech than by other communication variables. However, the significant Association 2 contrast ($\beta_5 = -1.342$, $p < .001$) indicates that toddlers' cries were significantly less likely than vocalizations to be followed by adult speech. The significant variance estimates for all contrasts in the model indicate significant variation in the frequencies of cries, vocalizations, and adult speech, and in the probabilities that adult speech followed cries and vocalizations, across the sample.

Thus, as expected, adult speech was more likely to follow toddlers' vocalizations than to follow toddlers' cries. However, toddler cries were more likely to be followed by adult speech than by any other communication variables (including no vocal communication).

3.2.1 | Follow-up analysis

We ran one follow-up analysis to explore the possibility that parents are more responsive to toddler's vocalizations simply because toddlers vocalize more when they are interacting with the parent and cry more when they are not interacting with the parent (e.g., when the parent is not present). Rather than using the record from the full waking day, we re-ran the analyses using only vocal activity blocks (blocks of vocal activity separated by periods of no vocal communication; LENA Foundation, 2011) containing *both* toddler and adult vocal activity. The results remained the same; adult speech was significantly more likely to follow toddler's vocalizations than to follow toddler's cries. Thus, whether focusing only on parent–toddler interactions or on a full day, parents were more responsive to toddlers' vocalizations than to toddler cries.

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TABLE 4 Results of multilevel log-linear analysis for Aim 1

Parameter	Effect	Contrast	Estimate (*SE*)	Estimate/*SE*	Variance (*SE*)	Variance/*SE*
β_1	Row 1 (Lag0)	CRY vs. VOC	−0.065 (.079)	−0.824	.150 (.033)	4.481***
β_2	Row 2 (Lag0)	VOC vs. $OTH_{(adt, nvc)}$	−0.660 (.048)	−13.677***	.053 (.020)	2.661**
β_3	Col. 1 (Lag1)	ADT vs. $OTH_{(cry, voc, nvc)}$	−0.649 (.033)	−19.472***	.029 (.008)	3.824***
β_4	Association 1	CRY → ADT vs. CRY → $OTH_{(voc, nvc)}$	1.026 (.112)	9.196***	.313 (.063)	4.950***
β_5	Association 2	CRY → ADT vs. VOC → ADT	−1.342 (.123)	−10.917***	.378 (.079)	4.754***
	Model Fit: AIC = −55.920; BIC = 7.303; Log-linear Likelihood = 48.960					

**p < .01.
***p < .001.

TABLE 5 Covariance parameters for Aim 1

	β_1	β_2	β_3	β_4	β_5
β_1: CRY vs. VOC	–				
β_2: VOC vs. $OTH_{(adt, nvc)}$	0.067**	–			
β_3: ADT vs. $OTH_{(cry, voc, nvc)}$	−0.049**	−0.038**	–		
β_4: CRY → ADT vs. CRY → $OTH_{(voc, nvc)}$	0.192***	0.074**	−0.066***	–	
β_5: CRY → ADT vs. VOC → ADT	−0.196***	−0.078**	0.071***	−0.338***	–

**p < .01.
***p < .001.

3.3 | Aim 2: Toddlers' cries and vocalizations following parent verbal responses

The overall transitional probabilities for the three-event sequences beginning with toddler cries, with toddler vocalizations, or with "Other" are presented in Table 6. Of note, because codes cannot repeat, when adult speech followed $Other_{(adt, nvc)}$, this can be interpreted as adult speech following NVC, in other words, an adult speaking after a period of no vocal communication. Similarly, when $Other_{(adt, nvc)}$ followed adult speech, this can be interpreted as NVC following adult speech, or, communication ending following adult speech. The results of the three multilevel models (sequences beginning with toddler cries, with toddler vocalizations, or with "Other") are displayed in Table 7, and the covariance estimates are presented in Table 8. The significant variance estimates for all contrasts in all three models indicate significant variation in the frequencies of cries, vocalizations, and adult speech, and in the sequential associations among them.

3.3.1 | Sequences beginning with toddler cries

When adult speech followed a toddler cry, the probability of toddlers crying next was 33%, whereas the probability of toddlers vocalizing next was 44%. The results of the multilevel model (Table 7a) indicated that, when adult speech followed a toddler cry, toddlers were marginally more likely to

TABLE 6 Transitional probabilities for Aim 2

	Target (Lag2) transitional probabilities		
	Toddler CRY	**Toddler VOC**	**OTHER$_{(adt, nvc)}$**
Given Lag0CRY			
Lag 1 parent speech (ADT)	.33	.41	.26[a]
Lag 1 other$_{(voc, nvc)}$	.33	.16	.51
Given Lag0VOC			
Lag 1 parent speech (ADT)	.14	.59	.28[a]
Lag 1 other$_{(cry, nvc)}$	.10	.50	.40
Given Lag0OTH$_{(adt, nvc)}$			
Lag 1 parent speech (ADT)	.09[b]	.26[b]	.65[a,b]
Lag 1 other$_{(cry, voc, nvc)}$	.10	.14	.77

[a]Because codes cannot repeat, these values represent the probability that, when adult speech occurs at Lag 1, NVC occurs at Lag 2.
[b]Because codes cannot repeat, these values represent transitional probabilities at Lag0 NVC, Lag1 ADT.

vocalize next than to cry next ($\beta_4 = -0.082$, $p = .060$), and were significantly more like to vocalize next than for communication to stop ($\beta_5 = 0.719$, $p < .001$).

3.3.2 | Sequences beginning with toddler vocalizations

When adult speech followed a toddler vocalization, there was a 14% probability of toddlers crying next, whereas there was a 59% probability of toddlers vocalizing next. However, the results of the multilevel model (Table 7b) indicate that, once accounting for other model effects, when adult speech followed a toddler vocalization, toddlers were significantly more likely to cry next, relative to their likelihood of vocalizing ($\beta_4 = 0.211$, $p = .003$). Nonetheless, it was significantly more likely for toddlers to vocalize next than for communication to stop ($\beta_5 = 0.336$, $p < .001$).

3.3.3 | Sequences beginning with "Other"

When adult speech followed a period of no vocal communication, there was a 9% probability that a toddler cry followed next, and a 26% probability that a toddler vocalization followed next. The multilevel model (Table 7c) indicates that, when adult speech followed no vocal communication, a toddler vocalization was most likely to follow, compared both to toddler cries ($\beta_4 = -0.165$, $p < .001$), and to another period of no vocal communication ($\beta_5 = 0.328$, $p < .001$).

3.3.4 | Aim 2 result summary

When adult speech followed a toddler cry, as expected, toddlers were most likely to vocalize next. Once accounting for overall frequencies of communicative behaviors, toddlers were marginally more likely to vocalize next than to cry, and significantly more likely to vocalize than to end communication. When adult speech followed a toddler vocalization, as expected, transitional probabilities indicate that toddlers were most likely to vocalize next. Interestingly, however, once accounting for overall frequencies of communicative behaviors in the multilevel models, toddlers were significantly more likely to cry than to vocalize following an adult response to their vocalization. Finally, when

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TABLE 7 Results of multilevel log-linear analysis for Aim 2

Parameter	Effect	Contrast	Estimate (*SE*)	Estimate/*SE*	Variance (*SE*)	Variance/*SE*
a) Lag0Cry						
β_1	Row 1 (Lag1)	ADT vs. $OTH_{(cry, voc, nvc)}$	−.254 (.043)	−5.873***	.045 (.010)	4.736***
β_2	Col. 1 (Lag2)	CRY vs. VOC	.027 (.047)	0.569	.055 (.015)	3.711***
β_3	Col. 2 (Lag2)	VOC vs. $OTH_{(adt, nvc)}$	−.569 (.034)	−16.714***	.029 (.009)	3.253***
β_4	Association 1	CRY → ADT → CRY vs. CRY → ADT → VOC	−.082 (.043)	−1.879†	.046 (.010)	4.860***
β_5	Association 2	CRY → ADT → VOC vs. CRY → ADT → $OTH_{(nvc)}$	.719 (.086)	8.324***	.179 (.049)	3.633***
	Model Fit: AIC = 78.700; BIC = 141.923; Log-linear Likelihood = −18.350					
b) Lag0VOC						
β_1	Row 1 (Lag1)	ADT vs. $OTH_{(cry, voc, nvc)}$	.028 (.048)	0.574	.058 (.013)	4.609***
β_2	Col. 1 (Lag2)	CRY vs. VOC	−.992 (.041)	−24.149***	.027 (.009)	2.916**
β_3	Col. 2 (Lag2)	VOC vs. $OTH_{(adt, nvc)}$	−.432 (.037)	−11.149***	.034 (.009)	3.824**
β_4	Association 1	VOC → ADT → CRY vs. VOC → ADT → VOC	.211 (.071)	2.974**	.123 (.027)	3.333***
β_5	Association 2	VOC → ADT → VOC vs. VOC → ADT → $OTH_{(nvc)}$	.336 (.072)	4.668***	.126 (.034)	3.700***
	Model Fit: AIC = 40.301; BIC = 103.524; Log-linear Likelihood = 0.849					
c) Lag0$OTH_{(adt, nvc)}$						
β_1	Row 1 (Lag1)	ADT vs. $OTH_{(cry, voc, nvc)}$	−.580 (.027)	−21.294***	.017 (.006)	2.921**
β_2	Col. 1 (Lag2)	CRY vs. VOC	−.836 (.039)	−21.198***	.033 (.012)	2.759**
β_3	Col. 2 (Lag2)	VOC vs. $OTH_{(adt, nvc)}$	−1.272 (.033)	−38.524***	.021 (.010)	2.125*
β_4	Association 1	$OTH_{(nvc)}$ → ADT → CRY vs. $OTH_{(nvc)}$ → ADT → VOC	−.165 (.036)	−4.630***	.027 (.009)	3.002**
β_5	Association 2	$OTH_{(nvc)}$ → ADT → VOC vs. $OTH_{(nvc)}$ → ADT → $OTH_{(nvc)}$	.328 (.055)	5.961***	.078 (.016)	5.033***
	Model Fit: AIC = −47.110; BIC = 16.113; Log-linear Likelihood = 44.555					

†$p < .10$.
*$p < .05$.
**$p < .01$.
***$p < .001$.

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TABLE 8 Covariance parameters for Aim 2

	β_1	β_2	β_3	β_4	β_5
a) Lag0Cry					
β_1: ADT vs. $OTH_{(cry, voc, nvc)}$	–				
β_2: CRY vs. VOC	0.013	–			
β_3: VOC vs. $OTH_{(adt, nvc)}$	−0.023***	0.011	–		
β_4: CRY → ADT → CRY vs. CRY → ADT → VOC	0.002	−0.022*	−0.009	–	
β_5: CRY → ADT → VOC vs. CRY → ADT → $OTH_{(nvc)}$	0.048**	−0.002	−0.051*	0.031	–
b) Lag0VOC					
β_1: ADT vs. $OTH_{(cry, voc, nvc)}$	–				
β_2: CRY vs. VOC	−0.029**	–			
β_3: VOC vs. $OTH_{(adt, nvc)}$	−0.023*	0.006	–		
β_4: VOC → ADT → CRY vs. VOC → ADT → VOC	0.047**	−0.031*	−0.004	–	
β_5: VOC → ADT → VOC vs. VOC → ADT → $OTH_{(nvc)}$	0.059**	−0.033**	−0.018	0.116**	–
c) Lag0$OTH_{(adt, nvc)}$					
β_1: ADT vs. $OTH_{(cry, voc, nvc)}$	–				
β_2: CRY vs. VOC	$-0.016^{\dagger}$	–			
β_3: VOC vs. $OTH_{(adt, nvc)}$	$-0.014^{\dagger}$	0.023*	–		
β_4: OTH → ADT → CRY vs. OTH → ADT → VOC	0.004	−0.001	−0.005	–	
β_5: OTH → ADT → VOC vs. OTH → ADT → $OTH_{(nvc)}$	−0.014*	−0.003	−0.008	0.018*	–

$^{\dagger}p < .10$.
$^{*}p < .05$.
$^{**}p < .01$.
$^{***}p < .001$.

parents speak after a period of no vocal communication, toddlers are more likely to vocalize than to cry next.

3.4 | Post hoc analyses

To examine whether toddler language ability or toddler age accounted for variability in communication patterns, we estimated transitional probabilities and adjusted residuals for the specific sequences of interest within each study aim, for each participant. Transitional probabilities represent the likelihood that a given communication behavior is followed by a target behavior. Adjusted residuals reflect the extent to which the observed joint frequency of two communicative behaviors differs from chance, in other words, whether the observed joint frequency is significantly different than would be expected given the overall frequencies of the behaviors. Thus, adjusted residuals indicate whether the frequency of a specific sequence is statistically meaningful. In Table 9, we report the pooled estimates and the range of these metrics for each sequence and then report the estimates' bivariate correlations with the toddler language composite and with toddler age.

Toddler language ability and toddler age were unrelated to the likelihood that adult speech followed a toddler cry ($r_{problang} = -.104$, $p = .621$, $r_{adj.residlang} = .036$, $p = .866$; $r_{probage} = -.007$, $p = .974$,

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TABLE 9 Estimates and ranges of transitional probabilities and adjusted residuals for selected associations, and their correlation with toddler language

	Statistic	Pooled estimate	Range	Correlation with toddler language	Correlation with toddler age
Aim 1					
CRY → ADT	Probability	.37	0.20 to 0.54	−.104	−.007
	adj. resid.	2.16	−2.99 to 11.70	.036	.134
VOC → ADT	Probability	.53	0.36 to 0.73	.103	.150
	adj. resid.	16.79	2.55 to 41.24	.520**	.523**
Aim 2					
CRY → ADT → CRY	Probability	.33	0.17 to 0.47	−.154	−.142
	adj. resid.	−0.07	−5.12 to 2.53	−.036	−.131
CRY → ADT → VOC	Probability	.41	0.18 to 0.66	.565**	.558**
	adj. resid.	6.08	0.08 to 18.04	.530**	.562**
VOC → ADT → CRY	Probability	.14	0.07 to 0.28	−.008	.056
	adj. resid.	1.76	−2.65 to 10.17	.332	.362†
VOC → ADT → VOC	Probability	.59	0.35 to 0.71	.624**	.602**
	adj. resid.	2.45	−2.87 to 8.81	.089	.225

Note: Reported transitional probabilities and adjusted residuals were estimated from the collapsed (3 × 2 and 3 × 2 × 3) tables. Adjusted residuals with values greater than |1.96| indicate that joint frequencies are significantly greater than would be expected by chance.

†$p < .10$.

**$p < .01$.

$r_{adj.residage} = .134$, $p = .522$), or to the likelihood that, when adult speech followed a cry, the toddler cried next ($r_{problang} = -.154$, $p = .463$, $r_{adj.residlang} = -.036$, $p = .865$; $r_{probage} = -.142$, $p = .497$, $r_{adj.residage} = -.131$, $p = .532$). However, higher toddler language ability and toddler age *were* associated with greater likelihood that, when a toddler cried and an adult spoke next, the toddler subsequently vocalized ($r_{problang} = .565$, $p = .003$, $r_{adj.residlang} = .530$, $p = .006$; $r_{probage} = -.558$, $p = .004$, $r_{adj.residage} = .562$, $p = .003$). This indicates that, when parents responded verbally to their toddler's cries, toddlers with higher language ability, or older toddlers, were more likely to vocalize next, at above chance levels (see Figure 1 for a scatterplot of this association).

Toddler language ability and toddler age were significantly associated with adult speech following toddler vocalizations at frequencies greater than expected by chance ($r_{problang} = .103$, $p = .624$, $r_{adj.residlang} = .520$, $p = .008$; $r_{probage} = -.150$, $p = .474$, $r_{adj.residage} = .523$, $p = .007$). Moreover, both higher toddler language ability and older toddler age were associated with higher probability that, after adult speech followed a vocalization, the toddler vocalized next ($r_{prob} = .624$, $p = .001$; $r_{probage} = .602$, $p = .003$). However, toddler language ability and toddler age were not correlated with the adjusted residual for this sequence ($r_{adj.residlang} = .089$, $p = .672$; $r_{adj.residage} = .225$, $p = .279$). This indicates that, although older toddlers with higher language skills are more likely to vocalize again after their parents respond to their vocalization, language ability and age do not enhance this likelihood over and above what one would expect by chance.

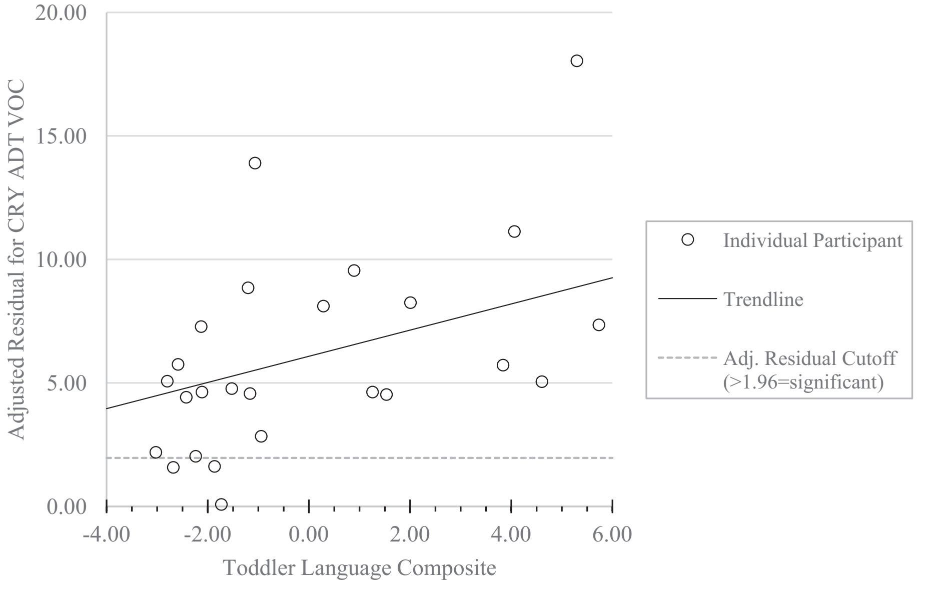

FIGURE 1 Scatterplot of the association between toddler language ability and the adjusted residuals for the CRY → ADT → VOC sequence

3.5 | Results summary

Toddler cries were less likely than toddler vocalizations to be followed by parent speech. However, when parent speech followed toddler cries, toddlers were most likely to vocalize next, and this likelihood was stronger for toddlers with higher language ability or older toddlers.

4 | DISCUSSION

The toddler period is characterized by frequent negative emotion expression and by the emergence of verbal communication (Brownell & Kopp, 2010); thus, studies that exclude emotion expressions from examination of verbal communication ignore a salient feature of toddlerhood. How toddlers' cues—both emotional and verbal—naturally emerge within parent–toddler communication, and how they elicit and are subsequently influenced by parents' verbal responses, is largely unknown. We addressed these gaps by examining the sequential patterns of toddlers' negative emotion and language and parent language as they naturally unfolded over the course of a day of toddlers' lives.

As expected, parents were less verbally responsive to toddlers' vocal negative emotion expressions than they were to toddlers' preverbal or verbal vocalizations; yet when parents did respond to toddlers' negative emotion expression, toddlers were most likely to vocalize next. In the following sections, we further discuss and interpret these findings, then summarize the strengths and limitations of the present study as well as future directions for this line of research.

4.1 | Parent responses to toddler negative emotions and verbalizations

As we hypothesized, parents were more verbally responsive to toddlers' verbal or preverbal vocalizations than they were to toddlers' vocal negative emotion expressions; these results held whether

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considering responsiveness across the full day or only within parent–toddler interactions. The results are consistent with empirical and theoretical literature suggesting that parents become differentially responsive toward verbal compared to negative cues in the early toddler period (Kochanska & Aksan, 2004; Kubicek & Emde, 2012). The results suggest that parents may be less willing to treat toddlers' negative emotions as communicative and may ignore negative expressions or delay response to them. Yet parents were not *un*responsive to their toddlers' negative emotions. Although just over a third of toddlers' negative emotions expressions received an (immediate) parent verbal response, toddler cries were more likely to be followed by parent speech than by any other type of communication (including an end in communication). Moreover, nearly half of toddlers' preverbal or verbal vocalizations also went without an immediate parent response.

Importantly, the results do not address the appropriateness or intentions of parents' responses (or non-responses) to toddlers' cues. In many cases, parents may have felt it was appropriate to ignore, or delay their responses to, toddlers' negative emotions. Indeed, delayed or passive responding to young children's negative emotion is associated in some studies with greater ability to regulate distress independently (Grolnick et al., 1998; Hubbard & van IJzendoorn, 1991). In other cases, parents' attention may have simply been occupied; there are many demands on parents' time and attention in addition to child-rearing (Crnic & Booth, 1991) that may influence parent responsiveness. Most studies of caregiver responsiveness measure parent–child interactions during brief, semi-structured tasks, which may result in overestimations responsiveness (Crockenberg & Leerkes, 2003; McHale et al., 2003). In contrast, LENA's unobtrusive, day-long recording may have enabled more ecologically valid estimates of parental responsiveness to toddler cues (Timmons et al., 2017; Zauche et al., 2016).

4.2 | Effect of parent responses to toddler cues

We were interested not only in *whether* parents responded verbally to toddlers' negative emotion, but also in the effect of these verbal responses on toddlers' subsequent communication. Our findings suggest that, when parents responded verbally to toddler negative emotion, their responses often seemed to encourage or facilitate toddlers' verbal communication; toddlers were most likely to vocalize next, even marginally more so than to continue crying. Previous studies show that parents' responses to infant or toddlers' verbal or preverbal cues encourage this behavior; young children are likely to vocalize or verbalize again, sometimes in more advanced ways (Goldstein & Schwade, 2008; Warlaumont et al., 2014). Our findings suggest that parents' responses to toddlers' negative emotions also encourage more advanced communicative behaviors; that is, they often seem to facilitate a shift from emotional to verbal communication. Moreover, given that toddlers at this age have difficulty integrating negative expression and speech (Bloom & Beckwith, 1989), toddlers' shift from negative emotion to verbal expression also suggests that parents' responses may have helped downregulate their toddlers' negative emotion.

Of course, the present study does not address content or quality of parental verbal responses to their toddlers' negative emotion expressions. Did parents explicitly talk about toddlers' emotions or the emotion-eliciting situation? Did they use instrumental language to manage toddler behavior without addressing the toddler's emotional experience? Studies of emotion socialization during this period suggest parents' verbal regulatory responses to negative emotions peak in the middle of the second year of life (Grolnick et al., 1998; Spinrad et al., 2004). However, parents rarely use emotion labels or direct instruction in response to toddlers' negative emotions; rather, they often talk about the situation surrounding the emotional event or use distraction or redirection (Capatides & Bloom, 1993; Grolnick et al., 1998; Spinrad et al., 2004).

We also cannot assume that parental responses to their toddlers' negative expressions were always sensitive, planful responses; it is possible that some responses were insensitive or harsh, which may have maintained or exacerbated toddler negative arousal (Scaramella & Leve, 2004). Given that the toddler period is also a time of heightened stress and negativity for parents (Barry & Kochanska, 2010; Crnic & Booth, 1991), it is quite likely that parents sometimes responded in ways that were less sensitive and were unsuccessful in eliciting the desired toddler behavior. An interesting next step in this research is to identify instances in which parental responses to toddler emotions elicit a verbal response, and to compare the content and quality of these responses to those that result in another toddler negative expression.

The three-event sequence analyses also indicated that when parents verbally responded to toddler vocalizations, toddlers were likely to express negative emotion next. This was not the case when parents initiated the communicative exchange. In other words, parents sometimes *elicited* toddlers' negative emotions, and they were especially likely to do so when responding to toddler's verbal bids. The toddler period is characterized by increases in parent–child conflict, including increases in parents' commands and prohibitions, as well as increases in toddlers' autonomy assertion and noncompliance (Biringen et al., 1995; Gralinski & Kopp, 1993; Kochanska & Aksan, 2004). It is not surprising, therefore, that parents' responses to toddlers' verbalizations sometimes elicited toddler negative emotion. These findings reinforce the importance of examining bidirectional influences among child and parent behaviors, and of understanding parent–child communication as a transactional process (Pardini, 2008). Few studies examine the extent to which parental behavior elicits child negative emotions, and those that do tend to focus on harsh or maladaptive parenting behaviors (Snyder, Edwards, McGraw, Kilgore, & Holton, 1994). Yet many everyday routines and caregiving behaviors elicit toddler negative emotion (Karraker et al., 1994). How parents and their young children communicate around and resolve everyday emotions is an understudied topic, the study of which may be facilitated by technologies such as LENA (Repetti, Reynolds, & Sears, 2015).

4.3 | Toddler language ability and toddler age

We hypothesized that parents' responsiveness to their toddlers' negative emotions may vary as a function of toddlers' language abilities or toddler age. Specifically, we expected that parents of toddlers with more limited expressive language might treat negative emotion expression as communicative, whereas parents of toddlers who are more effective verbal communicators may be less responsive to their toddler's negative emotions. Contrary to these predictions, toddler language ability and toddler age were unrelated to parents' responsiveness to toddler cries. However, higher toddler language ability and higher toddler age *were* associated with increased likelihood that parents respond to their vocalizations, consistent with studies finding that parents become more responsive to more advanced communication as their children acquire expressive language (Bornstein et al., 2008; Tamis-LeMonda et al., 2014; Warlaumont et al., 2014).

Our results do suggest that older toddlers or toddlers with higher language ability are more likely to shift from negative expression to verbal expression following a parent's response to their negative emotion. This association was not explained by the overall frequency at which older or more verbally advanced toddlers vocalized. Toddlers with more advanced expressive language skills are better able to integrate emotion and speech (Bloom & Beckwith, 1989); they may be better able to speak while experiencing negative emotion. It is also possible that older toddlers have more mature self-regulatory capacities that help them downregulate negative emotions and more easily shift from emotional to verbal communication. Moreover, it is possible that their language skills may help them regulate their emotions, or that their parents were better able to harness their language skills to help them regulate (Cole et al., 2010; Roben, Cole, & Armstrong, 2013).

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4.4 | Strengths, limitations, and future directions

The study has several strengths that address gaps in the current literature. First, whereas emotional and language development are often studied separately, we integrated the study of toddlers' emotional and verbal communication. Second, we examined not only parents' responses to toddler cues, but also the effect of parent responses on toddlers' subsequent communicative behavior. Moreover, our statistical approach allowed us to capture sequential patterns and bidirectional influences among parent and toddler communicative behavior while accounting for heterogeneity in patterns across families (Howe et al., 2005). Finally, LENA allowed us to sample parent–toddler communication and emotions continuously as they naturally unfolded over the course of a day, an approach that may have resulted in a more ecologically valid characterization of these dynamic processes (Repetti et al., 2015; Timmons et al., 2017; Zauche et al., 2016).

One limitation of the present study is that LENA captures a narrow aspect of children's emotional experiences: vocal negative emotion expression. Yet emotion expression involves facial, postural, and behavioral cues in addition to vocal cues (Izard, 2013), and parents have access to these cues when they interpret and respond to toddlers' emotions. LENA also does not distinguish among discrete emotions (e.g., sadness, anger, or fear), which may influence both whether and how parents respond (O'Neal & Magai, 2005). Similarly, LENA is not able to identify when toddlers express negative emotions while verbally communicating, although the co-occurrence of vocal negative emotion and speech was relatively rare in our sample. Finally, LENA does not identify toddlers' positive emotion expressions, which are thought to encourage parent responsiveness and language input and to support early language development (Braungart-Rieker, Garwood, Powers, & Wang, 2015; Kochanska, Friesenborg, Lange, & Martel, 2004; Laake & Bridgett, 2014). Thus, though LENA facilitates efficient, ecologically valid sampling of real-time parent–child communication, there are trade-offs to its automated processing techniques. Coupling the use of LENA with more traditional methods (e.g., video-recorded semi-structured tasks and behavioral coding) would add richness to our understanding of parent–toddler emotional and verbal communication processes.

We found that, when parents verbally responded to toddler negative emotion, toddlers were most likely to vocalize next. However, we cannot assume that, when a toddler vocalizes following a negative emotion expression, the negative emotion is resolved. Cries and negative emotion expressions are dynamic signals that emerge and evolve; brief breaks in vocal expression of emotion do not necessarily indicate an end in negative emotion (Cole, Martin, & Dennis, 2004). A fruitful next step in this research is to identify negative emotional events (which may involve multiple vocal negative emotion expressions) and to examine sequential patterns of parent–toddler communication, and how they might change, across these events.

Although our statistical approach allowed us to account for heterogeneity in family communication, our small sample size precluded extensive examination of factors accounting for individual differences in these patterns. Our sample was a small, low-risk sample; future studies with larger and more diverse samples could extend upon the present results. For example, poverty and other contextual risk factors, as well as parents' own emotions and regulatory capacities, may influence the frequency, pattern, and quality of parents' responses to young children's cues (Bridgett et al., 2015; Dix, 1991). The toddler period is an especially important developmental stage because of the challenges it presents to parents. These challenges, particularly in the context of other risk factors, may contribute to the emergence of maladaptive parent–child interaction processes that confer risk for the development of emotional and behavior problems (Scaramella & Leve, 2004). Studying larger and more at-risk samples (e.g., oversampling for parent mental health challenges or emotion regulation deficits) would allow examination of how child or parent characteristics and contextual risk factors contribute to the development of adaptive or maladaptive emotional and verbal communication patterns.

5 | CONCLUSION

We examined sequential patterns of toddlers' vocal expressions of negative emotion, toddlers' verbal or preverbal vocalizations, and parent speech to better understand the role of negative emotion in parent–toddler verbal communication. We found that parents were less responsive to toddlers' negative emotions than to toddlers' verbal (or preverbal) communication; however, parents' responses to toddlers' emotions appeared to encourage verbal communication and may have also helped regulate toddlers' negative emotions. These results have potential implications for understanding the processes that support both language and emotional development. An important future direction in this research is to examine the quality and content of parent–toddler communication, and to study these dynamic processes in samples at risk for poor language outcomes or for emotional and behavior problems.

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REFERENCES

Bakeman, R., & Quera, V. (2011). *Sequential analysis and observational methods for the behavioral sciences*. Cambridge, UK: Cambridge University Press.

Barry, R. A., & Kochanska, G. (2010). A longitudinal investigation of the affective environment in families with young children: From infancy to early school age. *Emotion*, *10*(2), 237–249. https://doi.org/10.1037/a0018485

Bayley, N. (2006). *Bayley scales of infant and toddler development: Screening test*. San Antonio, TX: Harcourt Assessment, Psychological Corporation.

Beckwith, L., & Rodning, C. (1996). Dyadic processes between mothers and preterm infants: Development at ages 2 and 5 years. *Infant Mental Health Journal*, *17*(4), 322–333.

Bell, S. M., & Ainsworth, M. D. S. (1972). Infant crying and maternal responsiveness. *Child Development*, *43*(4), 1171–1190. https://doi.org/10.2307/1127506

Biringen, Z., Emde, R. N., Campos, J. J., & Appelbaum, M. I. (1995). Affective reorganization in the infant, the mother, and the dyad: The role of upright locomotion and its timing. *Child Development*, *66*(2), 499. https://doi.org/10.2307/1131593

15327078, 2019, 6, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/infa.12310 by Carnegie Mellon University, Wiley Online Library on [27/02/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Bloom, L., & Beckwith, R. (1989). Talking with feeling: Integrating affective and linguistic expression in early language development. *Cognition and Emotion*, *3*(4), 313–342. https://doi.org/10.1080/02699938908412711

Bloom, L., Tinker, E., & Scholnick, E. K. (2001). The intentionality model and language acquisition: Engagement, effort, and the essential tension in development. *Monographs of the Society for Research in Child Development*, *6*(4), 1–101.

Bornstein, M. H. (2012). Caregiver responsiveness and child development and learning: From theory to research to practice. In P. L. Mangione (Ed.), *Infant/Toddler Caregiving: A Guide to Cognitive Development and Learning*, 2nd ed (pp. 11–25). Sacramento: California Department of Education.

Bornstein, M. H., Tamis-LeMonda, C. S., Hahn, C.-S., & Haynes, O. M. (2008). Maternal responsiveness to young children at three ages: Longitudinal analysis of a multidimensional, modular, and specific parenting construct. *Developmental Psychology*, *44*(3), 867–874. https://doi.org/10.1037/0012-1649.44.3.867

Bornstein, M. H., Tamis-LeMonda, C. S., Tal, J., Ludemann, P., Toda, S., Rahn, C. W., … Vardi, D. (1992). Maternal responsiveness to infants in three societies: The United States, France, and Japan. *Child Development*, *63*(4), 808–821. https://doi.org/10.2307/1131235

Braungart-Rieker, J. M., Garwood, M. M., Powers, B. P., & Wang, X. (2015). Parental sensitivity, infant affect, and affect regulation: Predictors of later attachment. *Child Development*, *72*(1), 252–270. https://doi.org/10.1111/1467-8624.00277

Bridgett, D. J., Gartstein, M. A., Putnam, S. P., McKay, T., Iddins, E., Robertson, C., … Rittmueller, A. (2015). Maternal and contextual influences and the effect of temperament development during infancy on parenting in toddlerhood. *Infant Behavior and Development*, *32*(1), 103–116. https://doi.org/10.1016/j.infbeh.2008.10.007

Brophy-Herb, H. E., Schiffman, R. F., Bocknek, E. L., Dupuis, S. B., Fitzgerald, H. E., Horodynski, M., … Hillaker, B. (2011). Toddlers' Social-emotional competence in the contexts of maternal emotion socialization and contingent responsiveness in a low-income sample. *Social Development*, *20*(1), 73–92. https://doi.org/10.1111/j.1467-9507.2009.00570.x

Brownell, C. A., & Kopp, C. B. (2010). *Socioemotional development in the toddler years: Transitions and transformations*. New York, NY; London, UK: The Guilford Press.

Camaioni, L. (2001). Early language. In G. Bremner, & A. Fogel (Eds.), *Blackwell handbook of infant development* (pp. 404–426). Hoboken, NJ: Blackwell Publishing Ltd.

Capatides, J. B., & Bloom, L. (1993). Underlying process in the socialization of emotion. *Advances in Infancy Research*, *8*, 99–135.

Casillas, M. (2014). Turn-taking. In D. Matthews (Ed.), *Pragmatic development in first language acquisition* (pp. 53–70). Amsterdam, The Netherlands: John Benjamins.

Cole, P. M., Armstrong, L. M., & Pemberton, C. K. (2010). The role of language in the development of emotion regulation. In S. D. Calkins, & M. A. Bell (Eds.), *Human brain development. Child development at the intersection of emotion and cognition* (pp. 59–77). Washington, DC: American Psychological Association.

Cole, P. M., Martin, S. E., & Dennis, T. A. (2004). Emotion regulation as a scientific construct: Methodological challenges and directions for child development research. *Child Development*, *75*(2), 317–333. https://doi.org/10.1111/j.1467-8624.2004.00673.x.

Crnic, K. A., & Booth, C. L. (1991). Mothers' and fathers' perceptions of daily hassles of parenting across early childhood. *Journal of Marriage and the Family*, 1042–1050.

Crockenberg, S. C., & Leerkes, E. (2003). Infant negative emotionality, caregiving, and family relationships. In A. C. Crouter, & A. Booth (Eds.), *Children's influence on family dynamics: The neglected side of family relationships* (pp. 57–78). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Dagne, G. A., Howe, G. W., Brown, C. H., & Muthén, B. O. (2002). Hierarchical modeling of sequential behavioral data: An empirical Bayesian approach. *Psychological Methods*, *7*(2), 262–280. https://doi.org/10.1037/1082-989X.7.2.262

Dix, T. (1991). The affective organization of parenting: Adaptive and maladaptative processes. *Psychological Bulletin*, *110*(1), 3–25. https://doi.org/10.1037/0033-2909.110.1.3

Dixon, W. E., & Smith, P. H. (2000). Links between early temperament and language acquisition. *Merrill-Palmer Quarterly*, *46*, 417–440.

Fenson, L., Bates, E., Dale, P. S., Marchman, V. A., Reznick, J. S., & Thal, D. J. (2007). *MacArthur-Bates communicative development inventories*. Baltimore, MD: Paul H. Brookes Publishing Company.

Goldstein, M. H., & Schwade, J. A. (2008). Social feedback to infants' babbling facilitates rapid phonological learning. *Psychological Science*, *19*(5), 515–523. https://doi.org/10.1111/j.1467-9280.2008.02117.x

15327078, 2019, 6, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/infa.12310 by Carnegie Mellon University, Wiley Online Library on [27/02/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Goldstein, M. H., Schwade, J. A., & Bornstein, M. H. (2009). The value of vocalizing: Five-month-old infants associate their own noncry vocalizations with responses from caregivers. *Child Development*, *80*(3), 636–644. https://doi.org/10.1111/j.1467-8624.2009.01287.x

Gralinski, J. H., & Kopp, C. B. (1993). Everyday rules for behavior: Mothers' requests to young children. *Developmental Psychology*, *29*(3), 573–584. https://doi.org/10.1037/0012-1649.29.3.573

Grolnick, W. S., Kurowski, C. O., McMenamy, J. M., Rivkin, I., & Bridges, L. J. (1998). Mothers' strategies for regulating their toddlers' distress. *Infant Behavior and Development*, *21*(3), 437–450. https://doi.org/10.1016/S0163-6383(98)90018-2

Gros-Louis, J., West, M. J., & King, A. P. (2015). Maternal responsiveness and the development of directed vocalizing in social interactions. *Infancy*, *19*(4), 385–408. https://doi.org/10.1111/infa.12054

Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Paul H Brooks Publishing.

Hoff, E. (2006). How social contexts support and shape language development☆. *Developmental Review*, *26*(1), 55–88. https://doi.org/10.1016/j.dr.2005.11.002

Howe, G. W., Dagne, G., & Brown, C. H. (2005). Multilevel methods for modeling observed sequences of family interaction. *Journal of Family Psychology*, *19*(1), 72–85. https://doi.org/10.1037/0893-3200.19.1.72

Hubbard, F. O., & van IJzendoorn, M. H. (1991). Maternal unresponsiveness and infant crying across the first 9 months: A naturalistic longitudinal study. *Infant Behavior and Development*, *14*(3), 299–312. https://doi.org/10.1016/0163-6383(91)90024-M

Izard, C. E. (2013). *Human emotions*. New York, NY: Springer Science & Business Media.

Karraker, K. H., Lake, M. A., & Parry, T. B. (1994). Infant coping with everyday stressful events. *Merrill-Palmer Quarterly*, *40*(2), 171–189.

Ko, E.-S., Seidl, A., Cristia, A., Reimchen, M., & Soderstrom, M. (2016). Entrainment of prosody in the interaction of mothers with their young children. *Journal of Child Language*, *43*(02), 284–309. https://doi.org/10.1017/S0305000915000203

Kochanska, G., & Aksan, N. (2004). Development of mutual responsiveness between parents and their young children. *Child Development*, *75*(6), 1657–1676. https://doi.org/10.1111/j.1467-8624.2004.00808.x

Kochanska, G., Friesenborg, A. E., Lange, L. A., & Martel, M. M. (2004). Parents' personality and infants' temperament as contributors to their emerging relationship. *Journal of Personality and Social Psychology*, *86*(5), 744–759. https://doi.org/10.1037/0022-3514.86.5.744

Kubicek, L. F., & Emde, R. N. (2012). Emotional expression and language: A longitudinal study of typically developing earlier and later talkers from 15 to 30 Months. *Infant Mental Health Journal*, *33*(6), 553–584. https://doi.org/10.1002/imhj.21364

Laake, L. M., & Bridgett, D. J. (2014). Happy babies, chatty toddlers: Infant positive affect facilitates early expressive, but not receptive language. *Infant Behavior and Development*, *37*(1), 29–32. https://doi.org/10.1016/j.infbeh.2013.12.006

Laible, D., & Thompson, R. A. (2007). Early socialization: A relationship perspective. In J. E. Grusec, & P. D. Hastings (Eds.), *Handbook of socialization: Theory and research* (pp. 181–207). New York, NY: Guilford Press.

Landry, S. H., Smith, K. E., Swank, P. R., Assel, M. A., & Vellet, S. (2001). Does early responsive parenting have a special importance for children's development or is consistency across early childhood necessary? *Developmental Psychology*, *37*(3), 387–403. https://doi.org/10.1037//0012-1649.37.3.387

Leerkes, E. M., Blankson, A. N., & O'Brien, M. (2009). Differential effects of maternal sensitivity to infant distress and nondistress on social-emotional functioning. *Child Development*, *80*(3), 762–775. https://doi.org/10.1111/j.1467-8624.2009.01296.x

LENA Foundation (2011). *The LENA advanced data extractor (ADEX) user guide version 1.1.2*. Boulder, CO: LENA Foundation.

Lester, B. M., & Boukydis, C. Z. (1992). No language but a cry. In H. Papousek, U. Jurgens, & M. Papousek (Eds.), *Nonverbal vocal communication. Comparative and developmental approaches* (pp. 145–173). Cambridge, UK: Cambridge University Press.

Lewis, M. D., Zimmerman, S., Hollenstein, T., & Lamey, A. V. (2004). Reorganization in coping behavior at 1½ years: Dynamic systems and normative change. *Developmental Science*, *7*(1), 56–73. https://doi.org/10.1111/j.1467-7687.2004.00323.x

15327078, 2019, 6, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/infa.12310 by Carnegie Mellon University, Wiley Online Library on [27/02/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Masur, E. F., Flynn, V., & Eichorst, D. L. (2005). Maternal responsive and directive behaviours and utterances as predictors of children's lexical development. *Journal of Child Language*, *32*(1), 63–91. https://doi.org/10.1017/S0305000904006634

McHale, J. P., Kavanaugh, K. C., & Berkman, J. M. (2003). Sensitivity to infants' cues: As much a mandate for researchers as for parents. *Children's influence on family dynamics: The neglected side of family relationships* (pp. 91–108). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Messinger, D. S., Mahoor, M. H., Chow, S.-M., Haltigan, J. D., Cadavid, S., & Cohn, J. F. (2014). Early emotional communication: Novel approaches to interaction. In J. Gratch, & S. Marsella (Eds.), *Social emotions in nature and artifact* (pp. 162–180). New York, NY: Oxford University Press.

Moreno, A. J., & Robinson, J. L. (2005). Emotional vitality in infancy as a predictor of cognitive and language abilities in toddlerhood. *Infant and Child Development*, *14*(4), 383–402. https://doi.org/10.1002/icd.406

Muthén, L. K., & Muthén, B. O. (1998). *MPlus user's guide* (7th ed.). Los Angeles, CA: Muthén & Muthén.

Nicely, P., Tamis-LeMonda, C. S., & Bornstein, M. H. (1999). Mothers' attuned responses to infant affect expressivity promote earlier achievement of language milestones. *Infant Behavior and Development*, *22*(4), 557–568.

Nozadi, S. S., Spinrad, T. L., Eisenberg, N., Bolnick, R., Eggum-Wilkens, N. D., Smith, C. L., … Sallquist, J. (2013). Prediction of toddlers' expressive language from maternal sensitivity and toddlers' anger expressions: A developmental perspective. *Infant Behavior and Development*, *36*(4), 650–661. https://doi.org/10.1016/j.infbeh.2013.06.002

O'Neal, C. R., & Magai, C. (2005). Do parents respond in different ways when children feel different emotions? The emotional context of parenting. *Development and Psychopathology*, *17*(2), 467–487. https://doi.org/10.1017/S0954579405050224

Oller, D. K., Niyogi, P., Gray, S., Richards, J. A., Gilkerson, J., Xu, D., … Warren, S. F. (2010). Automated vocal analysis of naturalistic recordings from children with autism, language delay, and typical development. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(30), 13354–13359. https://doi.org/10.1073/pnas.1003882107

Papousek, H., Jürgens, U., & Papoušek, M. (1992). *Nonverbal vocal communication: Comparative and developmental approaches*. Cambridge, UK: Cambridge University Press.

Pardini, D. A. (2008). Novel insights into longstanding theories of bidirectional parent–child influences: Introduction to the special section. *Journal of Abnormal Child Psychology*, *36*(5), 627–631. https://doi.org/10.1007/s10802-008-9231-y

Raikes, H. A., Robinson, J. L., Bradley, R. H., Raikes, H. H., & Ayoub, C. C. (2007). Developmental trends in self-regulation among low-income toddlers. *Social Development*, *16*(1), 128–149. https://doi.org/10.1007/s10802-008-9231-y

Repetti, R. L., Reynolds, B. M., & Sears, M. S. (2015). Families under the microscope: Repeated sampling of perceptions, experiences, biology, and behavior. *Journal of Marriage and Family*, *77*(1), 126–146. https://doi.org/10.1111/jomf.12143

Roben, C. K., Cole, P. M., & Armstrong, L. M. (2013). Longitudinal relations among language skills, anger expression, and regulatory strategies in early childhood. *Child Development*, *84*(3), 891–905. https://doi.org/10.1111/cdev.12027

Robinson, J. L., & Acevedo, M. C. (2001). Infant reactivity and reliance on mother during emotion challenges: Prediction of cognition and language skills in a low-income sample. *Child Development*, *72*(2), 402–415. https://doi.org/10.1111/1467-8624.00286

Salley, B. J., & Dixon, W. E. (2007). Temperamental and joint attentional predictors of language development. *Merrill-Palmer Quarterly (Wayne State University Press)*, *53*(1), 131–154.

Scaramella, L. V., & Leve, L. D. (2004). Clarifying parent–child reciprocities during early childhood: The early childhood coercion model. *Clinical Child and Family Psychology Review*, *7*(2), 89–107. https://doi.org/10.1023/B:CCFP.0000030287.13160.a3

Snyder, J., Edwards, P., McGraw, K., Kilgore, K., & Holton, A. (1994). Escalation and reinforcement in mother-child conflict: Social processes associated with the development of physical aggression. *Development and Psychopathology*, *6*(2), 305–321. https://doi.org/10.1017/S0954579400004600

Spinrad, T. L., Stifter, C. A., Donelan-McCall, N., & Turner, L. (2004). Mothers' regulation strategies in response to toddlers' affect: Links to later emotion self-regulation. *Social Development*, *13*(1), 40–55. https://doi.org/10.1111/j.1467-9507.2004.00256.x

15327078, 2019, 6, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/infa.12310 by Carnegie Mellon University, Wiley Online Library on [27/02/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Tamis-Lemonda, C. S., Bornstein, M. H., Baumwell, L., & Damast, A. M. (1996). Responsive parenting in the second year: Specific influences on children's language and play. *Early Development and Parenting*, *5*(4), 173–183. https://doi.org/10.1002/(SICI)1099-0917(199612)5:4<173:AID-EDP131>3.0.CO;2-V

Tamis-LeMonda, C. S., Kuchirko, Y., Luo, R., Escobar, K., & Bornstein, M. H. (2017). Power in methods: Language to infants in structured and naturalistic contexts. *Developmental Science*, *20*(6), e12456. https://doi.org/10.1111/desc.12456

Tamis-LeMonda, C. S., Kuchirko, Y., & Song, L. (2014). Why is infant language learning facilitated by parental responsiveness? *Current Directions in Psychological Science*, *23*(2), 121–126. https://doi.org/10.1177/0963721414522813

Timmons, A. C., Baucom, B. R., Han, S. C., Perrone, L., Chaspari, T., Narayanan, S. S., & Margolin, G. (2017). New frontiers in ambulatory assessment: Big data methods for capturing couples' emotions, vocalizations, and physiology in daily life. *Social Psychological and Personality Science*, *8*(5), 552–563. https://doi.org/10.1177/1948550617709115

Tronick, E. Z. (1989). Emotions and emotional communication in infants. *American Psychologist*, *44*(2), 112–119. https://doi.org/10.1037/0003-066X.44.2.112

Walle, E. A., & Campos, J. J. (2014). Infant language development is related to the acquisition of walking. *Developmental Psychology*, *50*(2), 336–348. https://doi.org/10.1037/a0033238

Warlaumont, A. S., Richards, J. A., Gilkerson, J., & Oller, D. K. (2014). A social feedback loop for speech development and its reduction in autism. *Psychological Science*, *25*(7), 1314–1324. https://doi.org/10.1177/0956797614531023

Xu, D., Yapanel, U., & Gray, S. (2009). *Reliability of the LENA™ language environment analysis system in young children's natural home environment*. Boulder, CO: LENA Foundation.

Zauche, L. H., Thul, T. A., Mahoney, A. E. D., & Stapel-Wax, J. L. (2016). Influence of language nutrition on children's language and cognitive development: An integrated review. *Early Childhood Research Quarterly*, *36*, 318–333. https://doi.org/10.1016/j.ecresq.2016.01.015

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