JSLHR

**Research Note**

# How Chatty Are Daddies? An Exploratory Study of Infants' Language Environments

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**Purpose:** Fathers play a critical but underresearched role in their children's cognitive and linguistic development. Focusing on two-parent families with a mother and a father, the present longitudinal study explores the amount of paternal input infants hear during the first 2 years of life, how this input changes over time, and how it relates to child volubility. We devote special attention to parentese, a near-universal style of infant-directed speech, distinguished by its higher pitch, slower tempo, and exaggerated intonation.

**Method:** We examined the daylong recordings of the same 23 infants at ages 6, 10, 14, 18, and 24 months, given English-speaking families. The infants were recorded in the presence of their parents (mother–father dyads), who were predominantly White and ranged from mid to high socioeconomic status (SES). We analyzed the effects of parent gender and child age on adult word counts and parentese, as well as the effects of maternal and paternal word counts and parentese on child vocalizations.

**Results:** On average, the infants were exposed to 46.8% fewer words and 51.9% less parentese from fathers than from mothers, even though paternal parentese grew at a 2.8-times faster rate as the infants aged. An asymmetry emerged where maternal word counts and paternal parentese predicted child vocalizations, but paternal word counts and maternal parentese did not.

**Conclusions:** While infants may hear less input from their fathers than their mothers in predominantly White, mid-to-high SES, English-speaking households, paternal parentese still plays a unique role in their linguistic development. Future research on sources of variability in child language outcomes should thus control for parental differences since parents' language can differ substantially and differentially predict child language.

Sociocultural frameworks have long emphasized child development as a socially mediated process, in which caregivers scaffold their children's cognitive and linguistic development through social interactions (e.g., Bruner, 1981; Kuhl, 2007, 2011; Snow, 1977, 1999; Vygotsky, 1978). While research on parental language within these frameworks has largely focused on maternal contributions, emerging studies have highlighted the invaluable roles that fathers play in their children's linguistic development (for reviews, see Pancsofar, 2020; Tamis-LeMonda et al., 2012). This work is set against an evolving backdrop, as family structures diversify, more women pursue careers, and fathers become more directly involved in family life and childcare (Cabrera et al., 2000, 2018; Jones & Mosher, 2013). Controlling for maternal input and demographic factors, research has begun to chart fathers' language input during early childhood, revealing its unique associations with children's concurrent and subsequent language skills (Baker et al., 2015; Conica et al., 2020; Majorano et al., 2013; Malin et al., 2014; Pancsofar & Vernon-Feagans, 2006; Pancsofar et al., 2010; Quigley & Nixon, 2020; Reynolds et al., 2019; Tamis-LeMonda et al., 2012). In the present longitudinal study, we continue this endeavor, tracing exposure to paternal parentese during the first 2 years of life (i.e., infancy) to better understand sources of variability in children's language outcomes.

Several studies have connected paternal input *quality* during infancy to child language skills in later years. For example, father's use of metalingual talk and repetitions of children's utterances at 24 months have both been tied to children's vocabulary skills at 48 months and beyond (Conica et al., 2020; Malin et al., 2014). Likewise, paternal usage of *wh*-questions at 24 months is positively associated

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Editor-in-Chief: Stephen M. Camarata
Editor: Mary Alt

Received December 18, 2020
Revision received March 7, 2021
Accepted April 7, 2021
https://doi.org/10.1044/2021_JSLHR-20-00727

*Disclosure: The authors have declared that no competing interests existed at the time of publication.*

with concurrent child vocabulary and verbal reasoning skills at 36 months (Rowe et al., 2017). At the same time, fathers are widely reputed to differ *quantitatively* from mothers, with many studies suggesting that fathers talk less overall (Golinkoff & Ames, 1979; Hladik & Edwards, 1984; Leaper et al., 1998; Majorano et al., 2013; Pancsofar & Vernon-Feagans, 2006). For instance, in a study of Italian families during 20-min triadic free-play sessions, Majorano et al. (2013) found that fathers' but not mothers' noun frequency at 15 months predicted child language production and comprehension at 30 months, even though mothers had produced more words, greater vocabulary diversity, and longer utterances. In similar settings, Pancsofar and Vernon-Feagans (2006) found that fathers' but not mothers' vocabulary diversity at 24 months predicted children's expressive language skills at 36 months, even though fathers had produced fewer utterances, word types, and *wh*-questions, and took shorter conversational turns. These studies demonstrate the complex and unique associations between paternal and child language, even when fathers provide less input than mothers.

### Daylong Audio Recordings

Research using Language ENvironment Analysis (LENA) technology has added new dimensions to quantitative comparisons between mothers' and fathers' language input. LENA's pocket-sized recording devices are wearable by infants and facilitate daylong snapshots of their natural environments. These recordings offer a more ecologically valid glimpse of parent–child interactions and at a scale that exceeds traditional observations in a laboratory or from brief visits to infants' homes (Christakis et al., 2009; Oller et al., 2010; Xu et al., 2014; Zimmerman et al., 2009). In addition, LENA's proprietary software segments and classifies speech, tabulating volubility measures such as word counts. Recent work using LENA has further pointed to significant disparities between mothers and fathers in the amount of language input they provide. Gilkerson and Richards (2009) reported that mothers accounted for 75% of the total adult words spoken in their semilongitudinal study of children between 2 and 48 months of age. Pairing LENA's automatic measures with manual coding of child-directed speech (CDS), Bergelson et al. (2018) similarly found that infants hear 2–3 times more CDS from women than from men.

However, neither Gilkerson and Richards nor Bergelson et al. address how family dynamics may have contributed to the disparities they observed between maternal and paternal speech. In both studies, it is unclear whether the recordings came from single-parent or two-parent households and, in the latter families, whether the parents were of the same or different gender, or whether both parents were present during the recordings (e.g., a parent could have been away at work). Moreover, neither study connected parental differences to child language outcomes. Notably, Gilkerson and Richards found that parents' word counts *overall* predicted child vocalizations ("talkative parents have talkative children," p. 21; see also Hart & Risley, 1995), but did not consider how mothers and fathers may individually contribute to this effect.

### Parentese

Bergelson et al.'s (2018) finding that men produce less CDS motivates an interesting avenue of study when we consider the wealth of research that has shown different *registers* of CDS to vary in their impact on child language learning. Specifically, infants favor parentese, an acoustically exaggerated style of CDS that benefits infants' concurrent and subsequent language skills (Ferjan Ramírez et al., 2018, 2020; Golinkoff et al., 2015; Kuhl et al., 1997, 2003; Liu et al., 2003; Ramírez-Esparza et al., 2014, 2017a, 2017b; Singh et al., 2009; Song et al., 2010; Thiessen et al., 2005). Parentese is distinct from adult-directed speech and "standard/adult" registers of infant-directed speech (Farran et al., 2016; Ramírez-Esparza et al., 2014) in terms of its simplified lexicon and syntax, slower tempo, and melodic intonation contours (Fernald, 1985; Fernald & Kuhl, 1987; Genovese et al., 2020). The contributions of parentese to child language development are rooted in these characteristics, which evoke social responses from infants and enhance parent–child interactions (Golinkoff et al., 2015; Tartter, 1980). Accordingly, multiple studies have tied parentese to infant vocal activity, such as babbling (Ferjan Ramírez et al., 2018; Ramírez-Esparza et al., 2014), word production (Ferjan Ramírez et al., 2020; Ramírez-Esparza et al., 2014), and conversational turns (Ferjan Ramírez et al., 2020). In general, adult vocalizations that are higher in pitch and amplitude are more likely to be followed by infant vocalizations (Ritwika et al., 2020).

Despite parentese formerly being called *motherese*, fathers produce parentese cross-linguistically (Broesch & Bryant, 2018; Quigley et al., 2019; see also Saint-Georges et al., 2013), though they exhibit some prosodic differences from mothers (Fernald et al., 1989; Gergely et al., 2017; Warren-Leubecker & Bohannon, 1984). Nevertheless, the majority of the work on associations between parentese and child language has either not distinguished maternal and paternal parentese in their analyses (e.g., Ferjan Ramírez et al., 2018, 2020; Ramírez-Esparza et al., 2014, 2017a, 2017b) or has focused exclusively on mothers (e.g., Kuhl et al., 1997; Liu et al., 2003). It thus remains unknown how mothers and fathers differ in the amount of parentese they produce and how their parentese might differentially relate to infant vocalizations and child language learning during the first 2 years of life and beyond.

### The Present Study

In the present exploratory study, we seek to contrast paternal and maternal input, posing the following questions: How much paternal input, especially parentese, do infants hear during the first 2 years of life and, relatedly, how might this input change throughout infancy? Moreover, how might the input of mothers and fathers differ in their associations to infant vocalizations?

We analyzed previously collected longitudinal data from the same group of 23 infants at ages 6, 10, 14, 18, and 24 months. All of the infants came from predominantly White, English-speaking families and were raised by mother–father parents. Using LENA technology, naturalistic daylong audio recordings were obtained from the 23 families at each age, during times when both parents were asked to be home with their child. This allowed us to control for parental disparities that could arise from a parent being absent during a recording (e.g., if one parent was away at work). In our analysis, we focused on three response variables: the total number of words heard by infants (adult word count [AWC]), the amount of parentese they heard, and the number of linguistic vocalizations they produced (child vocalization count [CVC]). Both AWC and CVC are measures of volubility ("chattiness"). In addition to looking at the effects of child age and parent gender (i.e., mother vs. father) on these variables, we also controlled for socioeconomic status (SES), which has been shown time and again to predict child language learning (for review, see Rowe, 2018). The participating families ranged from mid to high SES.

While past research has explored the benefits of parentese and the prosodic differences displayed by mothers and fathers, our study is, to our knowledge, the first to compare the amount of maternal and paternal parentese infants hear, and to do so longitudinally. Likewise, our study is the first to relate adult volubility and parentese to child volubility while simultaneously examining parental differences. As this analysis was exploratory, our only hypothesis was that the input from mothers and fathers would vary from one another, both synchronically and across infancy. Our primary goal was to study sources of variability in children's language environments and to see how this variation might relate to child volubility. More broadly, a thorough understanding of infants' language environments can inform theories of language acquisition, shape family-centered policy, and identify circumstances that might benefit from intervention.

## Method

### Participants and Data Collection

We analyzed daylong recordings collected from the same 23 infants at ages 6, 10, 14, 18, and 24 months. The participating families were part of the control group of a larger longitudinal study on parent–infant verbal interactions (see Ferjan Ramírez et al., 2018; Ferjan Ramírez et al., 2020). The original study recruited 79 English-speaking families, of which 55 families participated in a parent coaching intervention and 24 families served as the "no treatment" control group. Out of the 24 families, we excluded one single-parent household from our analysis, leaving 23 families to constitute our present data set on parental differences. The original study recruited the families in the greater Seattle area via the University of Washington Subjects Pool. All of the parents provided informed written consent. The study and its experimental procedures were approved by the institutional review board of the University of Washington and conformed to the U.S. Federal Policy for the Protection of Human Subjects.

The families were recruited when the participating infants were 5 months of age; each infant was born full term (± 14 days of due date), of normal birth weight (6 lb–10 lb), and without birth or postnatal complications. The parents of the 23 infants were all mother–father dyads. According to demographic data collected prior to the audio recordings, 12 of the infants were girls and 11 were boys. The families ranged from mid to high SES, as measured by the widely used Hollingshead Index (Hollingshead, 1975, 2011), a composite SES score (range: 8–66) based on parent education, occupational prestige, family income, and related factors. On the Hollingshead scale, the families fell between 30 (e.g., both parents had high school diplomas and worked in sales or construction) and 66 (e.g., both parents had advanced degrees and worked as engineers or attorneys; $M = 49.5$, $SD = 10.9$). Twenty-one of the infants were White, one was of unknown race, and one was of mixed race. All of the parents spoke English varieties standard to the U.S. Pacific Northwest.

The daylong recordings were collected between October 1, 2016, and August 5, 2018. The collection timepoints were set as close as possible to each infant's 6-, 10-, 14-, 18-, and 24-month birthdays (on average, within 3 days of the date). These timepoints were initially selected to parallel milestones in child language development (i.e., babbling, transition to first words, individual words, transition to word combinations, and combinatorial speech). At each timepoint, the infants were recorded over two consecutive weekend days, when both parents were home and not working. Parents were instructed to start each recording in the morning when their child awoke, to go about their day as usual, then to turn off the recorder at night when the child went to sleep. Throughout the day, the infants wore the lightweight LENA device inside the front pocket of a specially designed vest. The average duration of the daylong recordings was 12.8 hr (range: 8.7–16); recording lengths did not differ significantly between the five data collection timepoints ($p = .312$).

### Key Variables

The key variables in our analysis and their distributions are summarized in Table 1. Parent and child speech were quantified through a combination of automatic annotation by LENA software and manual (human) annotation. LENA's acoustic modeling software supplies various estimates of child speech and exposure to adult speech (cf. Gilkerson & Richards, 2020). Regarding the accuracy of these estimates, recent efforts have sought to assess and validate LENA's classification performance (e.g., Bulgarelli & Bergelson, 2020; Cristia, Bulgarelli, & Bergelson, 2020; Cristia,

Table 1. Speech variables and their distributions ($M \pm SD$) when infants were 6, 10, 14, 18, and 24 months old.

| Variable | Type | 6 months | 10 months | 14 months | 18 months | 24 months |
|---|---|---|---|---|---|---|
| AWC | LENA | 16,621.0 ± 7,605.6 | 15,380.3 ± 7,782.6 | 15,467.0 ± 7,416.3 | 16,164.3 ± 6,297.0 | 16,674.1 ± 6,425.7 |
| FAN | LENA | 10,956.7 ± 5,517.6 | 10,473.2 ± 5,681.7 | 9,589.8 ± 5,129.0 | 9,966.3 ± 4,691.0 | 10,217.1 ± 4,190.3 |
| MAN | LENA | 5,664.3 ± 3,230.7 | 4,907.1 ± 3,427.9 | 5,877.2 ± 4,016.6 | 6,198.0 ± 3,352.1 | 6,457.0 ± 4,198.2 |
| % Parentese | Manual | 44.6 ± 18.7 | 46.1 ± 20.7 | 52.4 ± 20.7 | 58.5 ± 26.0 | 66.9 ± 21.6 |
| % *M.* parentese | Manual | 33.3 ± 15.5 | 35.7 ± 18.2 | 38.4 ± 18.8 | 40.7 ± 22.2 | 45.7 ± 21.4 |
| % *P.* parentese | Manual | 14.9 ± 12.7 | 14.3 ± 11.9 | 18.7 ± 12.5 | 23.2 ± 17.1 | 30.3 ± 16.5 |
| Proportion of *M.* input containing parentese | Manual | 0.50 ± 0.18 | 0.50 ± 0.21 | 0.57 ± 0.22 | 0.60 ± 0.22 | 0.67 ± 0.20 |
| Proportion of *P.* input containing parentese | Manual | 0.30 ± 0.21 | 0.34 ± 0.21 | 0.40 ± 0.19 | 0.45 ± 0.27 | 0.57 ± 0.22 |
| CVC | LENA | 1,177.9 ± 393.9 | 1,270.0 ± 472.0 | 1,146.5 ± 441.3 | 1,639.6 ± 585.0 | 2,604.2 ± 1,165.5 |

*Note.* AWC = adult word count; FAN = female adult nearby words; MAN = male adult nearby words; CVC = child vocalization count; *M.* = maternal; *P.* = paternal; LENA = Language ENvironment Analysis estimate; manual = manually coded.

Lavechin, et al., 2020; Lehet et al., 2020; Wang et al., 2020). According to one meta-analysis, LENA achieves a mean recall and precision of 0.59 and 0.68, respectively, for recognizing adult words and a mean recall of 0.77 for recognizing child vocalizations (Cristia, Bulgarelli, & Bergelson, 2020). Such validation studies demonstrate that LENA is a useful tool for studying infants' language environments, but one that should be supplemented by manually quantified measures—as we do in this study with parentese.

We drew on several automatic metrics from LENA: Adult speech was measured in AWC, the estimated number of adult words spoken near the infant, whether child-directed or adult-directed. The LENA Advanced Data EXtractor tool subdivides AWC into words spoken by women and those spoken by men, what they term "female adult nearby" (FAN) words and "male adult nearby" (MAN) words. We used FAN and MAN to approximate maternal and paternal word counts, respectively. Infant vocal activity was measured in CVC, the estimated number of segments that contain meaningful child speech (excluding nonspeech signals like cries and vegetative sounds). Child vocalization segments can be of any length, as long as they are surrounded by 300+ ms of nonspeech. These variables —AWC, FAN, MAN, and CVC—are all considered measures of volubility and, as such, do not index the quality of utterances. Each variable was measured over the length of each daylong recording, then averaged across each timepoint, producing a single estimate per child at each age.

Following Ramírez-Esparza et al. (2014, 2017a, 2017b), we supplemented LENA's estimates with manual annotations of parentese. We segmented the daylong recordings into 30-s intervals, then selected the 50 intervals with the highest AWC from each recording day. This yielded 100 30-s segments per family at each age. Past studies have shown that 30-s clips of ambient sounds provide sufficient information for characterizing observed behaviors (Mehl et al., 2006; Orena et al., 2019; Ramírez-Esparza et al., 2009). To collect a broad range of environments, we further required that the selected intervals be spaced at least 3 min apart. Ten research assistants then manually annotated the selected segments for three binary variables: (a) the presence/absence of *any* parentese, (b) the presence/absence of *maternal* parentese, and (c) the presence/absence of *paternal* parentese. Note that any interval could contain both maternal and paternal parentese. The annotators identified parentese by its higher pitch and wider pitch range, showing high intercoder agreement (0.99 intraclass correlation). Finally, for each infant at each timepoint, "% parentese" was quantified as the percentage of intervals that contained parentese, intended to reflect the proportion of parental input that is parentese. Percent maternal parentese and % paternal parentese were likewise quantified. For readability, we will refer to "% parentese" as parentese, "% maternal parentese" as maternal parentese, and "% paternal parentese" as paternal parentese.

### Statistical Analysis

We evaluated associations of child age, SES, and parent gender with the outcomes AWC and parentese, using multivariable linear mixed-effects regression. Both AWC and parentese were log-transformed to reduce right-skewness. Child age and SES were included as continuous covariates, while parent gender was treated as a binary variable. We also included random intercepts per subject and parent nested within subject to account for the repeated measures at each age. To assess how adult linguistic input might vary by parent with child age, we added an interaction term between child age and parent gender to the main effects models for both AWC and parentese.

We again used linear mixed-effects regression to analyze CVC and its associations with child age, SES, FAN, MAN, maternal parentese, and paternal parentese. We log-transformed CVC, FAN, and MAN to reduce right-skewness and included random intercepts per subject to account for the repeated measures. FAN, MAN, and maternal and paternal parentese were incorporated as continuous covariates. We subsequently added interaction terms between child age and each of the four adult speech variables to explore how their associations with CVC might vary with child age.

For our analyses, we used the statistical computing language R (Version 3.6.2; R Core Team, 2013) and, in particular, the lme4 package (Bates et al., 2015) to fit the linear regression models. With the help of the lmerTest package (Kuznetsova et al., 2017), we conducted two-sided tests to determine statistical significance, defining the threshold for significance as $\alpha = .05$.

## Results

### *Adult Words and Parentese*

On average, infants in the present sample heard 16,061.4 adult words per day: 10,240.6 words from women and 5,794.8 words from men. In relation to AWC, we found a significant main effect of parent gender ($p < .001$), such that infants heard on average 46.8% fewer words from men than from women. However, AWC was not significantly associated with SES ($p = .860$), child age ($p = .255$), or with an interaction between child age and parent gender ($p = .112$). Table 2 summarizes the results for both AWC and parentese.

Across all of the timepoints, 53.7% of the manually coded intervals on average contained parentese, 38.8% included maternal parentese, and 20.3% included paternal parentese (Recall that an interval could contain parentese from both parents; hence, maternal and paternal parentese do not sum to total parentese, 53.7%). We found that parentese was significantly associated with parent gender ($p < .001$). Based on the model that included only main effects, fathers produced on average 51.9% less parentese than mothers. While there was no main effect of SES ($p = .334$), we did find a significant main effect of child age ($p < .001$) and, furthermore, that child age interacted significantly with parent gender ($p = .002$), as depicted in Figure 1. In particular, maternal parentese increased by 1.7% each month, whereas paternal parentese increased by 4.8% each month. At 6 months of age, infants heard on average 62.8% less parentese from fathers than from mothers, but by 24 months, they heard only 35.5% less parentese from fathers.

Since our results show that mothers produced significantly more words than fathers in our sample, a potential concern is that the present data set favors maternal parentese. By only annotating % parentese in the 30-s segments with the highest AWC (see Ferjan Ramírez et al., 2018, 2020), the original study could have incidentally biased the selection towards segments that contain more female words, contriving or inflating the gap between maternal and paternal parentese. In a post hoc analysis, we thus looked at the relative proportions of each parent's input that contained parentese—hereafter, their "relative parentese proportions." We did so by identifying which of the coded segments contained maternal speech and which contained paternal speech, then calculated their respective proportions of parentese. From this analysis, we excluded segments that additionally contained speech from a third (i.e., nonparent) adult to avoid how this might affect parents' usage of parentese. The distributions of these proportions are included in Table 1. Mixed-effects linear regression revealed that parentese constituted a significantly smaller proportion of fathers' input than mothers' input (41.0% vs. 56.6%, on average; $p < .001$), as shown in Table 3. We discuss the implications of these results in the Discussion.

### *Child Vocalizations*

The infants in our study produced on average 1,567.6 vocalizations per day. As relayed in Table 4, CVC was significantly associated with child age ($p < .001$) but not with SES ($p = .959$). While we found no main effect of MAN ($p = .275$), CVC was significantly associated with FAN ($p < .001$), with child vocalizations increasing by 4.8% on average per 10% increase in FAN. Conversely, CVC was significantly associated with paternal parentese ($p = .023$), but not with maternal parentese ($p = .313$), with child vocalizations increasing by 0.8% on average per 1.0% increase in fathers' usage of parentese in the coded intervals. In the interaction model, child age and FAN also interacted significantly ($p = .004$). At 6 months of age, infant vocalizations increased on average by 2.1% per 10% increase in FAN; however, by 24 months, this rate had grown to 8.9%. On the other hand, CVC was not significantly associated with interactions between child age and MAN ($p = .924$), paternal parentese ($p = .358$), or maternal parentese ($p = .356$).

## Discussion

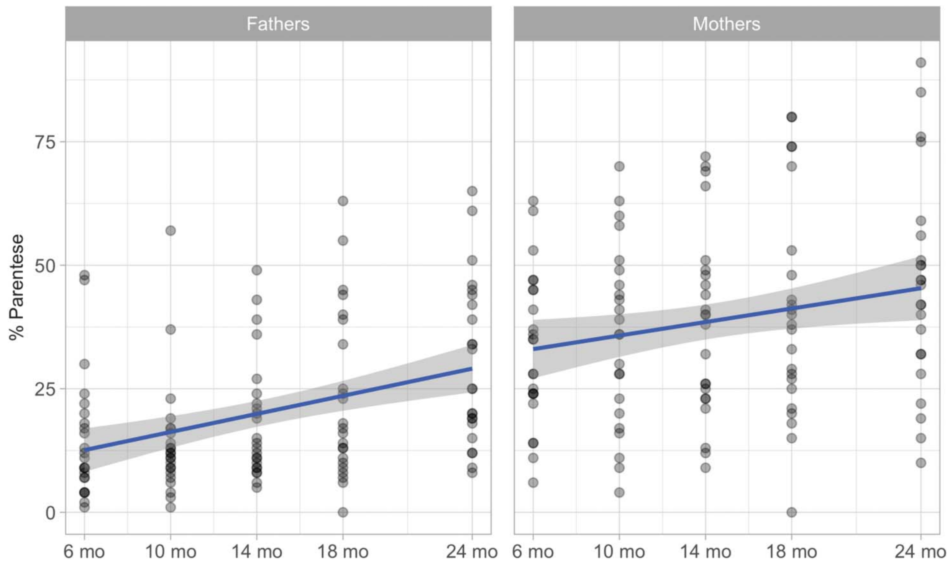
This study examines mother and father differences in parental language input, focusing on the number of adult

**Table 2.** Associations with adult word count (AWC) and % parentese.

| | Outcome: AWC | | | Outcome: % Parentese | | |
|---|---|---|---|---|---|---|
| **Main effect** | **%Δ** | **95% CI** | ***p*** | **%Δ** | **95% CI** | ***p*** |
| SES (per 1-point increase) | 0.13 | (–1.26, 1.54) | .860 | 0.86 | (–0.84, 2.60) | .334 |
| Child age (per 1-month increase) | 0.42 | (–0.30, 1.13) | .255 | 3.22 | (2.21, 4.24) | < .001 |
| Parent gender (male) | –46.78 | (–56.45, –34.97) | < .001 | –51.92 | (–63.22, –37.14) | < .001 |
| **Interaction** | | | | | | |
| Child age × Parent gender (male) | 1.16 | (–0.26, 2.61) | .112 | 3.10 | (1.15, 5.09) | .002 |

*Note.* AWC = adult word count; %Δ = mean change in outcome per unit increase in variable; CI = confidence interval; SES = socioeconomic status. The main effect terms are from the main effects models and the interaction terms are from the interaction models.

**Figure 1.** The percentage of coded input containing paternal and maternal parentese for the same 23 infants at ages 6, 10, 14, 18, and 24 months. The blue regression lines reflect linear predictions of % paternal and maternal parentese, and the gray bands reflect 95% confidence intervals. Note that, at 18 months, there were two separate households in which one parent did not produce any parentese in the coded segments (one father and one mother).




words and parentese heard by infants in English-speaking households. We quantified these measures through a combination of automatic and manual annotation. To our knowledge, this is the first study to perform a longitudinal comparison of the amount of maternal and paternal parentese infants hear during the first 2 years of life, as well as the first to probe how parental input differences relate to child volubility. Using LENA technology, we analyzed the daylong recordings of 23 infants with their mothers and fathers at ages 6, 10, 14, 18, and 24 months. The parents were predominantly White and ranged from mid to high SES.

After controlling for SES and asking families to record on weekends when both parents were present, we found that children heard significantly more words and parentese from mothers than from fathers. This gap persisted throughout infancy, even as fathers increased their usage of parentese over time at a faster rate than mothers. In a follow-up analysis, we analyzed relative parentese proportions to allay the concern that the reported parentese gap fell out of coding parentese in the intervals that had the highest AWCs. Mirroring our % parentese findings, parentese constituted a significantly smaller proportion of paternal input than maternal input, with fathers' relative parentese proportions increasing over time at a faster rate than mothers' relative parentese proportions. These trends suggest that the gap in infants' paternal parentese exposure does not merely stem from fathers producing fewer words in the coded intervals or overall, and instead reflect genuine differences in parents' usage of parentese.

We additionally found that maternal word counts and paternal parentese predicted child vocalizations, with the

**Table 3.** Associations with relative parentese proportion.

| Main effect | %Δ | 95% CI | *p* |
|---|---|---|---|
| SES (per 1-point increase) | 0.03 | (–0.39, 0.46) | .873 |
| Child age (per 1-month increase) | 0.84 | (0.66, 1.02) | < .001 |
| Parent gender (male) | –10.06 | (–14.21, –5.70) | < .001 |
| **Interaction** | | | |
| Child age × Parent gender (male) | 0.42 | (0.06, 0.78) | .024 |

*Note.* %Δ = mean change in relative parentese proportion per unit increase in variable; CI = confidence interval; SES = socioeconomic status. The main effect terms are from the main effects model and the interaction term is from the interaction model.

**Table 4.** Associations with child vocalization count (CVC).

| Main effect | %Δ | 95% CI | *p* |
|---|---|---|---|
| SES (per 1-point increase) | –0.03 | (–0.99, 0.94) | .959 |
| Child age (per 1-month increase) | 3.74 | (2.69, 4.84) | < .001 |
| FAN (per 10% increase) | 4.78 | (2.83, 6.69) | < .001 |
| MAN (per 10% increase) | –0.87 | (–2.33, 0.72) | .275 |
| % Maternal parentese (per 1% increase) | –0.26 | (–0.74, 0.22) | .313 |
| % Paternal parentese (per 1% increase) | 0.76 | (0.12, 1.38) | .023 |
| **Interaction** | | | |
| Child age × FAN | 0.39 | (0.14, 0.65) | .004 |
| Child age × MAN | –0.01 | (–0.21, 0.19) | .924 |
| Child age × % Maternal parentese | –0.03 | (–0.08, 0.03) | .356 |
| Child age × % Paternal parentese | 0.04 | (–0.04, 0.11) | .358 |

*Note.* %Δ = mean change in CVC per unit increase in variable; CI = confidence interval; SES = socioeconomic status; FAN = female adult nearby words; MAN = male adult nearby words. The main effect terms are from the main effects model and the interaction terms are from the interaction model.

relation between child vocalizations and maternal word counts strengthening over time. Interestingly, paternal word counts and maternal parentese did not predict child vocalizations. These asymmetries exemplify how the language of mothers and fathers can differentially relate to child language. Building on earlier work, we thus show that fathers play a unique role in children's linguistic development and deserve further study in order to better understand sources of variability in child language outcomes. We now turn to more detailed discussions of parental input and child volubility.

## *Parental Input*

We approximated parental word counts with LENA's AWC estimates. As expected, we found no apparent effects of child age on parent volubility (cf. Gilkerson et al., 2017). The infants in our sample heard on average 46.8% fewer words from fathers than from mothers, consistent with prior literature that has attested significant gaps between total maternal and paternal input (Gilkerson & Richards, 2009; Golinkoff & Ames, 1979; Hladik & Edwards, 1984; Leaper et al., 1998; Majorano et al., 2013; Pancsofar & Vernon-Feagans, 2006).

All of the fathers in this study produced at least some parentese. In the analyzed coded segments, paternal parentese constituted on average 41.0% of all paternal input and 20.3% of children's language exposure. Nonetheless, we found that infants heard on average 51.9% less parentese from fathers than from mothers. This finding most resembles that of Bergelson et al. (2018), who observed that women produced 2–3 times more CDS than men (including both standard CDS and parentese). One possible explanation for these trends is that fathers took on comparatively fewer caregiver responsibilities, leading to fewer direct interactions with their infants (cf. Cabrera et al., 2000; Lamb & Tamis-LeMonda, 2004; Pleck, 2010). Concomitantly, these trends may be explained by differing beliefs regarding child language development. For instance, in a survey of 180 female and 120 male undergraduates in the Midwest, Kennison and Byrd-Craven (2015) found that men were significantly less likely to believe that infant-directed speech was beneficial to infants' development. Moreover, significantly more men reported that using "baby talk" had been discouraged in their families. Future studies that compare maternal and paternal input should also collect data that probes parents' beliefs and attitudes surrounding childcare responsibilities and child language development.

Our analysis further revealed that both parents increased their usage of parentese over time, with fathers doing so at a faster rate. This may reflect a trend of parents, especially fathers, talking more to their infants as their children became more socially active with age. This analysis is partially supported by our finding that paternal parentese predicts CVC, as discussed in the following subsection. Nevertheless, while the fathers in our sample increased their parentese at a 2.8-times faster rate than mothers, mothers still produced substantially more parentese overall. As was visualized in Figure 1, the amount of parentese that fathers produced when the infants were 24 months old was, on average, the same amount that mothers had produced when the infants were 6 months old. Our finding that exposure to parentese increases over time, however, does diverge from Bergelson et al. (2018), who did not encounter any age-related effects for CDS with infants from 3 to 20 months of age. A possible explanation for this divergence is that their cross-sectional sample (i.e., recordings subsampled from infants of different ages) obscured relative increases in CDS over time that our longitudinal data set captures.

It is also notable that gaps arose between maternal and paternal input even though both parents were asked to be present at home when the recordings in our study were collected. In addition to differing beliefs and familial responsibilities, contrasting workforce obligations may diminish or intensify these gaps during the work week—something worthy of explicit investigation in the future.

## *Child Volubility*

Consistent with prior work, child vocalizations in our sample increased with child age (cf. Gilkerson & Richards, 2009; Gilkerson et al., 2017). When looking at child vocalizations and its associations with parental input, asymmetries emerged between maternal and paternal speech. In particular, we found maternal total words to predict child vocalizations at each age, with this association strengthening over time. However, we found no such effects of paternal word counts. In contrast, and perhaps most surprisingly, we found that paternal parentese predicted child vocalizations, but maternal parentese did not.

These effects appear to reflect a quantity–quality distinction, where the sheer quantity of maternal input relates more to child volubility, whereas the quality of paternal input is more relevant than its quantity. What we are thus seeing is that mothers' volubility predicts child volubility. This dovetails with a threshold/saliency analysis of the parentese asymmetry, resembling the "threshold effect" postulated by Pancsofar and Vernon-Feagans (2006): It is possible that the mothers in the present sample all provided ample verbal input, including parentese, to the point where maternal parentese was not predictive of child volubility; alternatively, their extensive usage of parentese could have prompted infants to monitor and model maternal volubility. In contrast, since paternal word counts and parentese were less likely to exceed such a threshold or to match maternal input, this allowed paternal parentese to become more salient and differentially relate to child vocalizations.

Paternal parentese and child volubility may have also been mutually reinforcing. When the fathers engaged with their children in parentese, it may have been especially salient, prompting more social and vocal responses from the infants. Likewise, when the infants were more socially and vocally interactive, this may have spurred paternal engagement, including the use of parentese. To infer causality, future studies should examine maternal and paternal parentese in the context of conversational turns and temporally contingent language (cf. Pretzer et al., 2019). If paternal parentese does *lead* to child volubility as a result of its saliency, these transactions may be partially enabled by the contrast provided by high maternal volubility. Specifically, it is possible that the quality of paternal speech was salient not just because fathers provided input below some threshold, but because the mothers in our sample had also created rich communicative environments. Future research can delve into the asymmetries displayed by parents, focusing on the relationships between the quantity, quality, and saliency of parental input.

It is also worth noting that, even though maternal parentese did not predict child volubility in the present study, it has still been tied to many aspects of infant language development, such as phonetic learning (Kuhl et al., 1997; Liu et al., 2003) and vocabulary acquisition (Hartman et al., 2017; Kalashnikova & Burnham, 2018; Newman et al., 2016). At the same time, much of the work in this area has excluded fathers and has not controlled for parental differences. The asymmetries discussed here underscore the importance of distinguishing maternal and paternal input, as their effects on child language do not necessarily parallel one another. Paternal parentese is thus worthy of deeper investigation, while controlling for maternal language, and vice versa.

### *Additional Future Directions*

First and foremost, efforts that seek to relate caregivers' language to child language development should control for parental differences, since the quantity and quality of parents' language can differ substantially and differentially predict child language outcomes. As our analysis was exploratory, future work should continue to compare maternal and paternal parentese and how they relate to child volubility, as well as to more fine-grained child language measures (e.g., babbling, vocabulary diversity, utterance complexity). These relationships should also be explored during the first 6 months of life to further illuminate the trajectory and role of parentese during infancy. Related research can also assess the impact of family-centered interventions (cf. Bagner, 2013; Bagner & Eyberg, 2003) that target closing the gap between mothers' and fathers' usage of parentese.

With regards to LENA, future endeavors to compare parental input in daylong recordings should attempt to track interlocutors and activities, at least within a subset of segments. This is especially important, since many laboratory-based studies have shown mothers' and fathers' language to vary across contexts (e.g., dyadic and triadic interactions, as in Bingham et al., 2013) and activities (e.g., shared book reading, as in Malin et al., 2014). This would enable a more ecologically valid inspection of how maternal and paternal input varies across events. When manually coding daylong recordings, we also recommend that future efforts focus on segments from a wider range of environments (e.g., those that contain the highest FAN, MAN, and CVC values), especially when quantifying maternal and paternal speech. In addition, it would be interesting to explore nonbinary annotations of parentese that are more sensitive to variation in infants' linguistic environments.

Relatedly, we used LENA's adult volubility measures to approximate parent speech (akin to Gilkerson & Richards, 2009). Future studies should validate what proportions of these word counts can be attributed to mothers and fathers, versus other individuals, in addition to evaluating their general accuracy. Such validation is vital, given the growing body of work that has found LENA to make systematic errors as a function of speaker gender (Bergelson et al., 2018; Bulgarelli & Bergelson, 2020; Cristia, Bulgarelli, & Bergelson, 2020; Cristia, Lavechin, et al., 2020; Lehet et al., 2020). For example, Bergelson et al. (2018) noted that LENA was more likely to mislabel male speakers as female when they were using CDS and, conversely, female speakers as male when they were addressing adults. Similarly, studies have found that LENA has a harder time identifying female speakers when their speech is infant directed (Lehet et al., 2020), but, when recognizing female speech versus male speech overall, it exhibits greater precision (0.60 vs. 0.43) and comparably low recall (0.32 vs. 0.31; Cristia, Lavechin, et al., 2020). These findings also emphasize the importance of supplementing automatic measurements with manual variables, as we have done in the present study with parentese. For instance, despite the shortcomings of LENA's gender-specific tags, it is promising that our automatic and manual analyses yielded such similar results: that infants heard 46.8% fewer words and 51.9% less parentese from fathers.

With respect to SES, in none of our analyses did an effect of SES appear, contrary to previous literature that has linked lower SES to less parental input (e.g., Gilkerson et al., 2017; Hart & Risley, 1995; Hoff, 2003a, 2003b; Rowe, 2008). However, our sample did not include low SES families, who may exhibit more pronounced variation in parental speech. The lack of differentiation between the mid and high SES families could also reflect a genuine social shift towards the merger of parental language behaviors across certain SES groups (cf. Gilkerson et al., 2017). Future comparisons of parental language should sample families from a broader range of socioeconomic backgrounds. It would also be interesting to see how different dimensions of SES (e.g., education and income; cf. Rowe, 2018) might vary by parent in their associations to parentese.

Finally, it is important to acknowledge that the infants in our sample were each raised by predominantly White, English-speaking mothers and fathers. This narrow demographic may exhibit different patterns of language input compared to families who are not represented in the current study. Future research should address parental parentese differences among more diverse populations, such as non-White families, multilingual and non–English-speaking households, single-parent families, and families with same-sex parents. In particular, while we believe fathers in mother–father households have been largely sidelined by past research and deserve greater attention, this is even more true of LGBTQ+ parents. The language development literature on these families is virtually nonexistent. While parent gender did predict parental input in this study, future work that relates parental language to child language should also explore to what extent gender differences can be explained by family dynamics, differing responsibilities, and the diversity of beliefs surrounding family roles and child development. Future efforts might also consider modeling parent gender as a variable that is multifaceted, rather than binary (Cameron & Stinson, 2019).

## Conclusions

This exploratory study has illustrated how maternal and paternal language can differentially predict infant volubility, highlighting the need to control for both parents when relating parental input to child language outcomes. In our sample of English-speaking families, maternal word counts and paternal parentese predicted infant vocalizations during the first 2 years of life, whereas paternal word counts and maternal parentese did not. These asymmetries emerged even as infants heard considerably fewer words and less parentese from fathers. Quantifying these patterns is an important step towards better understanding paternal contributions to child language development. The observed paternal parentese gap also presents an opportunity to design culturally sensitive interventions that enhance father–infant interactions.


## Acknowledgments

We thank Patricia K. Kuhl, Denise Padden, Julia Mizrahi, and Bo Woo for their valuable assistance during the data collection in the original intervention study. We are also grateful to Kevin Chen for his extensive feedback on the present article. Both the intervention study and current analysis were supported by the Overdeck Family Foundation and the University of Washington's Language Acquisition and Multilingualism Endowment.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