1 | INTRODUCTION

Decades of research suggest that parental language input plays an important role in children's language learning. Both quantitative and qualitative measures of parental speech have been associated with children's language outcomes (e.g., Hart & Risley, 1995; Hirsh-Pasek et al., 2015; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991), and children's neural language processing (Romeo et al., 2018). Measures of maternal language input, such as the number of word tokens, diversity of vocabulary, mean length of utterance, use of decontextualized language, and symbol-infused joint engagement have been shown to be related to children's vocabulary growth (Hirsh-Pasek et al., 2015; Hoff, 2003; Hurtado, Marchman, & Fernald, 2008; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Romeo et al., 2018).
Huttenlocher et al., 1991; Rowe, 2012; Weizman & Snow, 2001). These studies, employing correlational measures, demonstrate a strong pattern of association between different input measures and children’s language development.

Investigations have also highlighted a particular characteristic of language input in infancy that focuses on parental speaking style. From the first months of life, infants show a preference for “parentese”: an acoustically exaggerated speech pattern often used by caregivers when addressing infants and young children (Fernald, 1985; Fernald & Kuhl, 1987; Grieser & Kuhl, 1988). Compared to standard speech, parentese uses a higher pitch, slower tempo, and exaggerated intonation contours (Fernald, 1985). In parentese, the articulatory gestures and social affect are exaggerated, the grammar is simplified, and sentences are shorter and often repeated (Burnham, 1985; Fernald & Kuhl, 1987; Grieser & Kuhl, 1988).

Parentese is simplified, and sentences are shorter and often repeated (Burnham, 1985; Fernald & Kuhl, 1987; Grieser & Kuhl, 1988). Compared to standard speech, parentese uses a higher pitch, slower tempo, and exaggerated intonation contours (Fernald, 1985). In parentese, the articulatory gestures and social affect are exaggerated, the grammar is simplified, and sentences are shorter and often repeated (Burnham, 1985; Fernald & Kuhl, 1987; Grieser & Kuhl, 1988). It has been suggested that parentese facilitates language learning and processing (Fernald, 1985; Fernald & Kuhl, 1987; Hirsh-Pasek et al., 2011). Parents’ use of parentese has been shown to correlate with infants’ sound discrimination measured in the laboratory (Liu, Kuhl, & Tsao, 2003; Trainor & Desjardins, 2002), word segmentation (Theissen, Hill, & Saffran, 2005), word recognition (Singh, Nestor, Parikh, & Yull, 2009), and fast mapping (Ma, Golinoff, Houston, & Hirsh-Pasek, 2011). It has been suggested that parentese facilitates language learning and processing (Fernald, 1985; Fernald & Kuhl, 1987; Hirsh-Pasek et al., 2011).

Another key characteristic of language input in infancy is the social context in which caregivers and children interact (Kuhl, 2007). Infants are capable of learning aspects of a second language in the context of social interactions with live tutors, but not from the same input delivered via audiotape or TV monitor (Conboy & Kuhl, 2011; Kuhl, Tsao, & Liu, 2003). Moreover, infants’ social behaviors, including eye gaze shifts between objects and language tutors during these sessions, are strongly and positively related to infants’ phonemic learning (Conboy, Brooks, Meltzoff, & Kuhl, 2015).

One aspect of social interaction positively associated with infant speech development is the level of parent-child engagement. Infants who participate in frequent episodes of joint engagement with their caregivers have larger vocabularies than infants who participate in fewer such episodes (Carpenter, Nagell, & Tomasello, 1998). Furthermore, the amount of child-directed, but not overheard speech at 19 months predicts children’s language processing skills and vocabulary size at 24 months, suggesting that children with more exposure to speech directed to them orient to familiar words more efficiently, and learn new words more rapidly (Weisleder & Fernald, 2013).

Two other key aspects of social interactions are social feedback and the contingency of parent-child interactions. Mothers are sensitive to and adjust their child-directed speech in accordance with their infants’ responses (Braarud & Stormark, 2008; Smith & Trainor, 2008). Further, when caregivers respond to infant babbling with fully resonant vowels or words, infants increase the production of the same type of utterance and extend their vocalizations to new phonetic forms (Goldstein & Schwade, 2008).

Taken together, research suggests that social interactions in which parents use parentese, direct language to children, and engage children in contingent back-and-forth exchanges may be beneficial to child language development. But what is the impact of social interactions on children’s language development in natural settings?

This question has recently been addressed in a series of studies using the Language Environment Analysis System (LENA), which enables recordings of both language input and children’s vocalizations in children’s natural environment (Ramírez-Esparza, García-Sierra, & Kuhl, 2014, 2016, 2017). Ramírez-Esparza et al. evaluated the impact of social interactions on children’s language growth by defining three clusters that categorized social interaction variables: (a) Speech Partners: is parental speech directed to the child or not? (b) Speech Style: are parents using parentese or standard speech? (c) Social Context: are parents and children interacting in one-on-one (1:1) or group settings? Infants at 11 and 14 months from families ranging in socioeconomic status (SES) were recorded over 4 days with LENA recorders placed into chest pockets of the children’s vests. The hypothesis was that the use of parentese, particularly in 1:1 contexts, would be associated with advanced later language development.

Results showed that the social variables within the three clusters were correlated with one another, and varied widely: some children received most of their language input in utterances directed specifically to them, through parentese, and in 1:1 interactions, while other children experienced predominantly overheard speech, with little to no parentese, and few 1:1 interactions. Importantly, the proportion of parentese speech in 1:1 contexts at 11 and 14 months was positively correlated with concurrent speech (babbling) and with productive vocabulary at 24 and 33 months of age. By contrast, the sheer number of adult words that children heard was not related to child outcomes (Ramírez-Esparza et al., 2014, 2016, 2017). Along similar lines, a recent intervention study with 11-month-old British infants using LENA in combination with video recordings shows a social gradient in caregiver contingent talk, but not in overall quantity of parental language input (McGillion, Pine, Herbert, & Matthews, 2017).
Prior studies have employed correlational designs to investigate patterns of association between parental language input and children’s language outcomes. The goal of the current study was to use a design that gets closer to determining a causal relationship between social aspects of parental input and language development. Using a randomized controlled design, we asked whether “coaching” parents on the three clusters of social variables as defined by Ramírez-Esparza et al. (Speech Partners, Speech Style, and Social Context) would both enhance the parental language input and in turn increase the children’s language growth. It is currently unknown whether these social variables are malleable in parents of typically developing infants, and whether altering these variables results in enhancements in children’s language development. Given the wealth of literature on the effects of SES on language learning and processing (for review, see Rowe, 2018), our goal was also to assess the potential effects of SES on altering parental language input, and in turn, child outcomes. Families across a range of SES backgrounds were recruited into the study, and SES was used as a covariate in statistical analyses.

Families of 6-month-old infants were assigned to one of three conditions: (a) Parent coaching (PC): these parents received “coaching,” which included linguistic feedback about their own language input and social interaction with their child. They were told about the relationship between these variables and language development as shown in previous research. (b) Parent coaching plus group support (PC+): these parents received the same type of parent coaching as PC parents, but also attended group support sessions, to examine whether additional opportunities to share experiences about language interactions would impact parent or child measures. (c) Control condition (C): these parents were given no feedback on language input or social interaction with their child. All families recorded children’s audio environments and vocalizations using the LENA equipment (LENA Pro Version 3.4.0, 2015) at 6, 10, and 14 months, to measure changes in parental language input and child language outcomes.

We predicted that the intervention would enhance multiple aspects of social interaction between parents and children, and that changes in parental behaviors between 6 and 14 months would be related to growth in children’s language during the same period. Specifically, we hypothesized that, between 6 and 14 months: (a) The proportion of speech directed to the child would show greater increases in the Intervention (PC and PC+) compared to Control groups. (b) The proportion of parentese speech, but not standard speech, would show greater increases in Intervention compared to Control groups. (c) The proportion of 1:1 interactions, but not group interactions would show greater increases in Intervention compared to Control groups. (d) Infant Babbling and Infant Outcomes (gestures, words) at 14 months would be higher in the Intervention compared to Control groups, and (e) Participation in the social gathering with other participating families (PC+) would provide an additional advantage (greater growth in social input variables, better child outcomes in PC+ compared to PC condition).

1.1 | The present study

2 | METHODS

2.1 | Participants

The CONSORT diagram is shown in Figure 1. Inclusion criteria were that infants were full-term (within ±14 days of due date), of normal birth weight (6–10 lbs), and had no major birth or postnatal complications. English had to be the only language spoken in the home. The eligibility criteria did not change after trial commencement. Most families were traditional two parent households (n = 65), some had additional family members living in the household (n = 12), and some were single-parent families (n = 2). No families were excluded due to family type.

One hundred and fifty-eight families were recruited through the University of Washington Subject Pool (recruitment period: 9/18/2016–1/19/2017), and assessed for eligibility and SES over the phone, by a research assistant in our laboratory. Seventy-nine families were successfully recruited into the study and assigned into one of the four predetermined SES blocks. SES was measured with the Hollingshead Index (Hollingshead, 1975, 2011), a widely used measure, which codes parent educational attainment and occupational prestige to generate a number between 8 and 66. Participants were working- to upper-middle-class families, with a mean Hollingshead Index of 49.6 (SD = 10.3), and a range from 30 (e.g., both parents with high school diploma/some college, working in sales or construction) to 66 (e.g., both parents with advanced degrees, working as professionals). Educational attainment and occupational prestige are highly correlated, so it is possible to generally describe education and occupation characteristics associated with the range of Hollingshead Index scores that define each block: SES1 (medium–low, 30–39): e.g., both parents hold a high school diploma and may have completed some college or technical training, and work as a welder, delivery driver, plumber, or grocery clerk. SES2 (medium, 40–49): e.g., both parents have completed some college or have a college degree, and work as a restaurant manager, fitness instructor, preschool teacher, or marketing assistant. SES3 (medium–high, 50–59): e.g., both parents hold a Bachelor’s degree and may have completed some post-graduate training, and work as a registered nurse, high school teacher, accountant, or project manager. SES4 (high, 60–66): e.g., both parents hold advanced degrees and work as an attorney, physician, engineer, or executive director.

Within each SES block, families were randomly assigned to the PC (n = 33, SES: M = 50.1, SD = 10.6), PC+ (n = 22, SES: M = 48.8, SD = 9.6), or C (n = 24, SES: M = 49.4, SD = 10.8) condition. Sample size was calculated based on past findings (Ramírez-Esparza et al., 2014, 2016, 2017) to detect a large effect size for the primary outcome measure of parentese with a 0.80 power at the 0.05 level of significance, allowing for up to 20% attrition. The randomization was conducted prior to baseline data collection by the laboratory manager who was otherwise not involved in data collection or analyses. Using a random function in Excel, each family within each SES block was assigned the number 1.
The number 3 was assigned 1/3-times more often than numbers 1 and 2, to ensure a larger group size for the PC condition, anticipating higher attrition due to the requirement to attend parent coaching meetings, and having no group support sessions.

Two PC families withdrew from the study after enrollment, randomization, and baseline (6 months) data collection. All other families \( n = 77, 97\% \) remained in the study and completed all study procedures at 6, 10, and 14 months. The ethics committee at the University of Washington approved the study, and written informed consent was obtained from all participating parents. The study conforms to the US Federal Policy for the Protection of Human Subjects.

### 2.2 | Study design

Prior to the first data collection point, all enrolled families attended individual orientation visits in our laboratory, led by a research assistant (aware of the family’s condition allocation) who collected informed consent, showed the families how to use the recorders, and informed them that we are studying the relationship between language input and language development. At each data collection point (6, 10, and 14 months), the research assistant reminded families by phone or email (parents’ choice) to complete the recordings. The communication about the logistics of the study was separate from parent coaching. The intervention behaviors were discussed exclusively during the coaching appointments, and only by the parent coach.

LENA recordings were made at 6, 10, and 14 months, to assess language input and child language. Parent coaching took place when infants were 6 and 10 months of age. At 6 and 10 months of age, PC+ families additionally attended 1-hr social gatherings, with 8-12 other participating PC+ families. To evaluate the effect of these PC+ gatherings, we conducted an analysis comparing the PC and PC+ conditions on all parental input and child language variables. There were no significant differences between these two conditions (all \( p < 0.1 \)), which were therefore collapsed into a single group (Intervention, I; \( n = 53 \); see Table 1) for the remaining analyses.

### 2.2.1 | Parent coaching

Following the 6- and 10-month recordings, I families attended individual coaching sessions. Both parents were invited; however, 80
out of 106 appointments (39 at 6 months, 41 at 10 months) were attended by mothers only. One appointment (at 10 months) was attended by father only. Twenty-five out of 106 appointments (14 at 6 months, 11 at 10 months) were attended by two parents, and seven families had two parents at both the 6- and the 10-month appointments. We conducted an analysis comparing the effects of having both parents versus one parent present at the 6-month, 10-month, and 6- and 10-month appointments, on all parental and child variables. There were no significant differences between these two conditions (all $p$s < 0.1), which were therefore collapsed.

Sessions were ~45 min long, took place an average of 22 days ($SD = 7.7$) after the recording, and followed a four-step format:

1. The coach shared feedback on the language measures (number of adult words, number of adult-child turn-taking exchanges, and proportion of intervals with parentese), derived from each family’s latest LENA recordings. Parents’ data were compared against research-based targets. The targets for adult word counts and adult-child exchanges were adopted from the LENA normative dataset (Gilkerson & Richards, 2008). The targets for parentese were adopted from previous research by Ramírez-Esparza et al. (2014), which employed the same procedures as the current study. The coach told the parents that these measures have been shown in research to affect language growth, and discussed with the parents how and why they may vary from family to family or from day to day. The coach described that social interactions in which parents speak in parentese, use rich language directed to the child, and engage the child in contingent, 1:1 back-and-forth exchanges may be beneficial to child language development. Parents were encouraged to think of specific scenarios or activities that help them engage in the intervention behaviors. For example, parents were asked to name examples of daily routines (such as diaper changes, meals, bath time) when they are particularly likely to engage their child in contingent 1:1 interactions, use parentese, or talk directly with their child. They were encouraged to discuss with the coach why these particular routines may be important for their child’s language development, and propose what they can do to create additional, similar moments throughout the day.

2. The coach asked parents to listen to hand-selected audio samples from their most recent recordings to highlight examples of speech directed to the child, parentese, and contingent back-and-forth 1:1 exchanges. For each selected audio clip, the coach asked the parents to identify the intervention behavior (talking directly to the child, contingent 1:1 interactions, and parentese), encouraged the parents to consider why and how it may positively affect their child’s language growth, and suggested that they think of other similar scenarios that they may engage in throughout the day. Instances of the child’s babbling or producing words were also played, and parents were encouraged to recognize that infants’ utterances are often not fully formed. Parents were told that an isolated vowels such as /æ/ or /ə/ are speech vocalizations that may reflect the child’s attempt to produce a word, particularly when the utterance is accompanied by a finger point or consistent eye gaze to an object.

### TABLE 1 Family composition and socioeconomic status in Intervention and Control group

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of families</th>
<th>Number of families with siblings</th>
<th>Number of siblings in household $M (SD)$</th>
<th>Number of adults in household $M (SD)$</th>
<th>SES $M (SD)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>53, 27 boys</td>
<td>21</td>
<td>0.6 (0.9)</td>
<td>2.2 (1.6)</td>
<td>50.0 (10.2)</td>
</tr>
<tr>
<td>C</td>
<td>24, 12 boys</td>
<td>9</td>
<td>0.4 (0.5)</td>
<td>2.3 (1.1)</td>
<td>48.8 (9.6)</td>
</tr>
</tbody>
</table>

**FIGURE 2** Front and back side of an example card from Vroom Brain Building Moments®. Cards were selected to highlight occasions when parents might interact in ways to support their child’s language development.
3. The coach gave parents a set of age-appropriate Vroom cards (Vroom Brain Building Moments®, see www.vroom.org) that contained information about opportunities for language input and social interactions (specific scenarios such as diaper changes, feedings, or bath time; Figure 2). The Vroom Brain Building Moments® highlight everyday activities and encourage parents to interact with their child. The coach discussed the cards with the parents and encouraged them to think of specific scenarios and activities in their daily lives that provide opportunities to engage in the intervention behaviors.

4. Finally, the coach discussed the child’s next expected language milestone (i.e., canonical babbling, first words) and strategies to support language growth, through engaging their child in age-appropriate social interactions that include the intervention behaviors (parentheses, contingent 1:1 interactions, speaking directly with the child). Parents received an age-appropriate book, and were encouraged to engage the child in positive, language rich daily activities.

2.3 | Language input and child language assessment

2.3.1 | LENA data collection

All I and C families used the LENA devices at 6, 10, and 14 months over two weekend days (Table 2). Parents were asked to start each recording in the morning when the infant woke up, and to turn off the recorder at night when the infant went to sleep. The average duration of the recordings was 12 hr and 50 min (range: 9 hr and 28 min to 16 hr). Recording duration and range did not differ between the groups at 6, 10, or 14 months.

Parents of I and C children were instructed to record a “typical” weekend, defined as two consecutive days when both parents were home and not working. Families were not told to explicitly practice the intervention behaviors prior to or during the recordings. They were asked to go about their activities as usual, and complete an activity diary for each day (i.e., 12–2 p.m.: birthday party; 2–4 p.m.: grocery shopping). The number of adults living in the household did not differ between I and C groups (Table 1). Because the goal was to capture children’s natural language environments, most infants interacted with multiple other adults not living in the household during the recordings. However, the total number of adult words heard by the children did not differ between I and the C group at baseline (see Table 5).

If initial attempts to record were not successful (e.g., the family forgot to turn on the recorder, or the recorder malfunctioned), the families were asked to record again, on two consecutive weekend days as soon as possible. This occurred on a total of 9 out of 231 recordings. Additionally, 2 of the 231 recordings came from non-consecutive weekend days, due to equipment failure, followed by the families’ inability to rerecord a full 2-day weekend within an acceptable timeframe.

2.3.2 | LENA data preparation

The goal of the present study was to test whether the three clusters of social variables (Speech Partners, Speech Style, and Social

<table>
<thead>
<tr>
<th>TABLE 2 Information about 6-, 10-, and 14-month recordings in Intervention and Control group</th>
<th>Group</th>
<th>Duration of 6-month recording M hr: min (range)</th>
<th>Duration of 10-month recording M hr: min (range)</th>
<th>Duration of 14-month recording M hr: min (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (N = 24)</td>
<td>12:34 (10:01–16:00)</td>
<td>12:53 (9:28–16:00)</td>
<td>13:04 (10:45–16:00)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Average age for the first day of the recording is given in parentheses, in days before (+) or after (−) the 6-, 10-, and 14-month birthday.
Context) as defined by Ramírez-Esparza et al. would enhance parental language input and in turn increase children’s language growth. For this reason, the LENA data preparation procedures followed those outlined in the three published studies by Ramírez-Esparza et al. (2014, 2016, 2017). The LENA software produces an automatic count of child vocalizations, words produced by nearby adults, and adult-child conversational turns. Because we recorded the families on weekends and told them to go about their days as usual, the recordings varied in types of activities families engaged in, levels of ambient noise, amount of overlapping speech, and channel acoustics, which affect the accuracy of the LENA automatic counts (see Gilkerson & Richards, 2008, 2009). We had no specific predictions about the LENA automatic counts; however, the number of adult words and the number of conversational turns were used in the parent coaching appointments to provide feedback to the families and discuss how and why each measure may be particularly high or low on a given day.

The LENA audio files were further processed using the LENA Advanced Data Extractor Tool (ADEX) to identify intervals with the language activity of interest (high adult word counts) for manual analysis, in order to avoid coding when there is no social or linguistic activity (e.g., during naps). Each participant’s two daily recordings were segmented into 30-s intervals. For each of the two recording days, 50 intervals with the highest adult word count that were at least 3 min apart were selected, yielding a total of 100 30-s coding intervals per participant.

2.3.3 | LENA data coding

Six research assistants were trained to code the selected intervals. In each interval for each participant, they determined the presence or absence of 11 Social Interaction Categories within the three clusters of social variables (see Table 3), and the presence or absence of infant babbling (at 6, 10, and 14 months) and infant words (at 14 months).

Coders were blind to the family’s condition assignment, but were provided with basic information about each selected interval (date, time of day) and with participants’ activity diaries. All coders were members of our research team, had prior experience coding parentese and infant vocalizations, and used the same audio files, training, and reliability assessment as described by Ramírez-Esparza et al. (2014, 2016, 2017). During training, the coders listened to examples of each of the 11 Social Interaction Categories. To distinguish parentese from standard speech, the same criteria were adopted as described by Ramírez-Esparza et al. (2014, 2016, 2017); variable definitions in Table 4; see also Supporting Information.

After training, all coders were tested independently with a training file from Ramírez-Esparza et al. (2014), used to evaluate intercoder reliability. The reliability analysis produced an average intra-class correlation of 0.94, indicating effective training and reliable coding (Table 3; see also Ramírez-Esparza et al., 2014, 2016, 2017; Shrout & Fleiss, 1979).

Following the procedures outlined in Ramírez-Esparza et al. (2014, 2016, 2017), coders listened to each 30-s interval and entered a ‘YES’ or a ‘NO’ for each category for that interval. The data matrices containing YES and NO responses for each participant were aggregated to provide relative time use data by calculating the percentage of intervals coded for each category.

2.3.4 | Input variables

Based on past coding of the three clusters and 11 Social Interaction Categories, we examined the following social interaction variables: (a) Total percentage of intervals with speech directed to child (% Speech Directed to Child); (b) Total percentage of intervals with parentese speech (% Parentese Speech); (c) Total percentage of intervals with standard speech (% Standard Speech); (d) Total percentage of intervals with 1:1 interactions (% 1:1 Interactions); (e) Total percentage of intervals with group interactions (% Group Interactions). As expected based on past work (Ramírez-Esparza et al., 2014, 2016, 2017), multiple variables within the three clusters of social interaction (Speech Partners, Speech Style, and Social Context) were significantly correlated at baseline (for a complete correlation matrix of social interaction variables see Supporting Information Table S1), confirming that they are part of a shared underlying construct of social interaction. The current study retained them as individual measures because parents were coached on individual variables within each cluster, and we were curious to study where the strongest intervention effects would be.

We also examined the total number of adult words heard by the child (Adult word count, AWC). While we had no specific predictions about this measure, we report it here because it was used for the purpose of coding interval selection.

### Table 3 Social interaction and infant vocalization categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Intercoder reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Speech partners</strong></td>
<td></td>
</tr>
<tr>
<td>Mom speaks to infant</td>
<td>0.95</td>
</tr>
<tr>
<td>Dad speaks to infant</td>
<td>0.95</td>
</tr>
<tr>
<td>Other adult speaks to infant</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Speech style</strong></td>
<td></td>
</tr>
<tr>
<td>Mom using parentese</td>
<td>0.93</td>
</tr>
<tr>
<td>Dad using parentese</td>
<td>0.98</td>
</tr>
<tr>
<td>Other adult using parentese</td>
<td>0.92</td>
</tr>
<tr>
<td>Mom using standard speech</td>
<td>0.93</td>
</tr>
<tr>
<td>Dad using standard speech</td>
<td>0.93</td>
</tr>
<tr>
<td>Other adult using standard speech</td>
<td>0.91</td>
</tr>
<tr>
<td><strong>Social context</strong></td>
<td></td>
</tr>
<tr>
<td>Infant with one adult</td>
<td>0.99</td>
</tr>
<tr>
<td>Infant with two or more adults</td>
<td>0.99</td>
</tr>
<tr>
<td><strong>Infant vocalizations</strong></td>
<td></td>
</tr>
<tr>
<td>Babbling</td>
<td>0.94</td>
</tr>
<tr>
<td>Words</td>
<td>0.88</td>
</tr>
</tbody>
</table>
2.3.5 | Child language measures

Child language measures included the percent of coded intervals with babbling at 6, 10, and 14 months (% Infant Babbling), and percent of coded intervals with words at 14 months (% Infant Words; analyzed with a log transformation to correct for skewed data). Babbling was defined as: fully resonant vowels, consonant-vowel (CV) syllables, with a log transformation to correct for skewed data). Babbling was included in Ramírez-Esparza et al., 2014). Infant vocalizations were counted as variegated strings of consonant–vowel syllables, speech utterances pendent variables, for all input variables. Baseline level measures were included in repeated measures ANOVAs. There were no significant main effects of group. A significant main effect of time, indicating developmental trends regardless of group membership, was identified for the following variables: % Speech Directed to Child $F(2, 75) = 26.74, p < 0.001, \eta_p^2 = 0.26$; % Parentese Speech $F(2, 75) = 18.21, p < 0.001, \eta_p^2 = 0.20$; % Standard Speech $F(2, 75) = 36.27, p < 0.001, \eta_p^2 = 0.33$; % 1:1 interactions $F(2, 75) = 8.08, p < 0.001, \eta_p^2 = 0.10$; % Group Interactions $F(2, 75) = 4.82, p = 0.009, \eta_p^2 = 0.06$.

Of greater interest was the interaction of time and group, as it indicates the impact of the intervention on the patterns of change over time. As hypothesized, significant time by group interactions were identified for % Speech Directed to Child $F(2, 75) = 3.23, p = 0.042, \eta_p^2 = 0.04$ and % Parentese Speech $F(2, 75) = 3.23, p = 0.043, \eta_p^2 = 0.04$. For both variables, I families showed greater increases across age compared with C families. These interactions of time by group remained significant after controlling for SES as measured by the Hollingshead Index (covariance analysis), respectively: $F(2, 74) = 3.27, p = 0.041, \eta_p^2 = 0.04$; $F(2, 74) = 3.30, p = 0.040, \eta_p^2 = 0.04$ (see also Supporting Information Figure S1).

Because of the significant time by group interaction, we further explored the improvements in parental behaviors in I families. We conducted paired t tests to analyze the changes between 6 and 10 and between 10 and 14 months. I families significantly increased their use of % Speech Directed to Child between 6 and 10 months, and 10 and 14 months, respectively: $t(52) = 5.25, p < 0.001, d = 0.72$; $t(52) = 3.73, p < 0.001, d = 0.51$. I families also increased their use of % Parentese Speech during both intervals, respectively: $t(52) = 3.50, p < 0.001, d = 0.73$; $t(52) = 2.35, p = 0.023, d = 0.32$. By contrast, C families did not demonstrate significant gains in % Speech Directed to Child or % Parentese Speech during either interval ($p > 0.10$).

### TABLE 4 Input variable names and definitions

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Variable definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Speech Directed to Child</td>
<td>Mother, father, or other adult spoke directly to the infant, parentese or standard speech was used, and one or more than one adult voice was recorded during the interval</td>
</tr>
<tr>
<td>% Parentese Speech</td>
<td>Mother, father, or other adult spoke directly to the infant, parentese speech style (high pitch, slow tempo, and exaggerated contours) was used, and one or more than one adult voice was recorded during the interval</td>
</tr>
<tr>
<td>% Standard Speech</td>
<td>Mother, father, or other adult spoke directly to the infant, standard (ordinary) speech was used, and one or more than one adult voice was recorded during the interval</td>
</tr>
<tr>
<td>% 1:1 interactions</td>
<td>Mother, father, or other adult spoke directly to the infant, parentese or standard speech was used, and only one adult voice was recorded during the interval</td>
</tr>
<tr>
<td>% Group interactions</td>
<td>Mother and/or father and/or other adult spoke directly to the infant, parentese or standard speech was used, and two or more adult voices were recorded during the interval</td>
</tr>
<tr>
<td>AWC</td>
<td>Total number of adult words heard by the child during the recording, calculated automatically by the LENA software, and averaged over two recording days</td>
</tr>
</tbody>
</table>

3 | RESULTS

We first tested that the groups were equivalent on all input and child language measures at baseline. There were no significant group differences between I and C groups (all t tests < 1.66, $p > 0.1$) at baseline (6 months, left columns in Table 5).

3.1 | Changes in language input

Changes in language input between 6 and 14 months were analyzed by conducting repeated measures analyses of variance (ANOVA) with time (6, 10, 14 months) and group (C vs. I) as independent variables, for all input variables. Baseline level measures were included in repeated measures ANOVAs. There were no significant main effects of group. A significant main effect of time, indicating developmental trends regardless of group membership, was identified for the following variables: % Speech Directed to Child $F(2, 75) = 26.74, p < 0.001, \eta_p^2 = 0.26$; % Parentese Speech $F(2, 75) = 18.21, p < 0.001, \eta_p^2 = 0.20$; % Standard Speech $F(2, 75) = 36.27, p < 0.001, \eta_p^2 = 0.33$; % 1:1 interactions $F(2, 75) = 8.08, p < 0.001, \eta_p^2 = 0.10$; % Group Interactions $F(2, 75) = 4.82, p = 0.009, \eta_p^2 = 0.06$.

Of greater interest was the interaction of time and group, as it indicates the impact of the intervention on the patterns of change over time. As hypothesized, significant time by group interactions were identified for % Speech Directed to Child $F(2, 75) = 3.23, p = 0.042, \eta_p^2 = 0.04$ and % Parentese Speech $F(2, 75) = 3.23, p = 0.043, \eta_p^2 = 0.04$. For both variables, I families showed greater increases across age compared with C families. These interactions of time by group remained significant after controlling for SES as measured by the Hollingshead Index (covariance analysis), respectively: $F(2, 74) = 3.27, p = 0.041, \eta_p^2 = 0.04$; $F(2, 74) = 3.30, p = 0.040, \eta_p^2 = 0.04$ (see also Supporting Information Figure S1).

Because of the significant time by group interaction, we further explored the improvements in parental behaviors in I families. We conducted paired t tests to analyze the changes between 6 and 10 and between 10 and 14 months. I families significantly increased their use of % Speech Directed to Child between 6 and 10 months, and 10 and 14 months, respectively: $t(52) = 5.25, p < 0.001, d = 0.72$; $t(52) = 3.73, p < 0.001, d = 0.51$. I families also increased their use of % Parentese Speech during both intervals, respectively: $t(52) = 3.50, p < 0.001, d = 0.73$; $t(52) = 2.35, p = 0.023, d = 0.32$. By contrast, C families did not demonstrate significant gains in % Speech Directed to Child or % Parentese Speech during either interval ($p > 0.10$).
TABLE 5  Input and child language variables measured at 6, 10, and 14 months.

<table>
<thead>
<tr>
<th></th>
<th>6 months</th>
<th>10 months</th>
<th>14 months</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I M (SD)</td>
<td>C M (SD)</td>
<td>I M (SD)</td>
<td>C M (SD)</td>
</tr>
<tr>
<td>% Speech Directed To Child</td>
<td>48.8 (18.2)</td>
<td>52.8 (17.7)</td>
<td>57.7 (16.8)</td>
<td>56.1 (19.5)</td>
</tr>
<tr>
<td>% Parentese Speech</td>
<td>42.0 (18.3)</td>
<td>47.4 (17.7)</td>
<td>51.6 (17.5)</td>
<td>49.4 (19.7)</td>
</tr>
<tr>
<td>% Standard Speech</td>
<td>32.0 (14.5)</td>
<td>31.4 (11.7)</td>
<td>41.2 (14.1)</td>
<td>45.9 (18.6)</td>
</tr>
<tr>
<td>% 1:1 Interactions</td>
<td>23.7 (16.2)</td>
<td>28.8 (14.5)</td>
<td>29.2 (14.1)</td>
<td>31.2 (15.2)</td>
</tr>
<tr>
<td>% Group Interactions</td>
<td>25.0 (12.1)</td>
<td>24.0 (11.7)</td>
<td>28.5 (11.7)</td>
<td>25.0 (14.2)</td>
</tr>
<tr>
<td>AWC</td>
<td>19432.3 (7307.7)</td>
<td>16579.4 (6845.6)</td>
<td>19083.3 (7401.3)</td>
<td>15288.5 (6602.9)</td>
</tr>
<tr>
<td>% Infant Babbling</td>
<td>26.2 (7.5)</td>
<td>29.5 (11.6)</td>
<td>37.5 (11.5)</td>
<td>28.8 (12.2)</td>
</tr>
</tbody>
</table>

Note. Sig: significance level of time (6, 10, and 14 months) by group (I vs. C) interaction from repeated-measures ANOVAs. **p < 0.05. ***p < 0.01.

3.2 | Infant language

Changes in infant language between 6 and 14 months were analyzed by conducting repeated measures ANOVA with time (6, 10, 14 months) and group (C vs. I) as independent variables for % Infant Babbling. The ANOVA yielded a significant main effect of group, F(1, 75) = 13.00, p < 0.001, ηp² = 0.15, a significant main effect of time, F(2, 75) = 12.66, p < 0.001, ηp² = 0.14, and a significant time by group interaction, F(2, 75) = 11.44, p < 0.001, ηp² = 0.13. % Infant Babbling in the I group showed greater increases across 6 and 14 months compared to the C group, and the interaction of time by group remained significant after controlling for SES (covariance analysis), F(2, 74) = 11.26, p < 0.001, ηp² = 0.25 (see also Supporting Information Figure S1).

Follow-up paired t-tests showed that in I children % Infant Babbling increased significantly between 6 and 10 months, and between 10 and 14 months, respectively: t(52) = 6.35, p < 0.001, d = 0.87; t(52) = 2.65, p = 0.011, d = 0.36. In C children, by contrast, % Infant Babbling did not increase significantly in either interval (ps > 0.10).

For outcomes measured only at 14 months, the effect of intervention was tested for infant words (% Infant Words from LENA recordings and CDI Percentile Words Produced) and for gestures (CDI Total Gestures). There was a significant effect of group for % Infant Words from LENA, t(75) = 2.79, p = 0.007, d = 0.70, and for CDI Percentile Words Produced, t(75) = 2.52, p = 0.014, d = 0.63. For both measures, the I group had larger vocabularies than the C group. These two group effects remained significant after controlling for SES, respectively: F(1, 74) = 7.82, p = 0.007, ηp² = 0.10; F(1, 74) = 6.56, p = 0.012, ηp² = 0.08. Marginally significant between-group differences were detected for CDI Total Gestures, t(75) = 1.89, p = 0.062, d = 0.47; F(1, 74) = 3.91, p = 0.052, ηp² = 0.05 (after controlling for SES), with the I group using more gestures than the C group.

We considered the possibility that I parents could be better reporters of their children's language than C parents. We examined the relationship between the observed infant language (as coded from LENA) and parent report of infant language (as measured with the CDI) at 14 months. The CDI Percentile Words Produced at 14 months correlated with % Infant Babbling (LENA) and % Infant Words (LENA) at 14 months, respectively: r(75) = 0.37, p < 0.001 and r(75) = 0.25, p = 0.030. Importantly, these relationships did not differ significantly by group (ps > 0.50), suggesting that parents in both groups are equally reliable in reporting their child's language.

3.3 | Correlations between changes in input and infant language

The previous analyses showed that adult input and child language both changed between 6 and 14 months. To examine whether these changes were related, we considered the patterns of association between changes in input between 6 and 14 months and child language development during the same time period. As a preliminary step, Figure 3 displays the change scores for I and C families.

We found a significant correlation between the change in % Speech Directed to Child and change in % Infant Babbling between 6 and 14 months, r(75) = 0.24, p = 0.039 (Figure 4a) and a significant correlation between the change in % Parentese Speech and change in % Infant Babbling between 6 and 14 months, r(75) = 0.31, p = 0.007 (Figure 4b). These correlations remain significant after controlling for SES, partial r(74) = 0.24, p = 0.036; r(74) = 0.31, p = 0.006, respectively. Together, these data indicate that children whose parents showed the largest increases in percentage of input directed to them or parentese also showed the largest increases in babbling.
4 | DISCUSSION

The present study examined whether parents across SES can be “coached” to improve specific social aspects of language interactions with their children, and whether parent coaching, in turn, would support children’s language growth. Intervention, but not Control families participated in individual parent coaching when their infants were 6 and 10 months of age. These appointments provided parents with linguistic feedback on three clusters of social variables (Speech Partners, Speech Style, and Social Context) and on the quantity of speech and turn-taking they provided to their child. Parents were also armed with practical tips for interacting with their children through everyday moments.

Confirming our hypotheses, parent coaching significantly enhanced parent-child interactions as measured by two variables: percentage of intervals with speech directed to the child, and percentage...
of intervals with parentese speech. It should be noted that these two variables were positively correlated with one another at baseline, supporting the notion that they are part of a shared underlying construct of social interaction. In the current study, we are unable to disentangle the effects of these two input measures; however, future studies using path statistical analyses should continue to study how the variables within the three clusters of social interaction coevolve over time. Previous research suggested that directing language to infants, using parentese, providing social feedback, and engaging infants in contingent interactions facilitate language learning (Braarud & Stormark, 2008; Carpenter et al., 1998; Fernald & Kuhl, 1987; Goldstein & Schwade, 2008; Liu et al., 2003; McGillon et al., 2017; Smith & Trainor, 2008; Theissen et al., 2005; Trainor & Desjardins, 2002; Weisleder & Fernald, 2013). Further, Ramírez-Esparza et al. (2014, 2016, 2017) demonstrated that the proportion of parentese speech in 1:1 context in children’s homes at 11 and 14 months is positively related to babbling at 14 months, and predictive of vocabulary size at 24 and 33 months. The results of the present study demonstrate that parental social language behaviors are malleable, and can be enhanced through parent coaching, across SES.

The results also show that speech development is positively linked to the social environments that infants’ experience, and that this is true across the wide SES range studied here. We found that Intervention infants increased their babbling between 6 and 14 months more than Control infants, and were above Control infants on two separate measures of word production (LENA and CDI) as well as the use of gestures at 14 months. Importantly, correlation analyses controlling for SES showed that the growth in use of parentese and speech directed to the child were related to the growth in infant babbling between 6 months and 14 months, indicating that infant and parent behaviors coevolved during this time period, across the SES range studied here.

Previous studies have shown that babbling is positively related to later word production (Oller, Eilers, Neal, & Schwartz, 1999; Ramírez-Esparza et al., 2014; Stoel-Gammon & Sosa, 2009). Research also demonstrates that early vocabulary skills predict later vocabulary skills (Bates, Dale, & Thal, 1995; Fenson et al., 1994), and that children’s use of gesture at 14 months is related to their vocabulary skills at 54 months (Rowe & Goldin-Meadow, 2009). While we are currently unable to evaluate the effects of the present intervention on children’s language outcomes beyond 14 months, previous research shows continuity of language skills over time, suggesting that enhancing parental input in infancy may have long-lasting positive effects on children’s language development. Follow-up studies should assess children’s language at later ages when children can be objectively assessed in the laboratory, to monitor the potential effects of interventions in infancy on long term language outcomes.

Contrary to our hypotheses, we did not detect a significant effect of the intervention on the proportion of one-on-one interactions between parents and infants. One reason for this may be that families completed their recordings on typical weekends when both parents were home, potentially limiting the amount of one-on-one time. Previous studies in infants’ homes suggest that one-on-one interactions, particularly when combined with parentese, are positively related to infant language development (Ramírez-Esparza et al., 2014, 2016, 2017), and laboratory research suggests that parental social feedback in one-on-one settings enhances infant speech development (Goldstein, King, & West, 2003; Goldstein & Schwade, 2008). Future interventions should investigate the role of one-on-one versus group interactions by sampling families during typical weekdays and on weekends.

We also did not detect a significant effect of the intervention on the sheer quantity of adult speech. This may have been because most participating families had a relatively high adult word count at baseline, or because the effects of the intervention were measured several months after coaching. A previous intervention study reported significant effects of coaching on increasing parental word count at one week, but not four months post-intervention (Suskind, Leffel, & Graff, 2016). The fact that the current study demonstrated effects of parent coaching on selected social variables that persisted over several months is encouraging, and suggests that the parental social aspects of parent–child interactions has the potential to improve infants’ language growth.

Interestingly, we found that participation in a group support gathering (PC+), which offered parents additional opportunities to share experiences about their language interactions, produced no significant effects on any of the variables. It is possible that these gatherings were not frequent enough, or that no effect was detected because, unlike the individual appointments, the group gatherings did not provide parents with linguistic feedback. Our interactions with the parents suggest that receiving linguistic feedback may have been a particularly important aspect of the intervention. Previous studies have shown that parents and caregivers are rarely aware of their own language behaviors (see Gilkerson & Richards, 2009; Suskind et al., 2013, 2016). In agreement with these findings, many participating parents were surprised to hear themselves use parentese, and did not know how often, or in what contexts they use it.

Receiving feedback on specific measures, and hearing themselves interact with their child in specific ways, allowed parents to understand the language environment they create and reflect on their critical role in the language learning process.

Another interesting finding was that there were no differences in outcomes between those families who had both parents versus one parent (mother) present at the coaching appointments. The LENA normative study of 329 American families with infants between 2 months and 4 years of age shows that mothers account for 75% of all language input (Gilkerson & Richards, 2009). In the time period studied here (6 to 14 months), this percentage may be even higher, which could, in part, explain why we found no differences between coaching both parents versus only the mother. It should be noted, however, that the present study was not designed to measure such differences and that the sample of families who brought both parents to the appointments may have been too small to detect them. Other studies have shown that fathers’ engagements are positively related to children’s language development (see, for example, Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004). Future interventions should investigate the role of...
providing linguistic feedback to fathers, and measuring how it may affect language input and child language outcomes.

The present coaching intervention consisted of multiple components (providing linguistic feedback, providing concrete tips on how to interact through daily activities, discussion of upcoming milestones), and the effects of the intervention were measured on a relatively limited set of social interaction and child language outcome variables. It is, of course, possible that the intervention changed other parental or child behaviors that were not assessed in the present study. Follow-up studies will also be needed to separate the effects of each of the coaching strategies on parental behavior.

Besides providing quantitative and qualitative linguistic feedback, one potentially important component of the present intervention was arming parents with concrete, research-based tips for implementing what they learned at home. The tips were provided through age-appropriate cards from Vroom Brain Building Moments®, selected to highlight occasions during which parents might interact with their children to support language development. During coaching appointments, it was evident that many parents were already aware that interacting with their child promotes language learning. Yet, many of them struggled to name specific daily activities and routines that may be conducive to such behaviors, and were grateful to leave the appointments with something they could implement at home. While further investigation is necessary, we speculate that providing linguistic feedback and/or providing concrete activity tips may serve as useful strategies to increase parental awareness of their own behaviors and modify them appropriately.

An important issue to consider is the sustainability of the observed parental behavior changes. An inherent weakness of studies that use recording devices is that an individual’s knowledge of being recorded may result in positively modifying their behavior. While it is not possible to rule out that parents behaved differently on recording days, sustaining an altered behavioral pattern over two 13-hr recordings while going about one’s usual day with an infant seems difficult. Furthermore, many Intervention parents informally reported that using parentese and directing language to their child had become a habit during the study. In the current study, the Control group was also recorded with LENA, but did not receive (or expect to receive) any feedback based on the recordings. Future studies should include a control condition that uses the LENA recordings and receives non-linguistic feedback. Another potential limitation of the current study is that participating families were all monolingual English-speaking families, with typically developing infants. Future studies should investigate how the findings described here may generalize to other populations.

The current study shows that a multi-component parent coaching intervention at 6 and 10 months successfully enhances parental language and the use of social behaviors that encourage language, and that these changes are related to children’s concurrent language development. Given the plethora of research demonstrating the relationship between parental language input and child language development, and the critical role of early language for success in school, translational science that creates research-based parental interventions has the potential to improve children’s language and school outcomes.

ACKNOWLEDGMENTS

The authors thank Denise Padden and Neva Corrigan for valuable assistance throughout study design, data collection, and analyses. The authors also thank Julia Mizrahi, Bo Woo, Nicole Dunn, Spencer Sherwin, and Ruofan Cai for assistance in participant recruitment and data coding. The research described here was supported by the Overdeck Family Foundation and the University of Washington Institute for Learning & Brain Sciences Ready Mind Project.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES


SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Ferjan Ramírez N, Lytle SR, Fish M, Kuhl PK. Parent coaching at 6 and 10 months improves language outcomes at 14 months: A randomized controlled trial. Dev Sci. 2018:e12762. https://doi.org/10.1111/desc.12762