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RESEARCH ARTICLE

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Infants who experience more adult-initiated conversations have better expressive language in toddlerhood

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Abstract

To understand how infants become engaged in conversations with their caregivers, we examined *who* tends to initiate conversations between adults and infants, differences between the features of infant- and adult-initiated conversations, and whether individual differences in how much infants engage in infant- or adult-initiated conversations uniquely predict later language development. We analyzed naturalistic adult–infant conversations captured via passive recording of the daily environment in two samples of 6-month-old infants. In Study 1, we found that at age 6 months, infants typically engage in more adult- than infant-initiated conversations and that adult-initiated conversations are, on average, longer and contain more adult words. In Study 2, we replicated these findings and, further, found that infants who engaged in more *adult*-initiated conversations in infancy had better expressive language at age 18 months. This association remained significant when accounting for the number of *infant*-initiated conversations at 6 months. Our findings indicate that early interactions with caregivers can have a lasting impact on children's language development, and that the extent to which parents initiate interactions with their infants may be particularly important.

Language develops in the context of social interactions composed of speakers and listeners (Bruner, 1981; Snow, 1972; Tomasello, 2008; Vygotsky, 1978). Both the quantity and quality of speech that adult caregivers offer young children during day-to-day verbal interactions reliably predict their later language abilities (Bornstein et al., 2020; Hoff, 2003; Huttenlocher, 1998; Huttenlocher et al., 1991, 2007; Pan et al., 2005; Rowe, 2012; Topping et al., 2013). Research examining early language exposure has often emphasized the number and the diversity of adult words that infants and young children experience (e.g., d'Apice et al., 2019). However, the number of verbal exchanges or "conversational turns"—that is, responsive and contingent back-and- forth utterances—in which children engage with adults appear to be particularly important for language development (Gilkerson et al., 2018; Zimmerman et al., 2009).

Theories of child development have increasingly embraced a dynamic interaction model in which children are active players in their environment (e.g., Sameroff & Mackenzie, 2003); only recently, however, has this lens been used to examine the conversations that take place in early life. Research assessing parent responses to child-initiated interactions suggests that, across stages of early language development (e.g., understanding words, producing words, combining words into sentences), children whose parents provide appropriate and timely verbal responses when prompted by a change in their child's behavior develop greater competence (Tamis-LeMonda et al., 2006). Thus, by eliciting important parent–child interactions, children may contribute to their own language development. In fact, Lopez et al. (2020) found that infant-initiated conversations (i.e., infant vocalizations followed by caregiver responses) between 13-month-olds and their caregivers were positively associated with the infants' concurrent productive vocabulary. However, researchers have also found nuanced associations between the number of conversations between children and adults and later language skills. For example, one study found that conversational turns measured when infants were aged 18–24 months were positively associated with language skills 10 years later, but conversational turns measured earlier (i.e., 2–17 months) or later (i.e., 25–36 months) in development were *not* associated with the same language skills assessed later (Gilkerson et al., 2018). Importantly, although researchers have suggested that it is important for caregivers to initiate conversations with their infants (Christakis et al., 2009; Zimmerman et al., 2009), previous research has not identified and distinguished who is initiating conversations between children and their caregivers in order to directly compare the qualities and predictive utility of child- versus adult-initiated conversations.

Understanding differences between adult- and infant-initiated interactions, as well as differences in the associations of these two types of interactions with language outcomes, may be particularly important in the first year of life. Around age 6 months, infants are highly dependent on adults to facilitate verbal interactions. Although infants at this age are starting to engage more frequently with their social world, they typically do not exhibit the signs of intentional communication that are likely to elicit responses from caregivers, such as gestures and words (Donnellan et al., 2020), and canonical syllables (containing at least one consonant and one vowel sound; Gros-Louis et al., 2016). In general, infants also tend to vocalize less than older children do (Gilkerson et al., 2017). For these reasons, caregivers may be less likely to respond to infants' vocalizations than they are to those of older children, and child-initiated conversations may be less common during the first year of life. Another important reason to consider infants' conversations at 6 months, despite differences in their verbal and communicative abilities, is that the number of conversational turns in which they engage is linked to individual differences in brain networks associated with language production and comprehension (King, Camacho, et al., 2021). Ultimately, although adult-initiated conversations are likely to be more prevalent during infancy than are infant-initiated conversations, we do not know which form of communication is associated most strongly with infants' language development. Understanding the relative contributions of adult- and infant-initiated conversations in infancy—a period of unparalleled

brain development—to subsequent language development has important implications for determining recommendations for caregivers and for identifying features of the language environment that could be targeted in early interventions.

Across two studies, we compare the nature and amount of infant-initiated and adult-initiated conversations at infant age of 6 months and explore how these two types of infant–adult conversation uniquely predict subsequent language development. In Study 1, in a sample of mother–infant dyads residing in the southeastern United States, we explored whether adults or infants initiate a greater proportion of naturalistic conversations in infants' daily lives, as well as differences in the nature of adult- and infant-initiated conversations. Specifically, we examined whether adult- and infant-initiated conversations differ in the duration of the conversation, the number of "turns" within the conversation, and the number of adult words within the conversation. In Study 2, we sought to replicate and extend these findings in a second sample of mother–infant dyads residing in the northwestern U.S. in whom we also assessed child language abilities at age 18 months. In addition to testing whether differences in the proportion and nature of adult- and infant-initiated conversations observed in Study 1 would replicate in this second sample, we examined whether individual differences in patterns of conversations at infant age of 6 months predicted subsequent vocabulary in toddlerhood.

1 | STUDY 1

1.1 | Methods

1.1.1 | Participants

All procedures and recruitment methods were in accordance with the ethical standards of the Declaration of Helsinki and the American Psychological Association and were approved by the Institutional Review Board of Vanderbilt University. All mothers provided written informed consent for themselves and their infants prior to participating. Data for this study come from a larger study, with an initial visit in pregnancy, examining the association between early life experiences and infant development. Participants were recruited from the greater Nashville area from obstetrics clinics and through digital and print advertisements. Participants engaged in additional sessions during pregnancy and at infant age of 6 months which are outside the scope of the current paper. Inclusion criteria for the 6-month assessment were that mothers were at least 18 years of age and were fluent in English. Exclusion criteria included severe complications during birth, infant head trauma, infant premature birth (<36 weeks gestation), and infant congenital, genetic, neurological disorders. Of the 132 women who participated in the initial session during their pregnancy, 95 mother–infant dyads returned for the infant age 6-month follow-up. Of those, 20 did not complete a recording of the infant's language environment when the infant was approximately 6 months (≥5 months, <8 months) and 3 completed their recordings when the infant was older than 8 months, yielding a final sample of 72 dyads. See Table 1 for detailed sample characteristics. Participants with missing data differed from those who were included in the final sample in terms of maternal employment status; see supplemental Table S3 for demographic statistics for those with missing data and Table S4 for a comparison of those with complete and missing data.

TABLE 1 Study 1 and Study 2 sample demographics

	Study 1 (*N* = 72)	**Study 2 (*N* = 89)**
Infant age at LENA recording mean (SD) months	6.59 (0.54)	6.56 (0.54)
Infant race number (percent)		
White	61 (85%)	55 (62%)
American Indian/Alaska Native	1 (1%)	0 (0%)
Asian/Asian American	0 (0%)	14 (16%)
Black/African American	7 (10%)	2 (2%)
Native Hawaiian/Pacific Islander	1 (1%)	1 (1%)
Other	2 (3%)	17 (19%)
Infant ethnicity number (percent)		
Hispanic or latinx	5 (7%)	13 (15%)
Infant sex number (percent)		
Male	33 (46%)	45 (51%)
Maternal education number (percent)		
High school diploma/GED	6 (8%)	0 (0%)
Some college	4 (6%)	7 (8%)
Associate's degree	5 (7%)	0 (0%)
Trade/Technical school	0 (0%)	1 (1%)
Bachelor's degree	24 (33%)	30 (34%)
Graduate degree	33 (46%)	51 (57%)
Maternal marital status number (percent)		
Married/Domestic partnership	60 (84%)	82 (92%)
Single, never married	11 (15%)	6 (7%)
Divorced	1 (1%)	0 (0%)
Not reported/Other	0 (0%)	1 (1%)
Maternal employment status number (percent)		
Employed for wages	45 (62%)	48 (54%)
Homemaker	9 (13%)	23 (26%)
Out of work, looking for work	3 (4%)	2 (2%)
Out of work, not looking for work	11 (15%)	7 (8%)
Self-employed	2 (3%)	6 (7%)
Student	2 (3%)	1 (1%)
Not reported/Other	0 (0%)	2 (2%)
Annual household income number (percent)		
$5,001–15,000	0 (0%)	1 (1%)
$15,001–30,000	3 (4%)	1 (1%)
$30,001–60,000	13 (19%)	12 (14%)
$60,001–90,000	21 (29%)	6 (7%)
$90,001–150,000	24 (33%)	25 (28%)
More than $150,000	11 (15%)	44 (49%)

TABLE 1 (Continued)

	Study 1 ($N = 72$)	Study 2 ($N = 89$)
Children (≤17 years) in the home number (percent)		
1	32 (44%)	50 (56%)
2	31 (43%)	28 (32%)
3	8 (12%)	8 (9%)
4	0 (0%)	1 (1%)
5	1 (1%)	2 (2%)

1.1.2 | Procedures

Mothers provided informed written consent for themselves and their infants and were compensated for their time. When infants were approximately 6 months of age, dyads were provided with a Language ENvironment Analysis (LENA) digital processing device, specialized infant clothing for wearing the LENA device, and instructions that the infant wear the device from waking to bedtime on a typical day at home. The LENA device records for up to 16 h. To be included in the current analyses, we required families to have completed the full 16 h of recording and for the recording to have been completed when the infant was at least 5 months and less than 8 months of age.

1.1.3 | Measures

Conversation Type. We extracted all of the conversations that took place between the target infant and an adult over the course of the recording using the LENA software (see Gilkerson & Richards, 2020 for details regarding how the LENA algorithm defines all audio segments). Conversations are defined as comprising one or more alternation between the target infant (the infant wearing the LENA DLP) and an adult speaker, in which the infant produces speech-related vocalizations (i.e., cannot include only cries or vegetative sounds) and the adult produces at least one vocalization. To be identified as a conversation, the speech segments must be separated by no more than 5 seconds of silence or other nonspeech. If another speaker interrupts within the 5 second allowed gap, the conversation is ended. After extracting all the conversations, we defined each conversation as either *adult-initiated* or *infant-initiated* by identifying the first speaker in that conversation.

Conversation Features. For each conversation, we also identified the duration of the conversation, the number of conversational turns, and the number of adult words. *Duration* of a conversation was the span of time from the start of the conversation-initiating vocalization segment to the end of the final vocalization segment. *Conversational turns* were the number of speaker alternations that took place during the conversation. Turns were only counted upon a response. For example, if in one conversation initiated by the infant, an adult responded and then the infant responded, that conversation would contain two conversational turns. *Adult words* were the estimated number of words spoken by an adult during the conversation, derived using acoustic information in the speech segment (Gilkerson & Richards, 2020).

1.2 | Results

All analyses were conducted in R version 4.0.2 (R Core Team, 2020). De-identified data and primary analysis scripts are available at https://github.com/vanderbiltsealab/6m_convos. Descriptive statistics for adult- and infant-initiated conversation are presented in Table 2. In total there were 12,481 conversations across the 72 infants. We found that, on average, infants engaged in more adult-initiated than infant-initiated conversations, $t(71) = 10.16$, $p < 0.001$, $d = 1.20$, 95% CI [0.90, 1.51]. Adult-initiated conversations made up approximately 58% of adult–infant conversations (Range: 40%–75%).

Next, we examined differences in features of the conversations based on whether the conversation was adult- or infant-initiated. We used mixed-effects models to account for the nested nature of conversations occurring within individuals in which conversation type (dichotomous variable with adult-initiated conversations coded as 1 and infant-initiated as 0) was modeled as a fixed effect, accounting for the random effect of participant intercept. First, using a linear mixed-effects model, we tested whether the duration of the conversation differed based on whether it was initiated by an adult or an infant. Duration was significantly skewed (skew = 13.33) and model residuals were not normally distributed; thus, we log-transformed this variable, yielding a more normal distribution (skew = 0.23). We used log-transformed values in subsequent analyses. Second, using generalized linear mixed models with Poisson distributions (log link) for the dependent variable, we tested whether the number of conversational turns and the number of adult words within a conversation differed based on whether the conversation was initiated by an adult or an infant.

We present results of the models examining the associations between conversation type and each conversation feature in Table 3. Accounting for within-individual differences in the average number of conversations, adult-initiated conversations were longer and contained more adult words than did infant-initiated conversations. The incidence rate ratio parameters produced by the generalized linear mixed models can be interpreted such that the expected count of the dependent variable is multiplied by a factor of the incidence rate ratio when the independent variable increases from 0 to 1. Thus, infants heard 2.35 times as many adult words in adult-initiated conversations as they did in infant-initiated conversations. There was also a small but statistically significant difference in the number of conversational turns based on conversation type: adult-initiated conversations contained more conversational turns. We provide a visual comparison of conversation features within infant-initiated and adult-initiated conversations in Figure 1.

TABLE 2 Study 1 descriptive statistics for adult-initiated and infant-initiated conversations

	Adult initiated	Infant initiated
	Mean (SD)	
	Range	
Total count across the day	100.51 (44.91)	72.83 (34.79)
	13–215	10–186
Duration of each conversation (seconds)	31.15 (50.00)	18.92 (25.07)
	1.40–2070.56	1.41–469.26
Count of turns in each conversation	1.73 (1.94)	1.57 (1.57)
	1–49	1–30
Count of adult words in each conversation	56.92 (135.78)	23.34 (47.36)
	1–6870	1–959

Note: Statistics derived from raw data.

TABLE 3 Results of Study 1 mixed models examining differences in features of conversations based on whether the conversation was adult- or infant-initiated

	Duration			Conversational turns			Adult words		
Predictors	**B**	**CI**	***p***	**Incidence rate ratios**	**CI**	***p***	**Incidence rate ratios**	**CI**	***p***
(Intercept)	2.47	2.41, 2.52	<0.001	1.51	1.45, 1.58	<0.001	21.39	19.44, 23.53	<0.001
Conversation type	0.41	0.37, 0.44	<0.001	1.09	1.07, 1.12	<0.001	2.35	2.34, 2.37	<0.001
Random effects									
σ^2	0.95			0.49			0.03		
τ_{00}	0.04_{ID}			0.03_{ID}			0.18_{ID}		
$ICC_{adjusted}$	0.04			0.05			0.87		
$ICC_{conditional}$	0.04			0.05			0.45		
N	72_{ID}			72_{ID}			72_{ID}		
Observations	12,481			12,481			12,481		
Marginal R^2/	0.039/			0.004/			0.477/		
Conditional R^2	0.076			0.055			0.931		

Note: Model of duration is a linear mixed model utilizing the log-transformed dependent variable. Models of conversational turns and adult words are generalized linear mixed models with Poisson (log link) distributions.

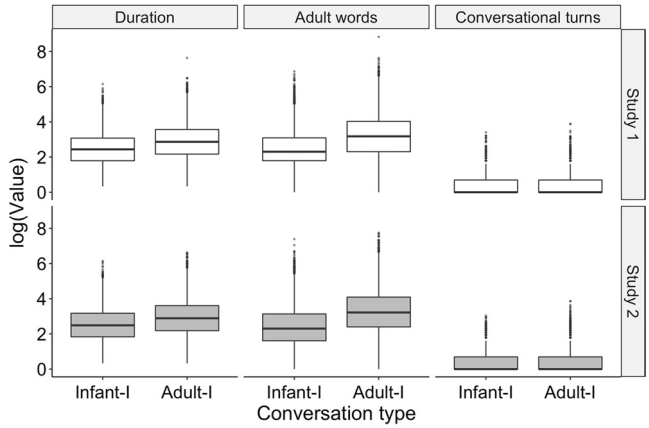

FIGURE 1 Box-plots of the features (duration, count of adult words, and count of conversational turns) of infant-initiated (Infant-I) and adult-initiated (Adult-I) conversations observed in Study 1 and Study 2. Feature values have been log transformed to align with presented analyses. The black bar represents the median value, and the lower and upper box boundaries mark the 25th and 75th percentiles, respectively. Filled circles represent data points beyond 1.5 times the interquartile range

2 | STUDY 2

2.1 | Methods

2.1.1 | Participants

All procedures and recruitment methods were in accordance with the ethical standards of the Declaration of Helsinki and the American Psychological Association and were approved by the Institutional Review Board of Stanford University. Prior to participating, all mothers provided informed written consent for themselves and their infant. Dyads were compensated for their time. Participants were women and their infants who were recruited from communities in the San Francisco Bay Area to participate in the Brain and Behavior Infant Experiences (BABIES) project (Humphreys et al., 2018; King, Camacho, et al., 2021; King, Querdasi, et al., 2021), an observational study of the association between perinatal experiences and infant and toddler psychobiological development. Inclusion criteria for the 6-month assessment were that mothers had a singleton infant aged 5–9 months, were at least 18 years of age, were fluent in English, and had no immediate plans to leave the geographic area. Exclusion criteria included severe complications during birth, infant head trauma, infant premature birth (prior to 36 weeks gestation), and infant congenital, genetic, or neurological disorders.

The sample for the current analyses included mother–infant dyads who completed a recording of the infant's language environment when the infant was approximately 6 months (infant assessment) and an online follow-up assessment of the infant's receptive and expressive vocabulary at age 17–21 months (toddler assessment). Of the 155 dyads who provided any data at the infant assessment, 36 did not participate in the LENA assessment and 17 did not provide useable LENA recordings for the naturalistic assessment of infants' environments (15 completed their recordings when the infant was older than 8 months, 2 did not complete full recordings). Of those who provided useable LENA

data, 13 did not complete the toddler assessment by the time of the current analysis, yielding a final sample of 89 dyads. Demographic statistics for the final sample are presented in Table 1. Participants with missing data did not differ from those included in the final sample in demographic variables; see supplemental Table S2 for demographic statistics for those with missing data and Table S3 for a comparison of those with complete and missing data. Further, participants who did and did not provide data at age 18 months did not differ significantly in terms of the measures derived from the LENA assessment at infant age of 6 months; see supplemental Table S4 and Table S5.

2.1.2 | Procedures

A subset of participants engaged in additional sessions during pregnancy and all participants who provided completed additional tasks at infant age of 6 months are outside the scope of the current paper. Mothers provided informed written consent for themselves and their infants and were compensated for their time. As in Study 1, at the 6-month assessment mother–infant dyads were provided with a LENA digital processing device, specialized infant clothing, and instructions that the infant wear the device from waking to bedtime on a typical day at home. Again, families were required to have completed the full 16 h possible of recording and for the recording to have been completed when the infant was at least 5 months and less than 8 months old to be included in the current analyses. At infant age 18 months, the infant's mother was asked to complete a series of questionnaires regarding the infant's development, including a measure of infant expressive and receptive vocabulary.

2.1.3 | Measures

6-month Adult–Infant Conversations. The same measures were extracted from the LENA data in this study as were extracted in Study 1.

18-month Expressive and Receptive Vocabulary. Infants' expressive and receptive vocabulary skills were measured at 18 months via parent report using the short, toddler form of the MacArthur Communicative Developmental Inventories (Fenson et al., 2000). This form of the CDI provides a checklist of 100 words for parents to indicate whether their infant *understands* or *understands and says* each word. The total number of words a parent indicates that their infant understands serves as a measure of the infant's receptive vocabulary. Similarly, the total number of words a parent indicates their infant understands and says serves as a measure of the infant's expressive vocabulary.

3 | RESULTS

Comparisons of the two study samples on the primary variables of interest are presented in the Supplemental Materials. Descriptive statistics for each type of conversation are presented in Table 4. In total there were 18,245 conversations across the 89 infants. We conducted the same set of analyses as we did in Study 1, comparing differences in the quantity and features of conversations on the basis of whether the conversation was adult- or infant-initiated. Replicating the results obtained in Study 1, we found that, on average, infants engaged in more adult-initiated than infant-initiated conversations, $t\,(88) = 9.30$, $p < 0.001$, $d = 0.99$, 95% CI [0.73, 1.24]. Similar to Study 1, adult-initiated conversations comprised approximately 57% of all adult–infant conversations (Range: 39%–79%).

We then tested differences in features of the conversations based on who initiated the conversations. As in Study 1, we use mixed-effects models in which conversation type (dichotomous variable with adult-initiated conversations coded as 1 and infant-initiated as 0) was modeled as a fixed effect, controlling for the random effect of participant intercept. In the linear mixed-effects model, testing whether the duration of the conversation differed based on whether the conversation was adult- or infant-initiated, we again used a log-transformed duration variable to account for skewness (raw duration skew = 5.81; log-transformed skew = 0.21) and non-normal residuals. We also conducted generalized linear mixed models with Poisson distributions (log link) for the dependent variable to test whether the number of conversational turns or adult words within a conversation differed based on who initiated the conversation. Results of the models examining the associations between conversation type and conversation feature are presented in Table 5. Replicating the findings from Study 1, adult-initiated conversations were longer and contained more adult words, compared to infant-initiated conversations. As in Study 1, we again found a small but statistically significant difference in the number of conversational turns based on conversation type, such that adult-initiated conversations contained more conversational turns. A visual comparison of conversation features within each type of conversation can, again, be seen in Figure 1.

Lastly, we examined whether engaging in either type of conversation differentially predicts later language skills. At 18 months, mean parent-reported expressive vocabulary was 24.46 (SD = 20.14, Range: 0–96) and mean parent-reported receptive vocabulary was 60.98 (SD = 21.64, Range: 12–100). The mean age-normed percentile score for expressive vocabulary was 35.47, with scores ranging from 0 to the 99th percentile, suggesting this sample represented a wide range of relative language ability. We conducted a series of generalized linear models with quasi-Poisson distributions for the dependent variable to test whether the number of each type of conversation in which infants were engaged accounted for a significant proportion of the variance in the subsequent language, either when considered as the sole predictor or when accounting for the other type of conversation. The quasi-Poisson distribution accommodates the nature of the dependent variables as counts as well as the observed overdispersion (variance greater than the mean).

We present the results of the models predicting expressive vocabulary in Table 6. Infants who engaged in more adult-initiated conversations at 6 months had significantly greater expressive vocabulary at 18 months. Similarly, infants who engaged in more infant-initiated conversations at 6 months had significantly greater expressive vocabulary at 18 months. When both adult- and

TABLE 4 Study 2 descriptive statistics for adult-initiated and infant-initiated conversations

	Adult initiated	**Infant initiated**
	Mean (SD)	
	Range	
Total count across the day	116.38 (40.72)	88.62 (32.19)
	16–239	22–178
Duration of each conversation (seconds)	32.17 (45.90)	20.15 (26.10)
	1.40–755.13	1.40–466.38
Count of turns in each conversation	1.81 (2.04)	1.60 (1.45)
	1–48	1–21
Count of adult words in each conversation	58.84 (113.86)	24.05 (50.76)
	1–2323	1–1613

Note: Statistics derived from raw data.

TABLE 5 Results of Study 2 mixed models examining differences in features of conversations based on whether the conversation was adult- or infant-initiated

	Duration			Conversational turns			Adult words		
Predictors	**B**	**CI**	***p***	**Incidence rate ratios**	**CI**	***p***	**Incidence rate ratios**	**CI**	***p***
(Intercept)	2.52	2.48, 2.57	<0.001	1.56	1.51, 1.62	<0.001	22.95	21.12, 24.93	<0.001
Conversation type	0.37	0.34, 0.40	<0.001	1.12	1.09, 1.14	<0.001	2.27	2.26, 2.28	<0.001
Random effects									
σ^2	0.97			0.47			0.03		
τ_{00}	0.04_{ID}			0.03_{ID}			0.16_{ID}		
$ICC_{adjusted}$	0.04			0.05			0.86		
$ICC_{conditional}$	0.04			0.05			0.46		
N	89_{ID}			89_{ID}			89_{ID}		
Observations	18,245			18,245			18,245		
Marginal R^2/	0.032/			0.006/			0.473/		
Conditional R^2	0.074			0.058			0.928		

Note: Model of duration is a linear mixed model utilizing the log-transformed dependent variable. Models of conversational turns and adult words are generalized linear mixed models with Poisson (log link) distributions.

TABLE 6 Results of generalized linear models predicting 18-month expressive vocabulary from count of adult- and infant-initiated conversations at 6 months

Predictors	Incidence rate ratios	CI	*p*	Incidence rate ratios	CI	*p*	Incidence rate ratios	CI	*p*
(Intercept)	11.06	6.75, 17.91	<0.001	15.33	9.25, 24.99	<0.001	11.59	6.88, 19.26	<0.001
Count of adult-initiated conversations	1.01	1.00, 1.01	<0.001				1.01	1.00, 1.01	0.006
Count of infant-initiated conversations				1.01	1.00, 1.01	0.047	1.00	0.99, 1.00	0.575
R^2Nagelkerke	0.843			0.495			0.850		

Note: $N = 89$, models are generalized linear models utilizing quasi-Poisson distributions.

TABLE 7 Results of generalized linear models predicting 18-month receptive vocabulary from count of adult- and infant-initiated conversations at 6 months

Predictors	Incidence rate ratios	CI	*p*	Incidence rate ratios	CI	*p*	Incidence rate ratios	CI	*p*
(Intercept)	52.07	41.51, 65.14	<0.001	56.10	44.99, 69.70	<0.001	52.81	41.55, 66.91	<0.001
Count of adult-initiated conversations	1.00	1.00, 1.00	0.146				1.00	1.00, 1.00	0.206
Count of infant-initiated conversations				1.00	1.00, 1.00	0.427	1.00	1.00, 1.00	0.712
R^2Nagelkerke	0.168			0.054			0.178		

Note: $N = 89$, models are generalized linear models utilizing quasi-Poisson distributions.

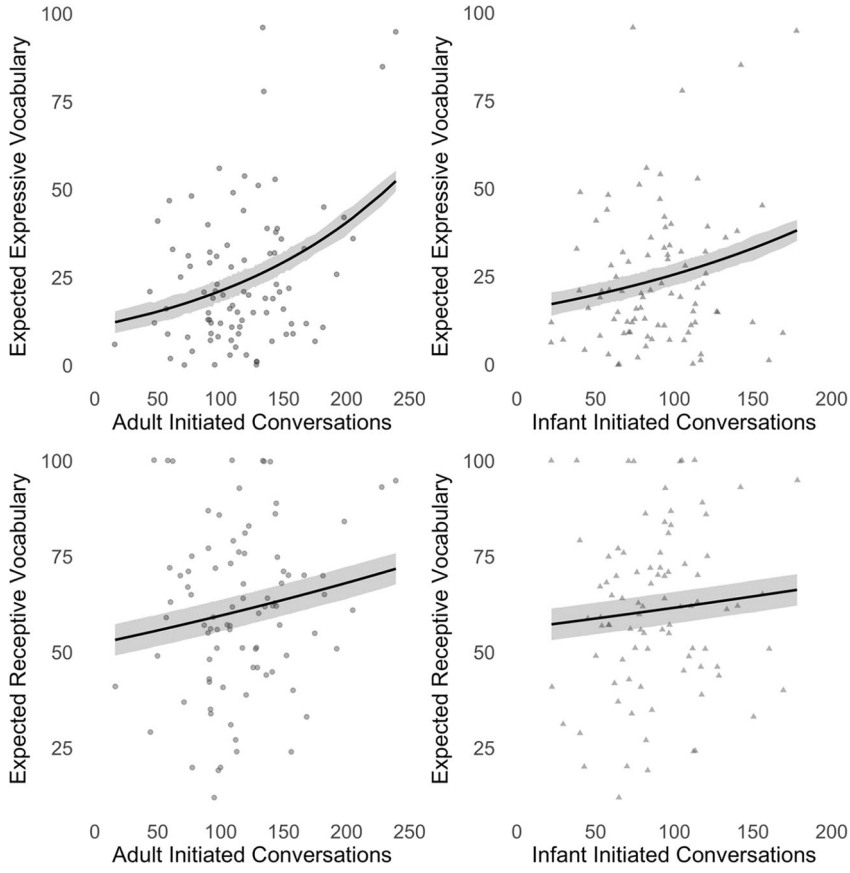

FIGURE 2 Associations between the number of adult- or infant-initiated conversations infants were engaged in at 6 months and their expressive or receptive vocabulary at 18 months. Black lines plot the model predicted vocabulary scores, with the 95% confidence interval represented by the shaded ribbon. Individual data points indicate the raw observed values

infant-initiated conversations were included as statistical predictors of toddler expressive vocabulary, only adult-initiated conversations were significantly associated with 18-month vocabulary. Specifically, a 1% increase in expressive vocabulary is predicted for every additional adult-initiated conversation the infant experienced. Results of the models predicting receptive vocabulary are presented in Table 7. Neither adult- nor infant-initiated conversations were associated with receptive vocabulary. Results of the models predicting expressive and receptive vocabulary with either adult-initiated or infant-initiated conversations as the sole predictor are depicted in Figure 2. A single multivariate outlier and potentially influential case was identified in the model predicting expressive vocabulary from infant-initiated conversations (operationalized as Cook's distance score >1). A corresponding model was computed removing that infant, which yielded a nonsignificant association between infant-initiated conversations and later expressive vocabulary ($p = 0.319$). The model predicting expressive vocabulary including both adult- and infant-initiated conversations was conducted after removing the outlying infant; adult-initiated conversations remained a significant predictor of expressive vocabulary. No outliers were identified in any of the other models.

4 | DISCUSSION

Our goal across two studies was to understand how infants become engaged in conversations with their caregivers. Specifically, we examined *who* tends to initiate conversations between adults and infants, differences in the nature of infant- compared to adult-initiated conversations, and whether individual differences in how often infants are engaged in infant- or adult-initiated conversations uniquely predict subsequent language development. To achieve these goals, we analyzed adult–infant conversations captured via LENA digital recording devices in two samples of 6-month-old infants. In Study 1, we found in exploratory analyses that at age 6 months, infants typically engage in more adult- than infant-initiated conversations and that adult-initiated conversations are, on average, longer, involve more conversational turns, and contain more adult words. In Study 2, we replicated these findings and, further, found that infants who engaged in more adult-initiated conversations in infancy had better expressive language at age 18 months. While vocabulary at age 18 months was also significantly associated with infant-initiated conversations, when we accounted for both types of conversations as predictors, only the number of adult-initiated conversations at age 6 months was significantly associated with language skills 1 year later. Early interactions with caregivers can have a lasting impact on children's language development. These findings indicate that the extent to which parents initiate those interactions with their infants may be particularly impactful.

The finding that, on average, infants were engaged in more adult- than infant-initiated conversations at age 6 months is consistent with our prediction and is perhaps not surprising given that, at this age, infants are likely highly dependent on adults to facilitate verbal interactions. Further, the communicative behavior that 6-month-old infants exhibit is rarely viewed as intentionally communicative and, therefore, less likely to elicit responses from caregivers (Donnellan et al., 2020). Across both samples, 21–60% of an infant's conversations were infant-initiated, and only 9% of infants were involved in more infant- than adult-initiated conversations. Thus, regardless of the specific ratio, all infants in these studies were engaged in a large proportion of adult-initiated conversations throughout their day, emphasizing the need to understand the kind of input that infants experience during these interactions.

Interestingly, across both samples, conversation type (adult- versus infant-initiated) explained only a small (albeit statistically significant) portion of the variance in duration of conversations (3%–4%) and an even smaller, almost negligible, portion of the variance in the number of turns (<1%) within a conversation. In contrast, conversation type explained almost half (~47%) of the variance in the number of adult words in a conversation. When an adult initiated a conversation, or—considered from the other perspective—when an infant responded to an adult's bid to begin a conversation, the infant experienced far more adult words than when the infant initiated a conversation. Relatedly, the conditional intraclass correlation (ICC) values derived from the mixed regression models indicate that individual (family level) differences explain a much larger portion of the variance in the number of adult words that infants experience within conversations (45%–46%), than in the duration of (4%) or conversational turns within (5%) conversations. In other words, unmeasured characteristics of the infant or their family account for roughly the same amount of variance in the number of adult words an infant experiences in a conversation as does who is initiating that conversation. These findings suggest that beyond who is initiating the conversation, several unmeasured infant- and family-level factors likely influence the nature of the input children receive in conversations with adults. The context in which an interaction occurs (e.g., book reading, toy play, mealtime, and dressing) is associated with different patterns in both parent and child communication (Hoff-Ginsberg, 1991; Yont et al., 2003), as is time of day (Soderstrom & Wittebolle, 2013). Examining such additional characteristics as primary predictors of the quantity and quality of language used within caregiver–child conversations, as well

as how they interact with the person who is initiating the conversation, would be a fruitful next step for explaining individual differences in language environments.

Although previous studies have not directly compared adult- versus child-initiated conversations, there is a growing body of research suggesting that engaging in conversations with adults in early life has a generally positive impact on language development (Lopez et al., 2020; Rowe & Snow, 2020; Zimmerman et al., 2009). These early experiences are even linked to individual differences in brain networks associated with language production and understanding (King, Camacho, et al., 2021; Romeo, Leonard, et al., 2018; Romeo, Segaran, et al., 2018). The current findings provide evidence that differences in linguistic input, during even short conversational interactions with caregivers, lead to substantial cumulative differences in children's communicative experiences during early life, thus influencing their language development. Further, our results suggest that the positive impact of adult–infant conversations at the age of 6 months is driven by adult-initiated conversations. Null associations between conversations in infancy and later language skills observed in prior studies (Gilkerson et al., 2018) may be due to the fact that these studies did not differentiate between adult- and infant-initiated conversations.

We did not find a statistically significant association between the number of infant-initiated conversations and later vocabulary after accounting for adult-initiated conversations, which may appear to contrast with research emphasizing parents' responses to child communicative bids for language development (Tamis-LeMonda et al., 2006). However, it is important to note that the current methodology—capturing adult–infant conversations via audio recording—accounts for responsiveness only indirectly, given that it does not capture conversations initiated by an adult's response to an infant's *non-vocal* behavior. While there is evidence that infant gestures (e.g., pointing) are more likely to elicit responses from caregivers if they are paired with a vocalization (Ger et al., 2018), the predictive significance of infant initiations might have increased if gestures or other behaviors were also measured as initiations of communicative exchanges (Donnellan et al., 2020). Given that the infants in the current study were only 6 months, shifts in eye gaze (e.g., directing gaze at a caregiver or at a toy) or reaching toward objects may have been interpreted as communicative bids by caregivers, who then responded. Similarly, infants at this age may be sensitive to their caregivers' gaze shifts as signs of communicative intent (Csibra, 2010). Another possibility for why we did not observe a significant association between infant-initiated conversations and later vocabulary, but one that is beyond the scope of the current data, is that infants who experience greater adult-initiated conversations at 6 months develop stronger communicative skills prior to the onset of their first words and building their vocabulary. For example, these infants may develop greater use of gestures or pragmatic understanding, which in turn leads to the larger vocabularies we observed at 18 months.

It is further helpful to consider our results specifically in light of the developmental stage during which the language environment was assessed. At 6 months, infants produce fewer behaviors that are interpreted as intentional communicative bids (e.g., gestures, canonical syllables, and words) than do older infants. If caregiver–child conversations were observed at 9 or 12 months, for example, we might expect to see caregivers responding more often to infants' vocalizations and thus a greater proportion of conversations being initiated by infants. Even at 12 months, however, caregivers tend to verbally respond more often to infants' object-directed gestures (e.g., pointing) than to their object-directed vocalizations (Wu & Gros-Louis, 2015), potentially attenuating a LENA-derived estimate of infant-initiated conversations even at that age. A recent analysis suggests that by 30 months, children are initiating significantly more conversations than are their caregivers (VanDam et al., 2022); however, the extent to which this is driven by differences in child vocalizations from age 6–30 months (either in number or kind), by caregivers responding to a greater proportion of child bids, or by a combination of these is unknown. In addition, prior research suggests that predictors of language outcomes depend

on the age at which children are assessed. This is true when the predictors in question are child- (Choi et al., 2021) or caregiver-communicative behavior (Newman et al., 2015; Rowe, 2012). Thus, our findings may be specific to middle infancy.

In addition, an important limitation of the current findings is that conversations were defined solely in terms of timing of vocalizations (a response, or counter-vocalization, occurring within 5 s of the initial vocalization). While timeliness (typically considered as responding within a few seconds) is an important part of verbal responsiveness, so is semantic or pragmatic contingency (Tamis-LeMonda et al., 2014). That is, adult utterances that are related both semantically and temporally to a child's vocalizations appear to have the greatest impact on child language (McGillion et al., 2013). Thus, assessing the semantic match of responses to infant- or adult-initiated conversations may yield a more nuanced understanding of the impact of each type of conversation on language development, and may be one of the previously mentioned "unmeasured characteristics" that influence the nature and impact of conversation type. Further, we should note that the difference in the observed effect of conversation type on conversational turns and adult words may be due, in part, to differences in how reliably the automated LENA analysis identifies each metric. Efforts to validate the LENA measures against human coding suggest that the automated extraction of adult word count is more reliable than the extraction of conversational turns (Cristia et al., 2020). Automated LENA identification of adult speech has also been reported to be more reliable than the case for child or infant speech (Bulgarelli & Bergelson, 2020), although counts of conversational turns have higher test–retest reliability than do counts of adult words (Gilkerson et al., 2017).

Another limitation of the current methodology is that the automated LENA analysis does not distinguish among individual adult speakers. A large literature has examined caregiver characteristics that explain the number of words to which a child is exposed, without considering whether or not the input occurs within a certain type of conversation (e.g., age of the caregiver (McDonald Culp et al., 1996; Rowe et al., 2005), caregiver knowledge of child development (Rowe, 2008), and caregiver educational attainment (Vernon-Feagans et al., 2020)). Many of the infants in our studies likely interacted with more than one adult during the day; however, examining individual caregiver-level predictors of adult engagement with the infant was beyond the scope of the current analyses. Important complements to this work will be to compare the current results with a similar analysis of manually coded linguistic interactions and to explore which factors might be related to adults' tendency either to initiate or respond in conversations with their child. Finally, it is important to couch these findings within the relatively homogeneous samples we recruited. The mothers who participated in the current studies were primarily White with at least a 4-year college degree living in suburban or urban areas of the United States. There is a large body of research documenting differences in the home language environment across socioeconomic strata in the US (Golinkoff et al., 2019), although there is also wide variation in children's language experiences *within* socioeconomic strata (Sperry et al., 2018). It may be a uniquely WEIRD (Western, Educated, Industrialized, Rich, Democratic) notion to engage in "conversations" with an infant (Han, 2020). Thus, further investigation is warranted to explore the generalizability of these findings, both across families with different demographics backgrounds within the U.S. and across different cultural groups outside the U.S.

Despite these limitations, the present study is important in providing evidence across two unique samples that infants' experiences differ in infant- and adult-initiated conversations, and that engaging in adult-initiated conversations may be particularly important for later language development. Identifying unique patterns in the kind of input infants receive in adult- and infant-initiated conversations increases our understanding of the language experiences of typically developing infants in naturalistic settings. These findings have important implications for recommendations given to caregivers and for potential targets in approaches to early intervention, specifically emphasizing the importance of

caregivers initiating verbal interactions with infants even before the emergence of infants' first words. However, caregiver–child interactions encompass much more than words and spoken conversational turns. An important next step will be to consider how the factors identified in the current study interact with other important characteristics of caregiver–child interactions to predict language outcomes.

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