Sibs and Bibs: Older Siblings and Infant Vocabulary Development

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1. Introduction

First language acquisition is intrinsic to childhood development. Language itself is woven into everything we do – our unique ability to produce language is a large part of what makes us human. Many studies have investigated how best to facilitate this the process of language acquisition. The focus is input from children's primary caregivers, most commonly their parents (Rowe, 2012). The impact of siblings is mentioned occasionally (Hoff, 2006), but much of the research is inconclusive (Havron et al., 2019; Prime et al., 2014). Using a longitudinal corpus, the goal of this study is to investigate the effects of older siblings on infants' language development.

1.1. Parental Language Input

All theories of language acquisition recognize the importance of the language learning environment. Hart & Risley's seminal work found that a child from a family with high socioeconomic status (SES) will hear 30 million more words within the first four years of life than a child from a family with low SES, which was linked to children's vocabulary size (Hart & Risley, 1995). There has been controversy surrounding this work (Gilkerson et al., 2017; Sperry et al., 2019), but follow-up research has further emphasized the importance of language input quantity and quality for language development (Rowe, 2012).

Quantity of language input is measured using the number of words, utterances, and/or tokens heard by the child. One common measure of quantity is adult word count (AWC), the number of words a child hears from an adult within a specific period. Language input quality can be defined and measured in many ways, and different aspects of quality become more and less important according to the child's age and language level (Rowe, 2012). Infants (under the age of 2

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years) are known to benefit immensely from social interactions (Golinkoff et al., 2019; Kuhl et al., 2003). The present study focuses on two key variables within parent-infant social interactions: parentese and conversational turn-taking.

Used while speaking to infants, parentese is characterized by acoustical exaggerations including elongated vowels, higher pitch, and slower pace (Kuhl et al., 1997). This speech style promotes early childhood language acquisition because the exaggerations create phonetic exemplars, which make meaningful phonetic differences more salient (Ramírez-Esparza et al., 2017). Parentese also employs exaggerated social affect and gestures (Weikum et al., 2007), making the input more engaging for infants (Golinkoff et al., 2015), who are known to prefer parentese over standard speech (Fernald & Kuhl, 1987; The ManyBabies Consortium, 2020). Finally, studies demonstrate the benefits of parentese speech on child language development. One found that infants are better able to recognize novel words introduced to them in parentese than in standard speech (Singh et al., 2009). Another demonstrated the positive effects of parentese in infancy on language outcomes at 24 and 33 months of age (Ramírez-Esparza et al., 2017).

Another key aspect within caregiver-infant social interactions are conversational turns (CTs). A CT occurs when two interlocutors alternate between one another while speaking in conversation, and often include nonverbal aspects of communication (Romeo et al., 2018), building upon paralinguistic devices through which infants communicate, such as eye gaze and pointing (Donnelly & Kidd, 2021). Thus, CTs may act as a more comprehensive measure of engagement. Infants begin learning through engagement, particularly in one-on-one social exchanges with their primary caregiver (Hilbrink et al., 2015). This dyadic setting provides a comfortable and familiar context within which the infant may learn and practice language (Hilbrink et al., 2015). Research has shown that increased engagement in CTs has a significantly positive effect on language development (Donnelly & Kidd, 2021).

Recently, daylong recordings have emerged as a cornerstone method for studying the quantitative and qualitative aspects of language input in ecologically valid ways, with many studies using Language ENvironment Analysis (LENA) technology (Gilkerson & Richards, 2020). LENA uses a small device worn by a child over an entire day to record their naturalistic linguistic environment for up to 16 hours. Several LENA studies have demonstrated positive associations between language input quantity, language input quality, and children's language development (Bergelson et al., 2019; Wang et al., 2017). One LENA study found that parentese is associated with improved concurrent child speech and enhanced child language outcomes, particularly if parentese occurs within one-on-one interactions (Ramírez-Esparza et al., 2017). Further research using LENA has shown that parents who are coached to enhance their use of parentese have infants who babble more between 6 and 14 months, have higher vocabularies at 14 and 18 months, and are engaged in more conversational turns between 6 and 18 months of age (Ferjan Ramírez et al., 2018; Ferjan Ramírez et al., 2020).

1.2. The Sibling Effect

The presence of older siblings has been shown to play a crucial role in a child's language development (Brody, 2004). However, whether this effect is positive or negative remains to be determined. One study concluded that the presence of older siblings has a negative effect on younger siblings' language development due to a reduction in high-quality parental input (Havron et al., 2019). The authors postulated that this may be due to divisions of parental resources between their multiple children (Havron et al., 2019). The idea of resource dilution, in which parental resources are said to be finite (Gibbs et al., 2016) extends to linguistic input in that children with siblings might receive less one-on-one input from their caregivers than children without siblings. This is important because dyadic conversational turns have been shown to promote language acquisition in early childhood (Donnelly & Kidd, 2021; Romeo et al., 2018). Fewer one-on-one interaction with caregivers may reduce engagement and/or the amount of parentese heard by the child (Ramírez-Esparza et al., 2017).

A recent study used the LENA software in Swedish families to investigate the sibling effect (Nyberg et al., 2020). Results showed that the number of siblings in each linguistic environment did not affect any of the variables measured by LENA, nor did it affect infants' productive vocabularies as measured by the MacArthur Bates CDI (Nyberg et al., 2020). Though this study focuses on sibling number instead of presence, its results suggest that there may be aspects of older sibling presence that mitigate the sibling effect.

The notion of "mitigation" is further supported by the finding that children can employ certain aspects of parentese in conversation (Weppelman et al., 2003), although perhaps not as effectively as adults. Children are known to slow their speaking rate, but they are less likely to add other aspects of parentese, such as pitch modulation (Weppelman et al., 2003). Furthermore, in conversations directed to one-year-olds, older siblings have been shown to be primarily directive (McGillicuddy-De Lisi, 1993). They also did not adjust the length or complexity of their utterances, nor did they provide nonverbal information to their sibling (Tomasello & Mannle, 1985). Thus, older siblings, while they can and do serve as linguistic partners, may be less engaging than adult caregivers.

Regarding language outcomes, one study reports that toddlers who did not have a sibling performed better in tests of language production, but those who did have a preschool aged sibling performed better in tests of language comprehension (Malmeer & Assadi, 2013). Another study showed that firstborns were more advanced in vocabulary and grammar than later-borns (Hoff, 1998), a finding that was later replicated (Bornstein et al., 2004), though only in parental report, not in objective assessments of child language. Other papers have found that, in general, birth order does not affect language development overall (Oshima-Takane et al., 1996; Pine 1995).

1.3. The Present Study

The present study utilizes a longitudinal corpus of daylong recordings taken by the LENA software in combination with parental report to examine changes in language input received by infants between 6 and 24 months in families with and without older siblings. LENA can capture the language heard and produced by the child wearing the recorder. Furthermore, it quantifies and provides data regarding the speech of other children. Overall, LENA's main advantage is its collection of data in ecologically valid settings, as families go about their day as usual. The advantage of using LENA longitudinally, as we do here, is to observe developmental patterns over time. The present study analyzes Other Child Speech (CXN) and Adult Word Counts (AWC), which are variables automatically provided by LENA. Further, we incorporate manually coded conversational turn counts (CTCs). While CTCs are automatically enumerated by LENA, the numbers that LENA reports are frequently inaccurate due to accidental contiguity (for example, a mother speaking on the phone to a friend while the infant is babbling nearby; Ferjan Ramírez et al., 2021). We also include measures of parentese that were manually coded for a previous study (Ferjan Ramírez et al., 2020). Finally, we relate sibling presence with measures of child language vocalizations (CVCs) and vocabulary as measured by the MacArthur Bates Communicative Development Inventory, or CDI (Bates et al., 1995).

We ask three specific questions, one about parental language input, one about child language output, and one about child language outcomes.

Question 1: Does the presence of older siblings affect AWC, parentese, and CTC? Based on the resource dilution model (Gibbs et al., 2016), and based on previous studies suggesting that older sibling presence alters parental input (Oshima-Takane & Robbins, 2003), we hypothesize to see a reduction in AWC, parentese, and CTCs in families with older siblings.

Question 2: Does the presence of older siblings affect CVCs? Based on previous research that shows parents are less attentive to younger siblings (Huttenlocher et al., 2007), we hypothesize that sibling presence will reduce CVC due to our expectation that children with siblings will have fewer opportunities to speak.

Question 3: Does the presence of older sibling affect infant productive vocabularies? Based on previous research demonstrating that later-borns generally have lower vocabularies compared to firstborns (Bornstein et al., 2004; Hoff, 1998; Malmeer & Assadi, 2013) we hypothesize that the presence of older siblings will be associated with lower productive vocabularies as measured by the CDI (Bates et al., 1995).

2. Methods

2.1. Sample

We analyzed a sample of 24 children recorded with LENA at 6, 10, 14, 18, and 24 months of age. Nine of these children had at least one older sibling, while

15 had no siblings. All families were English-speaking, with mother-father parents of varying socioeconomic status (See Ferjan Ramírez et al., 2018, 2020, which uses portions of the same dataset. The present sample constitutes the Control group in the Intervention study reported by Ferjan Ramírez et al., 2018, 2020). Two daylong recordings of each family were analyzed at each age.

2.2. Variables

The LENA speech variables are summarized in Table 1. In addition, our analyses include infants' productive vocabularies as measured by the CDI (Bates et al., 1995).

Table 1: Language variable names, types, and definitions

Variable Name	Variable Type	Variable Definition
AWC	LENA	Total number of adult words heard by the child during the recording, estimated automatically by LENA and averaged over two recording days.
CVC	LENA	Total number of vocalizations made by the child during the recording, estimated automatically by LENA and averaged over two recording days.
CXN	LENA	Total number of vocalizations from other children heard by the child wearing the LENA recorder during the recording, estimated automatically by LENA, and averaged over two recording days.
% Parentese	Manual	Percent of segments where mother, father, or another adult spoke directly to the infant and parentese speech style was used (high pitch, larger pitch range), and one or more than one adult voice was recorded during the interval.
CTC	Manual	Instances in which child and other individual present engage in back-and-forth alternation, with no more than five seconds between each interlocutor's utterance.

AWC = adult word count; CVC = child vocalization count; CXN = other child speech; LENA = LENA estimate; manual = manually coded

2.3. Coding

Annotators (coders) were trained to recognize the parentese speech style, and then identified instances of it in 100 30-s coding intervals per participant per age. Because the recordings took place over two days, there were 50 intervals per day, highest in AWC and three minutes apart, as described in detail in

previous studies using portions of this dataset (Ferjan Ramírez et al., 2018, 2020). As described in Ferjan Ramírez et al., 2021, the same 100 30-s segments per family were coded for CTCs. The CDIs were collected from families at 14, 18, 24, 27, and 30 months of age

2.4. Statistical Analysis

Continuous variables are described as mean ± standard deviation (Table 2). Independent samples t-tests were used to compare means of all six variables between the Sibling versus No Siblings families across all timepoints. Repeated measures ANOVAs were run to compare AWC, parentese, CTCs, CVCs, and CDI scores between both groups (Siblings/No Siblings) over time.

3. Results

As expected, CXN (other child speech) differed significantly between the families with and without older siblings ($t(22) = -4.67$, $p = .01$), demonstrating that indeed, there is more "other child" speech present in families with siblings.

Question 1: Does the presence of older siblings affect AWC, parentese, and CTC?

Table 2 demonstrates that there is a noticeable numerical, although not statistically significant difference between the AWC heard by children in families with versus without older siblings ($t(22) = 2.74$, $p = .48$). Children in sibling families also heard numerically less parentese and are engaged in numerically fewer conversational turns compared to children in families with no siblings. However, as for AWCs, the independent samples t-test across all timepoints did not demonstrate statistical significance for parentese ($t(22) = 5.61$, $p = .94$) or for CTC ($t(22) = 4.35$, $p = .66$).

Table 2. Speech input variables and their distributions by sibling presence across all ages and time points

Variable	Mean ± Standard Deviation
CXN by sibling presence	
One or more siblings	6999.46 ± 2214.42
No siblings	4036.71 ± 873.72
AWC by sibling presence	
One or more siblings	63074.11± 15070.71
No siblings	85761.10 ± 21826.08
Parentese by sibling presence	
One or more siblings	1.98 ± 0.52
No Siblings	3.33 ± 0.60
Conversational turns by sibling presence	
One or more siblings	270.11 ± 107.24
No siblings	509.40 ± 142.08
CVC by sibling presence	
Siblings	6533.17 ± 1120.68
No Siblings	8163.2 ± 2028.02

To assess the effects on AWC, parentese, and CTC over time, we conducted a repeated measures ANOVA with Time and Group (Siblings/No Siblings) as independent variables. This yielded a significant interaction for both parentese ($F(4, 88 = 3.773$, $p = .007$; Figure 1) and CTC ($F(1.709, 37.6) = 6.029$, $p = .0008$; Figure 2), but not AWC ($F(4, 88) = 0.495$, $p = 0.74$). This demonstrates that while parentese and CTs increase more in families without siblings between 6 and 24 months of age, AWC does not.

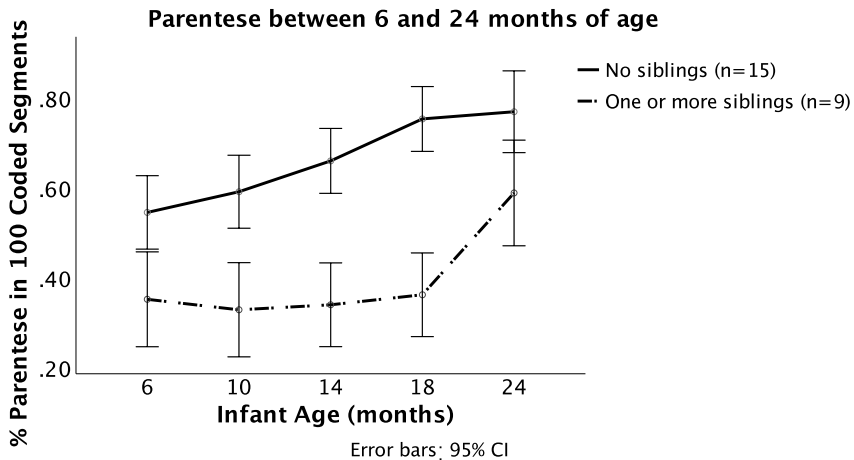

Figure 1. Parentese in families with siblings (dashed line) and without siblings (solid line) between 6 and 24 months of age

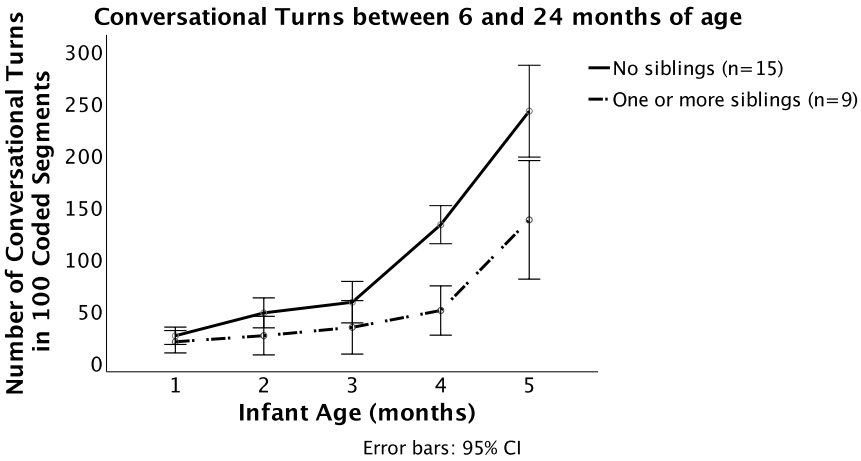

Figure 2. Conversational Turns in families with siblings (dashed line) and without siblings (solid line) between 6 and 24 months of age

Question 2: Does the presence of older siblings affect CVCs?

Table 2 demonstrates that CVC is numerically lower in the Sibling compared to No Sibling group; however, this difference is not statistically significant as determined by a t-test ($t(22) = 2.21$, $p = .19$). Likewise, an ANOVA with Time and Group (Siblings/No Siblings) as independent variables was not significant ($F(1.628, 35.805) = .882$, $p = .403$).

Question 3: Does the presence of older sibling affect infant productive vocabularies?

Figure 3 shows the productive vocabularies in children with and without Siblings. An independent samples t-test was conducted at each age separately, and significance was reached only at 14 months ($t(22) = .74$, $p = .038$), and marginal significance was reached at 18 months ($t(21) = 1.52$, $p = .054$), while the groups were not different at 10, 24, 27, and 30 months ($ps > 0.1$). The repeated measures ANOVA we ran concerning CDI demonstrates a marginally significant difference between the two groups ($F(4, 76) = 2.707$, $p = .084$), demonstrating a faster vocabulary growth in families with no siblings.

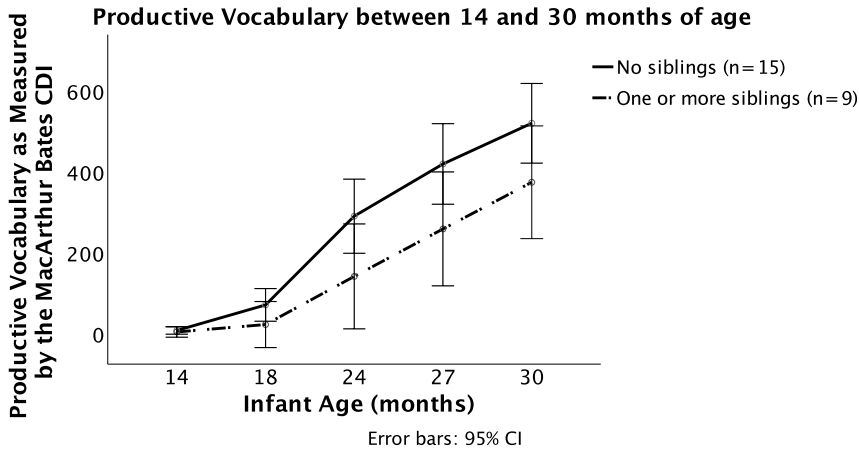

Figure 3. Productive Vocabulary of infants with siblings (dashed line) and without siblings (solid line) between 14 and 30 months of age

4. Discussion

The present analyses demonstrate that infants with older siblings do not hear fewer words from their parents than infants without older siblings. While they receive similar amounts of linguistic input, the growth in parental use of parentese and parent-infant turn taking was slower in infants with older siblings compared to infants without older siblings. Therefore, the linguistic environments of infants with siblings differ significantly from those of infants without siblings. The effects of this difference were seen in the marginally significant difference between CDI scores of the two groups over time. The marginal nature of this difference may be due to our small sample size. Follow-up studies with larger samples will be needed to confirm these effects.

We interpret these results as speaking in support for the conclusion that infants with older siblings certainly engage in reduced social interaction with their parents. Engagement in social interaction with parents is important for infants' language development as it has been shown to be related to enhanced language outcomes (Ferjan Ramírez et al., 2020; Ferjan Ramírez et al., 2018).

While our main research question has been answered, the results give rise to further queries. It is not clear why the observed reduction in social variables from adults did not interact significantly with language output and only resulted in significant differences between productive vocabularies at certain time points with marginal significance overall. We now ask which aspects of linguistic input help the language outcomes of infants with siblings to approach those of infants without siblings. One possibility is that infants may compensate for reduced social variables from parents through interactions with siblings. Previous research shows that older children can and do employ the acoustic characteristics of parentese when speaking with infants (Weppelman et al., 2003) and take on teaching roles within naturalistic environments such as those in the present study (Segal et al.,

2018). These instances of teaching may include the use of parentese by the siblings or sibling-sibling conversational turns, which may be an avenue through which younger siblings learn language in a way that others do not.

There are certain factors that may affect an older sibling's ability to engage in these social variables, however. One such factor is cognitive sensitivity, defined as the extent to which they are aware of and attend to their younger sibling's cognitive needs (Prime et al., 2014). The presence of an older sibling with high cognitive sensitivity has been shown to moderate the negative impact of sibling presence on language development (Prime et al., 2014). Another variable that may affect an older sibling's ability to aid their younger sibling is age (Hoff-Ginsberg & Kreuger, 1991). Though siblings provide fewer supportive interactions to young children than parents, siblings at older ages are more proficient at supporting their younger siblings (Hoff-Ginsberg & Krueger, 1991). Another sibling factor that might affect the benefit they provide is sex. A recent analysis of over 1,000 participants found the negative effects of older sibling presence to only occur in children with older brothers (Havron et al., 2019). It is not yet clear whether the impact of sex is present in the language development of all children in general. Some studies show that girls have an advantage over boys in early childhood language acquisition. (Carpenter & Tomasello, 1998; Ozcaliskan & Goldin-Meadow, 2010). One study regarding siblings found firstborn girls outperformed boys on all vocabulary competence measures, and secondborn girls outperformed boys on most measures (Bornstein et al., 2004), through other studies report no significant differences between boys and girls (Hyde, 2016; Zell et al., 2015).

5. Limitations and Future Research

Though our analyses have produced valuable results, there are some limitations. First, our sample size is small, affecting statistical power. Second, participating families came from predominantly white and monolingual English-speaking families, limiting the generalizability of the present findings.

This present study is part of a larger ongoing investigation. Currently, the segments of the daylong LENA recordings with the largest amount of CXN are being manually annotated and transcribed. The goal of this effort is to discover the characteristics of input that infants receive from their siblings in their homes.

Future research should investigate sibling interactions in different sociocultural contexts. There are many family structures that differ from what was investigated in this study. It would be interesting to study the sibling effect in families that are linguistically, racially, socioeconomically, and socioculturally distinct, such as Latinx families in North America, where older siblings may be more involved in childrearing.

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