The Relationship Between Conversational Pause Duration and Vocabulary Acquisition in Infants with Cochlear Implants

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Kelsey Alyssa De La Croix

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Abstract

Previous research has shown that maternal speech to normal hearing (NH) infants and speech to cochlear implant (CI) infants matched by hearing experience is characterized by similarly high pitch, increased intonation range and reduced rate of speech as compared to adult-directed speech (Bergeson, Miller, & McCune, 2006). These findings suggest that mothers demonstrate sensitivity to the infants’ hearing experience and tailor their speech to their infants’ auditory skill levels. Pause duration in infant-directed (ID) speech has also been shown to be influenced by age and hearing experience (Bergeson et al., 2006), but its relationship to language development is unknown. This thesis aimed to investigate conversational pause duration in mothers’ speech to CI infants compared to NH infants matched on hearing age (HA), and how that is correlated with vocabulary acquisition. Sixteen mother-infant pairs (8 NH; 8 CI) participated in individual audio recorded play sessions. Pause time between consecutive mother utterances and between a mother’s utterance and the infant’s response was measured and compared to the infant’s expressive vocabulary as measured by the McArthur-Bates Communicative Development Inventory (CDI). On average, mothers of CI infants and those of NH infants were comparable in the amount of time they allotted for their infants to respond. Mothers’ pause duration was not correlated with infants’ productive vocabulary. These results suggest that the duration of time a mother pauses in conversation is not related to hearing loss or the child’s vocabulary development.
Acknowledgements

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Mothers modify their speech to infants as compared to their speech to adults (Bergeson, Miller, & McCune, 2006). The characteristic pitch, rate and intonation patterns of infant-directed (ID) speech, known as motherese, has been shown to facilitate infant language development. Pause duration modifications in speech to children has been reported to shift as a function of age and/or language level in normal hearing (NH) children (Marklund, Marklund, Lacerda, & Schwarz, 2015).

Given the commonly lower language skills of infants with cochlear implants (CI), it is of interest to investigate variables that have the potential to positively or negatively impact language development in CI infants. A correlation between maternal pause duration and vocabulary acquisition in CI infants would have clinical implications for intervention as well as caregiver training for optimal interactions with this population.

Past research has found differences in pitch, intonation, and talking speed in mothers’ speech to infants when compared to mothers’ speech to adults. However, these features do not differ in mothers’ speech to NH infants versus mothers’ speech to infants with CI matched by hearing experience (Bergeson et al., 2006). Mother-infant pairs consisting of NH infants and CI infants participated in a play session that was video and audio recorded. Mothers and their infants played with toys such as a ball, turtle, dog, cat, key, and button. A third group included mothers interacting with adults Bergeson et al. (2006) reported longer pauses in infant-directed speech when compared to adult-directed speech, regardless of hearing status, but with sensitivity to the child’s hearing experience. The longer pauses were explained by the possibility that mothers may be trying to teach
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their infants about turn taking in conversation and allowing time for the child to talk.

Bergeson et al. (2006) also reported pause duration between mothers of CI infants and mothers of aged matched NH infants was more similar than pause duration of mothers of older NH infants. The difference was explained by the possibility that mothers of children with less hearing experience may not pause as long because they do not expect the infant to respond in conversation.

VanDam, Ambrose, and Moeller (2012) recorded parent-infant interactions outside of a lab setting for one full day using the Language Environment Analysis (LENA)1 device in the home. The purpose of the study was to compare language exposure and conversational interactions in hard of hearing infants to that of NH infants. Thirty families participated, twenty-two of them with infants who were hard of hearing. All infants’ chronological ages ranged from 24 to 36 months old. VanDam et al. (2012) found that the hearing status of the infant did not influence the average quantity of parent talk or the amount of conversational turns. These findings suggest that CI infants and NH infants are exposed to comparable amounts of language input. As pertaining to this thesis, the finding indicates there may not be a difference in the amount of maternal pause duration on average between mothers of CI infants and mothers of NH infants.

Caskey and Vohr (2013) found contrasting patterns of language exposure in their study of children with a hearing impairment using the LENA device. They had seven-year-old children with hearing loss take the LENA device home to record 16 hours of a typical day. The audio recordings from the LENA were analyzed. Caskey and Vohr

1 The LENA device is a compact recording device that a infant wears in his or her pocket or elsewhere on the body. It records speech with a directional microphone from both the infant and anyone talking to the infant. It can be hooked up to a computer and analyzed by researchers for various aspects of the speech and/or conversational environment to which an infant is exposed.
(2013) found that more exposure to silence recorded over the course of a day contributed to lower language scores when compared to children with normal hearing. If that finding holds up in this thesis, CI infants may be exposed to more silence during a play session via longer maternal pause durations. Additionally, their language scores by means of vocabulary production may be lower, on average.

Fagan and Pisoni (2010) investigated the receptive vocabulary skills of NH children as compared to CI children ages 6-14 years. They found that receptive vocabulary development of CI children was comparable to their normal hearing peers matched in terms of hearing age\(^2\). This finding demonstrates the close relationship between vocabulary development and language experience. It is of interest to understand what factors contribute to young CI children’s expressive vocabulary learning following late exposure to spoken language. Pause duration may be one of those factors, and based on the findings of Fagan and Pisoni (2010), productive vocabulary may be comparable between hearing status groups.

The purpose of this thesis is to examine pause duration in conversations between mothers and infants with NH and infants with CI in relation to their vocabulary acquisition. DesJardin and Eisenberg (2007) noted that the relationship between perceived differences in maternal speech to hearing impaired versus NH children and language development is unknown. The following research questions were investigated:

\(^2\) Hearing age refers to how long the infant has had the ability to hear. For a normal hearing infant, the hearing age is the same as the chronological age (how old the infant is). For an infant with a cochlear implant, however, hearing age begins on the day the implant is activated. For example, for a three year old implanted in August, his/her hearing age would be five months in the following January. As a result, a NH match is typically older chronologically.
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1. Do mothers of CI infants provide a different amount of conversational pause duration during an interaction when compared to mothers of NH infants?

2. Does the conversational pause duration provided by mothers to their infants correlate with language development in terms of vocabulary acquisition?

Bergeson et al. (2006) reported that mothers were sensitive to their child’s hearing experience, which would predict no difference in pause duration in the infant-directed speech of mothers of CI infants as compared to mothers of NH infants. That is because mothers speak to their infants based on how long the infants have been hearing. In this thesis, infants were matched based on hearing age, so the CI infants and the NH infants had been hearing the same amount of time. Other possible patterns proposed emphasize the need to explore speech patterns and the impact on language development. Following Caskey and Vohr (2013), mothers of CI infants will have longer pauses, and thereby will speak less during an interaction, resulting in lower scores on a productive vocabulary measure. According to Desjardin and Eisenberb (2007), decreased response time (i.e. more maternal speaking) provided by mothers to CI infants translates to limited time to experiment with oral language.

Method

Participants

Participants were recruited from the greater Indianapolis area as part of a larger study at the Babytalk Research Lab at Riley Hospital for Children (Riley). Participants with normal hearing were recruited via Facebook, and participants with hearing loss were recruited from the Riley Audiology Clinic. Selection criteria included access to the following: a 5-minute mother-infant play session sound file and
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a CDI from within three months of the play session. Participants included 16 mother-infant pairs: 8 pairs of normal hearing mothers and infants (NH), and 8 normal hearing mothers with infants who have cochlear implants (CI). Infants were matched based on hearing age, race, and gender. The mean chronological age of the CI infants was 31.3 months, with a mean hearing age of 14.1 months. The mean hearing age of the NH infants was 14.9 months. The infant match pairs included two African American pairs and six Caucasian pairs, three female pairs and five male pairs. Table 1 shows the demographic information for all infants in this study.

Each mother-infant pair came to the lab for participation in the study. The NH group was compensated $10 and free parking for their time. The CI group was compensated $20 an hour plus any hotel fees, since these participants sometimes traveled a long distance for their appointments. Mother-infant pairs sat in a sound booth and played on a mat with various toys (e.g. dog, cat, key, button, and turtle) for five minutes. The session was video and audio recorded in the sound booth for later analysis. Only the middle two minutes were analyzed to give the mother-infant dyads time to become comfortable in the sound booth and to control for the sample duration across participants (Bergeson et al., 2006).
Note. Participant 5150 did not have a CDI score on file at Riley, so that participant and the match, 4632, were not included in correlation analysis. C.A.= chronological age; H.A.= hearing age/experience.

**Measures**

**Conversational Pause Duration.** The play session audio file was analyzed for identification of type of pause and measurement of duration of all pauses.

Conversational turn-taking time, otherwise known as pause duration, was measured in milliseconds (ms) using Audacity software. Pause duration measurements under 200ms or over 10,000ms were thrown out, as those seemed unnatural in conversation (Wall, 2012).

### Table 1

**Participant Demographic Information**

<table>
<thead>
<tr>
<th>Participant</th>
<th>C.A. (Months)</th>
<th>H.A. (Months)</th>
<th>Sex</th>
<th>Ethnicity</th>
<th>CDI: Words Produced</th>
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<tbody>
<tr>
<td>CI</td>
<td>4791</td>
<td>34</td>
<td>13</td>
<td>F</td>
<td>Caucasian</td>
</tr>
<tr>
<td></td>
<td>3374</td>
<td>24</td>
<td>10</td>
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<tr>
<td></td>
<td>4394</td>
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<td>11</td>
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<td>Caucasian</td>
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<tr>
<td></td>
<td>4632</td>
<td>26</td>
<td>12</td>
<td>F</td>
<td>Caucasian</td>
</tr>
<tr>
<td></td>
<td>3259</td>
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<tr>
<td>CI Match</td>
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<td>5150</td>
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<td>14.88</td>
<td>14.88</td>
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</tbody>
</table>

**Note.** Participant 5150 did not have a CDI score on file at Riley, so that participant and the match, 4632, were not included in correlation analysis. C.A.= chronological age; H.A.= hearing age/experience.
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A mother-mother (MM) pause was the silence between the end of a mother utterance and the beginning of a subsequent mother utterance. An example of a MM pause was, “Do you see the ball?” after a few seconds of silence, “Here, look at the ball.” An infant-mother (IM) pause was the silent time between the end of the infant’s utterance and the mother’s response. The average pause duration for each group and type of pause was calculated.

**Vocabulary Acquisition.** The measure of vocabulary acquisition was the score of the number of words produced on the MacArthur Bates Communicative Development Inventory (CDI; Thal, DesJardin, & Eisenberg, 2007). The score serves as an estimate of how many words each infant was producing at the time of the study. Each infant’s mother completed this survey within three months of the play session. The words produced score did not include signed communication.

**Results**

Mean pause duration for each type of pause was calculated for each group. An independent samples t-test was conducted for each type of pause (MM and IM) to determine if the group averages significantly differed from each other. As illustrated in Figure 1, the mothers of the NH infants did not differ in their pause duration (M=1653.50 ms, SD=1336.76) compared to the mothers of the CI infants (M=1750.01 ms, SD=1368.31), t(330)=0.65, p=0.52) for MM pauses. Additionally, it was found that there was no significant difference in pause duration for mothers of NH infants (M=839.82 ms, SD=779.89) compared to mothers of CI infants (M=945.76 ms, SD=1035.17), t(143)=0.70, p=0.49) for IM pauses. Figures 1 and 2
show the average pause durations for each group, NH and CI, and for each pause type, MM and IM.

**Figure 1** Group average pause duration for MM pauses. Error bars represent standard error.

**Figure 2** Group average pause duration for IM pauses. Error bars represent standard error.

A paired samples t-test was conducted for participant CDI scores (excluding participant 5150 and match 4632 due to participant 5150 not having a CDI score on
The NH infants did not have a significant difference in CDI scores (M=36.86 ms, SD=43.82) compared to the CI infants (M=70.86 ms, SD=48.87); t(6)=1.20, p=0.27. Although it seems the group means, found in Table 1, are very different, the variability in the individual CDI scores is very large, ranging from 26 words to 161 words for CI infants and 4 words to 107 words for NH infants. Variability is expected in infants of such a young age as speech and language develop at varying rates for each individual.

Visual inspection of the data in Figures 3 and 4 shows that the data are very scattered and not aligned in a strong linear manner, suggesting no correlation. A Pearson product-moment correlation coefficient revealed there was no correlation between the two variables (r=-0.12, n=14, p=0.70). The correlation between IM pauses and CDI scores for all infants was not significant (r=-0.38, n=14, p=0.18).

![Graph](image-url)

**Figure 3** The correlation between individual MM average pause duration and CDI scores.
Figure 4 The correlation between individual IM average pause duration and CDI scores.

Additionally, separate correlation coefficients were computed for each group. A Pearson product-moment correlation coefficient revealed that neither the correlation between MM pauses and CDI scores for CI infants \((r=-0.01, n=7, p=0.98)\) nor the correlation between MM pauses and CDI scores for NH infants \((r=-0.004, n=7, p=0.99)\) were significant. Finally, a Pearson product-moment correlation coefficient was computed to assess the relationship between IM pauses and CDI scores for CI infants \((r=0.25, n=7, p=0.59)\) and for the relationship between IM pauses and CDI scores for NH infants \((r=-0.70, n=7, p=0.08)\). There were no significant correlations found.

These results indicate that the time a mother pauses in conversation is not significantly different when comparing mothers of NH infants to mothers of CI infants. The results also showed that maternal pause duration is not correlated with the productive vocabulary of the infants.
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Discussion

This thesis aimed to investigate if mothers of CI infants provided a different average pause duration in conversation as compared to mothers of NH infants. It also investigated if the time mothers allowed their infants to respond is correlated with vocabulary acquisition. It was found that the conversational pause duration of mothers of CI infants and NH infants was not significantly different. The lack of significance noted for pause duration between maternal speech to CI infants matched by HA to infants with NH is in line with Bergeson et al.’s (2006) finding that mothers are sensitive to their child’s hearing status. In the Bergeson et al. study, mothers of children with similar hearing experience used the same pitch, intonation and speaking rate, regardless of hearing status. In the current study, the mother-infant pairs were similarly matched on hearing experience, therefore these results contribute pause duration as yet another feature of infant-directed speech that remains consistent across populations, regardless of hearing status. The fact that no group difference in vocabulary was noted may indicate that the mother is providing time for her CI infant to respond and develop spoken language as are mothers of NH infants. This finding is consistent with Fagan and Pisoni (2010). Fagan and Pisoni (2010) found that receptive vocabulary development of CI children was comparable to their normal hearing peers matched in terms of hearing age. This thesis found that the productive vocabulary was comparable across groups as well.

Caskey and Vohr (2013) reported that children who were hard of hearing were exposed to more silence throughout a day and also had lower language scores. That suggested that CI infants may be expose to more silence via longer pause duration on
average. The present data revealed no correlation between the maternal conversational pause duration and the vocabulary acquisition of the infants. It was expected that the group of CI infants would have a higher average pause duration to account for lower CDI scores, but this prediction was not revealed in the data. The discrepancy could be explained by the small sample size. A larger, more representative sample may would also permit more complex statistical analyses of the data.

Another potential limitation was the manner in which pauses were measured. Pauses were identified only when the duration of silence was long enough to be perceived to be clearly present. Within a speaking moment, there may have been multiple sentences with such brief pauses that they were not measured and included in the total number of pauses for the sample. If more pauses were accounted for, there may or may not have been a difference in the results, but the measurement would have been more thorough.

Finally, the lack of difference in amount of silence between groups may be a function of task type. The current study looked at a single play session, the mothers may have talked more because there was a task at hand that lasted a very short amount of time. The Caskey and Vohr (2013) study examined children’s exposure to language in the home for a whole day. Studying behaviors in the natural environment and across a whole day may reveal true communication patterns in some ways, but it is important to note that home activities also involve caregivers being busy with other tasks that do not lend themselves to conversation with the infant, such as household chores. If there is less talking throughout the day in general, there could be minimal
interaction and longer pause duration in conversation. The play session in the lab may not have been the most genuine example of mothers and their infants playing together.

It has also been found that there are perceived differences in speech to children with hearing aids compared to NH children, but the relationship between those differences and language development is unknown (DesJardin & Eisenberg, 2007). This thesis was a first step in identifying what feature contributes to those perceived differences. The results suggest that pause duration in mother-infant interactions does not impact the perceived differences, nor does it contribute to productive vocabulary development in CI infants compared to NH infants.

Future research can address various other aspects of conversation between mothers and their infants to pinpoint conversational or discourse features that contribute to the lower language achievements of CI children. It would be beneficial to analyze interactions for how many utterances the mother produced, the proportion of the sample that the mother spoke, how fast the mother talked, and the mother’s number of words per utterance. Some of these analyses may explain why there seems to be a difference in how mothers of CI infants interact with their infants when compared to mothers of NH infants. Additionally, the complexity of maternal speech could be investigated. It has been found that mothers of CI infants use more simplified speech as compared to mothers of NH infants (Fagan, Bergeson, & Morris, 2014). That difference could be attributed to what is being said rather than how it is being said or how much is being said.
It may also be beneficial to divide the hearing status groups by language ability (i.e. how much expressive vocabulary they have). Marklund et al. (2015) found that when children speak to adults (i.e. parents), the pause duration provided by adults varies in length depending on the size of the child’s expressive vocabulary. When the child had a small expressive vocabulary, parents utilized longer pause durations; a large expressive vocabulary was met with shorter pause duration. Considering the variability of CDI scores in this study, CI infants grouped by low, normal and high CDI scores may reveal the anticipated differences not observed here.

On another note, maternal sensitivity to hearing status could be broadened to other interaction partners. It may be beneficial to have other caregivers or professionals speak to the children. Are they sensitive to an infant’s hearing status as well or is it only the mother? That information could be informative as to how caregivers (babysitter, day care, etc.) interact with infants of varying hearing status.

Finally, it would be beneficial to have mothers and their infants participate in a play session that is longer than five minutes. Since this thesis only looked at the middle two minutes of a five-minute play session, the speech sample was very limited. If there was a longer play session, or multiple sessions throughout the day, there would be a more authentic interaction captured. As pertaining to pause duration, there may or may not be a difference in results, but it would be worth pursuing.

Overall, despite a lack of significant differences in pause duration between mothers of CI infants and mothers of NH infants, and no correlation between pause duration and vocabulary acquisition, the findings are informative for future work in the area of maternal interactions with CI children and language development. It
would be beneficial to investigate the other aspects of language that could be contributing to the perceived differences in speech to CI infants as compared to the speech to NH infants. This research is instrumental in identifying what mothers are doing that may be helping or hindering vocabulary acquisition in CI infants. The findings of such work would have a profound impact on how mothers speak to CI infants in order to get the most optimal vocabulary acquisition and quality of life. Clinical implications include common practice for educators and speech-language pathologists, as well as in training caregivers to communicate with CI infants.
References


