VANDERBILT UNIVERSITY MEDICAL CENTER

Objective Assessment of Speech in Noise Abilities & the Effect of Amplification in Children with Hearing Loss

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INTRODUCTION

- Individuals with hearing loss have difficulty understanding speech in background noise, even when amplification is worn (Hornsby et al., 2006).
- Compared to children with no hearing loss (CNHL), children with hearing loss (CHL) require a more favorable signal-to-noise ratio (SNR) for optimal speech understanding (Crandell, 1993) but still spend the majority of their time in classrooms that exceed recommended noise levels (Walinder et al., 2007).
- The P1-N1-P2 complex (Naatanen & Picton, 1987) and the P300 response (Sutton et al., 1965) are cortical auditory-evoked potentials (CAEPs) that have been used to assess objectively a listener's central auditory speech detection and ability to actively discriminate speech contrasts, respectively.
- When speech stimuli are presented in quiet, CAEPs are affected by the listener's degree of hearing loss (Oates et al., 2002) and are more robust with the use of hearing aids, particularly at low intensity levels (Korczak et al., 2005).
- When stimuli are presented in noise, normal hearing listeners show changes in CAEPs dependent on the SNR of the stimuli (McCullagh et al., 2012); however the effects of hearing loss and amplification on CAEPs using speech stimuli in noise are not well understood.

PURPOSE

1) Evaluate neural efficiency of speech in noise detection and discrimination in CHL compared to CNHL
2) Examine the effects of amplification on detection and discrimination of speech in noise in CHL

METHODS

Data were obtained as part of a larger ongoing study examining listening effort and fatigue in school-age children with hearing loss.

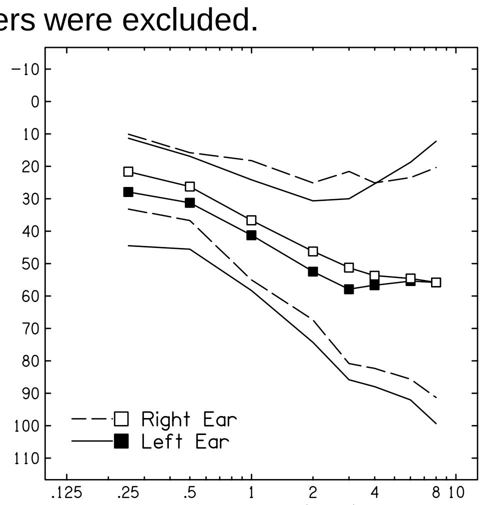
Participants

Table 1. Participant characteristics.

Table 1	N	# males	Mean age (years; SD)	Mean non-verbal IQ (SD)
CNHL	27	15	9.3 (0.19)	110 (9.42)
CHL	12	4	11.2 (1.44)	101 (14.8)

All participants were monolingual speakers of English. Children with diagnoses such as cognitive impairment, autism, and other development disorders were excluded.

Figure 1. Mean audiometric thresholds +/- 1 standard deviation (SD) for CHL group. CHL had sensorineural or mixed hearing loss that ranged from mild to severe. Mild hearing loss was defined as average pure tone air conduction threshold at 0.5, 1, 2 kHz between 20 and 40 decibels hearing level (dB HL) or pure tone air conduction thresholds greater than 25 dB HL at two or more frequencies above 2 kHz (i.e. 3, 4, 6, 8 kHz).



Hearing Aid Analysis & Use Time

Prior to testing, matches to DSL v5 child (Scollie et al., 2005) targets were measured in the ear using an Audioscan Verifit. Children were considered users or non-users of hearing aids based on recordings of device-use by parents and researchers on two separate school days.

Stimuli & Paradigm

A passive oddball paradigm (Standard: 70%; Target: 30%) with syllables [gi] and [gu] 610 milliseconds (ms) long at 75 dB SPL, were presented centered in multi-talker babble speech noise (1400 ms) at a +10 dB SNR. Syllable-to-condition assignment was counterbalanced across participants.

ERP Measures were recorded using a 128 channel Geodesic sensor net (EGI, Inc., Eugene, OR). EEG Sampling Rate: 250 Hz. Low Pass Filter: 100 Hz. **Figure 2** shows a participant wearing the net.

Figure 2.

RESULTS – Sound Detection in Quiet and Noise

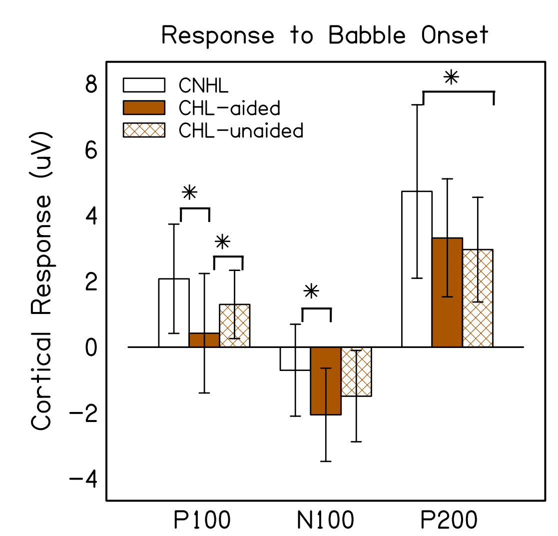
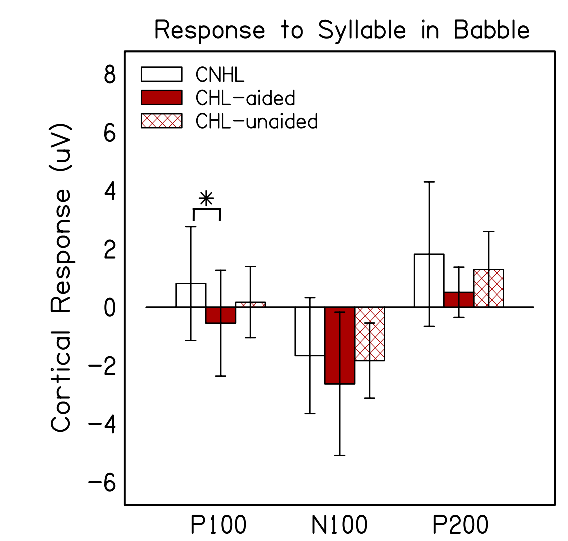


Figure 3. Mean cortical response (±1 SD) to onset of babble in CNHL, CHL-aided, and CHL-unaided. Asterisks indicate significant differences between conditions.

- Aided CHL showed less robust P1 response (p<.05) and more robust N1 (p<.05) response to onset of babble when compared to CNHL.
- In CHL, unaided P1 responses to speech onset in noise were more robust than aided responses (p<.05).
- Unaided CHL showed less robust response to onset of babble for P2 than CNHL (p<.05).

Figure 4. Mean cortical response (±1 SD) to onset of syllable in babble in CNHL, CHL-aided, and CHL-unaided. Asterisks indicate significant differences between conditions.

- Aided CHL show less robust P1 response to onset of speech in babble (p<.05) when compared to CNHL.
- No differences between unaided and aided responses to speech onset in noise.



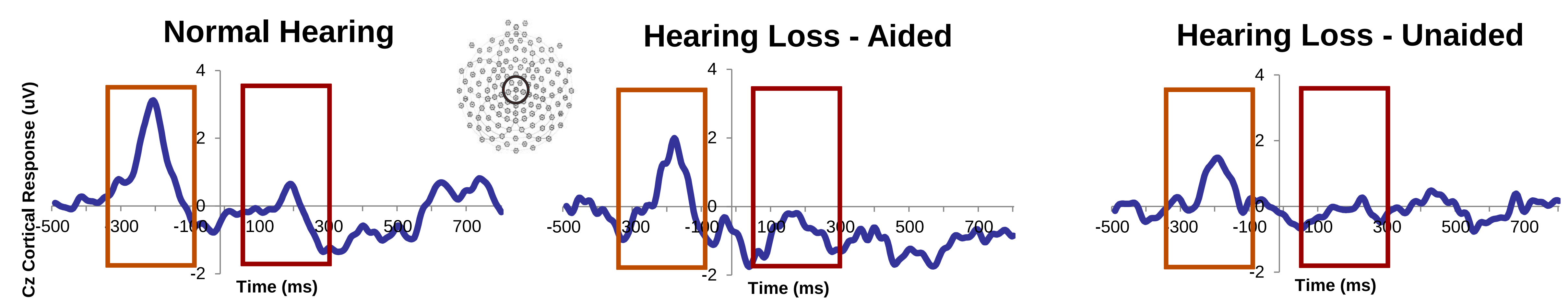


Figure 5. Mean cortical responses at Cz electrodes for CNHL, CHL-aided, and CHL-unaided. Response includes the 100ms silent baseline, pre-syllable babble, syllable in babble, and post-syllable recordings. Time zero indicates the onset of the speech syllable. Boxes indicate windows of analysis used to determine mean amplitude responses to babble onset (brown) and syllable in babble (red). Also shown is a schematic of the electrode cap indicating the electrodes used to average responses at the Cz location.

RESULTS – Sound Discrimination in Noise

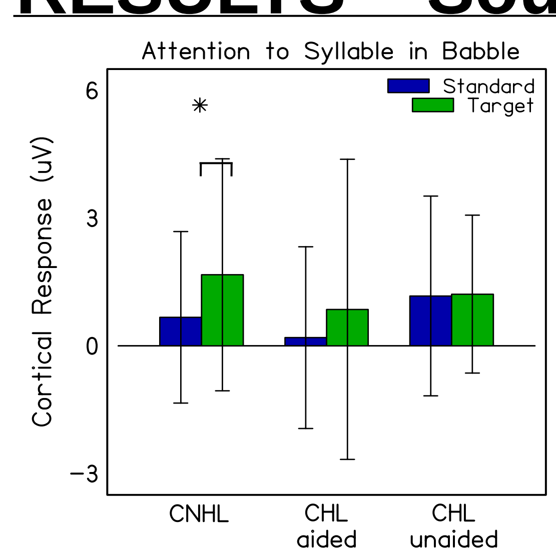
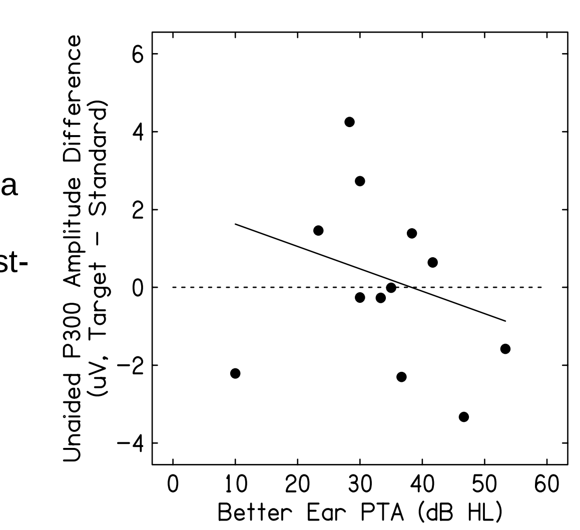


Figure 6. Mean cortical response amplitudes (±1 SD) recorded from the Pz location for both types of stimuli (standard & target). CNHL, CHL-aided, and CHL-unaided are shown. Asterisks indicate significant differences between stimuli.

- As expected, CNHL showed more robust responses at the Pz location to target stimuli when compared to standard stimuli (p<.05).
- Aided CHL showed a trend towards larger responses to target stimuli.
- Unaided CHL did not show this pattern.

Figure 7. Mean amplitude difference between target and standard stimuli recorded from unaided CHL at the Pz location shown as a function of the pure-tone average (PTA) of the better ear. Data falling above the zero line indicate larger mean amplitude of target stimuli. The best-fit linear regression line is also shown.

- As expected, children with poorer hearing sensitivity showed poorer speech in noise discrimination (r = -.237).



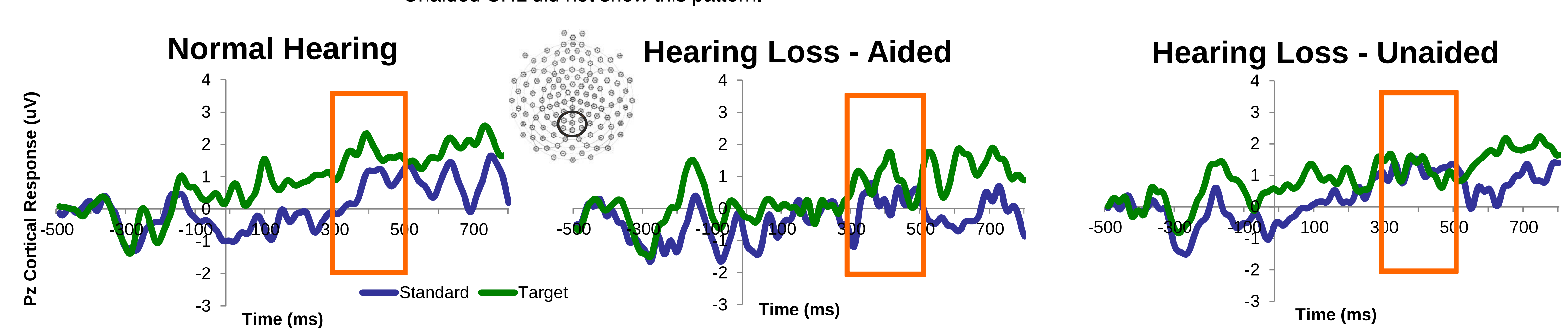
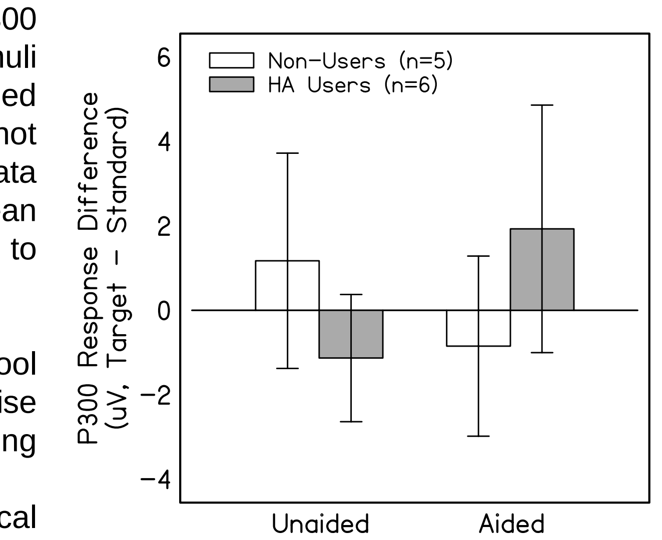


Figure 8. Mean cortical responses at Pz electrodes for CNHL, CHL-aided, and CHL-unaided. Response includes the 100ms silent baseline, pre-syllable babble, syllable in babble, and post-syllable recordings. Time zero indicates the onset of the speech syllable. Boxes indicate the window of analysis used to determine mean amplitude responses to syllable in babble for the target (green) and standard (blue) stimuli. Also shown is a schematic of the electrode cap indicating the electrodes used to average responses at the Pz location.

RESULTS – Hearing Aid Use

Figure 9. Mean differences (±1SD) of P300 response amplitudes to target vs standard stimuli recorded at the Pz location in unaided and aided listening conditions for children who do and do not use hearing aids on a typical school day. Data falling above the zero line indicate larger mean responses for target stimuli when compared to standard stimuli.



- CHL who use hearing aids on a typical school day show improved speech in noise discrimination with the use of their hearing aids.
- CHL who do not use hearing aids on a typical school day do not show this benefit with amplification.
- This interaction between device use group and listening condition was significant even when accounting for better-ear PTA (p=.003).

SUMMARY & CONCLUSIONS

- Early cortical responses to the onset of multi-talker babble and to the onset of speech in multi-talker babble suggests **sensory processes reflective of signal detection are similar between CNHL and CHL while listening at loud presentation levels without hearing aids**.
- When compared to CNHL and unaided CHL, aided CHL showed both reduced (P1) and enhanced (N1) early cortical responses to the onset of babble. Although the reduction in P1 amplitude was unexpected, the enhanced negativity of N1 suggests that **onset of babble was more audible for CHL when listening with hearing aids** and is consistent with previous work in adults that showed greater negativity of the N1 response when amplification was used (Korczak et al., 2005).
- **Cortical responses of CHL to detection of speech in multi-talker babble were neither improved nor degraded when amplification was used.**
- CNHL showed expected increases in attention to less frequently occurring speech syllables in multi-talker babble indicating successful discrimination between speech sounds in noise.
- **CHL did not show discrimination of target vs standard speech syllables in multi-talker babble when not using amplification.** This lack of discrimination of speech in noise appeared to be related to the child's severity of hearing loss, as children with poorer hearing showed poorer discrimination without hearing aids.
- **Preliminary results in CHL suggest that speech in noise discrimination may improve with increased daily use of hearing aids.**
- Data collection for this project is ongoing. These preliminary results should be interpreted with caution, as the number of CHL included in the reported analyses is small. Results will be re-evaluated when greater statistical power is obtained.

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