Introduction

Binaural processing, which refers to the integration of inputs from the two ears at central auditory centers, is important to be accurate for important localization and sound for segregation of target speech from noise (6,7). Individuals with CUCHL lack bilateral auditory input and thus do not display evidence of binaural processing, resulting in poor performance on localization and speech-in-noise tasks (8). Current knowledge on patients with CUCHL indicates improvement on localization accuracy and on speech-in-noise tasks in the short term after surgical correction (9). However, no improvement in localization accuracy or in listening ability in complex acoustic environments has been documented beyond short-term follow-up (> 6 months) (9). It is therefore unknown if these individuals demonstrate evidence of auditory plasticity and improved binaural processing at long-term follow-up.

In noisy environments, individuals who are able to utilize binaural processing strategies demonstrate improved speech intelligibility when target speech is separated in space from one or more masks. This phenomenon is known as Spatial Release from Masking (SRM) and is one method of assessing for the existence of binaural processing strategies (10).

Methods

Subjects

• Study design has 10 children ages 12 – 18 who underwent surgical correction of CUCHL
• Preliminary data are shown here in three subjects
  – All listeners demonstrated a maximal conductive hearing loss (air-bone gap > 50 dB) prior to surgery, and had normal hearing in the contralateral ear
  – All subjects demonstrated improvement on audiometric testing in the surgical ear (Mean postoperative four-frequency pure-tone average (PTA) = 31 dB)
  – Time between surgery and testing ranged from 20 months (1.75 years) to 76 months (6.3 years)

Localization Task

• Listener was positioned in the center of a 19 loudspeaker arc. Loudspeakers were placed 10° apart at 0° azimuth (Figure 1).
• Stimuli involved a train of four bursts of pink noise at 50 dB SPL with +/- 4° of white noise from each loudspeaker. Twenty repetitions per loudspeaker location were assessed.
• Perceived sound location selected on a touch-screen monitor typically within +/- 10° (90°)
• Root mean squared (RMS) error was calculated for each listener (MATLAB software)

Speech-in-Noise Task

• Target male talker (CNC words) presented at 0° azimuth. Two female maskers (IEEE sentences) were presented at 50 dB SPL in four possible configurations (0°, 90°, 180°, and 270°) (Figure 2)
• Testing conducted at signal-to-noise ratios (SNR) ranging from 0 to 30 dB SPL (MATLAB software)
• Listeners selected the heard word from a closed list of words on a touch screen
• Signal was computed in a binaural, symmetric masking configuration and in each unilateral masker position

Results: Localization and Speech-in-Noise

Conclusion

• Subjects undergoing surgical repair of CUCHL demonstrate SRM within the range of values of NH controls at long-term follow-up
• Localization accuracy was slightly worse in CUCHL subjects than in NH-younger
• Individuals undergoing repair of CUCHL demonstrated SRM at long-term follow-up. The presence of SRM may be a result of auditory plasticity, suggesting that binaural processing strategies may mature with continued auditory stimulation in a surgically corrected ear over the long term.

References


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Figure 1: Localization loudspeaker array setup

Figure 2: Touch screen used in localization task

Figure 3: Speech-in-noise test. Each subject was tested in the binaural listening condition in four spatial configurations: A: Masker (M) at 0°; B: M at +90°; C: M at -90°; D: M at +90°. Target speech (T) was always presented from 0° azimuth.

Figure 4: Spatial release from masking calculations. In each configuration (Figure 3, A), the SNR at which 50% of target localization errors was “done” was calculated for each subject in the binaural listening condition. The SRM(50%) was calculated for each subject in the binaural listening condition. The SRM(50%) was calculated for each subject in the binaural listening condition. The SRM(50%) was calculated for each subject in the binaural listening condition.

Figure 5: Spatial Release From Masking (SRM) values for CUCHL and normal-hearing (NH) subjects. SRM1 was measured using binaural masks (dark red bar), masker positioned to the right (green bar), and masker positioned to the left (blue bar). In NH subjects, masker right values are assumed identical to masker left results. Three CUCHL subjects (CHAA, CHAB, and CHAC) are compared to normal published values for NH children (NH C) ages 7-9 (Mistrelli and Litovsky 2012) and for NH younger adults (NH YA) ages 18-22 (Jones and Litovsky 2011).