INTRODUCTION

• Sensitivity to interaural time and level differences (ITD and ILD, respectively) is typically estimated as the just-noticeable-difference (JND) at a specific performance level (e.g., 70.7% correct) without information on the decision-making process. Listeners with bilateral cochlear implants (BiCI) typically have much higher JNDs than normal-hearing (NH) listeners as measured using clinical processors. [1]

• A novel method is introduced by providing acoustic stimuli through clinical processors that capitalize on the Advanced Combining Encoder (ACE) strategy to provide ILD and envelope ITD in a conventional left/right discrimination task, while simultaneously recording eye gaze behavior.

• Previous work has shown that eye gaze on screen in time-course trajectories can provide inferences on NH listeners’ decision-making process prior to providing responses [2,3].

• The present study attempts to explore subtle differences between BiCI and NH listeners in sensitivity to ITD/ILD, beyond JNDs as revealed by eye gaze patterns.

Study Aims

1. Measure sensitivity to ITD and ILD in BiCI listeners using clinical processors with the ACE strategy.
2. Investigate eye gaze behavior in BiCI and NH listeners, using stimuli with increasing saliency in binaural cues (ITD and ILD).

METHODS

Task: Left/Right Discrimination

• 2-Interval, 2-alternative forced-choice

Method of constant stimuli (30-40 repetitions per cue level)

ITD: Whole waveform shift in either ear, available in the envelope

ILD: Half-intensity offset between ears up to +3 dB, then full-intensity attenuation in one ear

RESULTS

• ITD JNDS were measured in 4 of 5 BiCI listeners using clinical processors. One BiCI listener (ICB) showed ITD JND within the range of measured JNDS from NH listeners (Figure 3).

• As the ITD became more salient, a general trend of decreasing α and increasing slope (1/β) occurred in NH and some BiCI listeners (Figure 4).

• ILD JNDS were measured in all BiCI listeners (Figure 5).

• As the ILD became more salient, a general trend observed in decreasing α and increasing slope (1/β) in NH and some BiCI listeners (Figure 6).

CONCLUSION, DISCUSSION & FUTURE WORK

• ITD JNDS were measured in BiCI listeners using clinical processors with a typical clinical stimulation rate (e.g., ≥ 900 pps), when a matched set of electrodes across ears was activated.

• As binaural cue saliency improves, even beyond the magnitudes of JND, an emerging trend is observed that both NH and some BiCI listeners show steeper slope in the eye gaze trajectories and are faster at reaching the 75% location to the final gaze position.

• The difference in eye gaze patterns between BiCI and NH listeners is not yet clear; ongoing data collection

REFERENCES


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METHODS (Cont.)

Stimulus: Complex of 8 transposed tones designed to provide high fidelity envelope ITD cues through the ACE strategy on Cochlear N5 processors [4]

BiCI: Complex targeting N5 electrodes No. 4-11 with everyday clinical maps: Playback via auxiliary input ports at listeners’ chosen comfortable level

NH: Complex targeting similar places of stimulation along the cochlea as BiCI listeners [5]; Playback via Sennheiser HD600 headphones at 60 dBa sound pressure level (re 20 µPa)

Figure 1. Waveform (upper panel) and spectrum (lower panel) of an example transposed tone complex created with 8 center frequencies (L), matching those of electrodes No. 4-11 in the default 22-channel frequency allocation table (FAI) for Cochlear N5 processor. Each transposed tone was modulated at 30 Hz before summing in the time domain to create a tone complex. Individual BiCI listeners’ transposed tone complexes were created based on actual FAIs from their clinical processors.

Participants

BiCI: 5 listeners, most had measured ITD JNDS in the past with pitch-matched single-pair electrodes through direct stimulation at 100 pulses/second (pps)

NH: 3 listeners, aged 19-22 years

Behavioral Data Collected Simultaneously

Left/Right Response: Provided by listeners with mouse-click; To obtain JND by calculating performance in varying cue levels and fitting psychometric function

Eye Gaze Data: Time-course eye gaze position during individual trials prior to listener response (correct only); To infer listeners’ looking behavior in responding to varying cue levels (Example fit in Figure 2)

Figure 2. Example curve fitted to a participant’s gaze trajectories, which was tested at an ITD (6 µs) nearest JND. Only correct trials are included to perform model fit. All model fits α > 0.9.

Figure 3. Individual listener data showing proportion correct (upper panels) from L/R responses in the ITD discrimination task. Individual listener’s average gaze trajectories are plotted (lower panels) for ITD JNDs and two ITDs with proportion correct above 0.9. Only correct responses are included to perform model fit. NH listeners showed similar psychometric functions and gaze trajectories; only one typical NH listener (TLX) data is shown. ITD JNDS for TLP and TUL (NH listeners) were 47 µs and 48 µs, respectively.

Figure 4. Fitted curve parameter estimates α & 1/β as a function of increasing magnitude in ITD from JND to the two ITDs above 0.9 proportion correct for individual listeners. BiCI listeners in solid lines; NH listeners in dash lines.

Figure 5. Individual listener data showing proportion correct (upper panels) from L/R responses in the ILD discrimination task. Individual listener’s average gaze trajectories are plotted (lower panels) for ILD JND and two ILDs with proportion correct above 0.9. Only correct responses are included to perform model fit. One typical NH listener’s (TLX) data is shown. ILD JNDS for TLP and TUL (NH listeners) were 0.4 dB and 0.5 dB, respectively.

Figure 6. Fitted curve parameter estimates α & 1/β as a function of increasing magnitude in ILD from JND to the two ILDs above 0.9 proportion correct for individual listeners. BiCI listeners in solid lines; NH listeners in dash lines.