INTRODUCTION

- Many bilateral cochlear implant (BCI) listeners demonstrate asymmetries in speech intelligibility across ears.
- Dynamic range (DR) is influenced by degree of hearing loss and electrode array insertion, and across-ear differences in DR could contribute to these performance asymmetries.
- Additionally, BCI users report elevated listening effort, which gives rise to stress, fatigue, and social withdrawal.1,2

PURPOSE

Experiment 1: Determine impact of asymmetric speech intelligibility on bilateral speech intelligibility and listening effort in individuals with BCI.

Experiment 2: Explore role of asymmetric DR on speech intelligibility and binaural performance in normal hearing (NH) individuals listening to vocoded speech.

METHODS

Participants

- 12 adults with BCIs; 4 adults with NH

Stimuli

- Target (T): 12-carat sentences spoken by a woman.
- Masker (M): Ablatio sentences spoken by a man or modulated speech-shaped noise (SSN).
- Stimuli were presented at 65 dB SPL.

Task

- Listeners repeated target sentences and responses were scored by an experimenter.
- Each sentence had five key words, which were scored individually.
- Participants completed 30 trials per condition.

Experiment 1 procedure: BCI listeners

- Speech intelligibility and pupil dilation were measured.
- Pupil size is a correlate of listening effort/engagement.

Experiment 2 procedure: NH listeners

- Speech intelligibility was measured.
- Stimuli were processed with a 16-channel sine wave vocoder and presented over headphones.
- All masker/noise conditions were presented at a signal-to-noise ratio (SNR) of +5 dB. Two subjects (TPA & TLY) were tested at 0 dB SNR on three conditions.
- Performance envelope of signal in one or both ears was compressed in Prat to reduce dynamic range of signal.

Participants were tested in ten conditions:

- Pupil data was analyzed as proportion change from baseline (moment before stimulus onset).
- Peak pupil dilation during post-stimulus wait period was used to compare effort across conditions (blue region on Fig. 1).3

RESULTS

EXPERIMENT 1: BCI RESULTS

Does speech asymmetry influence bilateral speech intelligibility and/or pupil dilation in quiet?

Table 2: Speech asymmetry across ears. Differences across ears were determined using 95% confidence intervals for each ear within-subjects.

TABLE 1. BCI participant demographics (ordered by years of bilateral experience).

EXPERIMENT 2: NH RESULTS

Does reduced DR contribute to performance asymmetries or influence binaural performance?

Figure 3: Individual subject intelligibility scores for unilateral conditions. Error bars represent SE.

Figure 5: 0 dB SNR: Substantial unmasking for all conditions; degree of DR asymmetry did not affect amount of unmasking.

Figure 6: 5 dB SNR: Less unmasking with reduced DR in both ears (purple) compared to asymmetric DR (yellow & green).

When contralateral noise is not coherent with ipsi noise [see SSN results], there is increased masking rather than unmasking.

SUMMARY

- BCI listeners with large asymmetries (purple group) demonstrated worse performance in the poorer ear and bilateral conditions than with small asymmetries, while better-ear performance was similar for both groups. This suggests that the benefits of BCIs may depend on the difference in performance across ears or possibly how poor the worse ear is.
- The poorer ear condition elicited the largest pupil dilation for both groups, but the difference was not significant. This task did not reveal a clear relationship between asymmetric speech intelligibility and pupil dilation in BCI listeners.

- Preliminary results from four NH listeners suggest that reduced dynamic range can impair speech intelligibility, but performance was still very high (~90% correct) even when the dynamic range of the signal was reduced to 50% of the original signal (Figure 3).
- The condition with the largest asymmetry elicited sizeable unmasking, but when dynamic range was decreased to 75% in both ears, the amount of unmasking was smaller (Figure 5). This suggests that overall degradation of the signal affects unmasking more than asymmetries across ears.

REFERENCES


Hughes, S. E., etc. (2018). Social connectedness and perceived listening effort in... to establish content validity for a new... patient-reported outcome measure. Prosthet. & A. 23993-23997.

Differences across ears were determined using 95% confidence intervals for each ear within-subjects.

Figure 2A: Task: High performance in all listening conditions.

Figure 2B: No differences in pupil dilation across any conditions within or between groups.

Figure 2C: Significant difference across ears. Red=no significant difference across ears.

Red=no significant difference across ears. Purple=significant difference across ears.

Figure 3: Target only: Intelligibility decreased when DR was reduced from 75% to 50%.

Figure 4: Performance was worse with masker; intelligibility decreased with reduced DR.

Figure 5: Performance high for all bilateral conditions +5 dB SNR.

Figure 6: Symmetric dynamic range.

Asymmetric dynamic range.

Control.

Bilateral conditions: intelligibility was high for all masker conditions (+5 dB SNR).

Figure 7: Binaural unmasking for individual subjects.

Figure 8: Binaural unmasking does not vary consistently with dynamic range.

Figure 9: Binaural unmasking of speech did not vary consistently with dynamic range.

Figure 10: Binaural unmasking of speech did not vary consistently with dynamic range.

Figure 11: Binaural unmasking of speech did not vary consistently with dynamic range.