

Speech enrichment: Listening effort and intelligibility

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ABSTRACT

In this study, we investigated differences between a hearing impaired (HI) and a normal hearing (NH) group on subjective, behavioural and neurophysiological measures of speech processing and listening effort. We fitted both groups with a hearing aid (HI for hearing loss compensation and NH with minimal amplification for comparison), and asked them to perform a speech-in-noise task. The target speech was presented in multi-talker babble noise in two SNRs (+5dB and 0dB). The hearing aid had three different settings: hearing loss compensation only, noise cancelling and beam forming. EEG (64 channels) was recorded during the experiment in order to analyse cortical entrainment as well as intersubject correlation. Results revealed a marked difference between cortical entrainment and other measures; whereas the subjective listening effort measure, behavioural performance (intelligibility) and intersubject correlation (as a measure of auditory attention) showed relatively small differences between the NH and the HI group, we found substantially larger cortical entrainment for the HI group, specifically in higher SNRs (+5dB). We suggest that these results might indicate that processing is altered for hearing impaired people specifically in the auditory stage.

Keywords: Hearing impairment, listening effort, EEG

1. INTRODUCTION

Compared to normal hearing people, hearing impaired people suffer from increased difficulties to understand speech in noisy conditions. Neurophysiological measures of online speech processing can be used to investigate this increased difficulty. Among those, there are two specifically that have been associated with auditory attention: neural entrainment and intersubject correlation. Neural (cortical) entrainment originates from neural oscillations in the cortex, which become phase-locked to low-frequency temporal modulations of speech (1, 2). Previous research has shown that selective attention can enhance cortical entrainment (3, 4, 5). Intersubject correlation (ISC), as a measure of similarity of the neural response between subjects, has been found to be significantly enhanced when listeners actively attend to a stimulus (6).

Based on previous findings and in conjunction with subjective and behavioral data, this study investigated differences in cortical entrainment and ISC between a normal hearing and a hearing impaired group. Additionally, the effect of algorithms commonly implemented in hearing aids (noise reduction algorithms, directional microphones) on our measures was assessed.

2. RESULTS

2.1 Cortical entrainment

Coherence in low-frequency regions (2-8Hz) to the target speaker was found to be significantly increased in the hearing impaired group, compared to the normal hearing group. Statistical analysis revealed a significant effect of condition ($\chi^2(5) = 56.489$, $p < 0.0001$), group ($\chi^2(1) = 6.7371$, $p < 0.001$) as well as the interaction between group and condition ($\chi^2(5) = 34.409$, $p < 0.0001$).

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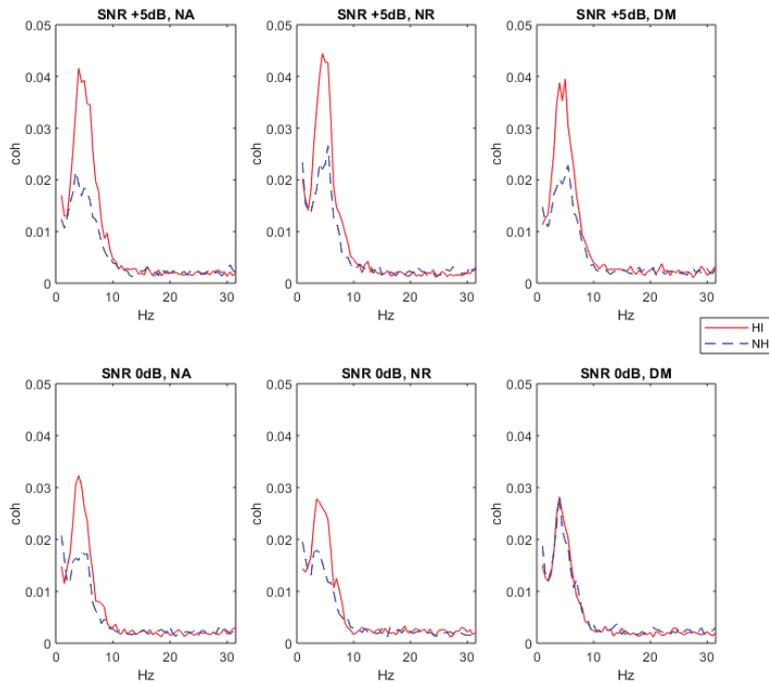


Figure 1 – Cortical entrainment for the hearing impaired and normal hearing groups

2.2 Intersubject correlation

For both groups, intersubject correlation (ISC) was higher for the easier noise conditions (+5dB SNR) than for the hard conditions (0dB SNR). Additionally, the normal hearing group showed a clear trend of higher ISC for conditions with enhancement compared to those without. For the hearing impaired group, this trend was less consistent. Statistical analysis (model comparison) revealed a significant effect of condition for both the normal hearing and the hearing impaired group (NH: $\chi^2(5) = 59.554$, $p < 0.0001$, HI: $\chi^2(5) = 31.14$, $p < 0.0001$). We found no significant difference in ISC between the two groups ($\chi^2(1) = 0.0172$, $p = 0.8956$).

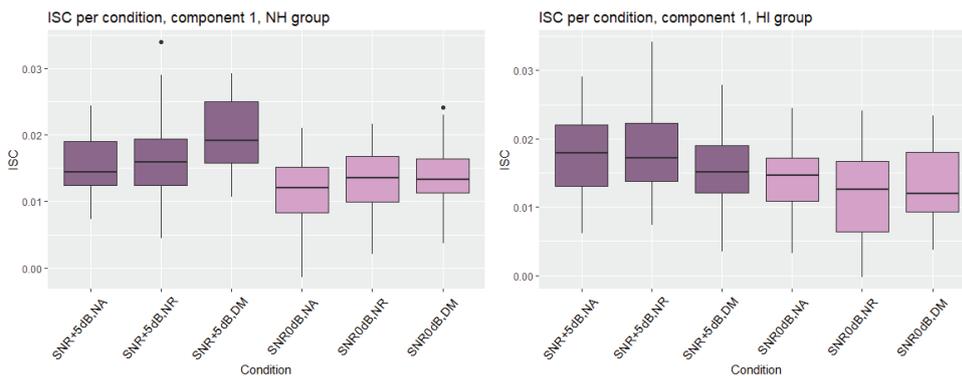


Figure 2 – Intersubject correlation for both groups

3. CONCLUSIONS

While cortical entrainment was significantly different between the hearing impaired and the normal hearing group, no such effect was found for ISC. These findings indicate that both groups were paying

attention at similar levels, but that processing specifically in the auditory stage was altered in the hearing impaired group.

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