Title: The Use of Binaural Beamforming to Reduce Listening Effort

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Abstract

Background: People with hearing loss often complaint about the amount of concentration required to follow a conversation in noisy venues. This research aimed to investigate whether a binaural beamformer designed to enhanced directivity – known as 'StereoZoom' (SZ) reduced the amount of cognitive effort required to understand speech relative to a soft beamformer aiming to replicate the natural pinna effect (known as 'Real Ear Sound' (RE) in the devices used) in a realistic, noisy scenario. It was hypothesized that the acoustic advantage provided by SZ would reduce the listening effort required to understand a speech stream coming from the front.

Methods: 20 hearing-impaired adults fitted with Phonak Marvel M90 hearing aids using Target software (v7.0.5) participated in an experiment that recreated a realistic cafeteria in the anechoic chamber of the Australian Hearing Hub. Listening effort was compared between RE and SZ via a novel dual-task which provided behavioural measures based on reaction time – with the hypothesis that longer reaction times would be associated with increased effort; physiological measures based on electroencephalography – aiming to characterise brain activation patterns associated with listening effort; and self-reported measures based on a questionnaire.

Results: Results showed that, relative to RE, (1) intelligibility improved with SZ from 83.8% to 88.9% (p-value = $1{\cdot}10^{-14}$) at signal-to-noise ratio corresponding to around 80% intelligibility (i.e. SRT-80), and from 90.9% to 93.4% (p-value = $2{\cdot}10^{-7}$) at SRT-95; (2) reaction times decreased with SZ by 75 ms (p-value = 0.003) at SRT-80 and by 50 ms (p-value = 0.02) at SRT-95; and (3) participants reported lower levels of self-perceived effort with SZ at the two SRTs – on a scale of 1 (No effort) to 7 (Extreme effort), self-perceived effort decreased with SZ from 4.72 to 4.22 at SRT-80 (p-value = $2{\cdot}10^{-16}$) and from 4.16 to 3.96 at SRT-95 (p-value = 0.0005). Electrophysiology data showed brain activation patterns consistent in the two evaluated SRTs, which were in accordance with previous literature of listening effort.

Conclusions: Together, results demonstrate that SZ reduces listening effort in a realistic noisy scenario, and validate the sensitivity of the proposed methodology to small changes in listening effort. The outcomes of this research have the potential to inform clinicians of technologies that can reduce the amount of concentration required to communicate in noisy environments. It also facilitates the management of expectations with regard to the possibilities of these technologies.