Reducing listening effort in a realistic sound environment using directional microphones: Insights from behavioural, neurophysiological and self-reported data

Joaquin T. Valderrama[1,2,3,4,*] (jvalderrama@ugr.es), Jorge Mejia[3,5] (jorge.mejia@nal.gov.au), Angela Wong[3] (angela.wong@nal.gov.au), Nicholas Herbert[6] (nicholas.herbert@sonova.com), Brents Edwards[3,4] (brent.edwards@nal.gov.au)

[1] Department of Signal Theory, Telematics and Communications, University of Granada, Granada, Spain
[2] Research Centre for Information and Communications Technologies, University of Granada, Granada, Spain
[3] National Acoustic Laboratories, Sydney, Australia
[4] Department of Linguistics, Macquarie University, Sydney, Australia
[5] School of Computing, Macquarie University, Sydney, Australia
[6] Sonova AG, Stäfa, Switzerland
* Presenting author

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Background: Individuals using hearing aids frequently report increased cognitive effort required to understand speech in challenging acoustic environments, such as noisy cafeterias or restaurants. Despite numerous hearing technologies designed to alleviate comprehension difficulties in noise, measuring listening effort poses important methodological challenges. This study aimed to quantify the efficacy of adaptive binaural beamforming microphones in reducing listening effort using a novel multidimensional approach.

Methods: Twenty adults with symmetric downward-sloping hearing loss (9 female, 19-81 years) participated. The study compared comprehension effort in ecological cafeteria noise between two hearing aid microphone modes: quasi-omnidirectional (OD) and adaptive binaural beamforming (BB). Listening effort was assessed using a novel paradigm comprising *behavioural* measures via a dual task, *neurophysiological* measurements based on alpha power, and *self-reported* measures. The experiment took place in an anechoic chamber equipped with an Ambisonics array of 41 speakers at the Australian Hearing Hub (Sydney, Australia), at signal-to-noise ratios (SNRs) corresponding to 80% and 95% speech-reception thresholds (SRT-80 and SRT-95).

Results: Compared to OD, participants using BB (1) increased speech intelligibility from 84% to 89% at SRT-80 and from 91% to 93% at SRT-95; (2) decreased reaction times by 75ms at SRT-80, and 50ms at SRT-95; and (3) reduced their self-perceived effort (rated on a 1-7 scale) from 4.72 to 4.22 at SRT-80 and from 4.16 to 3.96 at SRT-95. Additionally, BB led to decreased alpha power before the sentence onset and increased alpha power during the stimulus presentation at both SRTs.

Conclusion: Results indicate that BB reduces listening effort compared to OD in realistic cafeteria settings and confirm the sensitivity of the proposed methodology to subtle changes in listening effort. Importantly, these findings can assist clinicians in managing patient expectations regarding this technology. Furthermore, neurophysiological measures revealed two different (even paradoxical) indexes of listening effort: both an increase and a decrease of alpha power in different time events of the acoustic stimulus. These results contribute to the open discussion on cognitive and linguistic processes associated with this biomarker, including inhibition and information processing.