A COMPARISON BETWEEN CROS HEARING AIDS AND BONE-ANCHORED HEARING AIDS FOR PATIENTS WITH SINGLE-SIDED DEAFNESS: A LISTENING EFFORT-BASED PILOT STUDY

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1 Introduction

Single-sided deafness (SSD) is characterized by the near or total loss of hearing in one ear with normal hearing in the contralateral ear. SSD gives rise to a functional listening handicap : it impairs speech recognition in noise, sound localization, and decreases awareness of sounds due to the head acoustic shadowing in the auditory hemifield ipsilateral to the impaired ear [1–3]. The dominant therapeutic approach consists in rerouting incoming acoustic signals from the impaired ear to the non-impaired ear. This is done using either air conduction (e.g., contralateral-routing-of-signal – CROS – hearing aids) or bone conduction (e.g., bone-anchored – BA – hearing aids).

However, the relative benefits of using BA or CROS hearing aids are difficult to assess clinically. The inability to assess which device produces the best results for a given patient makes the clinical management of SSD patients challenging. In practice, device choice often relies on subjective patients reports of reduced listening effort and funding modalities that tend to differ for each device.

This research aims to address this long-standing issue, by using a combination of tests assessing how hearing aids impact SSD patients hearing outcomes. To do so, we used subjective (NASA Task Load Index) and objective (pupillometry) measurements of listening effort, together with behavioral performance assessment, to compare those two types of hearing aids during a speech-in-noise task.

2 Material and Method

2.1 Participants

Six adult men with single-sided sensorineural deafness, defined as having no residual bone conduction hearing with no residual speech recognition in one ear, and air conduction audiometric thresholds better than or equal to 25 dB HL at 0.25, 0.5, 1, 2, 3 and 4 kHz in the other ear, were assessed. Participants were native English speakers with no history of neurological disorders, no excessive caffeine intake prior to the measurement session, and no otologic co-morbidity in the good ear. During the measurements, participants remained seated in a comfortable chair inside a double-walled audiometric booth of the MUHC Department of Speech Pathology and Audiology. The study was reviewed and approved by the Research Ethics Board (REB) of the McGill University Health Centre (MUHC). Informed consent was obtained from all participants before they were enrolled in the study.

2.2 Experimental Procedure

Behavioral performance was assessed using Hearing-In-Noise Test (HINT) [4] conducted via the Oticon Medical Experiment Platform (OMEXP) in three conditions : while wearing a CROS hearing aid (Oticon CROS with OpenSoundNavigator™ 2), while wearing a BA hearing aid (Oticon Medical Ponto™ 4), and with no hearing aid. A total of 60 sentences was presented in the BA-fitted (20 sentences), CROS-fitted (20 sentences) and unaided (20 sentences) conditions. Speech signals were presented using a loudspeaker in frontal incidence and a white noise was presented using a second loudspeaker in the auditory hemifield ipsilateral to the good ear. The stimulation levels were determined via an adaptive HINT conducted prior to starting the experiment, by which the signal-to-noise ratio (SNR) yielding a 70% speech reception threshold (SRT) with no hearing aid was identified. Participants were instructed to listen and repeat aloud the sentences heard or understood. No feedback was provided.

While the participants were performing the behavioral task, pupil size and location in both eyes were measured using the Pupil Core eye-tracking platform (Pupil Labs, Berlin, Germany). Peak pupil dilation (PPD) was extracted during a time window corresponding to the pause between the sentence offset and the prompt to repeat the sentence [5]. This metric was then averaged across sentences for a given condition.

At the end of each condition, subjective assessment of listening effort was performed using the NASA Task Load Index (NASA-TLX) via a tablet computer. This subjective and multidimensional assessment tool is used to evaluate the mental workload level (MWL) of tasks performed by a participant, which in the present context was to repeat sentences heard in noise.

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3 Results

Preliminary results indicate no effect of the device on behavioral performance (HINT scores, Fig. 1A), in line with previous reports [6, 7]. We observed a trend in peak pupil dilation indicating that both CROS and BA hearing aids conditions require less cognitive effort compared to the unaided (UNAI) condition (Fig. 1B). Subjective effort result trends suggest that participants perceive requiring less cognitive effort during a speech-in-noise task when using BA hearing aids (Fig. 1C).

4 Conclusion and Future Work

The presented paradigm provides a combination of objective and subjective approaches to inform device choice and assessment in patients with SSD. Preliminary results suggest a reduced effort in SSD patients when aided, in absence of behavioral improvement. Future work will recruit more patients. Results might lead to the development of an objective biomarker that could be used in a clinical setting to provide personalized recommendations. Additionally, this would allow clinicians to longitudinally track patients' progress during their follow-up visits.

Acknowledgments

The authors would like to thank the participants for giving their time to take part in this study. This research project received financial support from the William Demant Foundation (Smørum, Denmark). The authors also wish to express their appreciation to the team at Oticon Medical for their feedback and expertise.

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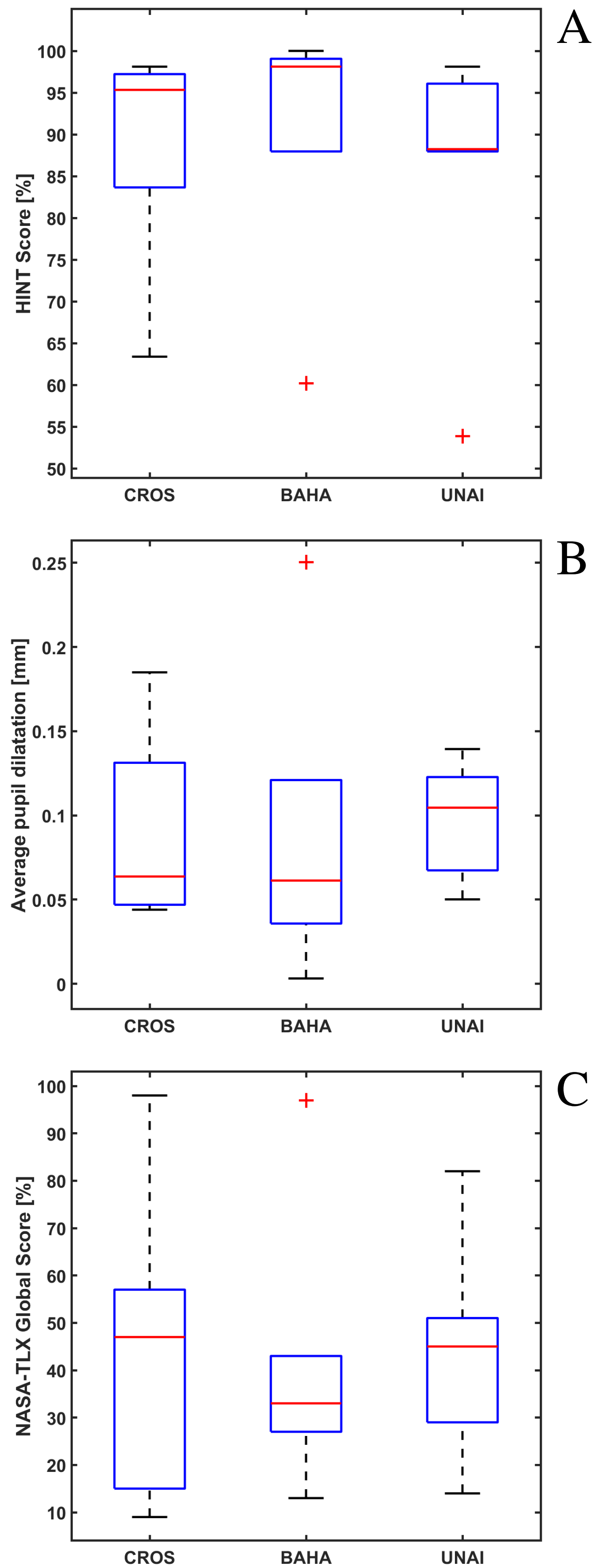

FIGURE 1 – Behavioral (A), objective (B), and subjective (C) results obtained with six SSD patients, with hearing aids (BAHA and CROSS conditions) and without hearing aid (UNAI condition). Medians are indicated by red central marks and outliers are plotted using "+" red markers.