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Listening Effort at Different Signal-to-Noise Ratios for Bone-Anchored Users

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Introduction

The efficacy of Bone anchored hearing systems(BAHS) has been widely demonstrated. However as technology improves, assessing the level of additional benefit experienced by users has proved challenging with existing outcome tools. There is a growing body of evidence to support the use of subjective outcome measurements such as questionnaires to assess the impact of intervention on listening effort.

Pupillometry is a technique used to measure pupil size and reactivity as a key element of neurological examinations. This study will explore the benefits of utilising the pupillometry technique as an objective measure of listening effort in BAHS recipients.

Objectives

The objective of this ongoing study is to evaluate listening effort in BAHS users using pupillometry over a wide range of signal-to-noise ratios.

The study also aims to evaluate the impact of the Open Sound Navigator (OSN) technology on listening effort through pupillometry.

The objective of this poster is to outline the methodological approach being taken in this study and to provide background information about the use of pupillometry in the audiological setting.

Methods

- This is a prospective study, where listeners serve as their own control.
- Listeners with a bilateral conductive or mixed hearing loss and with bone-conduction pure tone thresholds lower than 40 dB HL are included in the study.
- Subjects should have previous consistent use of a Ponto Pro, Ponto Plus or Ponto 3 processor for at least 6 months.
- Patients are fitted with Oticon Medical Ponto 4 (fig1).

Figure 1 Oticon Medical Ponto 4 BAHS Processor

- Self-reported performance with Ponto 4 is also evaluated via questionnaires including the impact on work related fatigue.

Speaker Set Up

- Subjects' task: Listen to the sentence in noise, retain the sentence for 3 s, repeat the sentence after noise offset.
- Target speech presented from the front and 4-talker babble noise presented at the side and back of the participant (fig 2).
- Pupil dilation is recorded at fixed signal-to-noise ratios ranging from -8 dB to + 8 dB (in 4-dB steps), for two different device settings.

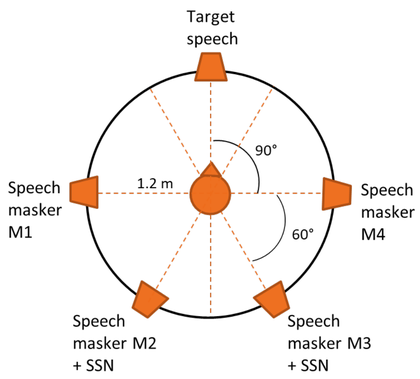

Figure 2 Sketch of the loudspeaker setup

Pupillometry Measurements

- Listening effort assessed by measuring pupil dilation with an eye-tracking camera (fig 3) during a speech-in-noise task.
- The headwear supporting the cameras is lightweight and comfortable for wear and can be worn with PPE without difficulties.
- The environment lighting is controlled using a specific dimmable light source and the subject is asked to maintain focus on a specific point.
- Subjects are required not to ingest caffeine within 6 hours of testing due to the influence on the pupil responses.

Figure 3- Pupil labs glasses (iMotions)

Listening task

- For each trial, noise started 3 s before sentence onset and ended 3 s after sentence offset.
- Subjects' task: Listen to the sentence in noise, retain the sentence for 3 s, repeat the sentence after noise offset.
- There are varying test conditions at each visit account for differing SNRs.
- The test conditions will be performed with the new Ponto 4 Open Sound Navigator (OSN) on and off to identify to evaluate its impact on listening effort.
- An eye-tracking camera monitors pupil dilation, as a measure of listening effort.

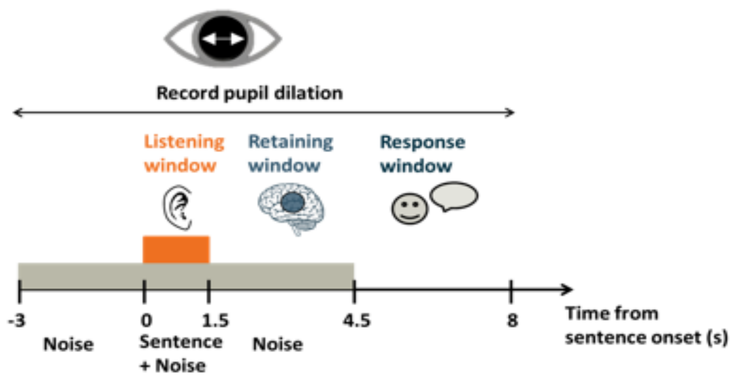

Figure 4 Recording of pupil dilation during listening task

Factors affecting listening effort

- Listening effort depends on subject's motivation and on the task demands.(fig 5)

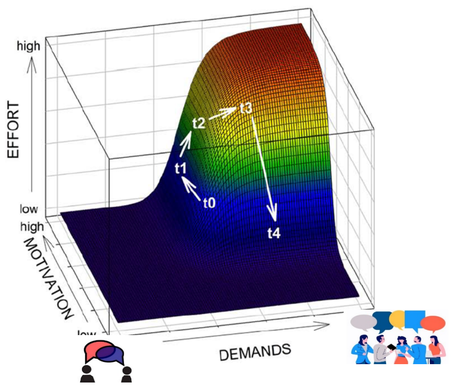

Image taken from Pichora-Fuller et al., Ear Hear (2016)

Figure 5 Listening effort, motivation and demands

- As motivation to listen increases, listening effort increases
- As demands increase, listening effort increases.
- At point demands become too high motivation reduces and listening effort decreases.
- At this stage disengagement occurs leading to further reduction in listening effort.

Pupillometry mechanism

- Controlled by the Autonomic Nervous System.
- Impacted by both stimulation of the Sympathetic Nervous System (SNS) activating the dilator muscle and inhibition of the Parasympathetic Nervous System(PNS) relaxing the sphincter muscle (fig 6).

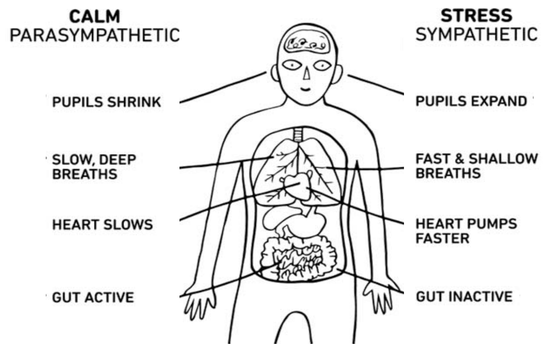

Figure 6 The Sympathetic and Parasympathetic Nervous systems. (Image taken from https://www.onthegophysicaltherapy.com/blog/tag/injury+prevention.)

- It is assumed the biggest contributor to pupil dilation is the SNS but inhibition of the PNS is a significant contributor particularly in cognitively demanding situations.
- As the listening environment becomes more demanding the SNS is stimulated and the PNS is inhibited resulting in pupil dilation.

Study Progress

The impact of COVID19 has been felt worldwide. Alongside the impact on NHS clinical services, the pandemic has also had a major impact on Research and Development. Between March 2020 and August 2020 all Non-COVID studies at UHB were suspended. In August 2020 this study was reopened. Currently 6 of a target of 30 patients have been recruited to this trial. Data collection remains ongoing, to date no results are available for publication.

References

Pichora-Fuller, M.K., Kramer, S.E., Eckert, M.A., Edwards, B., Hornsby, B.W., Humes, L.E., Lemke, U., Lunner, T., Matthen, M., Mackersie, C.L. and Naylor, G., 2016. Hearing impairment and cognitive energy: The framework for understanding effortful listening (FUEL). Ear and hearing, 37, pp.5S-27S.

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