WHITEPAPER
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Benefits of Oticon Opn for people with hearing loss and tinnitus

INTRODUCTION

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Imagine having a constant ringing, buzzing or hissing in your head that only you can hear. For the roughly 10-15% of the adult global population who experience chronic tinnitus, this is the case (Dobie, 2004). Tinnitus is defined as the perception of sound that occurs without any external sound stimuli (Langguth et al, 2013).

Eighty percent of those with chronic tinnitus are not considerably bothered by it. However, for the remaining 20%, their tinnitus can severely impair quality of life (Dobie, 2004). Having hearing loss significantly increases the risk of having tinnitus (e.g. Møller, 2011; Sanchez, 2004).

Tinnitus can further affect cognition like memory and attention (Mohamad et al, 2016; Andersson & McKenna, 2006; Tegg-Quinn et al, 2016). It is reasonable to assume that tinnitus increases cognitive effort, meaning that people with tinnitus and hearing loss must further intensify their level of effort. One example could be understanding speech in complex noisy environments in comparison to people who have hearing loss, but no tinnitus.

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Listening effort and OpenSound Navigator

The aim of traditional directional technology is to create a focus ahead of the listener. This means that all sound sources away from the listener are attenuated. While this type of technology is known to improve speech understanding in situations with a primary talker ahead, it also has limitations. In its most aggressive form, known as the binaural beamformer, it has been shown to decrease speech understanding and reduce the ability of localising sounds (Mejia et al, 2015).

OpenSound Navigator (OSN) represents a significant improvement over traditional directional technology. It is a fast-acting signal processing scheme with a combination of a minimum variance distortionless response (MVDR) algorithm for cancelling localised noise sources, and a post filter for handling diffuse noise. Both work in 16 channels. What this means is that the noise is assessed more precisely, resulting in better attenuation. Its precision allows the noise to be strongly reduced, yet still preserving distinct sounds (e.g. speech) in the environment. (See whitepaper Le Goff et al, 2016[1] for more details on OSN).

A recent study showed that OSN significantly reduces listening effort, as measured by pupil dilation, for people with hearing loss (Wendt et al, 2017). The measure of the effort associated with a certain task by pupil dilation, also known as pupillometry, has recently been developed in the context of speech understanding (e.g. Zekveld et al, 2011; Wendt et al, 2017). The basic idea is that pupils dilate more when tasks are perceived to be demanding. In the context of speech understanding in noise, the demands can change according to how loud the noise is, or if hearing aids have noise reduction algorithms activated or not. An example of the dilation of the pupil during a speech recognition in noise task is shown in figure 1.

To investigate potential benefits of noise reduction on cognitive effort for people with tinnitus and hearing loss, the following experiment was carried out.

Pupillometry study on patients with tinnitus

The effects of tinnitus and noise reduction on participants' listening effort were tested while participants wore Oticon Opns hearing aids (fitted with a first-fit approach). The benefit of noise reduction was measured by turning the noise reduction feature on and off in a randomised order.

Experiment

The methodology was a replication of the study by Wendt et al (2017). The participants of the present study were divided into two groups. The tinnitus group, with 16 listeners with both tinnitus and hearing loss, with an average age of 62 years (ranging from 42 to 79 years), and the control group, with 16 listeners with

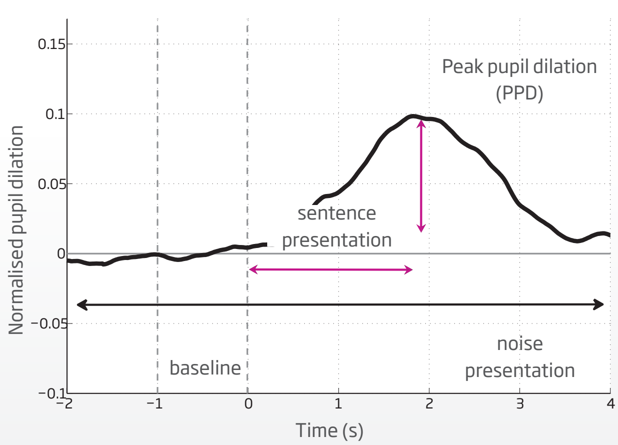

Figure 1. Example of normalised pupil curve. Pupil size is normalised according to the baseline where the noise was present in isolation.

Figure 2. Spatial setup of loudspeakers. The target loudspeaker presenting the sentence is positioned at 0°. The 4-talker-babble is presented from loudspeakers at +/- 90° and +/- 150° (corresponding to one competing talker per loudspeaker). The distance from participant to camera was approximately 60 cm.

only hearing loss, with an average age of 67 years (ranging from 47 to 84 years). The participants with tinnitus had an average Tinnitus Handicap Inventory score of 36, indicating an average of 'moderate' severity of tinnitus. All participants had mild to moderately severe bilateral sensorineural hearing loss (4-frequency average ranging from 28 to 68 dB HL with an average of 45). There were no significant differences between the groups on hearing loss or age, making comparisons on effort data appropriate.

The participants listened to Danish Hearing in Noise Test (HINT) (Nielsen & Dau, 2011) sentences presented in a 4-talker-babble noise, and were asked to repeat back the sentence after presentation. They performed four test lists, comprising four conditions. The noise was presented in a spatial loudspeaker setup at +/- 90° and +/- 150° (visualised in figure 2). While participants performed the HINT, pupil dilation was continuously recorded with an eye-tracking system (iView X Red System, Senso-Motoric Instruments).

The speech was presented at 70 dB SPL, and the SNR was adjusted for each participant to ensure they understood respectively 50% and 95% of the speech correctly. Noise reduction was expected to facilitate a reduced listening effort in the participants that did not have tinnitus, and it was expected that the participants with tinnitus would have an increased listening effort in all conditions, with the effects of OSN being less predictable.

Analysis and Results

The pupil data was analysed using the method of Wendt and colleagues (2017). For each participant, pupil data was measured for 25 trials. The first five trials were removed from analysis in order to eliminate training effects. For the remaining trials, data that had more than 20% of blinks and eye movements was excluded for analysis (two participants were excluded due to this). For the included trials, eye-blinks were removed by a linear interpolation. The remaining traces were normalised by subtracting a baseline value to allow comparison between conditions, and thus only focus on changes in pupil size and not the absolute size of the pupil. The baseline value was estimated by the mean pupil size one second prior to the onset of the sentence. During that second, the participant was only listening to noise. The peak pupil dilation (PPD) was calculated for each participant, and for each condition. The PPD is defined as the maximum pupil dilation during the time interval between sentence onset and noise offset (Figure 1).

Results from the tinnitus group are displayed in figure 3. This shows that the average PPD was at 0.19 mm for the 50% speech recognition without noise reduction, and 0.14 mm with noise reduction activated. For the 95% level, the average PPD went from 0.17 mm without noise reduction, while decreasing to 0.10 mm when noise reduction was activated. Figure 4 shows the average pupil dilation in each condition for the tinnitus group, where the dilation was reduced in the conditions where noise reduction was applied.

These results replicate those found in Wendt et al (2017), indicating that noise reduction benefits people with hearing loss, even when they have tinnitus.

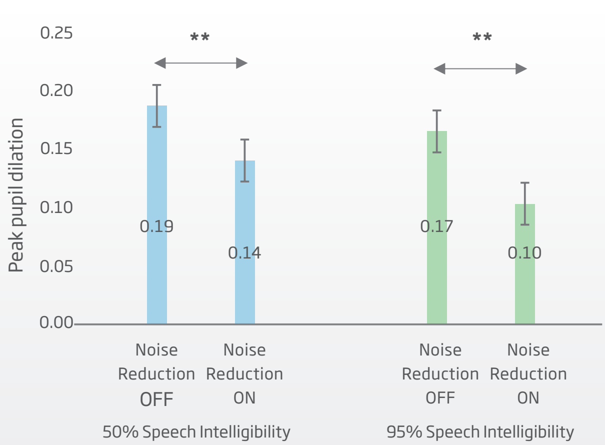

Figure 3. Peak pupil dilation averaged across all participants. Error bars show standard errors.

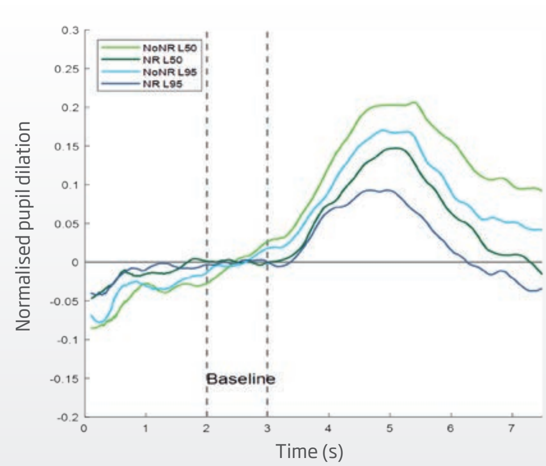

Figure 4. Average pupil dilation of tinnitus participants, showing a reduced dilation in conditions with noise reduction.

Interpretation of results

The study presented in this white paper demonstrated that people with tinnitus experience at least the same benefit on listening effort when using Oticon Opn as people without tinnitus. The benefit of reduced effort results in the freeing up of cognitive resources. When fewer cognitive resources are used, it is likely that the person has less difficulty in noise and with their tinnitus, and, as an example, may feel less tired after attending a dinner party.

Furthermore, it allows the person with tinnitus to allocate resources to other tasks instead of attending to the tinnitus. Thus, use of effective noise reduction, such as the OSN, can contribute to rehabilitation goals of tinnitus treatment, namely to enrich perception and make the tinnitus a less dominant aspect of daily life.

The study did not show that people with tinnitus and hearing loss used greater listening effort on this task than people with hearing loss alone. However, it does show that despite the tinnitus taking up additional cognitive resources, the participants perform equally well on the study tasks and use the same amount of effort. These results show that the OSN signal processing scheme applies just as successfully to people with tinnitus as it has been shown in people with hearing loss (whitepaper, Le Goff et al, 2016[2]).

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