WHITEPAPER
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Oticon More™ new evidence – Reducing sustained listening effort

ABSTRACT

This whitepaper presents the results of a clinical study that investigated the benefits of the key feature in Oticon More™ – MoreSound Intelligence™ (MSI) – in listening effort.

Previously, we have shown that Oticon More via the use of the intelligence of a Deep Neural Network is able to provide the brain with clearer sound and a better access to the full sound scene. In this study, by using a combination of running speech and advanced pupillometry test methodology to assess listening effort over time, we show that there is a significant reduction in sustained listening effort when MSI was on compared to when it was turned off. These astounding new results suggest that by effectively providing better access to the full sound scene, Oticon More helps the brain to work in the optimal way, so the brain consequently requires less effort to hear and understand.

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Introduction

Speech in noise for people with hearing loss

Separating out a speaker that one wants to listen to from other speakers in a noisy environment is challenging, not only for people with hearing loss but also for people with normal hearing. For people with hearing loss, listening is compromised, and the brain needs to work hard to understand what is being said in challenging environments such as restaurants, bars, crowded places, big lecture halls etc. Hearing difficulty in noise can be so great that they may choose to avoid or limit their social participation altogether (Crews & Campbell, 2004). Research has shown that there is a link between dementia and hearing loss that may be caused partly due to a limited participation in socially stimulating settings (Lin et al., 2011a; Lin et al., 2011b; Loughrey et al., 2018; Livingston et al., 2020). Further, if hearing loss goes untreated, the social isolation associated with the hearing loss can accelerate the cognitive decline leading to dementia (Lin et al., 2013, Griffiths et al., 2020; Livingston et al., 2020). Therefore, helping people with hearing loss to maintain good communication in social environments is not only a matter of hearing health but also a matter of general well-being.

In quiet environments, speech is not acoustically mixed with other sounds. Hence, listening in a quiet environment may not be challenging even for people with hearing loss. On the other hand, speech in everyday environments are acoustically mixed with other interfering sounds. The brain uses cognitive processes to focus on the relevant information and ignore the rest (Meyer et al., 2016; Pichora-Fuller et al., 2017). This function of effectively separating the relevant speech from irrelevant noise is compromised in people with hearing loss (Dai et al., 2018; Shinn-Cunningham & Best, 2008). Research has shown that to make sense of sound and to navigate our environment and communicate with others, we constantly combine our sensory, cognitive, and social abilities (Meyer et al., 2016; Pichora-Fuller et al., 2017).

MoreSound Intelligence in Oticon More

Conventional hearing aid technology supports communication in complex acoustical environments by attenuating noise and creating focus toward the speech by using directionality and noise reduction features. However, to have a successful hearing process it requires full access to the sound environment, so that our brain can effectively suppress the irrelevant ones and focus only on the relevant ones as the cognitive resources in our brain are limited (Pass et al., 2010).

Oticon More builds on the powerful Polaris™ platform, which is designed to provide access to the full sound scene, making it easier for the brain to decode sounds. In this way the brain can better orient, focus, and make sense of what is going on in the environment. It was shown by Santurette et al. (2020) that MSI in Oticon More makes meaningful sounds stand out from the background.

Listening effort

Listening effort is a specific form of mental effort that is exerted when a task involves listening, as defined in the Framework for Understanding Effortful Listening (Pichora-Fuller et al., 2016). In other words, it is the cognitive resources necessary for speech understanding (Hicks & Tharpe, 2002).

A common challenge among people with hearing loss is the effort it takes to listen. They often complain about being “exhausted” or “drained” from listening in noisy environments. Previous studies reported that even a mild hearing loss could lead to increased listening effort (Rabbit, 1991; McCoy et al., 2005). This happens because when hearing is compromised, the auditory system becomes more vulnerable to noise and disturbing sounds. The brain needs to work harder to hear in noise, which leads to tiredness and exhaustion. Indeed, researchers have found that people with hearing loss needed more time at the end of the day to rest and to recover from work (Nachtegaal et al., 2009).

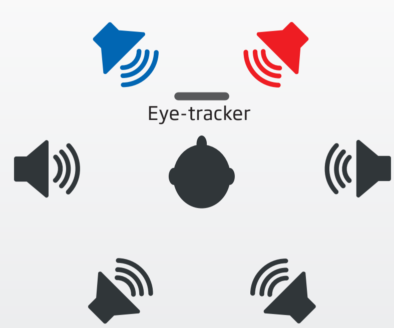

Figure 1. Test setup with a total of six loudspeakers, which is identical to the setup used in the Oticon More EEG study (Santurette et al., 2020). Pupillometry was done by placing an eye-tracker in front of the participants to measure sustained listening effort. Two frontal loudspeakers (blue and red) contained a male and a female talker reading audio clips simultanouely. Background noise, which is a 16-talker babble, came from the remaining four loudspeakers.

Real-life listening

Objective listening effort is typically measured using pupillometry, which involves continuously recording a listener's pupil dilation while performing a listening task (Ohlenforst et al., 2017; 2018; Wendt et al., 2017). When performing a demanding task – such as listening to speech in noise – an increase in effort is reflected by the change in the pupil size (Beaty, 1982). The larger the degree of pupil dilation, the more the listening effort is thought to be needed for the task.

In studies investigating listening effort, short sentences are typically used as speech material in the listening task. The participants are usually asked to listen to and repeat aloud sentences presented in noise. Peak pupil dilation during the presentation of the sentence-in-noise stimuli (4 to 5 seconds long) is commonly used as a measure of listening effort. However, this may not fully represent real-life listening situations because we often listen to running or continuous speech rather than isolated sentences in everyday conversations. Following a conversation requires paying attention to the talker over a sustained period, which is known as sustained attention, and staying engaged. To understand the gist of the conversation, we will also need to react, reflect and respond. By assessing the change in pupil dilation while listening to running speech using a longer time window as compared to the shorter 4 to 5-second time window in the previous studies, this gives us a measure of listening effort that is more representative of the real-life situations.

Real-life conversations require sustained attention

The aim of this study is to measure and compare sustained listening effort with and without MSI enabled. In our previous Oticon More EEG study, both EEG and pupillometry data were collected at the same time while the participants were performing a selective listening task. The EEG data were already reported in the Oticon whitepaper, Santurette et al. (2020). This whitepaper reports only the pupillometry data. Both sets of data were also reported in a peer-reviewed journal (see Andersen et al., 2021).

Methods

Seventeen experienced hearing-aid users (mean age 67 years) with a symmetrical, sensorineural hearing loss ranging from a mild to moderate were included in

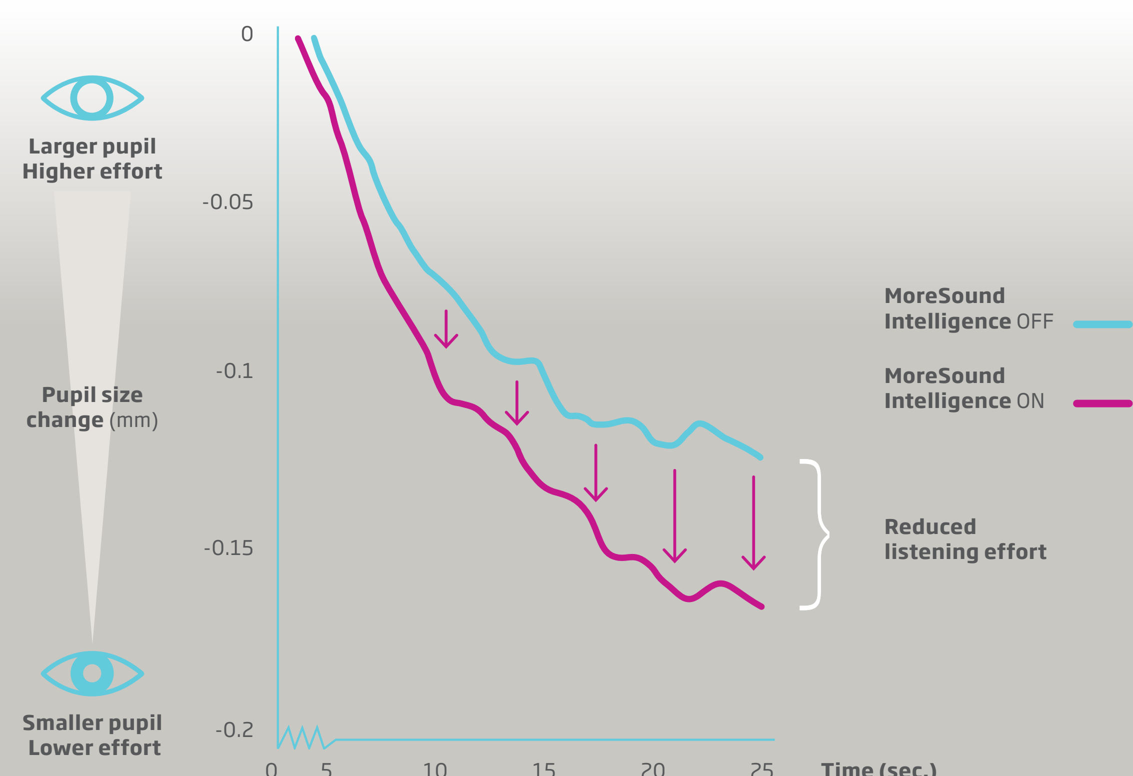

Figure 2. Change in pupil size with MSI on versus MSI off. The magenta line with MSI on indicates less sustained listening effort over 30 seconds.

the analysis. Here, pupil size were recorded using an eye-tracker when the participants listened to running speech in the presence of multi-talker babble noise. This advanced pupillometry test methodology was previously used in a previous study conducted by researchers from Eriksholm Research Centre (Fiedler et al., 2021). For running speech, audio news clips that were approximately 30 seconds long were used. The test setup (see Figure 1) and the procedure of this study are identical to what is described in Santurette et al. (2020). The audio clips spoken by a male and a female talker each came simultaneously from one of the two frontal loudspeakers, with each talker at 73 dB SPL. The background noise consisted of a 16-talker babble, presented at 70 dB SPL.

The participants were instructed at the beginning of each trial which talker to attend to while ignoring the other talker. We investigated how the pupil dilation over the time range of approximately 30 seconds compared between two conditions: MSI on and off. Twenty trials were administered for each condition. A higher pupil dilation is an indication of higher effort allocated to the listening task.

We compared listening effort, indexed by pupil dilation, with MSI on versus MSI off in Oticon More in a "real-life like" scenario. We use the term "real-life like" because in this study we used running speech for a longer duration. This is considered to be ecologically more valid and to promote stronger engagement during listening.

Results

Figure 2 shows the change in pupil size with MSI on versus MSI off over the course of 30 seconds. During the first seconds, the difference in effort between the two conditions is minor. This is believed to be related to the initial arousal or effort devoted to focusing on the talker the participants were told to attend to. After this initial period, we observed a general strong and highly consistent decrease in pupil size for the remaining time window. This reflects less listening effort and indicates a transition into the listening state such that the pupil size reaches a constant level. Sustained attention and engagement into the listening task is likely involved in this constant listening state.

The pupil dilation is significantly smaller with MSI on compared to MSI off. What should be noted in Figure 2 is the magenta line which corresponds to pupil dilation across time with MSI on. It indicates that less effort is required to listen to speech in noise when MSI is turned on compared to when it is turned off, illustrated by the blue line.

Next, we compared the average percent change in pupil dilation with MSI on versus off. We found that with MSI on there was 30% reduction from the baseline in the average pupil size compared to MSI off ($p < 0.001$). Figure 3 illustrates this finding, where especially the bar plot for MSI on should be noted. Here the values are more negative meaning that the listening effort is less with MSI on compared to off.

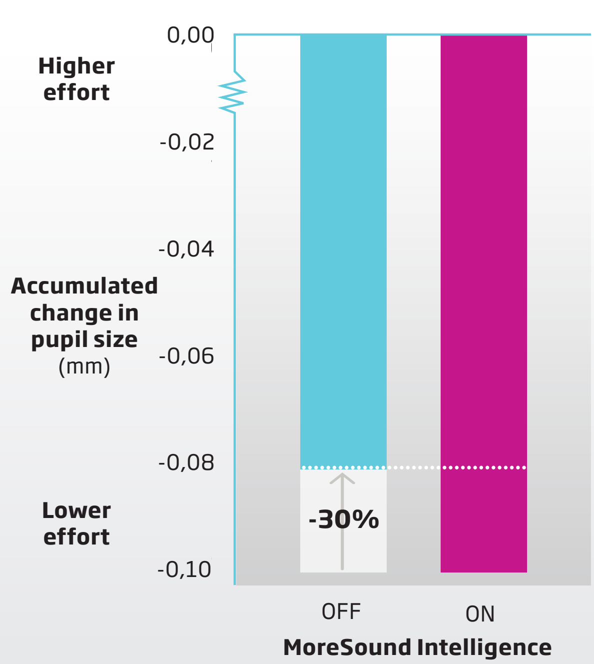

Figure 3 Average pupil size changes (accumulated over 30 seconds) with MSI on versus MSI off

Conclusions

We assessed pupil size as an established measure of sustained listening effort (Fiedler et al., 2021). Smaller pupil dilation (an indication of less listening effort) while listening to a running speech for a longer duration is observed with MSI on than MSI off. This suggests better sustained attention and engagement when listening with MSI in Oticon More.

Previously, we have shown that Oticon More via the use of the intelligence of a Deep Neural Network is able to provide the brain with a clearer sound and a better access to the full sound scene. Approximately 60% more clearer sound is given to the brain with MSI in Oticon More (Santurette et al., 2020). Together with the findings of this clinical study, MSI dramatically reduced sustained listening effort at the same time as it gives the brain access to more sound. These findings confirm the new approach of the BrainHearing technology in Oticon More. By providing access to the full sound scene, the brain can better orient, focus and recognize. Oticon More helps the brain to work in the optimal way, so it consequently requires less effort to hear, understand, and participate socially.

Clinical interpretation

We have shown that with MSI, less effort is required to listen in noise. Less effort during listening over a longer period means that 1) the brain is using less cognitive resources to understand speech in challenging situations such as a restaurant, and 2) the listeners with hearing loss can more easily react, respond, and engage in conversations. Even though the brain is getting more sound with Oticon More, less effort is required to listen to speech in noise, thanks to the groundbreaking MSI feature.

Even though the brain is getting more sound with Oticon More, less effort is required to listen to speech in noise, thanks to the groundbreaking MSI feature.

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