EPOS

EPOS BrainAdapt™ An Auditory Memory Study

The effect of noise attenuation on memory recall

Scientific Whitepaper
2023

This whitepaper presents the results of a clinical study that investigated the benefits of noise damping technology used in EPOS Enterprise and Gaming audio solutions. The aim was to demonstrate how damping effects the listening effort exerted by the study's participants.

BrainAdapt™

Scientific Whitepaper

Introduction

In both professional and personal contexts, we often need to understand speech and remember what is said to perform at our best. However, in today's world with distractions abound, this can be difficult.

Humans have limited cognitive capacity, so when we devote cognitive resources to listening, i.e., when recognizing speech, we will have a reduced capacity to perform other tasks, such as memory recall. If we listen to speech through headsets and speakers with poor audio quality, our ability to listen will be challenged even further.

This whitepaper presents the results of a clinical study that investigated the benefits of noise damping technology used in EPOS Enterprise and Gaming audio solutions. The aim was to demonstrate how damping effects the listening effort exerted by the study's participants.

This type of in-depth scientific research has been a key element in the development of audio solutions built on EPOS BrainAdapt™ technology, which supports the brain's natural way of processing sound (Christiansen and Ng, 2022). The custom-made components, acoustics and sophisticated algorithms that go into EPOS solutions ensure optimized cognitive performance, even in challenging sound environments.

EPOS product innovation is driven by psychoacoustic research
In the EPOS product innovation process, we start by defining the sound profile that supports the best cognitive performance in specific use cases. To ensure that EPOS solutions provide the most balanced, clear, and natural soundscape possible, we draw on more than a decade of research into how the brain perceives sound and how the brain's cognitive load can be lowered in various sound situations.

As we move into product development, we implement fine-tuned acoustics and sophisticated algorithms into our solutions. We look at the product holistically, integrate technical features and the right set of custom-made components to provide the best conditions for your brain.

Finally, before launch, we conduct psychoacoustic research in collaboration with the Demant Group to validate that EPOS users obtain the cognitive benefit intended. The following pages present the results of a recent study that will help EPOS continue deliver superior audio and video solutions with audio designed for the brain.

The technology tested in this study is featured in the following EPOS products:

- IMPACT 1060 ANC
- IMPACT 1060T ANC
- IMPACT 1061 ANC
- IMPACT 1061T ANC
- ADAPT 600 Series
- GTW 270 Hybrid
- H3PRO Hybrid
- H6PRO Closed

Scientific Background

In our first scientific whitepaper (Christiansen & Ng, 2022), we concluded that noise damping has a positive effect on speech intelligibility and required listening effort. In this whitepaper, we continue to explore the benefits of the EPOS noise damping in terms of memory recall performance.

This whitepaper focuses on the results of the Sentence final-Word Identification and Recall (SWIR) test which was conducted at the same time as the studies described in Christiansen & Ng (2022) and Jonsson et al. (2022). The SWIR test is designed to measure the resources devoted to listening as well as memory for speech, which is crucial for responding and reacting during communication.

Noise attenuation technology in hearing solutions can enhance recall performance by freeing up cognitive resources that would otherwise have been allocated to speech recognition (Ng et al., 2013). For listening tasks requiring the participants to immediately report back the sentence, such as the investigation reported in Christiansen & Ng (2022), an increase in task-evoked pupil responses is associated with increased listening effort. Previous studies found that for tasks involving both listening and remembering what is being said, an increase in baseline pupil dilation accompanied by better overall recall performance reflects higher memory effort due to speech encoding into memory.

The Aim of the Study

The aim of this investigation is to study the effect of noise attenuating technology on the dynamics of pupil responses during a speech recall task. Both recall performance and pupil responses were examined.

Materials and Methods

The study method, including the details of the participants, study setup, the specification of the noise attenuation, data analysis including the pupil responses can be found on page 7 to page 11 in Christiansen & Ng (2022).

The SWIR test (Ng et al., 2013), which was also referred to as the load block in Christiansen & Ng (2022), was administered. The tasks were to 1) identify and verbally repeat the final word after listening to each sentence, and 2) recall all final words when a list of seven sentences finishes. There were two test conditions: with and without noise attenuation. All sentence-in-noise stimuli were preprocessed. For each condition, seven lists of sentences were presented in a four-talker babble noise.

Results

1. SWIR Test

Word Identification Performance.
Significantly more words were correctly repeated with noise attenuation (mean 99.7%, SE 0.2%) in comparison to without noise attenuation (mean 96.2%, SE 1.3%) ($p < 0.01$).

Recall performance
When the average recall performance was calculated based on the total number of to-be-recalled words in a list (i.e., seven words), the participants recalled significantly more words with noise attenuation (mean 71.43%, SE 4.7%) than without (mean 64.8%, SE 3.8%) ($p < 0.05$; see Figure 1). This corresponds to a percentage point difference of 6.7, or alternatively a 10.3% increase in performance with noise attenuation, which is equivalent to half a word out of a list.

When the average performance was calculated based on the total number of words identified (i.e., word identification performance), the results showed a similar pattern (mean 71.7%, SE 4.7% with noise attenuation, mean 68.9%, SE 4.1% without noise attenuation).

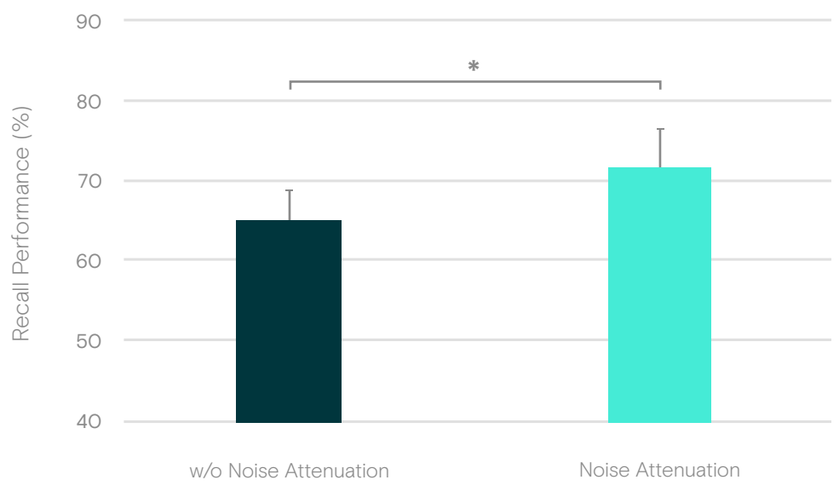

Figure 1: Average recall performance in test conditions with and without Noise Attenuation. Error bars represent standard errors.

2. Pupil Responses

Figure 2 shows the aggregated pupil traces obtained across all participants for each test condition. For each trial (sentence), we extracted two features: the baseline pupil dilation (BPD) and the mean pupil dilation (MPD). We applied linear fits to the data points across a list (7 points) for each feature. The slopes fits of BPD and MPD were then obtained for each participant (Bönitz et al., 2021).

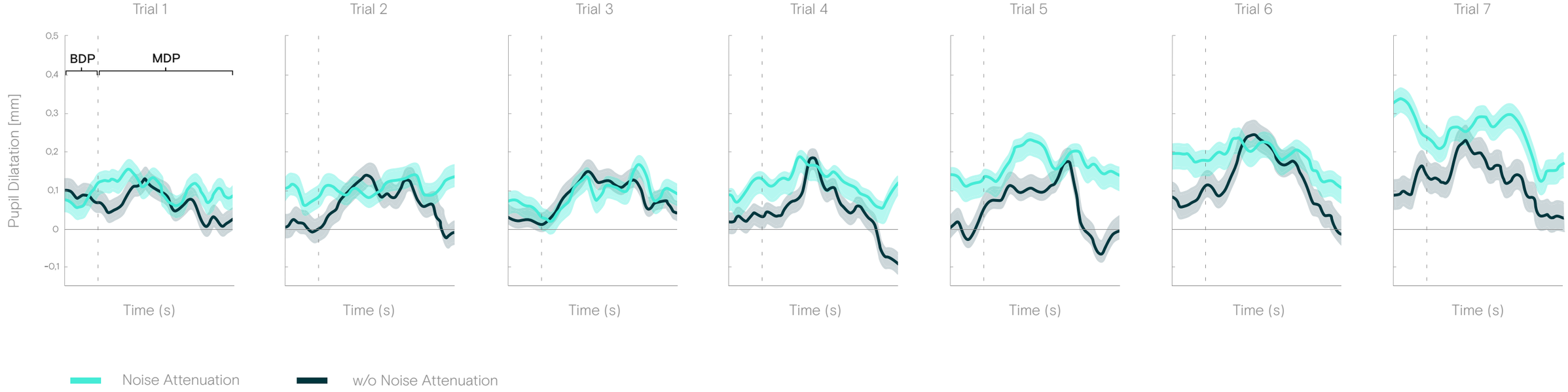

Figure 2:. Pupil traces aggregated within trial (sentence) and test conditions (blue = with noise attenuation, red = without noise attenuation) across participants. The aggregated pupil traces are relative to the list baseline. Time Os (the dotted line) indicates the sentence onset. The two features – the baseline pupil dilation (BPD) and mean pupil dilation (MPD) – are indicated in Trial 1. The shaded area indicates standard error.

In this investigation, we define BPD as an indication of the state of arousal including memory effort, and the BPD slope indicates the modulation of memory effort throughout the list. MPD is defined as listening effort, and the MPD slope indicates the dynamic change in listening effort thoughout the list/over the course of the seven trials.

The analyses showed that the BPD slope significantly increased ($p < 0.05$; Figure 3) and the MPD slope significantly decreased when noise attenuation was applied ($p < 0.01$; Figure 4).

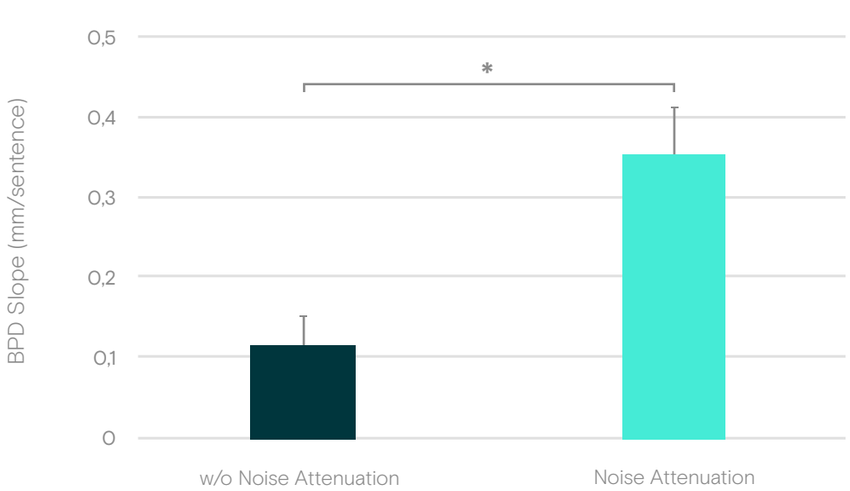

Figure 3: Increased BPD slope with noise attenuation than without. Error bars represent standard errors.

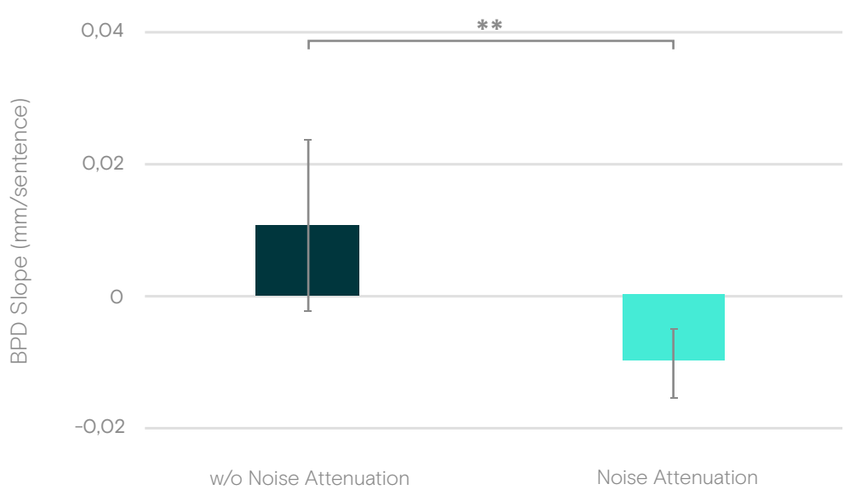

Figure 4: Decreased MPD slope with noise attenuation than without. Error bars represent standard errors.

Conclusions

To summarize, noise attenuation improved recall performance by 10%. This means that the listener is able to remember, on average, 0.5 words more out of 7 words.

When we look at the pupil responses while listening to the SWIR test lists, the mean pupil dilation (MPD) slope with noise attenuation decreased, suggesting less listening effort throughout a list. This is in line with the results reported in Christiansen & Ng (2022). The baseline pupil dilation (BPD) captures the cognitive resources allocated during speech encoding in memory. The increase in BPD slope with noise attenuation indicates higher memory effort. This corroborates with better recall performance in this investigation.

These findings suggest that reduced listening effort liberates cognitive resources that can be used for speech processing and encoding of information into long-term memory (Micula et al., 2022). In other words, noise attenuation can liberate cognitive resources that would have been used for listening effort which are instead used for memory.

This study is just one example of decades of psychoacoustic research conducted by the Demant Group, of which is EPOS is proud to be a part. The learnings collected in this study and others, including a recent study of the benefits of noise dampening, are applied in ongoing development of EPOS BrainAdapt™ solutions, which are designed to support the brain's natural way of processing sound. To learn more about EPOS solutions and the science behind them, visit eposaudio.com/brainadapt.

10%
better memory recall*

* 10% better memory recall as indicated through the results of the SWIR test

Implications

Humans have limited cognitive capacity when cognitive resources are devoted to recognizing (i.e., listening), responding and reacting to speech. Figure 5 conceptualizes how noise affects cognitive resource allocation in relation to a person's cognitive capacity, and how the person can benefit from an effective noise attenuation technology.

1. A person listening in quiet and in noise.
Listening goes from easy to difficult, increasing the resources that are devoted (hence increased listening effort). This also means less and less resources are available to be allocated for remembering what is being heard.

2. A person listening in noise with noise attenuation.
With an effective noise attenuation system, the person would be able to spend more resources on remembering. This is particularly crucial when the pressure is on, and one needs to have this extra capacity at their disposal.

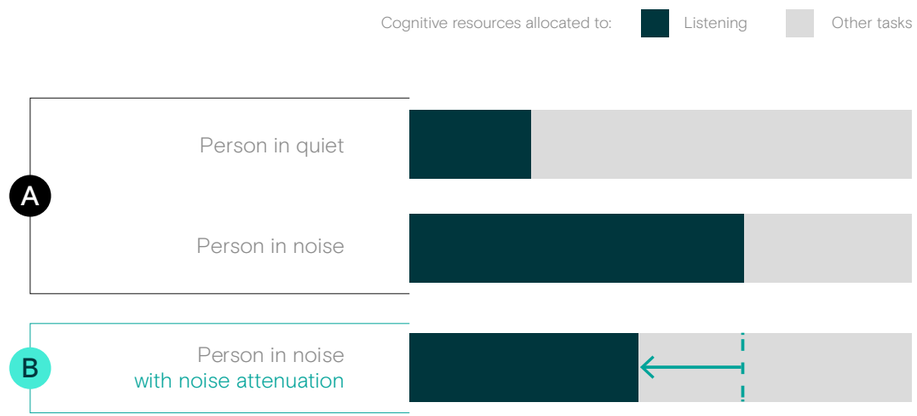

Figure 5: Schematic representations of cognitive resource allocation in different noise conditions. Inspired by Lunner et al. (2009).

References

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