WHITEPAPER
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Taking BrainHearing™ benefits to the next level: An overview of latest evidence on the Polaris™ platform

ABSTRACT

Inspired by the latest scientific insights, giving access to the full sound picture supports the natural way of sound processing in the brain . The Polaris™ platform is built specifically for hearing aids to support our BrainHearing™ philosophy and bring audiological performance and user benefits to next level. This whitepaper gives an overview of the latest evidence comparing Polaris against our previous technology as well as technologies from competitor high-end hearing aids. Through research, we demonstrate our technology is helping the brain in the right way to make sense of sound. Specifically, we summarize the benefits of our technology along the full auditory system, from improved sound clarity at the ears to better access to the full sound scene allowing for stronger focus on the sound of interest in the auditory cortex. These research findings confirm the BrainHearing approach.

EDITOR OF ISSUE

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BrainHearing Technology built on Polaris: A thought leader in the industry

New independent research reveals that the auditory cortex consists of two subsystems (orient and focus) that work together in a hierarchical manner (Puvvada and Simon, 2017, O'Sullivan et al., 2019). The two subsystems analyze the neural code and turn it into meaningful sounds. The better the neural code, the better the brain performs. This is the core of the BrainHearing™ philosophy, and is described in detail in the Oticon whitepaper Man and Ng (2020).

Conventional technology suppresses the sound scene and has used a "focus approach". With its directionality, gain reduction, speech prioritization and traditional compression, conventional technology restricts people's access to the full sound scene. This limiting approach suppresses the natural sound input and delivers a poor neural code to the brain. We believe that the conventional way of sound processing does not only cut people off from their surroundings, it goes against the brain's natural way of working. Hearing technology needs to work with the brain and support natural sound processing.

To achieve this, we need a fundamentally new approach to sound processing, which is supported by a new rapid and high resolution amplification strategy. This ensures

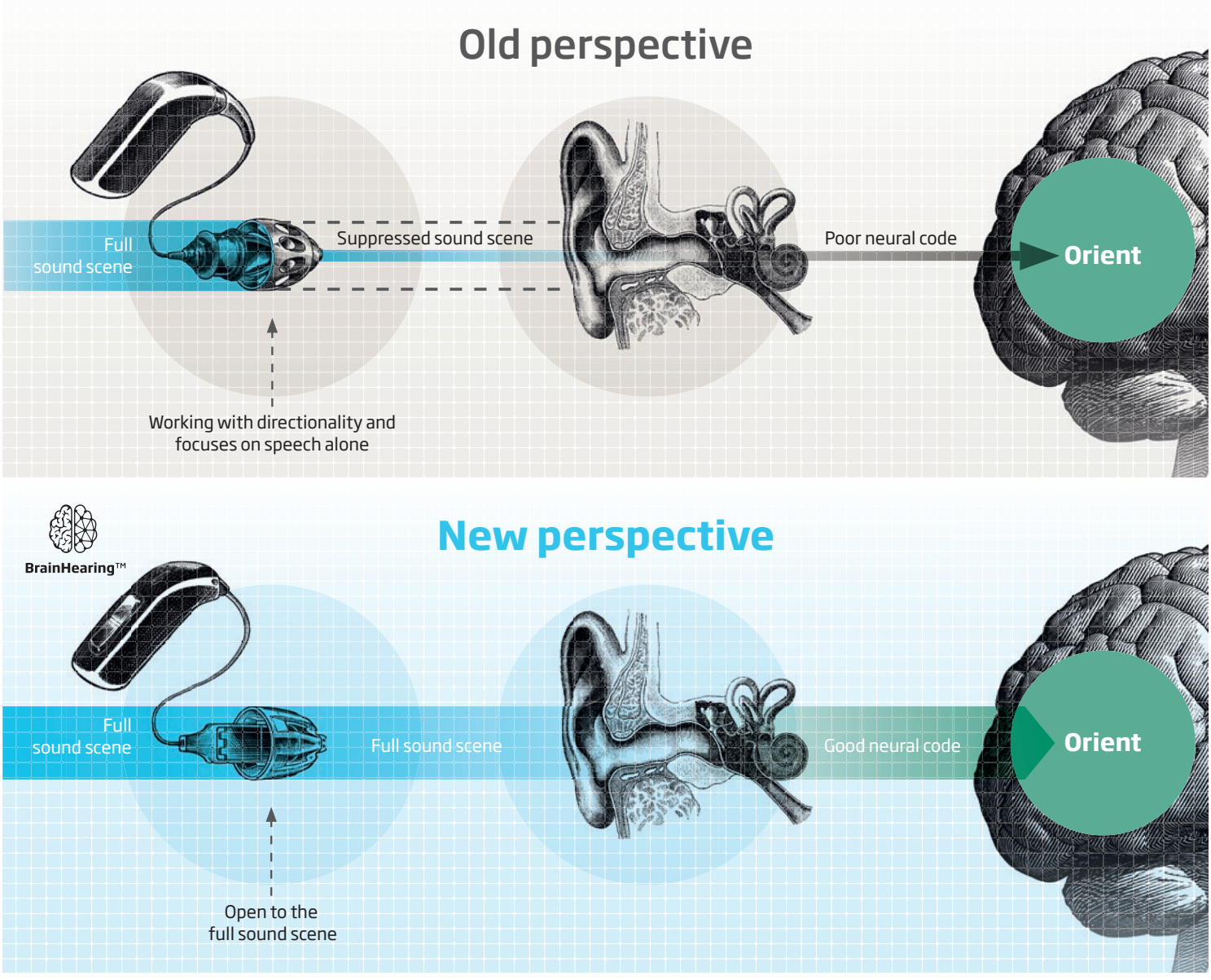

Figure 1: Conventional approach versus the Oticon's BrainHearing approach

that all important sound details are delivered to the brain. This new innovation in hearing technology differs from traditional noise reduction and compression approaches and address their limitations. It gives the brain access to more of the full sound scene, so that users can better focus on what matters to them without losing track of the meaningful sounds happening around them. This is illustrated in Figure 1.

Polaris is the world's first purpose-built platform featuring a Deep Neural Network (DNN) and it is built specifically for hearing aids. This approach allows it to constantly run a trained DNN, while powering all the technologies with more speed, precision and capacity than was ever possible before. More technical details on the Polaris platform and DNN can be found in the Oticon whitepaper Brændgaard (2020).

For more than a decade, we conducted research to document new benefits of the BrainHearing technology. This whitepaper gives an overview of the series of research studies showing the benefits of Polaris as well as the hearing technology enabled on this platform, such as MoreSound Intelligence (MSI) and MoreSound Amplifier. As Polaris is designed based on the BrainHearing insights, we chose research methods to show how our technology benefits the entire hearing process, from the ear to the brain as well as further auditory processing in the two subsystems in the cortex. This ultimately supports the recognition and interpretation of sound (Figure 2).

BrainHearing benefits delivered by Polaris: From the ear to the brain

1) Enhanced sound clarity translated to improved speech understanding in noise

We performed technical investigations to evaluate the performance of Polaris by measuring the output signal-to-noise ratio (SNR) of the hearing aid. This method allows for an objective comparison of different hearing technologies by showing the clarity of sound delivered to the ear. The DNN-based noise management system, as in MSI in Polaris, offers approximately 2 dB of SNR advantage over a non-DNN based system (Andersen et al., 2021).

To find out how the technical benefit can be translated to user benefit, we recruited a group of hearing aid users and evaluated the DNN-based and non-DNN based noise management systems using speech understanding performance. Results show that speech understanding is improved by 15% using Oticon More, which is built on Polaris, as compared to Opn S, which is built on the Velox S™ platform (more information can be found in the Oticon whitepaper Santurette et al., 2021). This confirms that having clearer access to sound can be translated to better speech understanding, which is the fundamental to BrainHearing benefits.

2) Better access to the full sound scene as well as stronger focus

To demonstrate that Polaris delivers the sound processing that best supports the brain, we conducted a brain

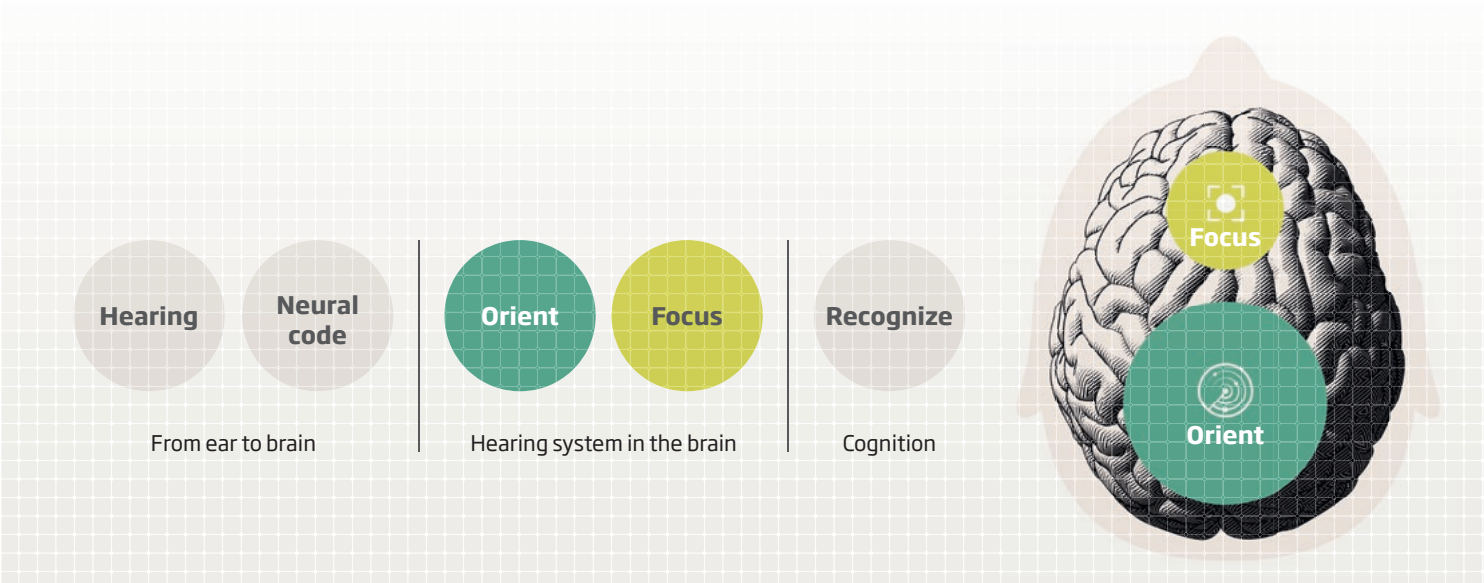

Figure 2: The hearing process: From the ear to the brain.

imaging study using electroencephalography (EEG) to test how clear the full sound scene is in early cortical processing stages (orient), and how clear individual sounds are in higher-order processing stages (focus). Compared to Opn S, results obtained using More showed 30% stronger brain responses towards the full sound scene, as well as 5% stronger brain responses to the attended talker (Alickovic et al., 2021, Oticon whitepaper Santurette et al., 2020). In addition to delivering clearer sound to the ear (see previous section), the EEG study shows that Polaris allows clearer access to the full sound picture. The brain needs the full sound scene to naturally monitor the entire sound environment, which in turn facilitates focus on the sound one may want to listen to.

3) Reduced sustained listening effort and better recall

One may wonder whether giving clearer access to the full sound scene would give a heavier load on the brain as it may need to process more sound information. To answer this, we measured sustained listening effort using pupillometry while recording the brain responses in the EEG study. Sustained listening effort is important in everyday communication because following a conversation requires paying attention to the talker over a sustained period and staying engaged. The pupillometry results confirm that by adding all these sounds we are actually reducing effort and not overloading the brain. We found that the activation of MSI reduced sustained listening effort by 30%. For more information, see Oticon whitepaper Murmu Nielsen and Ng (2021).

Less effort during listening over a longer period means that the brain uses less cognitive resources to understand speech in noise. More remaining resources can then be devoted to other cognitive processes, such as memory. Improved memory recall is another well-documented BrainHearing benefit. We have shown, for both adults and children, better recall performance for speech heard in noise when using hearing aids built on Polaris comparing to technology built on Velox S. Details are reported in the Oticon whitepapers written by Santurette et al. (2020) for the adult study, and Gordey and Ng (2021) for the pediatric study.

All these findings confirm the new approach of the BrainHearing technology enabled on Polaris, as well as taking the BrainHearing benefits to the next level, as indicated in Figure 3. By providing access to the full sound scene, the brain can better orient, focus and recognise. This helps the brain to work in an optimal way, so it consequently requires less effort to hear, understand, and interact.

Comparing the performance against two high-end competitor hearing aids

In one of our previous investigations, we performed technical measurements and used output SNR to compare the contrast between speech and background noise in real-life sound scenes delivered by three different hearing aids, namely Oticon More and two high-end competitor hearing aids.

As illustrated in Figure 1 in the Oticon whitepaper Santurette et al. (2021), when the target talker is located at an angle of -15° relative to the listen position in a cafe scene, Oticon More provides an output SNR of 2.5 dB, which is on par with Competitor A and outperforms Competitor B by 1 dB in terms of improving the contrast between speech and the background. When the target talker is moved further to the side at an angle

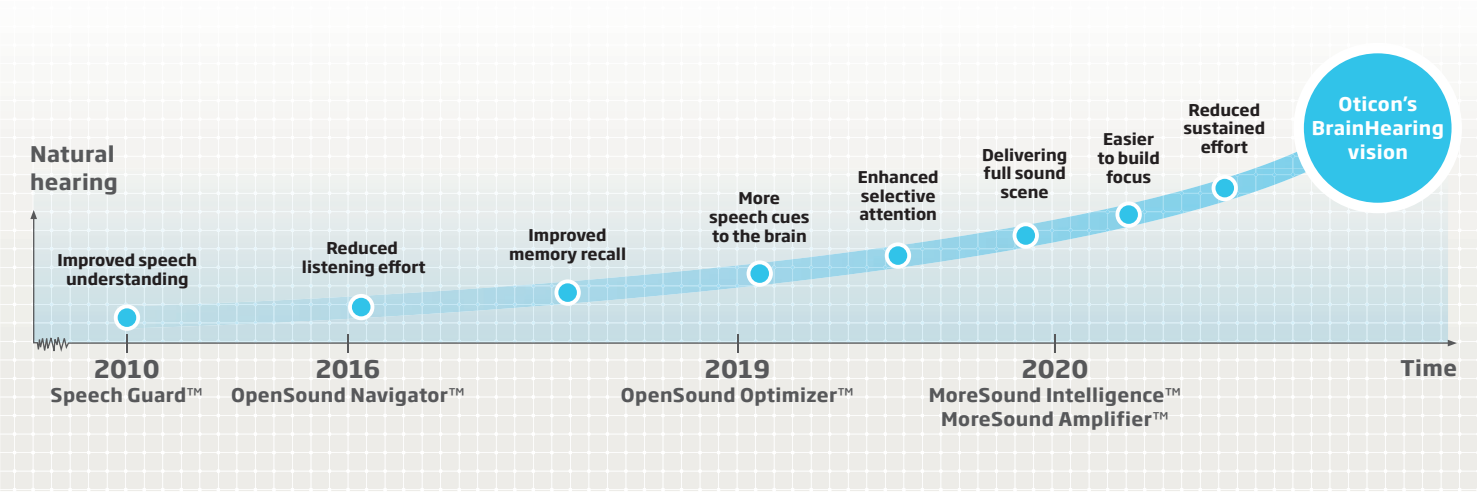

Figure 3: Oticon's BrainHearing journey over the past decade.

of -60°, More becomes the only hearing aid among those tested to provide a clearly favourable (positive) SNR of 2.0 dB, whereas both Competitor A and Competitor B yield around 0 dB of SNR output and do not provide clear access to speech any longer. Further results and descriptions are reported in the Oticon whitepaper Santurette et al. (2021).

To translate these measurement data into how much users can benefit from the technology, we converted the output SNR values into Speech Intelligibility Index (SII) based on the procedures described in ANSI S3.5-1997 (R2007). SII is commonly used to predict aided speech recognition performance (refer to Hornsby, 2004 for a comprehensive overview of SII) and allows us to understand how much speech information is available to listener with a given hearing loss. A sloping moderate hearing loss (N3 standard audiogram, Bisgaard et al., 2010) was used in the SII calculations. We replotted Figure 1 in Santurette et al. (2021) using the SII in percentage instead of output SNR (see Figure 4). In general, the SIIs are in good agreement with the output SNR values. It is noted that the SIIs for Oticon More are consistently higher than the competitor hearing aids in both target talker directions. This can be due to the fact that Oticon More delivers more speech energy in low frequencies, which is important for vowel perception. Based on the SIIs, Oticon More delivers up to 20% more speech information than the competitor hearing aids, even when the target talker comes from the side.

Closing remarks

BrainHearing insight inspires the design of Polaris and the technology built on this platform. Giving access to the full sound picture supports the natural way of sound processing in the brain. Even though the brain is getting more sound with Polaris, less effort is required to listen to speech in noise. By providing better access to speech cues and information in the sound environment, no matter whether coming from the front or the side, we believe this gives the optimal input to the brain to work on. Through research, we show that the BrainHearing benefits cover the entire hearing process, from the ear to the brain including further auditory processing in the two subsystems in the cortex. Not only our evidence brings the BrainHearing benefits to the next level, but more importantly, we are also demonstrating that our technology is helping the brain in the right way to make sense of sound, confirming the BrainHearing approach. With our technology, listeners can more easily react, respond, and engage in conversations in everyday life.

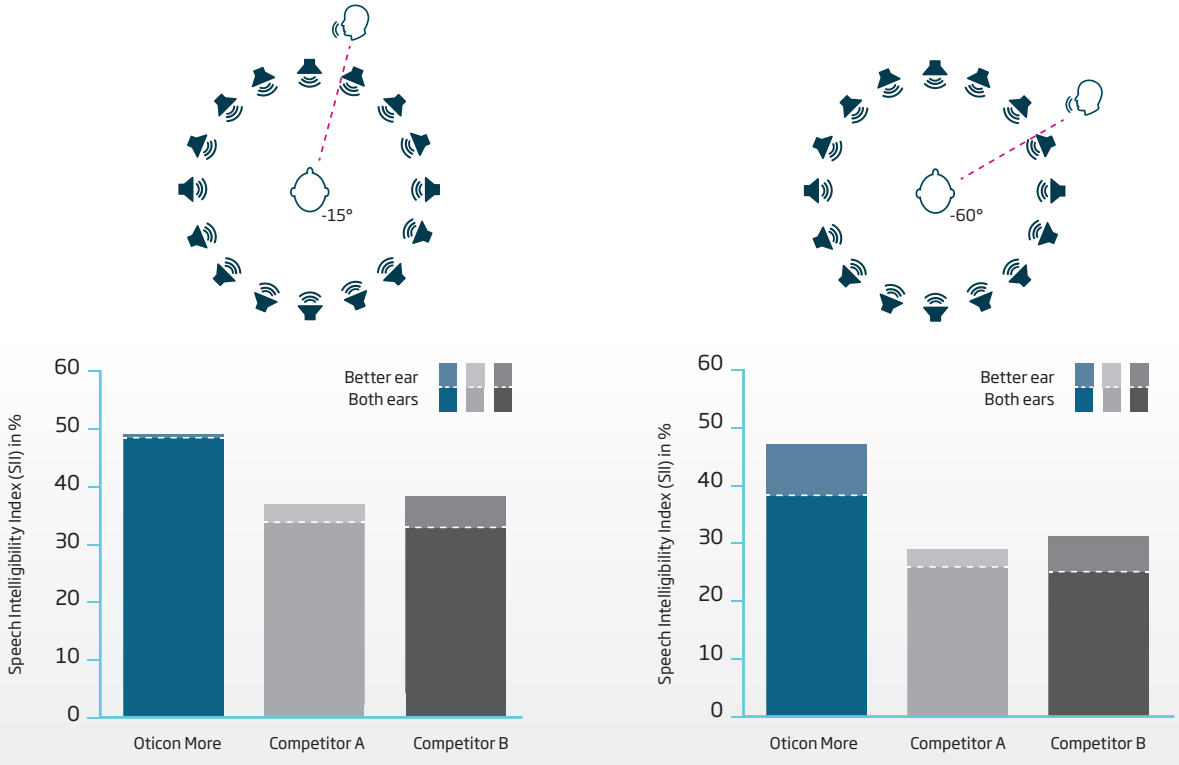

Figure 4: Illustration of talker positions and SII in % measured in the café scene. Left: Target talker positioned at -15° azimuth. Right: Target talker positioned at -60° azimuth. The lighter-colored, full-height bars show the right (better) ear SIIs and the darker-colored bars show the average SIIs across ears.

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