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MoreSound Intelligence™ for single-microphone custom hearing aids

For some users, discreetness is the most important factor when choosing a hearing aid, even if that means making some compromises. The IIC and CIC hearing aids are very small. This smaller size requires some hardware compromises. The IIC and CIC hearing aids only have one microphone, for example whereas the original version of MoreSound Intelligence is based on input from two microphones. So, for this feature to work in single-microphone hearing aids, it has been modified to provide the best possible output for single-microphone hearing aids. This paper will describe the differences between MoreSound Intelligence in single- and dual-microphone hearing aids.

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oticon
life-changing **technology**

Getting a hearing aid can be a big decision for some people. They may worry about how it will change their appearance or how they will be perceived by others. Discreetness and aesthetics can therefore play a big role in their decision to get a hearing aid or not. Such considerations can also influence their choice of hearing aid.

The smallest hearing aid on the market is the Invisible-In-Canal (IIC) hearing aid. The IIC is designed to sit deeply inside the ear canal invisible to other people. The current IIC from Oticon is the smallest hearing aid we have ever produced, and it is invisible in the ears of nine out of ten people (Rumley et al., 2022) – fulfilling the primary wish of many users: discreetness.

Sound scenes are dynamic, complex, and unpredictable. It is the brain's role to handle this complexity: to hear and to create meaning from it all. The latest independent research shows that the brain needs access to the full sound scene in order to work in a natural way (O'Sullivan et al., 2019; Hausfeld et al., 2018; Puvvada & Simon, 2017).

Oticon Own is built on our BrainHearing™ philosophy. This approach supports how we listen with our brains – not our ears.

Oticon's previous generation of custom hearing aids, the Oticon Opn™ family, used OpenSound Navigator™ to provide a 360° speech picture to the user. Now, we take the next step forward by implementing MoreSound Intelligence (MSI) in our new custom family – Oticon Own™. MSI processes the full sound scene, gives the brain input from all types of meaningful sounds and supports the brain's natural ability to make sense of the sound environment.

MSI in custom hearing aids with two microphones works the same way as it does in BTE-styles though with a different calibration to accommodate for the different microphone placement. The size of the IIC hearing aid – as well as the small and discreet Completely-In-Canal (CIC) hearing aid – sets some limitations as to what is possible from both a hardware and technology perspective. For example, the hearing aids only have one microphone which requires some audiological features to work differently. This paper will focus on MSI in single-microphone custom hearing aids. More in-depth information on MSI can be found in the MoreSound Intelligence tech paper (Brændgaard, M., 2020).

MoreSound Intelligence in single-microphone hearing aids

In dual-microphone hearing aids MSI is a three-step process – Scan and analyse, Spatial Clarity Processing, and Neural Clarity Processing. In single-microphone hearing aids, such as IIC and CIC hearing aids, Spatial Clarity Processing is not part of the processing flow as it requires input from two microphones. Instead, the user can utilise the natural pinna for the spatial awareness. The three-step process is then – Natural spatial awareness, Scan and analyse, and Neural Clarity Processing (see figure 1).

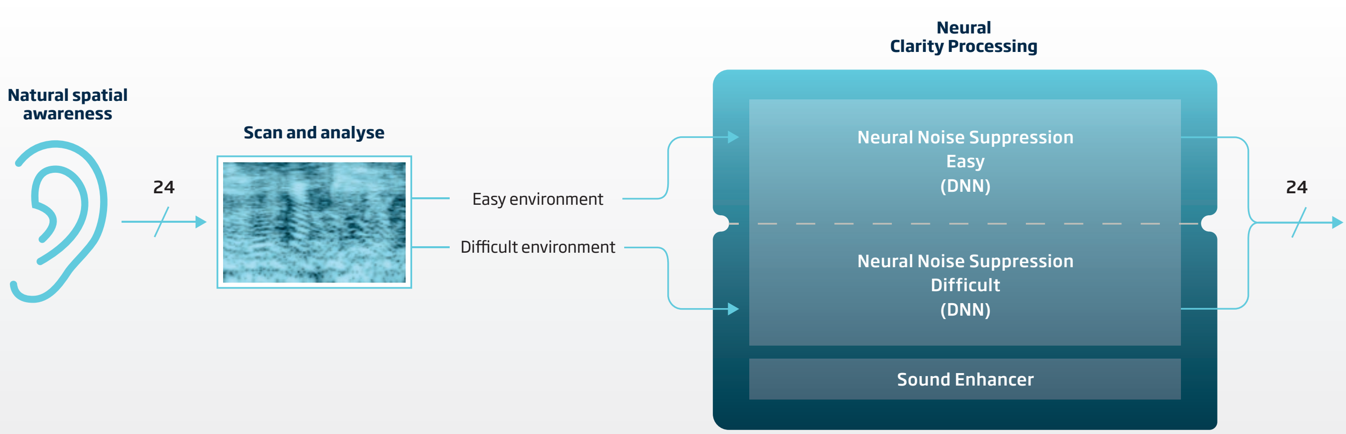

Figure 1: The processing flow of MoreSound Intelligence in single-microphone hearing aids.

Natural spatial awareness

People with normal hearing depend on several different types of cues for localization of sounds in the different planes – horizontal, vertical, front-back, and distance. Some of the cues used are interaural time differences (ITD), interaural level differences (ILD), and spectral differences due to head shadow and pinna effects.

Hearing loss interferes with the availability and quality of these cues and causes poorer localization ability. An IIC or CIC hearing aid, placed inside the ear canal, can provide pinna cues similar to a normal hearing ear. These pinna cues will, for instance, provide 2-3 dB gain for sounds originating from the front compared to the back for such hearing aid users. This improves front-back localization, an ability that is markedly worsened by a hearing loss. The pinna also provides frequency spectral cues which are very important for localization in the vertical plane. The hearing aid is calibrated to make up for the loss of ear canal resonance due to the placement of the hearing aid. This calibration makes the hearing aid mimic an unoccluded ear. In addition to the cues made available by the placement of the hearing aid in the ear canal, the hearing aids, of course, also provide better audibility of ITDs and ILDs. All of this provides the user with natural spatial cues which will improve the localization ability (Dillon, 2012; Moore, 2008; Best et al., 2010; Neher et al., 2009).

Scan and analyse

Sound scenes are dynamic and sound sources are constantly moving and changing. MSI updates 500 times per second based on the sound input to ensure that all details are captured. MSI uses the signal-to-noise ratio (SNR) as well as noise levels to do further calculations. The SNR and noise level estimators run in 24 channels, and the SNR estimator works in the range of -10 to +15 dB SNR. The SNR is the main driver used for distinguishing between easy and difficult environments, and the level of help provided by the system will be determined by both the SNR and the noise level estimates. Any changes in the sound scene will be detected by MSI, but only persistent changes (more than 2 secs) will make the hearing aid adapt the level of help.

MSI will process a sound scene as either an easy or difficult environment depending on the individual user's settings in Oticon Genie 2.

Neural Clarity Processing

The Neural Clarity Processing is handled by a Deep Neural Network (DNN). A DNN is an implementation of artificial intelligence that, for a given sound scene, has learned to recognize what should be put in the foreground (sounds of interest with a lot of information) and what should be put in the background (sounds of less interest with less information). The DNN uses a process of iterative learning from a huge quantity of real-world data to establish knowledge about sounds and how to process them.

The DNN in single-microphone hearing aids is the same as it is for all other Polaris based hearing aids. The DNN plays a very important role in sound processing in a single-microphone hearing aid since Spatial Clarity Processing (Virtual Outer Ear and Spatial Balancer), which helps create spatial focus on the most relevant sounds, is not part of the processing in these hearing aids. The absence of Spatial Clarity Processing means that the operating conditions for the DNN are slightly different as the input has not been optimized to handle spatially located and separated sound sources. The DNN therefore works directly on the information provided through the first steps of MSI - natural spatial awareness and scan and analyse.

The DNN responds differently depending on whether the environment is categorized as easy or difficult according to the user settings in Oticon Genie 2, just as it does in dual-microphone hearing aids.

Sound Enhancer
How much noise a user finds it suitable for their hearing aids to suppress will differ. Sound Enhancer provides dynamic sound detail when noise suppression is active – mainly in difficult environments – which allows the output to be individualised.

Sound Enhancer works somewhat differently in a single-microphone hearing aid as compared to dual-microphone hearing aids. In single-microphone hearing aids the calculations behind Sound Enhancer are based solely on the dynamic suppression done by the DNN since the hearing aid does not have Spatial Clarity Processing. Sound details are still added in the 1-4 kHz area which provides more emphasis on speech sounds. The amount of added sound is based on the user's personalized settings in Oticon Genie 2. Three settings can be chosen: *Detail, Balanced,* and *Comfort*. *Balanced* is the default setting. *Comfort* can be chosen for the full effect of the noise suppression system and *Detail* can be chosen for a stronger connection to the user's surroundings and attended talkers. Sound Enhancer will not constantly adapt to small changes, but only to the bigger general changes in the sound environment just as it does for dual-microphone hearing aids.

Perspective
MoreSound Intelligence has been modified to provide the best possible output in a single-microphone hearing aid. The IIC or CIC hearing aids cater to the wish for discreetness while still offering great hearing support and fantastic sound quality.

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