Breakthroughs in Signal Processing and Feedback Reduction Lead to Better Speech Understanding

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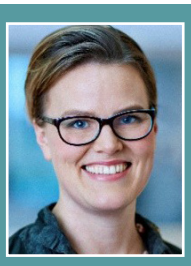
The OpenSound Optimizer (OSO) uses new methods to prevent feedback from occurring while simultaneously enabling greater fitting flexibility for the hearing care professional and improved access to speech sounds for the wearer. OSO is designed to provide more headroom for dynamic listening environments and better sound quality overall.

The perceived quality of amplified sound has been a long-time determining factor in the acceptance of a hearing device. Sockalingham et al[1] reported that initial observations of sound quality contribute significantly to the opinions and decisions of the first-time wearer. That is, the perceived sound quality must be maximal from the first time they try amplification, because negative experiences (ie, poor sound quality, acoustic feedback, etc) impact their opinions and decisions. To continually live up to first-time user expectations, and despite the success of OpenSound Navigator™ (OSN) as applied in Oticon's first generation Opn™, innovation has continued.

This article addresses a new feature in Oticon Opn S™ designed to deliver optimal gain in open-canal fittings, without the risk of feedback. A new multi-patented feedback prevention technology, the OpenSound Optimizer™(OSO), anticipates feedback so it can be effectively managed before it becomes audible. When feedback is accurately predicted, advanced processing can be engaged to prevent audible feedback from occurring. This protocol allows more gain to be applied without risk of feedback, and can mean improved prescriptive target matching, better access to important speech cues, and/or decreased occlusion.



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The OpenSound Optimizer™

Oticon's Opn S was introduced in 2019. Opn S incorporates the OpenSound Optimizer feedback prevention technology in tandem with the previously released feedback management system, Feedback Shield LX. OSO offers a proactive approach to feedback handling using a sophisticated, precision-deployed spectro-temporal modulation (STM) algorithm (see below) to selectively prevent audible feedback from occurring by monitoring the input sound at the microphone. This analysis occurs 56,000 times per second across 28 frequency channels. A soft non-intrusive STM is applied in selected frequency channels when feedback is anticipated,[2-4] thereby effectively preventing audible feedback.

Spectro-Temporal Modulation

Spectro-temporal modulations (STM) are patterns that change over time across the 28 channels in the hearing aid. STMs act as a nearly instantaneous breaker signal that stops the buildup of a feedback loop. They can be visualized on a spectrogram as a striped pattern with a cycle period of 32 ms. In **Figure 1**, the stripes at approximately 3000 Hz represent low-energy areas, indicating that the output from the speaker is reduced for 16 ms. These low-energy periods are followed by periods of fully restored gain (also 16 ms). Of note, it takes approximately 60 ms for audible feedback to be detected and prevented in the system. Importantly, STM is only applied in at-risk feedback channels, and only for the duration of risk. All other channels are unaffected by OSO. Research addressing STMs indicates that speech-like modifications to signals are more difficult for people with hearing loss to perceive, than for those with normal hearing.[5,6]

Clinical Benefits of OpenSound Optimizer

OpenSound Optimizer offers valuable clinical benefits that go beyond eliminating audible feedback. The following attributes are facilitated via OSO:

1) Meeting targets. OSO allows the hearing care professional (HCP) to meet prescribed gain targets which may have been previously unattainable due to audible feedback or imposed gain limits. Valente et al[7] showed that when gain is 10 dB (or more) below NAL-NL2 prescriptive targets for high frequencies, speech recognition for soft speech decreases by 15%.

2) Improved sound quality. When a hearing aid is close to feedback, sound quality is negatively affected because the signal becomes "peaky," causing a ringing effect ("sub-oscillatory feedback").[8] OSO contributes to a more stable system at higher gain levels, providing overall improved sound quality.

3) Performance in dynamic environments. Preservation of gain to a very high degree in dynamic situations in which an invisible precautionary gain reduction might have been implemented unbeknownst to the hearing aid wearer or the HCP.

4) More open-canal fittings. The ability to offer wider vents and more open canal fittings can improve the wearer's own voice perception and their perception of overall physical and acoustic comfort. Open-canal fittings may permit more successful first fittings and higher adoption rates.

Technical Investigations of OSO

In-house testing (Oticon, Denmark) evaluated Oticon Opn S with regard to the differences in the Speech Intelligibility Index (SII) score when target gain is achieved, versus a 6 dB "under-fit" condition.[9]

The SII indicates how much speech information is available (audible) to the listener. The SII is not a direct measure of speech intelligibility, but it is considered to be highly cor-

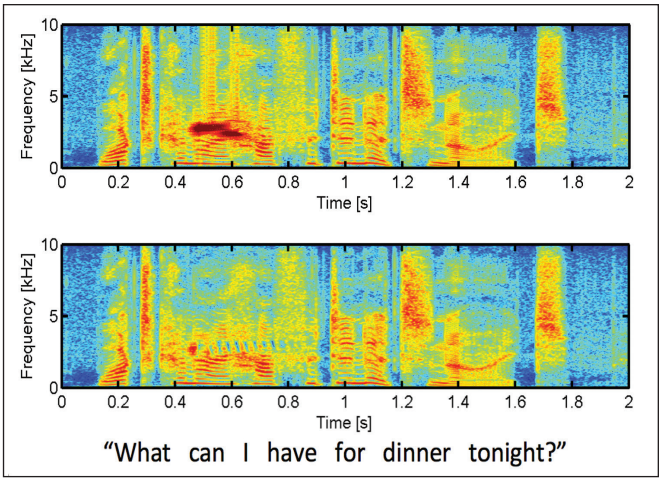

Figure 1. Top spectrogram shows audible feedback primarily (not exclusively) at 2-3kHz at 0.4-0.7 sec. Bottom spectrogram is identical but with STM engaged. Note: Audible feedback is eliminated and speech is preserved in the bottom spectrogram.

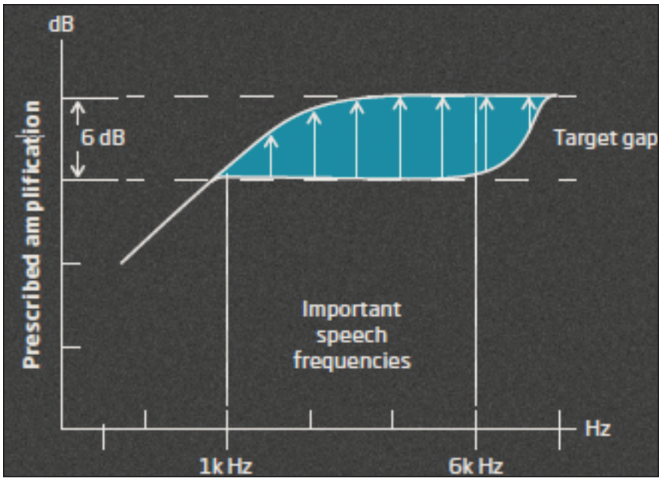

Figure 2. The research showed that providing the prescribed gain—in both noise and quiet—as enabled by the Open Sound Optimizer (OSO) provided access to as much as 30% more speech cues (in SII) when compared to being under-fit by 6 dB.

related with speech intelligibility.[10] SII is often displayed as a number between 0 and 1, or as a percentage. Scollie[11] characterized the SII as a weighted score in which the mid frequencies are weighted higher than the extreme low and high frequencies.

In this research, the choice of 6 dB below prescriptive target gain was based on the general consensus that a target is matched if the applied gain is verified to be within ±5 dB of the target.[12,13]

Multiple insertion gain simulations were carried out for speech at 62 dB SPL level with no noise masker and with a noise masker at 62 dB SPL as stated in the ANSI S3.5-1997 standard.[10] This investigation demonstrated that providing the prescribed target gain (in noise or in quiet) as enabled by the OSO provided access to up to 30% more speech cues (as indicated by the SII) when compared to being under-fit by 6 dB (**Figure 2**).

Another benefit of OSO and the additional 6 dB of gain is the initial fitting accuracy of Oticon Opn S. Fitting accuracy (in this experiment) was defined as the percentage of fittings that can successfully match targets using prescribed acoustics, prior to any fine-tuning. The hearing aids used in the simulations were Oticon Opn and Opn S with level 85 speaker units and prescribed open acoustics. The hearing aids were fit according to the Oticon VAC+ proprietary rationale. For Oticon Opn, the initial fitting accuracy was very good prior to fine-tuning. For Oticon Opn S, the initial fitting accuracy rose by 22 percentage points. The OSO's additional 6 dB of gain was determined to be the primary reason for the improved fitting accuracy before fine-tuning. These innovations in signal processing appear to have led to dramatic subjective preferences in favor of Opn S during in-house testing. Specifically, the majority of subjects, all of whom were previously satisfied Oticon Opn wearers, preferred Opn S (to learn more about OpenSound Optimizer and Opn S, see the white papers "Oticon Introduction to OpenSound Optimizer"[9] and "Oticon Opn S Clinical Evidence" by Josefine Juul Jensen).

Conclusion

OpenSound Optimizer in the Oticon Opn S is a multi-patented technological innovation which uses pioneering methods to prevent feedback from occurring while simultaneously enabling greater fitting flexibility for the hearing care professional and improved access to speech sounds for the wearer. OSO provides more headroom for dynamic listening environments and better sound quality overall.

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