WHITEPAPER
2018

OpenSound Navigator™ for Oticon Opn Custom Instruments

Principles and Benefits in Noise

SUMMARY

The Opn family has grown and is now available in all custom styles, including both single and dual microphone instruments. Built on the Velox platform, these new instruments offer people who wear hearing aids a higher level of discretion along with the benefits of the OpenSound Navigator (OSN). This white paper will compare the benefits of single and dual microphone versions of OSN and summarize the supporting clinical evidence.

Clinical data shows that dual microphone Oticon Opn custom is on par with the dual microphone Oticon Opn miniRITE in a speech intelligibility test, and that the single microphone version of OSN provides benefits in noise. The smallest custom hearing aid that Oticon has ever made is equipped with a single microphone OSN, which provides the sound quality and discretion the person who wears the hearing aid demands while giving good noise reduction in challenging listening environments.

Ruth Doran
Research Audiologist
Oticon A/S, Denmark

Nicolas Le Goff Ph.D.
Senior Researcher
Oticon A/S, Denmark

Fares El-Azm
Specialist, DSP
Oticon A/S, Denmark

oticon
PEOPLE FIRST

What is OpenSound Navigator and why is this important?

Hearing in noise is one of the biggest challenges people who wear hearing aids face, as they want to be able to focus on speech whilst minimising disturbing background noise. Previously only available in the Behind-the-ear (BTE) styles, Oticon's noise suppression algorithm OSN is now available in all custom styles. OSN replaces conventional directionality and noise reduction systems. Primarily, the main function of OSN is to preserve the natural nuances of speech whilst attenuating disruptive noise giving the person wearing the hearing aid a less demanding listening experience. OSN is important to the person wearing the hearing aid as it acts to preserve the information from the listening environment that the brain needs to make sense of sound, and retain a more natural sound scape. Importantly, as OSN is now available in a single microphone style some changes have been made to preserve the algorithm integrity, as will be discussed below.

OpenSound Navigator in one-microphone instruments

People who wear hearing aids may want their devices to be discreet. A 2011 Oticon Consumer Survey found that nearly half of the people wearing their first hearing aid want a completely invisible hearing solution. Additionally, acceptance and usage rates are higher for people with greater experience in wearing hearing aids when they perceive their devices to be small and discreet (MarketTrak 9: A New Baseline, 2015). As such Oticon prioritised to optimise custom instrument amplifiers and production processes to create Oticon Opn custom devices which are as small as possible. The smallest of these come with only one microphone, which is why a special version of OSN was created for these.

Until now OSN has been synonymous with a dual microphone setup. In order to apply this technology to a single microphone set up, important changes have been made to suit both the Oticon Opn Invisible-in-the-canal (IIC) and Oticon Opn Completely-in-the-canal (CIC) styles. Looking back to the traditional setup OSN consists of the Analyse-Balance-Noise Removal modules. Continuing this line of thought, single microphone OSN now consists of a natural balancing of the sound, due to the pinna that provides shaping of the sound before entering the device, where the Analyse and Noise Removal modules are found (see Figure 1).

Pinna effect

In the normal hearing ear monaural and binaural listening cues help inform the listener localise the sound source. Specifically horizontal and vertical localisation, front/back determination and distance perception are all perceptual qualities people with normal hearing use to inform them in their listening environment. In the impaired ear when sound is not audible the cues are lost. However, an IIC or CIC hearing aid placed inside the ear canal, can make the pinna cues available (Dillon, 2012).

With a binaural fitting where the hearing instrument is placed in the ear canal the shape of the pinna is providing the person wearing the hearing aid 2-3 dB gain of the front compared to the back. This helps reduce the front-back confusions that may emerge. By enabling people wearing the hearing aids to make use of the natural pinna effect, high frequency spectral cues (of speech) are retained. By calibrating for the loss of ear canal resonance due to the placement of the device in the ear canal, single microphone instruments act to mimic the way an unoccluded ear does the frequency-shaping of the sound. With the additional gain afforded by a deep set microphone the per-

OpenSound Navigator in a single microphone instrument

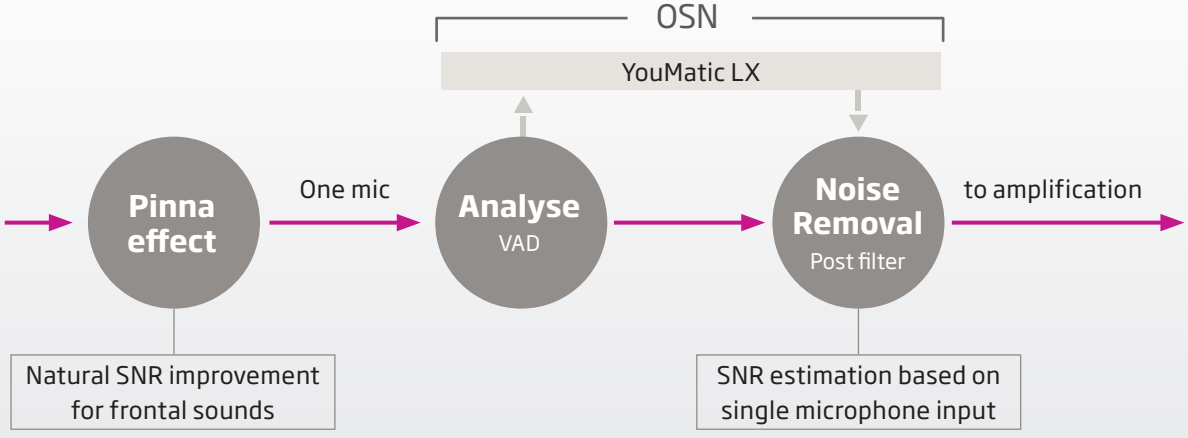

Figure 1: Modules in the single microphone OpenSound Navigator.

son wearing the hearing aid is provided with the natural spatial cues people may use to identify and localise sound sources (Moore, 2008; Best et al., 2010; Neher et al., 2009).

Analyse

Significantly, the speed and the function of the single microphone analyse module has inherited a lot of principles from the dual microphone setup. In a diffuse noise situation speech can be difficult to differentiate from noise. As in the dual microphone style the single microphone OSN has 16 frequency bands, each of which operates a Voice Activity Detector (VAD) separately and independently. Consistent with dual microphone OSN the noise estimation is still updated up to 500 times per second. This fast acting and precise system acts to 'analyse' the environment in order to identify and separate properties of the incoming sound that resemble speech and noise. However, the analysis done in the dual microphone instruments uses a spatial noise estimate. This is not possible in single-microphone instruments, so Oticon has developed and optimised the new VAD detector. The temporal qualities of the incoming sound are assessed by the VAD making decisions for short time segments based on the differences in characteristics of incoming sound. The detected differences will ensure that high Signal-to-noise ratio (SNR) segments are detected as speech and low SNR segments as noise (see Figure 2). For dual microphones, temporal modulations resembling 3 or less simultaneous talkers are recognized as speech, and modulations resembling 4 talkers or more are recognized as noise. This is also the setting applied to the external study discussed below.

Noise Removal

Finally the noise removal signal processing, the post filter, in single microphone OSN is also consistent with the dual microphone OSN in terms of speed of detection and gain applied. The noise removal module acts to attenuate the remaining noise. This module is capable of applying up to 9 dB of attenuation to noise in each band between words without disrupting the fundamental properties of the speech signal, thus giving the person wearing the hearing aid a clearer speech signal.

As the acoustical properties vary considerably between custom hearing aid styles these must be compensated for. In the IIC and CIC noise removal module these differences are compensated for in the calibration process in order to ensure that the input properties of sound are not adversely effected. Technical testing has shown that when the single microphone noise removal is compared to that of the dual microphone of an Oticon Opn miniRITE, the noise removal module is on par in terms of providing the person wearing the hearing aid with a favourable SNR.

External Study

In the winter of 2017-2018 an external study was undertaken at the Oldenburg Hörzentrum in Germany to test the single microphone Oticon Opn IIC as well as the dual microphone Oticon Opn ITC and compare performance to the dual microphone Oticon Opn 1 miniRITE. All devices used were Oticon Opn 1 models. Consisting of two parts the study aimed to illustrate the in-ear benefit of single microphone set up. Firstly, testing was undertaken in order to compare the localisation performance across styles, to investigate if the Oticon

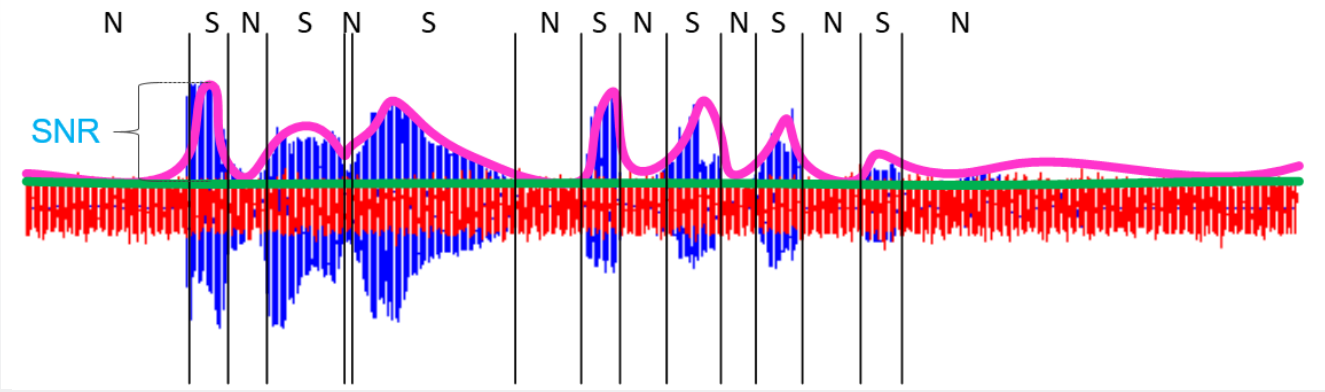

Figure 2: Voice Activity Detector (VAD) based on the differences in characteristics of incoming sound in different time segments. The detected differences will also ensure that high Signal-to-noise ratio (SNR) segments are detected as speech and low SNR segments as noise. "N" stands for noise, "S" stands for speech. Blue signal is speech and the red signal is noise. The purple line is the speech estimate and the green line is the noise estimate, thus as indicated, the SNR is the difference between the purple and the green line.

Opn IIC microphone position, preserving the pinna effect, provides improvements in capturing where sounds are coming from. Secondly, a study was conducted to establish speech intelligibility across the Oticon Opn IIC, ITC and miniRITE styles. These results were needed to investigate if the outcome of the Opn devices is equally good for the Oticon Opn ITC and miniRITE styles.

Additionally these results can be used to assist people who wear hearing aids and clinicians when considering the benefits of the different hearing aid styles in terms of audiological benefits (in this case speech understanding in noise), technology available and cosmetics.

Test Setup

In order to remain consistent an 85 dB speaker level was selected for each style and equivalent venting or domes were used. Programming also remained as consistent as possible, VAC+ was the rationale used, feedback manager was on, OSN was set to automatic in the dual microphone styles and omni in the Oticon Opn IIC taking advantage of the natural pinna effect. Participants (N=17) ranged in age from 48 to 84 years and the pure-tone average ranged from mild to moderate (see Figure 3).

There were two noise conditions: a 60 dB SPL low noise environment, which resembles an environment where conversation is relatively easy, and a 75 dB SPL high noise environment, which resembles settings such as restaurant and family dinner.

Experiment

Localisation

The participants were randomly fitted with both Oticon Opn IICs and Oticon Opn miniRITEs, and their localisation ability was tested. Half of the participants had their localisation ability tested first with Oticon Opn IIC, and the other half were tested first with the Oticon Opn miniRITE. In each condition the participant was seated in the centre of a 12 speaker array in a quiet room. The speakers were spaced 30 degrees apart at ear height and hidden from view via a curtain. A 60 dB SPL speech signal was randomly presented and the participants indicated where they felt the sound had originated from. There was a total of three presentations of speech signal from each individual speaker. On completion, a mean difference score was established per participant indicating how accurately they identified the sounds.

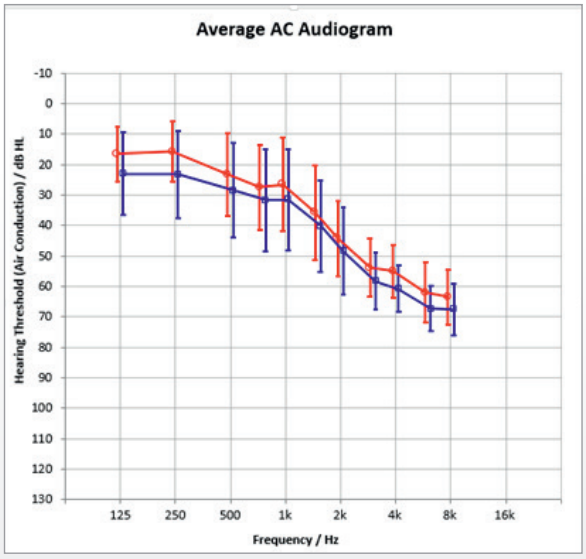

Figure 3: Average air conduction threshold of participants, with whiskers indicating +/- 1 standard deviation.

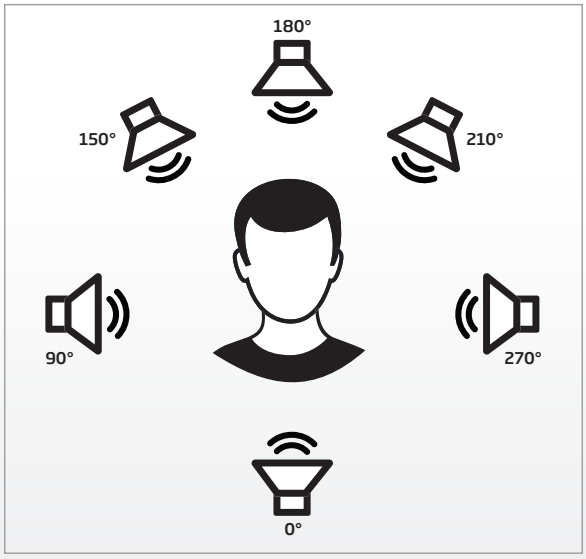

Figure 4: Stimuli in free field. Speech coming from the front (0°). International Speech Test Signal (ISTS) at 90°, 150°, 210°, 270°, and Oldenburg Sentence Test Noise (OLSA) at 180°.

Speech Understanding

The same participants were fitted with single microphone Oticon Opn IIC and dual microphone hearing aids Oticon Opn ITC and miniRITE. Two test conditions were used, a high noise listening environment in which the background noise was 75 dB SPL and a lower noise environment in which the background noise was 60 dB SPL. Using the adaptive Oldenburg Sentence Test (OLSA), the Speech Reception Threshold's (SRT) of each of the hearing aid styles was established in both noise environments. Two lists were presented, preceded by one practice list. Each list consists of 10 sentences, and each of these sentences contains 5 words. Speech and noise was presented from 6 loudspeakers, 1 speaker in front was used for speech and 5 speakers placed behind and to the sides of the listener was used for the noise, as shown in Figure 4.

Results and Discussion

Localisation

The results demonstrated that less front-back errors were induced when the participants wore the Oticon Opn IIC. However, this was not statistically significant with the number of test subjects used in the current experiment. Literature does show that pinna preserving fittings provide improved localisation, see for instance Jensen et al. (2013), so it is reasonable to assume some improvement.

Speech understanding

Results of the speech in noise experiment are provided in figure 5 below using the Oticon Opn miniRITE as the reference for comparisons. Results are provided in two subfigures to support the following discussion of the results in the text. When comparing the Oticon Opn IIC and miniRITE, see left panel in Figure 5, it was found that firstly, in the low noise environment (60 dB SPL) the speech intelligibility scores were not significantly different between the Oticon Opn IIC and the Oticon Opn miniRITE. This demonstrates that in low noise environment the participants performed equally well using the Oticon Opn IIC and miniRITE. Secondly, in the high noise environment the dual microphone Oticon Opn miniRITE outperformed the Oticon Opn IIC, which was expected. Importantly, with Oticon Opn IIC, it was seen that the average test result was improved by 1 dB SNR in high noise environment than in low noise environment. When comparing the Oticon Opn ITC and miniRITE (on the right panel), the dual microphone hearing aids were found to have on par performance in both environments.

Discussion on BrainHearing Benefits

When looking at the evidence presented the following conclusions can be drawn:

> The dual microphone Oticon Opn custom is on par with the dual microphone Oticon Opn miniRITE

Via the optimisation of the OSN algorithm, parity was achieved in terms of speech performance in the dual microphone custom hearing aids i.e. when Oticon Opn

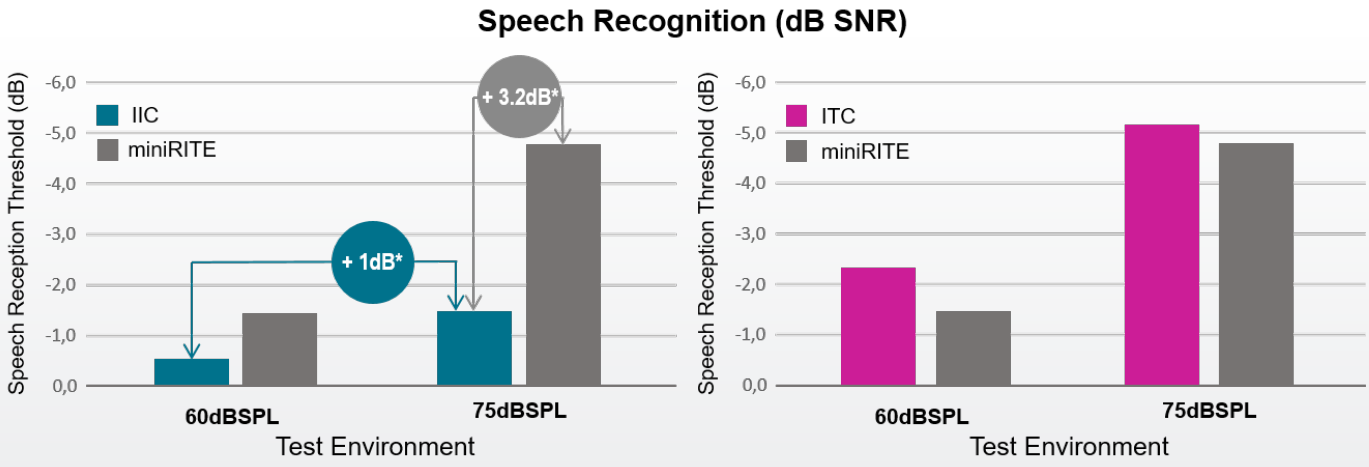

Figure 5: Speech Reception Threshold in dB SNR in 60 dB SPL low noise environment and 75 dB SPL high noise environment. Please note Speech Reception Thresholds plotted inversely, showing better performance with a higher bar. Asterisk indicates significant differences at a p-level below 0.05. Results provided separately in two panels to aid the discussion.

ITC is compared to the Oticon Opn miniRITE. The OSN algorithm is the same in both dual microphone styles. In all Oticon Opn styles Velox forms the base level of this advanced technology. Building upon this, the dynamic amplification features such as SpeechGuard, ClearDynamics, and VAC+ together with SoftSpeech Booster give the person wearing the hearing aid benefits consistent across both the dual microphone styles in the In-the-ear (ITE) and BTE-styles. This is best illustrated when looking at the latest evidence. When compared, the Oticon Opn ITC and miniRITE demonstrated that in both low and high noise environments there were no significant difference in speech reception. Whilst the microphone placement has changed, the benefit of Oticon Opn custom instruments have not, given the instruments are calibrated to take microphone placement into account. These results show that the Oticon Opn dual microphone instruments yielded comparable performance in both test environments, confirming earlier technical testing which also showed similar performance of Oticon Opn custom instruments relative to Oticon Opn miniRITE instruments. Having established functional equivalence of the algorithm for Oticon Opn custom and miniRITE form factors, BrainHearing benefits previously observed for Oticon Opn miniRITE instruments can also be applied to all dual microphone custom instruments in the Oticon Opn family.

Single microphone algorithm provides significant benefits in noise?

When looking at the evidence it becomes apparent that the single microphone Oticon Opn IIC actually yielded better speech understanding performance in high noise relative to low noise environment providing the person wearing the hearing aid with more support as listening environment becomes noisier. The single microphone OSN allows the person wearing the hearing aid to tolerate an extra 1 dB of noise in high noise environment compared to low noise environment and still understand 50% of the speech presented. This indicates that the noise removal module is providing help when the person wearing the hearing aid really needs it.

The results further showed that when in a low noise environment, the SRTs are comparable for all the hearing aids, as a pinna-like directional response is provided, either by the hearing aid (for the Oticon Opn miniRITE) or by the pinna itself (for the Oticon Opn IIC). For the Oticon Opn ITC, the placement of the device would give only a partial pinna effect, but the OSN design for the ITC ensures functional equivalence.

These results indicate that the OSN algorithm provides benefits in both high and lower noise situations in both single and dual microphone hearing aid styles.

Conclusion

The results combined with the technical data support that the OSN provides additional benefits for the person wearing the hearing aid in both single and dual microphone styles. By utilising the data provided, considering the lifestyle and needs of the person wearing the hearing aid the HCP's can help guide the person with hearing loss to select the most appropriate Oticon Opn hearing aid for them.

The smallest hearing aid that Oticon has ever made is equipped with a single microphone OSN, which provides the sound quality and discretion the person who wears the hearing aid demands while giving good noise reduction in challenging listening environments.

References

1. Colburn H.S. (1996) Computational Models of Binaural Processing. In: Hawkins H.L., McMullen T.A., Popper A.N., Fay R.R. (eds) Auditory Computation. Springer Handbook of Auditory Research, vol 6. Springer, New York, NY

2. Juul Jensen, J. (2018) Closing a Gap to Normal Hearing. Oticon White Paper.

3. Le Goff, N. & Beck, D. (2017) Pushing the Noise Limit. Oticon White Paper.

4. Le Goff, N., Ng, E., Wendt, D. & Lunner, T. (2016). Opn Clinical Evidence. Oticon White Paper.

5. Stevens, S., & Newman, E. (1936). The Localization of Actual Sources of Sound. The American Journal of Psychology, 48(2), 297-306. In Katz

6. Katz, J., Burkard, R. F., & Medwetsky, L. (2002). Handbook of clinical audiology (5th ed.). Philadelphia: Lippincott Williams & Wilkins

7. Dillon, Harvey. (2012). Hearing aids. Sydney : New York : Boomerang Press ; Thieme

8. Moore, B.C.J, (2008). An Introduction to the Psychology of Hearing Fifth Edition, Emerald Group Publishing Limited, UK

9. Weiss, R.J., Mandel, M.I., & Ellis, D.P. (2011). Combining localization cues and source model constraints for binaural source separation. Speech Communication, 53, 606-621.

10. Best, V., Kalluri, S., McLachlan, S., Valentine, S., Edwards, B. & Carlile, S. (2010). A comparison of CIC and BTE hearing aids for three-dimensional localization of speech. International Journal of Audiology, 49: 723-732.

11. Neher, T., Behrens, T., Carlile, S., Jin, C., Kragelund, L., Petersen, A. S., Van Schaik, A. (2009). Benefit from spatial separation of multiple talkers in bilateral hearing-aid users: Effects of hearing loss, age, and cognition. International Journal of Audiology, 48: 758-774.

12. Jensen, N. S, Neher, T., Laugesen, S., Johannesson, R. B., & Kragelund, L. (2013). Laboratory and Field Study of the Potential Benefits of Pinna Cue-Preserving Hearing Aids. Trends in Amplification 17(3/4) 171-188.

13. Oticon Consumer Survey (2011). Internal.

14. MarkeTrak 9: A New Baseline. (2015). "Estimating Hearing Loss and Adoption Rates and Exploring Key Aspects of the Patient Journey". Final Report, March 2015.

30994UK / 2018.0.9.05

oticon.global

oticon
PEOPLE FIRST