A Scoping Review 2019: OpenSound Navigator

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A review of foundational publications, as well as the outcomes-oriented benefits, related to the first generation of Oticon OpenSound Navigator (OSN) and Multi-Speaker Access Technology (MSAT).

One of the fundamental goals of any hearing aid fitting is to establish desired individual gain and output, which then can be used for the initial programming of the instruments. Over the years, numerous prescriptive fitting formulas have been developed and promoted for this purpose. Two have withstood the test of time and are commonly used by audiologists and hearing aid specialists today: the National Acoustic Laboratories Non-Linear v2 (NAL-NL2)[1] and the Desired Sensation Level v5 (DSL v5.0).[2]

The primary goals of amplification are personalized and maximal audibility, maximal speech intelligibility in quiet and in speech babble, and listening comfort. Beck and Le Goff[3] provided details on the Multi-Speaker Access Technology (MSAT) which was introduced in Oticon's OpenSound Navigator™ (OSN) to selectively reduce disturbing noise while maintaining access to all distinct speech sounds—thus supporting the ability of the user to attend to the voice they choose to listen to. They reported MSAT represented a new approach to speech enhancement technology and was intended to supplant current directional and noise reduction systems. They noted MSAT does not isolate one talker; it maintains access to all distinct speakers, thus facilitating BrainHearing™.

The primary auditory complaint from people with hearing loss, and people with traditional hearing aids, is the inability to understand speech in noise (SIN). Although it seems intuitive that people with hearing loss should complain that sounds are too quiet, the most common complaint is they cannot understand SIN. Specifically, in the background of multi-talker speech babble, people with hearing loss and people with traditional hearing aids report significant problems listening to, understanding, or making sense of speech.

To resolve SIN problems to the best of an individual's ability, the key is typically improving the signal-to-noise ratio (SNR). Of course, speech sounds must be heard (ie, made audible and perceived) before they can be understood. However, audibility no longer represents the major impediment it was decades ago. In 2019, we can provide audibility of speech sounds for most people with hearing loss via hearing aids, bone-anchored devices, cochlear implants, and auditory brainstem implants. Therefore, in some respects, the *primary task* of the hearing care professional (HCP) has changed, too: In addition to providing audibility, we strive to apply solutions which have been shown to make it easier for the end user/wearer to better achieve their goals. In most cases, the primary goal from the wearer's perspective is to improve their SIN ability.

In this article, we'll review previously published foundational and outcomes-oriented benefits attributable to the first generation of OSN products.

Beyond Thresholds: Hearing (Bottom-up) and Listening (Top-down)

Beck and Behrens[4] reported "hearing" is perceiving sound, whereas "listening" is the ability to assign meaning to sound. They stated well-fitted technologically advanced hearing aids improve not only the ability to *hear* (ie, perceive) sound, but also improve the opportunity to *listen* (ie, to apply meaning) to sound. However, all listeners do not have the same ability to listen. Listening is a dynamic process which depends on receiving and interpreting auditory information. Each person has their own unique knowledge of vocabulary, language competence, linguistic ability, working memory (the ability to encode, store, and process), auditory processing ability, and more. Other variables also impact listening ability and are present in each SIN task: age, the complexity of the listening task[5] (see James Jerger and Jeffrey Martin's article on p 14), clarity of speech, accents, distance, reverb, and more.

Bost et al[6] report sensorineural hearing loss presents "bottom-up" processing issues and supra-threshold (or "top-down") issues. They state supra-threshold deficits play an important role when transferring speech information into a meaningful message and non-auditory factors; cognitive and linguistic skills matter more as the listening situation becomes more challenging. Beck and Clark[7] reported "audition matters more as cognition declines, and cognition matters more as audition declines." As hearing loss increases, people require an improved SNR to understand speech in noise, and they generally increase their listening effort to make sense of a world delivered to them via compromised auditory input. That is, as hearing loss progresses and the auditory system provides incomplete bottom-up information, the demands on top-down processing shifts from relatively effortless hearing to effortful, attention-demanding listening.

Hearing Loss, Hearing Difficulty, and SIN Problems

A recent article[8] in *Hearing Review* by 24 prominent audiologists and auditory researchers estimated that 37 million Americans have audiometric hearing loss and another 26 million have hearing difficulty (HD) and/or SIN problems, despite having normal audiometric thresholds. There are many well-known etiologies from which people may have normal hearing thresholds yet may have substantial difficulty listening. For example, neurocognitive disorders such as Alzheimer's disease, mild cognitive impairment, hidden hearing loss, cochlear synaptopathy, auditory neuropathy spectrum disorder, auditory processing disorders, attention deficit disor-



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der, attention deficit hyperactivity disorder, dyslexia, traumatic brain injury, and more. Although speech sounds may be audible to the ear, the brain's ability to apply meaning to the perceived sounds is paramount. Indeed, listening is where hearing meets brain.[9]

Therefore, as the major problem for many people with hearing loss and for those with listening difficulty is SIN—and because the primary solution to SIN is improving the SNR—the remainder of this article explores and reviews the published outcomes of OSN and Multi-Speaker Access Technology with regard to the first generation of these products.

Evidence for OSN and MSAT

Ng et al[10] reported advanced noise reduction systems enhanced word recall performance in noise. Their study looked at hearing aid users with symmetrical moderate sensorineural hearing impairment who were tasked to recall the final words of lists of seven sentences in a 4-talker babble. Improved recall was shown as a result of the noise reduction, marking the first real-time noise reduction algorithm in a hearing aid, shown to free-up cognitive resources and significantly improve memory for speech in noise.

Beck and Behrens[4] reviewed multiple publications and noted modern digital noise reduction (DNR) circuits are highly beneficial for most people (adults and children) most of the time. They reported that advanced DNR circuits help facilitate more rapid word learning rates, better recall of words, and improved neural coding of words. Further, DNR circuits can provide an improved SNR at the hearing aid's output and can improve the wearer's Acceptable Noise Limits (ANL), as well as their ability to attend to the person speaking and their ability to quickly identify words. They recommended activation of the DNR circuit as the "go-to" setting for adults and children.

Le Goff et al[11] reported the reduction of cognitive effort and increased memory recall as a direct benefit of signal processing in actual hearing aids using pupillometry or the memory recall test to measure listening effort. The authors demonstrated an average reduction in peak pupil dilation (PPD) of 26% during the SIN recognition task (indicating less listening effort), while using Opn 1 compared to earlier non-MSAT processing. MSAT technology is a BrainHearing technology which improves speech understanding and reduces the effort required to understand speech. Reduced listening effort means more cognitive resources are available and can be used for other cognitive tasks, such as remembering conversations.

Beck and Porath[12] reported the first 700 consumer responses from people wearing Oticon Opn hearing aids. The results show that Opn appears to facilitate an increased trend towards very satisfied users who readily stream music, cell phone, and other applications. They report the effect of less effort, better recall, and better speech understanding in noise presents a real-world, significant impact resulting from the "paradigm shift" delivered in Oticon Opn.

Advanced DNR circuits provide more rapid word learning rates, less listening effort, better recall of words, an improved SNR at the hearing aid output, improved Acceptable Noise Levels (ANLs), and improved attention and quicker word identification...

Wendt et al[13] addressed how hearing loss affects processing demands. They noted people with hearing loss required an increase in listening effort to successfully comprehend speech in background noise. The effect of noise and different DNR schemes regarding listening effort were evaluated by measuring the PPD in 24 hearing-impaired listeners while performing a SIN task. The listeners were tested at two SNRs in a 4-talker babble condition with and without the use of DNR. The authors stated that applying a DNR scheme was beneficial, even in the presence of a previously determined "ceiling effect."

Chasin[14] reported the benefits of post 16-bit architecture and compression circuitry engaged prior to the digitization process, as in OSN. He found improved naturalness and clarity for musicians and non-musicians while listening to music. Both groups (musicians and non-musicians) reported that while using OPN, speech cues were easier to hear, listening effort in noisy locations was lower, the ability to hear speech in quiet was better, and the overall sound was more pleasant.

Le Goff and Beck[15] noted superior speech recognition using MSAT, compared to traditional directional and narrow-band directionality (beamforming), in typical noisy environments. They suggested MSAT supports people with hearing loss by allowing them to regain access to noisy places, which were previously too difficult and too frustrating to participate in.

Indeed, Beck and Le Goff[3] contended that OSN represents a paradigm shift regarding "how to facilitate better understanding of speech in noise." They reported OSN exceeds and supplants traditional directionality and noise-reduction protocols. Among the innovations introduced in OSN, they noted that rather than reducing acoustic information (as happens with traditional directional and beamforming strategies), OSN opens the acoustic landscape and preserves speech while reducing noise in complex acoustic environments. The speed and accuracy of the advanced processing algorithm enables selective noise reduction and provides the brain with more natural, important, and useful contextual acoustic information than was previously possible.

Browning et al[16] reviewed directional beamforming technology. The authors report although beamforming technology improves speech-in-noise recognition, the benefits are generally limited to situations in which the target signal is located directly in front of the listener. This orientation—speech directly in front of the listener—poses a significant barrier for the pediatric population. They stated children with hearing loss required a more advantageous SNR than children with normal hearing to achieve comparable performance. As such, they evaluated OSN compared to an omni-directional fitting, in a group of 14 pediatric hearing aid users (ages 8-15 years), and compared their results to 14 normal hearing, age-matched peers. The authors note that, unlike conventional beamforming, OSN applies directionality only after analyzing the sound sources in the environment. If noise is detected, the OSN algorithm is activated. For 12 of the 14 children with hearing loss, the average improvement in SNR achieved via OSN (as compared to omni) was 4.0 dB in noise—even when the children were not facing the target source. OSN did not impact speech recognition when the background noise was speech. The authors suggest OSN may offer advantages, as OSN does not depend on children facing the target talker and OSN provides access to multiple talkers within the environment.

Juul Jensen et al[17] investigated the impact of tinnitus on listening effort by comparing listeners with tinnitus and hearing loss to listeners with only hearing loss. They also evaluated the benefit of OSN on tinnitus patients. The effects of tinnitus and signal processing were examined by measuring the PPD while listeners performed a speech recognition-in-noise task at multiple intelligibility levels. The authors found that tinnitus patients generally had smaller pupil dilations across tasks, indicating increased levels of fatigue and a general effect of tinnitus on pupil dilations, but that OSN significantly reduced listening effort for the tinnitus patients.

Ohlenforst et al[18] studied the impact of multiple factors, such as SNR, masker type, and the DNR (on or off), on sentence recognition performance and listening effort as indicated by the PPD across multiple SNRs. The authors concluded that in 4-talker babble, engaging MSAT noise reduction facilitated improved intelligibility and less effortful listening.

Juul Jensen[19] reported OSN closes a gap to normal hearing. In two independent studies, PPD and speech recognition was tested in 4-talker babble in 8 different SNRs using age-matched normal-hearing and hearing-impaired listeners. The hearing-impaired listeners wore well-fitted amplification and were tested with and without OSN. The results revealed significant differences between normal-hearing and hearing-impaired listeners without OSN. Hearing-impaired listeners had poorer speech recognition and gave up trying to make sense of speech at relatively easy SNRs. Of note, the acoustic situations in which hearing-impaired listeners gave up were the same situations in which normal-hearing listeners were still participating and actively engaging listening effort to better understand speech. The implication is that hearing-impaired listeners miss out on social activities that are important for mental health, such as larger social gatherings at restaurants with more difficult SNRs. However, when OSN was engaged, the gaps in speech recognition and listening effort (between hearing-impaired and the normal-hearing listeners) was closed. OSN enabled the hearing-impaired listeners to push their own limit such that they were able to participate successfully in more difficult listening situations. The implications are that OSN enables hearing-impaired people to remain socially active in difficult listening environments, similar to their normal hearing peers.

Beck et al[20] reported children with hearing loss are known to require higher SNRs than adults to achieve similar speech recognition scores. The authors stated that to achieve an improved SNR, it is necessary to reduce secondary background noise, such that amplification facilitates hearing, listening, and learning, and provides maximal audibility of acoustic speech sounds to present the best possible SNR to the listener. They also briefly reviewed a report from Boys Town National Research Hospital in which Browning, Flaherty and colleagues[16] reported OSN was found to be beneficial for children with hearing loss, as it provides improved speech recognition in noise, even when the child was not facing the talker. Beck et al[20] reported the contributions from incidental learning and incidental hearing is a paramount concern for children. As such, maximally delivering the very best sound quality, noise reduction, speech-in-noise results and more, as provided through excellent contemporary hearing aid fittings, provides the pediatric wearer with maximal opportunities to hear, listen, and learn.

Summary

The most significant published advantages and outcomes from the first generation of OpenSound Navigator™ products have been briefly reviewed above. As noted, the primary goals of amplification are personalized and maximal audibility, maximal speech intelligibility in quiet and in speech babble, and listening comfort. The real-world interpretation of these goals, and the most important task of any hearing aid system is very likely to allow the wearer to improve their ability to understand SIN. Of course, there are other factors which impact the hearing aid selection process. Nonetheless, as hearing care professionals transitioning from simply making sounds loud enough to hear, to making sounds clear enough to listen to, we're obligated to examine products which result in highly satisfied wearers, and products which improve the SNR and offer the wearer the best opportunity to achieve their listening goals. ◗

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