The Power of Evolv AI: Meeting the Needs for Severe-to-Profound Hearing Loss

Starkey

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Introduction

Patients with severe-to-profound hearing loss are a unique and varied group that can pose various challenges when prescribing and fitting amplification in the clinic. Providing sufficient audibility, particularly in the high frequencies, is one of those challenges. The large amount of gain needed to provide audibility is often met with the patient's own, narrowed dynamic range of listening comfort and a persistent risk of feedback oscillation.

Moreover, severe-to-profound hearing loss is often indicative of significant cochlear damage and a probable loss of spiral ganglion fibers. As a result, even sounds made audible through well-fit hearing aids may be perceived as distorted (Souza & Hoover, 2018). These effects are further exacerbated by noise present in adverse listening conditions (Ng & Rönnberg, 2020). It is well-documented that as hearing loss worsens, the signal-to-noise ratio (SNR) required for the patient to correctly recognize speech stimuli also increases (Killion et al., 2004).

Even with innovations, such as directional microphones, these patients may still have difficulty understanding speech in certain, complex listening environments. Patients who continue to struggle may need additional hearing assistive technology to improve SNR. Difficulty understanding speech in the presence of background noise can contribute to listening fatigue and may lead patients to avoid difficult listening situations like restaurants, conversing in the car, or with use of the telephone.

Patients, especially adults with severe-to profound hearing loss seeking help, typically arrive with a well-defined list of what they want from hearing aids. Audibility without feedback and reliable performance are paramount, but it is also important to consider the role of wireless streaming capabilities and the other advanced features available today. The Evolv AI Power Plus Behind-The-Ear (BTE) hearing aid is designed to meet the difficult challenges these patients face. Redefining the category, the Evolv AI Power Plus BTE 13 offers a matrix of 140/80, a vertically-oriented telecoil, user controls, onboard motion sensors, and the all-day reliability that patients might have only expected from a much larger hearing aid.

The ability to use remote microphones is critical for hearing aid users with severe-to-profound hearing loss. Many will expect to use their hearing aids more than 16 hours each day and will rely heavily on wireless audio streaming capabilities. In the design of the Evolv AI Power Plus BTE 13, Starkey's engineering team sought to exceed even the most demanding patient's expectations through the readiness of a size 13 zinc-air battery and compatibility with low power 2.4 GHz wireless audio streaming protocols.

Hearing healthcare providers will welcome the intuitive Inspire X programming software, with its familiar wireless approach, to ensuring audibility and comfort. As with other Starkey Evolv AI hearing aids, the REM Target Match feature is available.

The REM Target Match pairs with the clinic's real ear systems to quickly achieve target match, allowing extra time for counseling and fine tuning.

A validation study was completed to evaluate the central capabilities of the Evolv AI Power Plus BTE 13 hearing aid. Throughout the course of the study, patients and providers assessed the fit, comfort, and usability of the hearing aids. The study also investigated the impact of various audiological features important to patients with severe-to-profound hearing loss. These features included **Edge Mode**, which was evaluated in real-world environments to better understand the subjective impact on listening effort for the severe-to-profound population. **Hearing assistive technologies (such as an onboard telecoil and connectivity with a Remote Microphone accessory)** were also evaluated, in combination with the Evolv AI Power Plus BTE 13, to determine the respective quantitative benefit of each for speech understanding in background noise. Additionally, **REM Target Match** was assessed to measure the impact this feature has on the efficiency of hearing aid fittings for this particular population. The focus of this paper will be on the audiological performance and patient benefit of the Evolv AI Power Plus BTE 13.

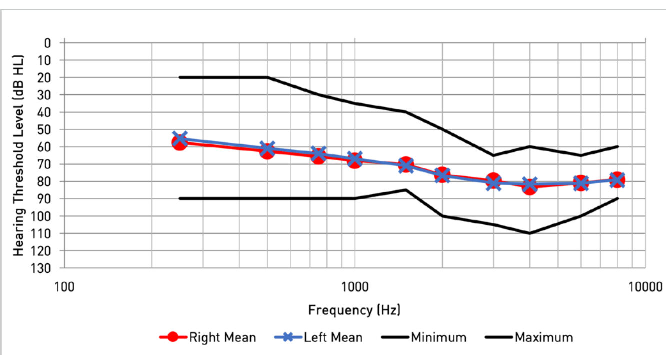


Figure 1: Average audiogram for research participants in the study. Red symbols represent average thresholds for the right ear, blue symbols represent average thresholds for the left ear.

Validation Study

Participants

Fifteen individuals, two females and thirteen males, were enrolled in the validation study of the Evolv AI Power Plus BTE 13 hearing aids. The mean age of all participants was 69.8 years, with a range of 52 to 85 years. Mean audiometric data, as well as group minimum and maximum thresholds, are show in Figure 1.

Methods

The validation study consisted of lab testing and hearing aid home trials to assess the Evolv AI Power Plus BTE 13 in both well-controlled laboratory environments and real-world listening environments. Fitting and REM Target Match was conducted in the lab during the first visit. Edge Mode was assessed in the real world during the home trial, and the assessment of hearing assistive technology took place at the final lab visit.

Prior to the start of the validation study, the QuickSIN was completed, under headphones, on all participants and administered according to test instructions (Killion et al., 2004). Mean SNR loss of all participants (30 ears) was 16.0 dB with a standard deviation of 5.5 dB, indicating severe SNR loss for the majority of participants. Participants were fit with standard tubing and custom earmolds (n=11) or thin-tubes and domes (n=4), per their audiogram.

REM Target Matching for Fitting the Power Plus BTE

The efficiency and accuracy of the REM Target Match functionality in Inspire X was evaluated as part of the validation study to better understand the impact of this technology on hearing aid fittings, specifically with the severe-to-profound hearing loss patient population. First, the hearing aids were programmed to NAL-NL2 prescriptive targets in the Inspire X software.

Then, the hearing aids were matched, manually, to NAL-NL2 targets using probe microphone measurements on the Audioscan Verifit 2 system. A 65 dB SPL ISTS signal was used. A second researcher kept record of the time that elapsed during the target-matching process, beginning at the onset of the first test stimulusand concluding at the end of the final test stimulus after aidable targets had been reached.

Following completion of the manual target match procedure, the settings were restored to default (NAL-NL2 targets in Inspire X software), and the second researcher kept a similar record of the time that elapsed while Starkey's REM Target Match feature automatically set the hearing aids' gain to match the same prescriptive targets at the 65 dB SPL input level.

The measured SII value corresponding to each of the three speech input levels, for both target-matching methods, are shown in Figure 2. Comparison of the SII measurements demonstrate that similar levels of audibility were achieved between REM Target Match and the manual target matching method performed by the researcher. The amount of time needed to attain these similar target-matched settings (in minutes) are shown for each participant's binaural hearing aid fitting in Figure 3.

The measurements showed that REM Target Match reduced the time needed to match prescriptive targets by approximately half, from an average of 8:04 minutes to 4:35 minutes. The measured duration times were analyzed using a paired t-test, which confirmed that these differences were statistically significant ($p < 0.05$). By reducing the time needed to program the hearing aids, providers have more time to focus on the patient and other important aspects of their treatment, without sacrificing the degree of precision and accuracy that is achieved through "manual" real-ear measurements.

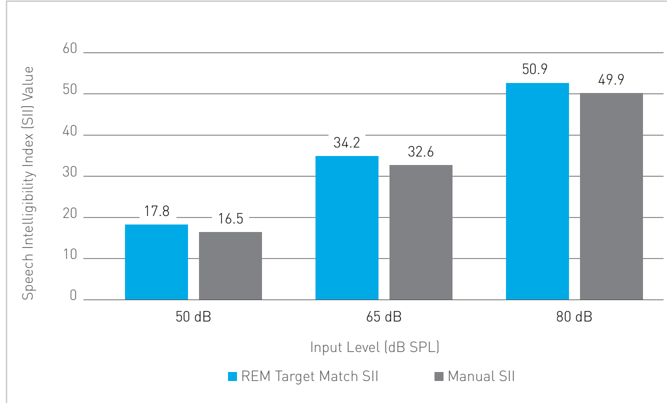


Figure 2. Average speech intelligibility, as represented by Speech intelligibility Index (SII) for the two REM methods.

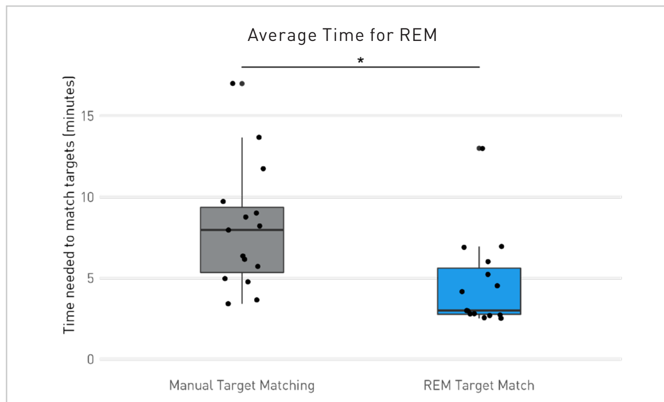


Figure 3. Average time to complete the hearing aid fitting using the two REM methods. The bars in this graph represent the interquartile range, and the datapoints beyond the ends of the whiskers are considered outliers. Results of a paired t-test show a significant difference in duration between the two target-matching methodologies (p < 0.05).

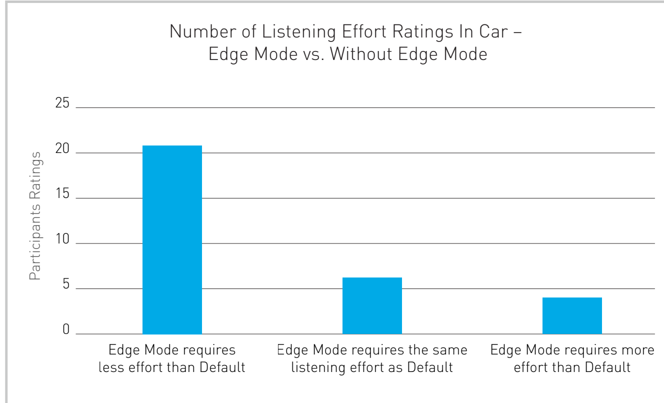
Edge Mode for Severe-to-Profound Hearing Loss

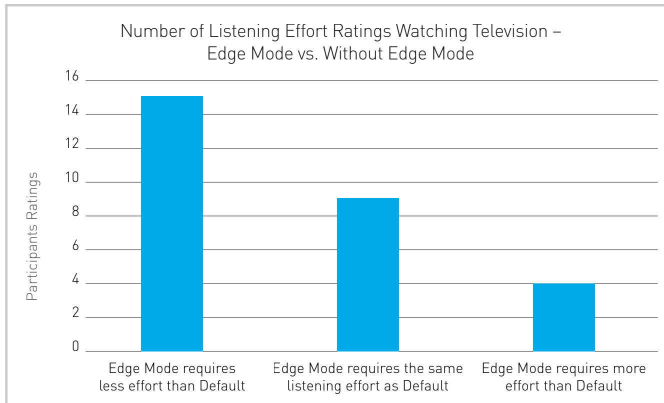
The ecological assessment of Edge Mode with individuals with severe-to-profound hearing loss was of particular interest for this validation study. Edge Mode is a unique feature that allows the patient to receive powerful, on-demand adjustment to their hearing aids' processing. Edge Mode was improved in Evolv AI to provide more fine-tuned adaptation towards comfort or clarity by recognizing specific nuances of complex listening environments. This additional level of adaptation is designed to better respond to the situational needs of the hearing aid user by delivering more natural sound quality and improving speech intelligibility.

No matter how well a hearing aid is programmed, at some point, patients will encounter situations where the acoustic environment presents a unique challenge. This can be particularly true in the case of individuals who have severe-to-profound hearing loss. To evaluate the real-world impact of the Edge Mode feature with this population of hearing aid users, participants were asked to complete a field evaluation in specific listening environments. These environments included driving or riding in a car and watching television. These two environments were selected as being particularly challenging and relevant for individuals with severe-to-profound hearing loss. The car involves the interference of road noise and engine noise, which can add to any difficulty with speech understanding. A television environment was also of interest because many patients with severe-to-profound hearing loss report marked difficulty watching television at levels that are comfortable for others.

The participants were given a structured diary and asked to provide subjective ratings comparing their listening experience with Edge Mode versus their default hearing aid settings without Edge Mode. When the participants performed a listening comparison, they provided a rating that indicated how each listening mode affected their perceived listening effort. Participants could provide a rating for each instance they were in the car or watching television. Their ratings are summarized in Figure 4 (speech understanding in the car) and Figure 5 (understanding of the television).

For the car scenario, thirteen participants (n=13) provided a combined 28 ratings. Eight (n=8) provided multiple ratings for the car situation. The results showed that more than half of the participant ratings indicated less perceived listening effort when using Edge Mode in the car compared to without.





Figures 4 and 5. The number of times participants selected each option comparing listening effort with Evolv AI Edge Mode and without for the car scenario (top) and watching TV (bottom).

A similar finding was shown for television-watching. Thirteen participants (n=13) provided a combined 33 ratings based on their experiences listening to the television; nine participants (n=9) provided multiple ratings. Results showed that well over half of the participant ratings indicated that Edge Mode reduced their listening effort while watching television.

Hearing Assistive Technologies – Remote Microphone and Telecoil

For the Evolv AI Power Plus BTE 13, it was essential to maintain an offering of assistive listening devices, like an onboard telecoil and compatibility with a Remote Microphone accessory, to provide a more advantageous SNR for speech in complex listening environments.

As was previously described, the majority (n=8) of the participants in the study were found to have a severe degree of SNR loss (>15 dB), as measured by the QuickSIN. Said differently, the expectation is that these participants would require a speech stimulus to be >15 dB louder than any type of background noise in order to score 50% correct on the Hearing in Noise Test (HINT) (Duncan & Aarts, 2006). To evaluate the degree of improvement provided by assistive listening technologies such as remote microphones and hearing loops, speech perception testing was conducted in a specifically challenging listening environment: a reverberant room with only a +10 dB SNR.

AzBio speech stimuli were selected, as they are a standardized speech corpus that is frequently used to evaluate hearing aid users' functional performance, particularly among patients with severe-to-profound hearing loss. Consistent with how the test is typically administered to this population, the speech stimuli were presented to the listener at +10 dB SNR (Brant et al., 2018).

AzBio sentences were played through the mouthpiece of a talking research manikin positioned 3 meters (118 in.) from the listener, in a reverberant room (reverberation time of 1.3 seconds, critical distance 5 feet). Multi-talker babble noise was played through four surrounding speakers positioned in the four upper corners of the room. The speech level (65 dBA) and noise level (55 dBA) were both calibrated at the position of the listener.

This scene was created in such a way that it was particularly complex and challenging, with the combination of reverberation and speech-in-noise, and speech presented beyond the critical distance. For those with severe-to-profound hearing loss this type of situation can be extremely difficult, given the poor SNR and the addition of reverberation to further degrade the speech signal. In this type of environment, even directional microphones cannot be as impactful due to the reverberant noise masking the direct energy of the target speech (Ricketts, 2001; Ricketts & Hornsby, 2003).

Fourteen participants (n=14) completed the listening task described above in three conditions: 1) hearing aids alone 2) audio streamed from a Remote Microphone +, worn by the research manikin, 6 inches below the manikin's mouth, and 3) using the Loop Memory/telecoil function of the Evolv AI Power Plus BTE 13 hearing aid. In the third condition, the signal from a microphone, placed 4 inches in front of the manikin's mouth, was driven through a hearing loop system installed beneath the research participant's chair.

Percent correct scores for these three discrete amplification input test conditions are shown in Figure 6. For analysis, intelligibility data were first transformed to rationalized arcsine units (RAU) in order to account for potential variance across the performance scale (Studebaker, 1985). The transformed speech intelligibility scores were analyzed using a repeated measures analysis of variance (RM-ANOVA) with one within-subjects variable (amplification input mode).

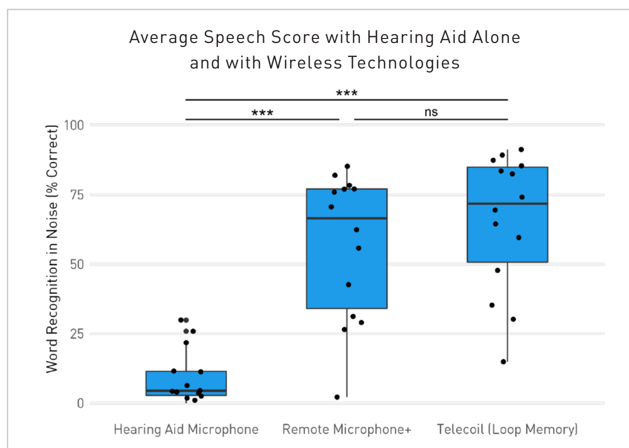


Figure 6. Mean AzBio speech perception scores comparing three different amplification audio input source conditions (% correct out of 100). Results of post-hoc t-tests show significant differences in speech intelligibility between the hearing aid microphone and remote microphone ($p < 0.001$) and telecoil ($p < 0.001$) amplification inputs. There was not a statistical difference observed between the remote microphone and telecoil amplification inputs ($p > 0.05$).

There was a significant main effect of amplification input mode [$F(2,26)=72.083$, $p<0.001$, generalized $\eta^2=0.608$] which suggests that individuals with severe-to-profound hearing loss performed significantly better with hearing aids and accessibility systems in background noise. Results of post-hoc t-tests show significant differences in speech intelligibility between the hearing aid microphone and remote microphone ($p < 0.001$) and telecoil ($p < 0.001$) amplification inputs. There was not a statistical difference observed between the remote microphone and telecoil amplification inputs ($p > 0.05$).

Together, these findings and the existing literature suggest that, first of all, patients with severe-to-profound hearing loss struggle tremendously in these extremely complex listening environments with reverberation and background noise. The findings also show the exceptional benefit provided through a Loop/telecoil hearing aid program, and/or a remote microphone. The degree of benefit in this extremely difficult listening environment demonstrates just how much of a difference these additional technologies can make. Loop systems and remote microphones can provide superior access to a target signal, beyond what a hearing aid alone can provide, that leads to significant improvements in speech recognition

Absolute Power Molds for RIC Devices

While not investigated in the present study, Receiver-in-the-Canal (RIC) style hearing aids may be another suitable option for patients with severe-to-profound hearing loss. As the leader in custom hearing aid manufacturing, Starkey created the Absolute Power (AP) Mold to provide a unique and flexible option for meeting the needs of difficult cases.

For patients with severe-to-profound hearing loss, AP molds can be built with either 120/60 or 130/70 matrix receivers, depending on the patient's measured uncomfortable loudness (UCL) threshold, and placed deep in the ear canal. The individually designed AP Molds are purposefully crafted to deliver maximal acoustic separation and optimal receiver placement in a comfortable and visually attractive form factor.

Conclusion

The Evolv AI Power Plus BTE 13 offers individuals with severe-to-profound hearing loss and their providers a unique set of tools and features to address the specific needs of this population. REM Target Match provides an exceedingly efficient hearing aid fitting process as compared to manual real-ear measurements, allowing additional time for counseling during an appointment.

The Evolv AI Power Plus BTE also has an improved Edge Mode capability that allows for more fine-tuned adaptation towards comfort or clarity, depending on the listening situation. The current study showed that Edge Mode, with the severe-to-profound hearing loss population, resulted in less perceived listening effort compared to the hearing aid settings without Edge Mode. This real-world finding shows the power of Edge Mode in the actual, challenging environments that people encounter on a daily basis.

It was essential that the Evolv AI Power Plus BTE offer a variety of compatible hearing assistive technology options to help in those most challenging listening environments, like those with background noise and reverberation. This study showed the incredible benefit that can be achieved with the combination of Evolv AI hearing aids and these assistive technologies. The Evolv AI Power Plus BTE is designed specifically for this population of hearing aid users and their providers. It has all the essential components of an effortless listening and fitting experience.

References

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