The information presented in this whitepaper applies to products manufactured by GN that are comparable with equivalent technology as ReSound. For further information, see reference list.

ReSound ENZO Q™ brings power and more to people with severe-to-profound hearing loss

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ABSTRACT

ReSound ENZO Q continues the ReSound commitment to bring the most advanced, evidence-based technology to people with severe-to-profound hearing loss, who are the most reliant on amplification. The fitting flexibility, range of connectivity options, opportunities for personalization, online services for enhanced assistance from their Hearing Care Professional (HCP), and compatibility with Cochlear™ implant systems, are unmatched in any other hearing aid for severe-to-profound hearing losses.

Introduction

Most people with severe-to-profound hearing loss use amplification as an integral part of their daily lives. They require high quality, dependable performance from their hearing aids. Incongruously, hearing aid technology for this group of users has traditionally lagged what was available in less powerful products. This could reflect the fact that, even though they have the most demanding needs, they nevertheless represent the smallest proportion of hearing aid candidates. ReSound changed all that with the ReSound ENZO family of hearing aids. For the first time, the most advanced technology and connectivity solutions were made available for those who stood to benefit most. ReSound is privileged to develop hearing aids that people can trust, and proves its commitment to those with severe-to-profound hearing loss with the introduction of ReSound ENZO Q. By upgrading the ReSound ENZO family with ReSound ENZO Q, people with severe-to-profound hearing loss get access to clear, comfortable, high quality sound and the most up-to-date connectivity and personalization options.

Although ReSound ENZO Q is built on the most advanced platform ReSound has ever introduced, it truly shines by getting the basics right. People with severe-to-profound hearing loss who wear amplification hear their entire world through the hearing aids and are highly dependent on them to function in their daily lives. ReSound ENZO Q makes sure that they have access to all sounds in their environment, that they can follow conversations even in noisy conditions, that sounds are kept at comfortable levels, and that they can easily manage how their hearing aids sound. In addition, ReSound ENZO Q users can connect to today's consumer technologies with ease.

Audibility

The most essential function of any hearing aid is to amplify sound in the environment to a level where the user can hear it. This implies that the levels must be louder than the person's thresholds of sensitivity. But how loud? The range into which the amplified sound must fit without being uncomfortably loud is typically quite small for a severe or profound hearing loss. Fitting rationales prescribe frequency and input level dependent gains based on average performance, loudness and preferences for persons with any particular audiogram. Many prescriptions provide a good starting point for a fitting but persons with severe-to-profound hearing loss have more variable results and preferences than is typical for those with milder hearing losses. ReSound ENZO Q fittings therefore allow for an unprecedented level of customizability to accommodate any individual's needs and preferences. Unlike with other hearing aids, the HCP is not locked into the manufacturer's opinion about the best way to fit it. Starting with choices in fitting prescriptions, the amplification is highly customizable with options for a more linear response, low frequency loudness boost, output limiting technique and time constant schemes. The HCP can therefore fit the hearing aids according to different strategies and has tools to create the sound preferred by the individual user. Sound Shaper frequency compression also gives the user the potential of greater high frequency audibility, which might contribute positively to sound quality[1] (without disturbing speech understanding[2]).

Because the gain needed for people with severe-to-profound hearing losses will in all cases be very high, there is also high risk that feedback will occur. With lower gain fittings, the acoustic leakage of amplified sound from the ear canal back to the hearing aid microphones typically dominates the feedback path.

This element is also important for high gain fittings, but because it is often well-controlled via the custom earmold, internal transmission paths in the hearing aids can be the main limiters of usable gain.

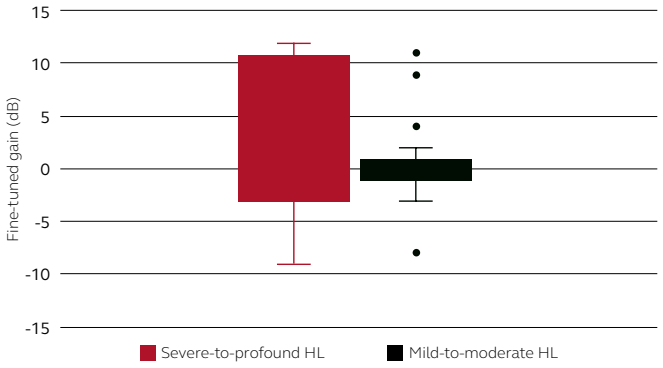


Figure 1: The preferred gain for individuals with severe-to-profound hearing losses is much more variable than for those with less severe hearing losses (data on file). This illustrates the importance of fitting flexibility. A fitting system that only allows one fitting strategy will not be able to meet the needs and preferences of as many users.

Therefore, feedback management starts with careful consideration of the hardware design. ReSound ENZO Q shares the same electroacoustic design as previous ReSound ENZO family devices and therefore offers the same industry-leading gain and output. Of particular note are the earhooks used on the two devices. The total forces acting on the earhook generally constitute the largest component of vibroacoustic feedback in the frequency range that is most important for high power Behind-the-Ear (BTE) hearing aids[3]. The hooks for the high power BTE and super power BTE in the ReSound ENZO family are unique in that they are manufactured from materials that are less susceptible to vibration than the standard plastic material used for earhooks. The high power BTE features a metal earhook while the super power BTE earhook is made from a combination of hard and soft plastic. Both allow approximately 5 dB additional usable gain compared to a standard plastic hook.

Even with an unvented earmold and skillful device design, usable gain may be limited to over 20 dB less than what ReSound ENZO Q is capable of providing without further feedback management. Therefore, DFS Ultra II has been redesigned for the new chip platform, providing the best feedback management yet. DFS Ultra II combines two phase cancellation filters with a gain correction algorithm that predicts feedback occurrence in dynamic situations, restoring gain to the desired levels before audible feedback occurs. DFS Ultra II not only allows the prescribed amount of gain at the fitting, it prevents feedback in daily life situations without reducing gain below the prescribed amount.

Figure 2 compares the performance of the DFS Ultra II in ReSound ENZO Q with another premium brand BTE for those with severe-to-profound hearing loss. To best isolate the effect of the feedback manager rather than the mechanical stability of the hardware design, each device was programmed with 20 dB flat insertion gain and fit to a mannequin ear with a non-occluding eartip. The aided response was measured for three conditions, that are shown in Figure 2. The first condition was with the feedback manager deactivated. Neither device showed feedback in this condition. The second condition was with the feedback manager active. The other brand showed a slight reduction in gain in this condition, while ReSound ENZO Q preserved the same gain. Finally, a hand was held up to the hearing aid. An audible spike of feedback was captured in the measurement for the other premium brand. No feedback occurred with ReSound ENZO Q, and the gain remained stable throughout the measurement.

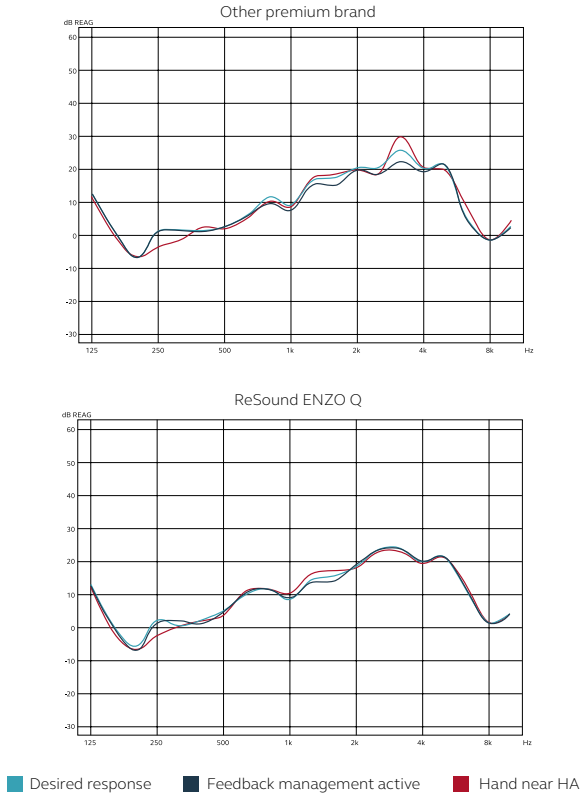


Figure 2: Feedback management effect for ReSound ENZO Q and another premium brand BTE for severe-to-profound hearing loss. The light blue curve is the desired response, dark blue is with feedback management on, and red is with a hand held near the hearing aid. ReSound ENZO Q maintains the desired response in all cases. The feedback manager of the other premium brand reduces gain slightly when it is activated, and still does not prevent feedback from occurring in a dynamic situation.

Improved hearing in noise

When hearing loss exceeds about 45 dB HL, poorer discrimination of speech and other sounds adds to the issues of sound not being audible[4]. This leads to the most frequent complaint of virtually all hearing aid users: hearing in noise. The knee-jerk reaction of HCPs and hearing aid manufacturers is that directional microphones must be the solution, as it is the only proven technique in ear level hearing aids shown to improve speech recognition in noise. However, the benefits of directionality in the lab have not translated directly to real-life benefit and preference for any level of hearing loss. Why not? Acoustics of the listening environment, interaction of intent of the listener with the environment, and the availability of other information such as visual or contextual cues are only some of the factors that make things in real life situations much more complicated than in the lab.

ReSound has followed a strategy for applying directionality that is radically different than in other premium hearing aids. Rather than focusing only on technically improving signal-to-noise ratio, a strategy was devised that supports different ways of listening in real life situations. Listening environments in the real world are infinite, complex and dynamic and so is the way people naturally move their heads, adjust their gaze and position, and change their speaking style and levels to adapt to the different environments and accomplish their listening and communication goals. For example, behavioral studies[5] show how people talking together will lean forward and turn their head to improve their ability to follow the conversation as the listening environment becomes more challenging. They will also use shorter utterances and may change their turn-taking patterns. These behaviors are also affected by how many people are participating in the conversation, and perhaps also cultural and situational factors, such as how well the people talking together know each other.

Binaural Directionality III provides the best responses to support three listening strategies that depend on the acoustic environment, the listening goals of the individual, and other intrinsic factors. Because the hearing aid intelligence only knows about the acoustic environment, Binaural Directionality III makes sure that the provided listening mode does not interfere with the unknown factors. For example, at a small family gathering at home, there may be several conversations going on at once. In addition, there may be a sports match on TV or music playing. While the hearing aids can identify sound levels, the presence and direction of speech and the presence of other sound, they don't know which conversation the listener wants to participate in, whether it's important for them to also monitor others, or whether they would just rather watch the game on TV. The most common approach to automatic switching of listening modes would dictate that the hearing aids should provide the best signal-to-noise ratio (SNR) for sounds in front and reduce any other sound as much as possible. At worst, this approach can be completely at odds with the individual's listening goals and make them harder to achieve than if the automatic function was not applied at all. This is supported by research showing that a high degree of directionality makes it more difficult to locate and follow speech if the source is not in front of the user[6,7].

Binaural Directionality III provides the appropriate sound to each ear so that the brain can naturally and unconsciously apply the best listening strategy in any given situation. In quiet or less complex situations where there typically are not competing sounds, listeners need audibility and auditory spatial information for the best sound quality and to orient themselves in their environment. As the environment becomes more complex with more competing sounds and more reverberation, listeners begin to shift to a better ear listening strategy. This means they rely on the ear that has the best representation of what they want to hear. To support this type of listening strategy, Binaural Directionality III automatically applies a directional response on one ear, and a specially calibrated omnidirectional response on the other ear. Combined with the head shadow effect, this results in larger contrasts of information provided to each ear and promotes spatial unmasking. Listeners can better resolve and focus on the sounds which are important to them. In diffuse noise conditions with detectable speech only in front of the listener, maximizing SNR for the sound in front is the preferred listening strategy. To support this, Binaural Directionality III will provide a directional response to both ears.

The way that Binaural Directionality III applies directional microphone technology has been shown to improve ease of listening compared to omnidirectionality[8,9,10]. In addition, it preserves awareness for surrounding sounds in the environment better than other directional microphone strategies while still providing better hearing in noise[11,12,13,14,15]. For people with severe-to-profound hearing loss, the directional benefit for speech located in front has consistently been 4 dB (corresponding to 60% better speech recognition compared to omnidirectionality) across ReSound ENZO family generations and versions of the Binaural Directionality approach (data on file). This improvement corresponds to that provided by other premium hearing aids using strong directional algorithms. However, as shown in Figure 3, Binaural Directionality III provides dramatically better access to sounds not in front compared to the other approaches. The importance of this may be even greater for those with severe-to-profound hearing loss than those with less severe losses. Ricketts & Picou[16] evaluated performance and preference for Binaural Directionality III listening modes in ecologically relevant lab conditions. They reported that preference for Binaural Directionality III mode changed depending on condition and also individual characteristics, such as speech recognition ability and degree of hearing loss. Those with more severe hearing loss had a stronger preference for the mode that supports the better ear listening strategy, where asymmetric directional microphone settings are applied. This may reflect greater perceived ease in monitoring the environment and locating the sound of interest while still being able to understand a talker in front better.

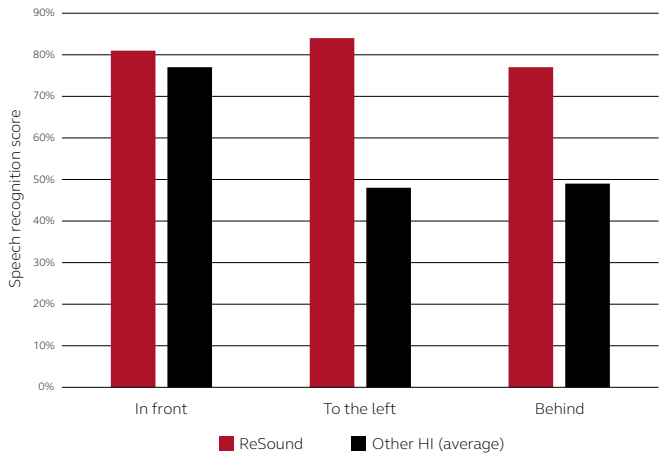


Figure 3: Results from a difficult speech recognition task, where participants had to locate and repeat sentences that were presented simultaneously from three different directions. When the target speech was in front, study participants performed equally well in locating and understanding the target speech with Binaural Directionality III as they did when wearing hearing aids with strong directionality. When speech originated from the left or behind the participant, performance with Binaural Directionality III far exceeded that when wearing the other hearing aids.[15]

Comfortable sound

Both hearing aid wearers and people with normal hearing experience annoyance with some sounds in their environment and discomfort with loud sounds. While there is overlap in the kinds of sounds that are found to be annoying, Keidser et al[17] reported that hearing aid users complain about transient noises while people with normal hearing do not. These noises include things like clattering cutlery, hammering, keys being dropped on a hard surface, and paper crinkling. Hearing aid users who logged noises they encountered in their daily lives reported that 1/3 of them were of a transient nature[18]. Considering the small dynamic range of those with severe-to-profound hearing loss and the high levels of amplification that are applied in their hearing aids, it is not surprising that they may find impulse sounds especially jarring. ReSound ENZO Q adds Impulse Noise Reduction to alleviate this issue and keep all types of sounds at comfortable levels. This algorithm uniquely provides instantaneous gain reduction that depends on environment, frequency content and level of the noise, and gain prescription of the user (see Sjolander et al[19] for a thorough description) to better manage suddenly occurring sounds such as the ones mentioned. The aim is for the gain applied to impulse sounds to be reduced in a way that is comfortable to the user without making sounds unnatural or distracting.

Ability to use today's technology with no fuss

Almost half of the population with severe-to-profound hearing loss is younger than 65 years[20]. While uptake of devices like smartphones and tablets is sharply on the rise among older adults – the largest group of hearing aid users – it is ubiquitous among younger people. Well over 90% of adults under 50 are smartphone owners and approximately three quarters of those 50 to 64 years own smartphones[21]. Because of the diversity of the demographics in this group and the severity of their hearing losses, it is important to support their ability to use technology such as smartphones.

ReSound ENZO Q offers the most complete ecosystem of connectivity options. Starting with traditional telecoil and direct audio inputs, the full line of ReSound digital wireless accessories also works with ReSound ENZO Q, allowing users to connect to virtually any audio source. The dramatic improvements in signal-to-noise ratio are well-established for remote microphone technology, such as the Multi Mic[22,23], but support in using the phone is perhaps one of the most significant benefits in everyday life.

Using the phone

Results from Jespersen & Kirkwood[24] illustrate why wireless streaming of phone calls makes such a difference for those with severe-to-profound hearing loss. In their study (see Figure 4), participants scored an average of only 6% on a speech recognition task where the speech was presented from a phone that was held up to the hearing aid microphone. In contrast, an average improvement of more than 45 percentage points was observed when the sound was streamed bilaterally to the hearing aids. This was true regardless of whether the sound was streamed directly from a smartphone or via the ReSound Phone Clip+ Bluetooth® phone accessory. Additional benefit resulted by adding visual cues. Individuals with any degree of hearing impairment benefit from being able to see who they are talking to, but those with severe-to-profound losses can potentially benefit the most. In fact, those with very severe losses rely as much on visual as on auditory information for speech understanding[25,26]. Compared to using the phone acoustically at the hearing aid microphone unilaterally, there was an average improvement of more than 70% when FaceTime was used and the participants could see the face of the talker during the test. For users of ReSound ENZO Q the benefit of the video chat apps is not limited only to iPhone users, as direct streaming from Android™ smartphones is also possible. With the ReSound Phone Clip+, any Bluetooth enabled smartphone can stream audio to ReSound ENZO Q hearing aids.

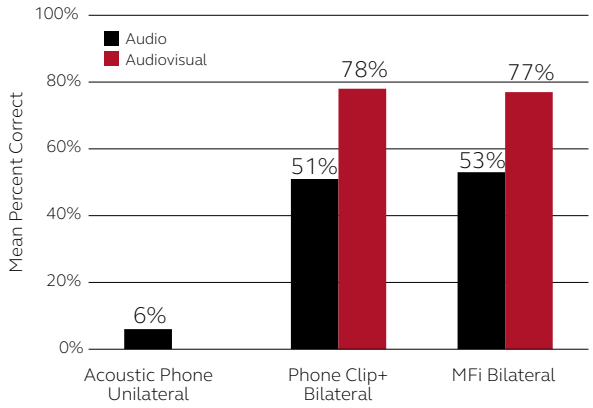


Figure 4: Spectrogram of the background noise only.

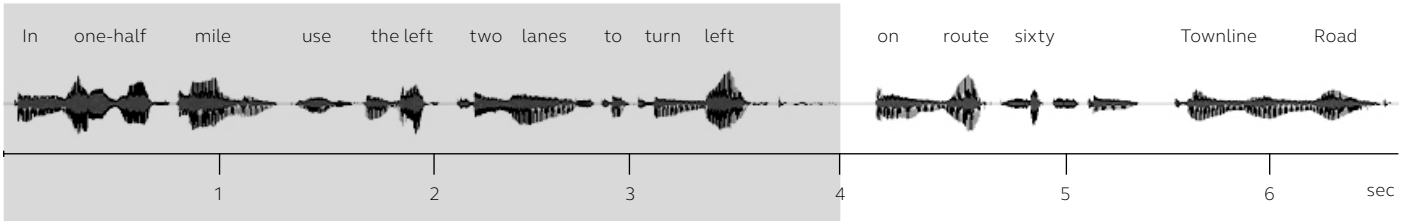


Figure 5: Without mix-in streaming, a delay occurs in streaming such that important information may be missed. In this example, the critical turn-by-turn driving instructions in the shaded area are seamlessly streamed to ReSound ENZO Q that could be missed if streaming to a hearing aid on the previous platform.

Never a word missed with mix-in streaming
One improvement enabled by the new chip platform that is of particular benefit to those with severe-to-profound hearing loss is that it is no longer necessary to change listening programs to access streaming from smartphones or via the Phone Clip+ wireless phone accessory. Previously, the small delay associated with changing programs to access streaming meant that some of the initial audio signal might not have been heard by the user. They might have missed out on the start of a phone conversation or the first part of a navigation system instruction. The delay in the signal could be as much as four seconds. Figure 5 uses an example of turn-by-turn navigation instructions to illustrate what might be missed with such a delay.

More ways to provide care for your patients
As with its predecessor, ReSound ENZO Q is compatible with ReSound Assist for added care and convenience outside of office visits. ReSound Assist has been shown to be a highly usable tool for asynchronous remote adjustment of hearing aids that provides similar outcomes to face-to-face fine-tuning[27,28]. ReSound Assist Live adds a synchronous option that lets HCPs and patients talk live on a video chat and adjust the hearing aids while online. A synchronous component has been shown to be especially helpful in troubleshooting minor issues such as difficulties with insertion and operation of the hearing aids, and patients may find it easier to explain their needs on a live chat than by filling out a questionnaire and sending a message[29].

Perfectly complements Cochlear™ implants

People with a cochlear implant (CI) on one ear may experience great benefits with a hearing aid fitted on the opposite ear. The Smart Hearing Alliance, a unique collaboration between Cochlear and ReSound, makes it easy to provide a bimodal solution. One important benefit of the Smart Hearing Alliance is that ReSound and Cochlear share wireless technology, so users of a bimodal solution can stream directly to their Cochlear™ implant and hearing aid simultaneously from a compatible iOS or Android device, or from a range of wireless accessories*[30].

Summary

It is a privilege to develop hearing aids that people with severe-to-profound hearing loss can trust, because hearing aids are an integral part of their lives. ReSound ENZO Q has the power – and so much more – to exceed their expectations. ReSound ENZO Q is the complete premium hearing solution for people with severe-to-profound hearing loss. Not only does it deliver industry-leading gain and output, it embodies the ReSound commitment to helping people lead their most productive lives by giving them full access to high-quality sound no matter where it comes from. They can hear better in their daily environments and enjoy seamless connectivity to virtually any audio source. Finally, the ReSound Smart 3D™ app with ReSound Assist and ReSound Assist live provides unique tools for personalization and enhanced care.

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*For compatibility information and devices visit cochlear.com/compatibility and resound.com/compatibility

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