Today’s hearing aids are generally targeted toward the active “baby boomer”, and this makes good sense. In the US, this generation is turning 70 at the rate of 10,000 people per day and a large proportion of them experience hearing loss that can be helped with amplification. Worldwide, roughly half of the general population has a hearing loss exceeding 35 dBHL by the age of 70. However, for severe and profound hearing losses, the age distribution looks quite different. In fact, half of those with severe and profound hearing loss are between the ages of 18 and 65 years, with fewer than 40% older than 65 years. This means that there is no prototypical individual with severe or profound hearing loss. They are baby boomers, Gen-X and Millennials. They are at all life stages. They are in school. They are in the labor force. Their preferences in terms of amplification are highly variable. One thing they do have in common is that they depend on their hearing aids in their daily lives. In short, their communication needs are what both hearing care professionals (HCPs) and hearing aid manufacturers would characterize as “demanding”. In spite of this need, hearing aids for severe and profound hearing losses have historically been last in line in terms of new technology developments.

As the only smart hearing aid for severe and profound hearing losses, ReSound ENZO 3D changes all that. ReSound ENZO 3D is part of a hearing ecosystem providing evidence-based solutions for people who are the most reliant on amplification. The range of connectivity options, compatibility with Cochlear™ cochlear implant, and opportunities for personalization and enhanced assistance from their HCP at their convenience are unmatched in any other hearing aid for severe-to-profound hearing losses. This paper presents three ReSound ENZO 3D users and illustrates how particular aspects of this unique hearing aid have enriched their lives.

In developing hearing aids for individuals with severe and profound hearing loss, it is a given that a high amount of maximum gain and output must be available, and that the hearing aids must be reliable and stand up to everyday use. However, because of the diversity of this severity group, other needs and desires are not as obvious. To this end, ReSound has conducted thorough qualitative research with members of this group. Common themes that were revealed included positive and appreciative attitudes toward amplification, and an acceptance of hearing loss. In addition, there is a strong desire to make the most of residual hearing ability combined with technology to “get on with it”. Not surprisingly, people with severe and profound hearing losses develop strategies to cope with limitations in their hearing. Many of these strategies are positive, such as paying attention to contextual cues, lip-reading, or manipulating the environment. However, there are also many that are less positive, such as dominating conversations in order to know what they are about, or, conversely, withdrawing from challenging situations. ReSound ENZO 3D offers technology that supports positive coping strategies and eliminates or reduces need to rely on less positive strategies. This paper presents three ReSound ENZO 3D users and illustrates how particular aspects of this unique hearing aid have enriched their lives.
Clarity and sound quality

Oscar is 23 years old and has worn hearing aids since grade school, although his hearing loss is most likely congenital. His family runs a farm, and he often pitches in during breaks from college, where he studies agriculture. Oscar was satisfied with his previous hearing aids and recognized the benefit they provided. However, there were situations he found difficult. One example was that he struggled to follow informal classroom discussions. In this situation, he reported that the speaker changes quickly and not always predictably, and the person speaking could be behind him, on either side of him, or in front. One of his coping strategies is to look at whomever is speaking, but he did not think his hearing aids supported his ability to locate and turn his attention to different people speaking very well. He often found himself straining to follow the quick changes in speaker and topic, which limited his ability to participate.

Oscar also expressed a sense of discomfort in situations where he needed to be aware of what was going on around him, such as when cycling in traffic or working on the farm. Generally, Oscar found sounds to be loud enough with his hearing aids, but lacking in clarity. He experienced hearing and communicating as quite effortful. In his words, “Where hearing is a passive activity for hearing people, for me and for people like me it is an activity you have to do. It’s work.”

ReSound has followed a unique path in applying directional microphone technology that does not focus on maximizing signal-to-noise ratio (SNR) benefit in controlled and contrived environments. The approach to using directional technology taken by ReSound is continually refined to consider how listeners will experience it in real-life, with the goal of providing the most natural listening experience possible. A hearing aid user is not just two ears. Therefore, the entire human auditory system is considered in the design, from the acoustic effects of the shape and location of the external ears on the head to the power of binaural processing by the brain.

Binaural Directionality III is the third generation of the microphone mode control strategy that meets the goal of providing a natural hearing experience. Like Binaural Directionality II, it steers the microphone configuration of two hearing instruments to support binaural sound processing by the brain. It is the only truly binaural strategy, taking advantage of scientifically proven listening strategies incorporating acoustic effects and auditory spatial attention strategies. The possible outcomes include a bilateral omnidirectional response with Spatial Sense, a bilateral directional response, or an asymmetric directional response. These outcomes were derived from research regarding the optimal microphone responses of two hearing instruments in different sound environments.

It might be questioned to what extent those with severe-to-profound hearing loss might benefit from advanced technologies like Binaural Directionality III and Spatial Sense. Given that the degree of hearing loss might severely restrict the audibility of the effects of special processing, this is a valid question. Binaural Directionality III has previously been demonstrated to provide individuals with mild-to-moderate hearing loss improved speech recognition in noise while greatly improving audibility of sounds not in front relative to the most advanced binaural beamforming technologies. For those with more severe loss, it was observed that absolute performance on speech-in-noise recognition was unsurprisingly worse. However, the benefit relative to other advanced directional technology was clearly shown. Regarding Spatial Sense, performance on a localization task showed that those with severe-to-profound hearing loss did benefit as well. The magnitude of
Behind To the left in noisy environments with speech in front cally changes microphone mode to a directional response
recommendations to use Softswitching, which automati loudness balancing. Her default program also conforms to diologist fit her hearing aid by first mapping the CI, then hear in noisy conditions is a top concern for her. Amy's au
as a cruise director so being able to talk with people and
ENZO 3D 998 super power BTE on the other. She works
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years old. Today she is a bimodal user with a cochlear
progressed throughout her childhood and into adulthood.
Amy is 48 and has had lifelong hearing impairment that
Bimodal hearing and connectivity

For Oscar, ReSound ENZO 3D made an impressive differ-
ence in the very situations where he had previously strug-
gled. While his speech-recognition-in noise results with a
conventional speech-in-noise test in the clinic were similar
to those with his previous state-of-the-art directional hear-
ing aids, he reported that in his daily life, he was able to fo-
low conversations in classes and other activities with less
effort. He stated that he did not feel “worn down” at the
end of each day. He even remarked that “I almost feel like
a normal hearing person” in describing the way in which
he is able to follow what is happening around him without
having to think about it in a deliberate way.

Bimodal hearing and connectivity

Amy is 48 and has had lifelong hearing impairment that
progressed throughout her childhood and into adulthood.
She did not wear hearing aids regularly until she was 17
years old. Today she is a bimodal user with a cochlear
implant (CI) from Cochlear on one ear and the ReSound
ENZO 3D 998 super power BTE on the other. She works
as a cruise director so being able to talk with people and
hear in noisy conditions is a top concern for her. Amy’s au-
diologist fit her hearing aid by first mapping the CI, then
fitting the hearing aid to NAL-NL2 targets and performing
loudness balancing. Her default program also conforms to
recommendations to use Softswitching, which automati-
cally changes microphone mode to a directional response
in noisy environments with speech in front\(^2^1\).

Amy had always avoided phone communication before
her current fitting. Her strategy was to use texting and
emails rather than making a call. If she received a phone
call, she would not answer but let it go to voicemail. Then
she would listen multiple times to the voicemail message
or even have someone else listen in order to be prepared
for returning the call. She found that if she did not know
in advance what the call was about, she could not under-
stand well enough to complete the conversation at all. “It
was like if you got a call from someone speaking a foreign
language to you except that I could also not even hear the
voice very well.” Because Amy’s implant is from Cochlear\(^2^4\)
with the Nucleus 7 processor, she has a complete range
of wireless streaming accessories that are compatible with
both her implant and her ReSound ENZO 3D hearing aid.
This includes receiving calls and audio from her iPhone. “I
avoided using my phone before. But now I have no hesi-
tation picking up because I get the sound straight in my
ears. And I would say to people, don’t use the landline,
even though it has volume control, because this way you
get more clarity.” Amy’s experience with the phone mir-
rors results from Wolfe et al (2015), who tested bimodal
users’ speech recognition in quiet and in a noisy environ-
ment when listening to a mobile phone held up normally
to the CI microphone versus streaming bilaterally via the
ReSound Phone Clip+. The improvement with bilateral
streaming averaged 25% in quiet and 23% in noise.

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 understand-
ing\(^2^3\). Amy also found that by adding visual cues via a
video chatting app such as Facetime, her conversations be-
came even easier and more enjoyable. “But now if I Face-
time with my sister, it’s connected to my hearing aid and
my implant and it’s much clearer. I can pick up the words,
I can pick up the dialogue, it’s so much clearer. And the
background noise gets cut off completely.” This is not sur-
prising considering the degree of benefit for audio stream-
ing combined with visual cues reported by Jespersen &
Kirkwood\(^2^5\). Their study participants showed an additional
average benefit of 23% when streaming bilaterally to hear-
ing aids combined with Facetime relative to streamed au-

![Figure 2. Results from a difficult speech recognition task, where parti-
cipants had to locate and repeat sentences that were presented simultane-
ously from three different directions. When the target speech was in front,
study participants performed equally well in locating and understanding
the target speech with ReSound ENZO 3D as they did when wearing hear-
ing aids with binaural beamforming. When speech originated from the left
or behind the participant, performance with ReSound ENZO 3D far exceed-
ed that when wearing the other hearing aids.]

![Figure 3. Amy’s audiogram for the ear fit with ReSound ENZO 3D.]

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**Figure 3. Amy’s audiogram for the ear fit with ReSound ENZO 3D.**

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dio only. Compared to using the phone acoustically at the
hearing aid microphone unilaterally, there was an average
improvement of more than 70%. This was true regardless
of whether direct connection to the iPhone was used or
whether the ReSound Phone Clip+ was used for the audio
connection. This means that the benefit of the video chat
ing is not limited only to iPhone users, as any smartphone
can stream audio to the ReSound ENZO 3D hearing aids
as well as the Cochlear Nucleus 6 and Nucleus 7 processor
via the ReSound Phone Clip+.

For Amy, the ReSound Multi Mic has also proven to be criti-
cal to her success with communication in many environ-
ments and particularly in her job. She reports using both
the table mic mode as well as clipping the microphone
onto her conversation partners with good effect. She re-
counted a story from one of her cruises about a dinner with
guests at a long table. By placing the ReSound Multi Mic on
the table further away from herself, she was able to con-
verse not only with people directly beside her, but also with
a couple who were sitting a couple of seats away. This was
not something she had ever been able to do before. Amy
was tested using the Hearing in Noise Test (HINT) with her
bimodal fitting alone and with bimodal streaming to her
ReSound ENZO 3D hearing aid and CI from the ReSound
Multi Mic. The ReSound Multi Mic was placed in front of
the speaker that delivered the speech material for the lat-
er condition. With the bimodal fitting, Amy performed at
an SNR of -3 dB, which in itself was impressive. However,
with the ReSound Multi Mic, her performance improved to
an astounding -23 dB SNR.

Added convenience and control
Steven is 63 years old and works as a property developer.
He has a very busy schedule and is frequently away from
home. Steven spends a lot of time driving and needs to
take calls while in the car. This was challenging for him
with his previous hearing aids. Usually, he tried to listen to
the phone calls through the car’s Bluetooth but did not
find it clear enough. Another issue he reported relates to
the varying listening environments in which he finds him-
self. Apart from being in the car, he has a great need to
be able to hear on the phone, he participates in frequent
meetings where he must negotiate, and he often visits
job sites where he is outdoors and there may be a good
deal of noise from construction equipment. He has found
himself trying to make volume adjustments or to try dif-
ferent listening programs that his HCP had put in his hear-
ing aids in order to hear better in these different environ-
ments, but often just gave up because the effort involved
seemed greater to him than any benefit. He stated that he
didn’t really know what was different about the programs
and didn’t understand or remember how he should be us-
ing them. Because his schedule is unpredictable and he is
often away from home, he has not found it easy to seek
additional help from his HCP. “If you need help, you need
help. I guess my problem is just that it’s so far away, so you
get a bit reluctant. Plus the nature of my job, it’s so hard to
take the time off to go see them.” Steven also recognized
that his listening situations might require specific settings
to be optimal for him: “The hearing aids are set up in a
quiet room, it’s not really everyday life. That’s not really a
benefit.” As a regular smartphone user, he believed that he
could most effectively find and try new settings on his own
rather than having to go back-and-forth to his HCP. “They
could just make an app on the phone, so you were able to
do it yourself.”

Figure 4. Compared to using the phone acoustically, bilateral streaming
alone provides more than 45% benefit. By adding visual cues via a video
chat app, more than 70% added benefit is attained.

Steven was fit with ReSound ENZO 3D 998 super power
BTE bilaterally. He also added a ReSound Phone Clip+ and
a ReSound Micro Mic to his hearing system. Because of
his need for hands-free phoning in the car, the ReSound
Phone Clip+ seemed to offer the best solution because of
the microphone to pick up his voice even though he did
have an iPhone and could stream calls directly. This elimi-
nated the need for him to hold his iPhone to have it near
enough to pick up his voice well in the car. Apart from the
streaming programs, Steven was fit with one program that
has Binaural Directionality III with Spatial Sense, and an
additional program with Autoscope adaptive directionali-
ity, NoiseTracker II noise reduction, and WindGuard wind
noise reduction. He downloaded the ReSound Smart 3D
app to his iPhone primarily to be able to experiment with
adjustments for different environments. Steven also ac-
cepted the ReSound Assist option25, which would let him
contact his HCP and ask for assistance remotely, without
having to make a special visit.

After a week of wearing the hearing aids, Steven sent a re-
quest to his HCP using ReSound Assist. One observation
was that he preferred a lower overall volume regardless of which program or listening situation he was in. By experimenting with the Sound Enhancer features in the ReSound Smart 3D app, he had also been able to find settings that he saved as favorites for some of his usual listening environments. Finally, he had also realized that the theater he sometimes attends has an induction loop system and wondered if he could connect to it to improve his experience. Acting upon his request, Steven’s HCP fine-tuned his fitting in the Smart Fit software to have less volume, and a telecoil program was added. These settings were sent to Steven via the secure cloud connection, and he was able to download them to his hearing aids at his convenience while traveling. This allowed Steven to try out the new settings in his actual daily life environments. He had the opportunity to ask for further adjustments in this way if needed. At his next visit, Steven expressed great satisfaction with both the adjustment possibilities available to him in the app, as well as the opportunity to get help easily without having to make time for an extra visit.

Summary
People with severe-to-profound hearing loss are highly dependent on amplification. They develop effective strategies for coping with hearing difficulties, and are interested in how technology can help them even more. ReSound ENZO 3D provides exceptional solutions that are of particular benefit. With the highest gain and output available today, ReSound ENZO 3D delivers clear sound that improves hearing in noise without limiting awareness of other sounds in the environment. The range of connectivity options, compatibility with Cochlear CI, and opportunities for personalization and enhanced assistance from their HCP at their convenience are unmatched in any other hearing aid for severe-to-profound hearing losses. The three users discussed in this paper illustrate how ReSound ENZO 3D can benefit people with the most severe hearing losses in ways that go beyond what conventional hearing aids have been able to provide.
References


