ReSound Alera™

ReSound Alera™ audiology background
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1. INTRODUCTION

A significant consequence of hearing loss is that it can be isolating for the individual, as the ability to
participate normally in social and work-related activities is restricted by communication difficulties.
Not only that, use and enjoyment of devices that those with normal hearing take for granted - such as mobile and landline telephones, televisions and radios – can also be problematic. Even
hearing instrument users can face issues both in terms of communication as well as making use
of communication devices. For example, hearing instruments may interfere with social interactions
when amplification must be reduced to prevent acoustic feedback. Speaking on a cell phone can be
hampered by interference from the phone as well as feedback. In a sense, individuals with
hearing loss experience a disruption in the connections that touch all aspects of their lives, whether
those connections are social, device-related or just being oriented as to what is happening in one's
surroundings. Using this idea of connections as inspiration, ReSound sought and applied state-of-
the-art wireless and non-wireless technologies including Surround Sound by ReSound to create
a hearing system providing true benefit to hearing impaired wearers. ReSound Alera™ combines
technologies that connect users to the people and sounds around them, to essential communication
devices and to their lifestyle.

UNDERSTANDING USER NEEDS THROUGH MARKET RESEARCH

To support and guide the development process, Resound investigated how users’ requirements
are and are not being met by current high-end hearing instruments. Extensive interviews were
carried out in the US, Germany and France with hearing instrument wearers in addition to a survey
of more than 450 hearing care professionals who had experience fitting hearing instruments with
wireless features from a range of manufacturers. Feedback from the end-users indicated that
most were not generally well-oriented regarding wireless features in hearing instruments. One
message that was clear from this group was that there was a strong desire for their devices to
function well in varying situations. Apart from being able to follow conversations in different types
of listening environments, they mentioned the importance of hearing when driving, being able
to localize sound sources, watching television, and talking on the phone. Also mentioned were
frustrations in dealing with overly loud sounds and hearing instrument whistling. These results
are in good agreement with the finding that user satisfaction with hearing instruments is strongly
related to the number of situations in which the devices are found to be useful¹. Furthermore,
wireless applications were recognized as potentially adding to the utility of hearing instruments in a number of important situations.

The survey responses of the hearing care professionals indicated that they judge hearing instruments with wireless features to be of benefit to their clients. More than 70% responded that their clients fit with such devices were “more satisfied” or “much more satisfied” than those fit with hearing instruments not having wireless features. However, they tend to reserve fitting this type of product to their younger, technically savvy clients. This finding seems surprising in light of the fact that facilitating television viewing and cell phone usage were rated in this survey as the most desired improvements in wireless features. Watching television is a common activity for all ages and cell phone usage has also become widespread across age groups.

Regarding fitting of such hearing instruments, most of the professionals interviewed indicated that there was no difference from fitting conventional programmable hearing instruments. However, several found fitting of hearing instruments with wireless features to be more cumbersome: “It is additional work, more difficult, and the patient has something else to learn.” Based on their knowledge and experience with hearing instruments currently available, only a few saw opportunities for improving or simplifying the fitting process with wireless technology.

Conclusions drawn from this research were that both wireless and non-wireless features could be combined to add benefit for hearing instrument users and that these benefits would be easily recognized. However, a successful product would require simplicity for both the user as well as the fitter.

A CORE UPGRADE FOR ADDED FUNCTION

ReSound® hearing instruments are software-based, which means that the sound processing is determined by the software that is loaded on to the instrument’s computer processor. While many new hearing instruments can be built on a particular computer processing platform by writing new software, major advancements and new functionality sometimes require an upgrade to the computer chip. The ReSound Alera is the first hearing instrument to utilize the Resound Range™ chip, which doubles the processing speed and triples the memory compared to existing technology. An enhanced output stage to this chip further extends the dynamic range, virtually eliminating the noise floor. This improvement to the underlying platform provides a step up in sound quality and makes Alera the ideal instrument for fitting clients who have regions of good hearing and are sensitive to even the slightest amount of noisiness.

The ReSound Range™ incorporates a proprietary 2.4 GHz radio, which was selected for its ability to provide strong connections over a range of up to 10 meters. Existing wireless hearing instrument solutions build on near-field magnetic induction, which has an extremely limited range of connectivity. So limited in fact, that wearers of current wireless hearing instruments must also wear a gateway device to receive sounds from any sources beyond 1 meter and transfer them on to the hearing instruments. This adds complexity and inconvenience to the system and for the user. An additional issue with the current wireless technology in hearing instruments is that the transfer of audio data from the sound source to the gateway device and on to the hearing instruments can take anywhere
from 35 ms to 120 ms depending on the product. While this may be acceptable if listening to a sound-only source, such as a radio, it will have disturbing perceptual effects like echoes or lack of synchronization between the sound and picture when watching television. In stark contrast to such a long lag in signal transmission, the streaming delay for audio signals for the ReSound system is just 18 ms.

2. CONNECTING TO PEOPLE AND SURROUNDINGS WITH SURROUND SOUND BY RESOUND

“Natural hearing is what we all want.” (hearing instrument user on desired improvements)

Roughly half of current hearing instrument users are satisfied with their devices as “natural-sounding”\(^2\), a statistic which leaves much room for improvement and which has not changed significantly throughout the era of digital hearing instruments. “Natural” sound quality relates to the holistic experience of hearing and perceiving sound, encompassing fidelity and qualitative dimensions as well as understanding speech. When sound is experienced as natural, the listener can effortlessly segregate and group the continuous stream of sound in the environment. A hearing instrument achieves natural sound quality by preserving spectral, dynamic, and temporal aspects of the input sound to an extent that higher level auditory and cognitive processing can interpret these physical attributes and construct auditory environments. Surround Sound by ReSound combines advanced features that preserve and convey acoustic information to provide a rich, full sound picture so that wearers can connect with their actual environments.

WARP™ SOUND PROCESSING: CLOSER TO NATURAL HEARING

Warp processing forms the backbone of Surround Sound by ReSound. In addition to establishing Wide Dynamic Range Compression as a method to compensate for the lost compressive non-linearity of the damaged cochlea, ReSound is the first and only manufacturer to base amplification on an accurate model of cochlear frequency analysis through frequency warping. While most digital techniques for frequency analysis yield constant bandwidth with uniform spacing of the bands, the ReSound system efficiently resolves frequencies into 17 smoothly overlapping frequency bands corresponding to the auditory Bark scale\(^3\). The Bark scale incorporates the human auditory system critical bandwidth as the scale unit\(^4\). Apart from the intuitive logic of a scheme which replicates auditory system frequency analysis, frequency warping has the added advantages of effectively no distortion and exceedingly short processing delay.
SURROUND SOUND PROCESSOR FOR THE BEST POSSIBLE SOUND TREATMENT

“I was at a conference last week, there was a speaker and questions from the audience. I had to turn my head all around to find out who was asking questions, I had no idea if they were at the left, the right, or behind me. Your colleagues look at you strangely, because you move like that all the time“ (hearing instrument user on not hearing naturally)

Another feature contributing to surround sound quality which was developed to emulate the human ear is the surround sound processor. This technology gives wearers the advantages of directionality without compromising on sound quality. The idea behind the surround sound processor is to promote good speech intelligibility and natural sound quality by preserving the acoustic characteristics of the open ear. This unique technology considers the individual’s audiometric data and physical properties of the device in calculating a personalized mix of directional and omnidirectional processing. Incoming sound will be preprocessed, with higher frequency components delivered to the directional system while an omnidirectional response is maintained in low frequencies. This processing strategy replicates directionality patterns of the unaided ear even for BTE microphone placement, contributing to natural perception of sound for the user. Figure 1 illustrates how the surround sound processor preserves open ear directional characteristics. The left panel shows the open ear directional response for 4 frequencies measured on KEMAR. Note how the response is omnidirectional with only subtle asymmetries for the 2 lower frequencies while in the higher frequencies there is relatively more amplification for frontal incident sound than for sound coming from other directions. The right panel presents the same measurement performed with a Resound Alera™. The surround sound processor ensures that the directional characteristics with the hearing instrument in situ are a good match to those of the open ear.

Figure 1. The surround sound processor creates spatial directivity patterns similar to the open ear.
The surround sound processor also solves byproducts of directional processing that have limited even the most advanced adaptive systems, including added noise from low frequency equalization, distortion of near-field sounds such as own voice and wind, as well as disruption of the low frequency interaural time differences which are crucial for localization. These shortcomings of directionality can be perceptually significant enough to cause wearers not to use an otherwise beneficial feature of their hearing instruments. In their laboratory study investigating the impact of visual cues on directional benefit, Wu and Bentler\textsuperscript{5} reported that many individuals fit with an equalized directional response experienced a “hissing sound”. In a subsequent field trial\textsuperscript{6} with the same participants and hearing instruments, these investigators determined that loudness and internal noise were the most important predictors for preference of omnidirectional microphone mode over directional. Other studies have also demonstrated strong preferences for omnidirectional microphone mode even in situations where directional processing should be of benefit\textsuperscript{7,8}. The surround sound processor provides a directional pattern closer to a person’s own, thereby striking a natural balance between environmental awareness and directional advantage. The result is sound closer to the way hearing instrument wearers remember their acoustic world – what they describe as “natural” sounding.

Evidence has been mounting in support of the benefits afforded by the surround sound processor. Three studies\textsuperscript{9,10,11} investigated the effects of directional processing schemes on sound quality. These investigations used a double-blind design in which hearing-impaired listeners expressed a preference for the surround sound processor, omnidirectional processing or a conventional full directional response. As illustrated in Figure 2, listeners indicated an overwhelming preference for the sound quality of omnidirectional processing over full directional with or without low frequency equalization. When comparing to the surround sound processor, listeners preferred this processing over full directionality more than twice as often.

In addition to sound quality, the surround sound processor has also been shown to contribute to localization ability\textsuperscript{12}. Van den Bogaert and colleagues asked hearing impaired listeners to perform localization tasks wearing BTE hearing instruments with the surround sound processor and BTE hearing instruments featuring an ear-to-ear algorithm designed to enhance localization via wireless coordination of settings bilaterally. While performance for right-left localization was similar in both

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\textbf{Figure 2.} Hearing instrument wearers expressed a sound quality preference for a directional response when achieved with the surround sound processor twice as often as traditional directionality.
conditions, participants made more than twice as many front-back confusions when wearing the devices with the ear-to-ear feature than when wearing the instruments with the surround sound processor (Figure 3).

Figure 3. Hearing impaired listeners fit with BTE devices with the surround sound processor performed better on a localization task than when fit with BTEs featuring ear-to-ear processing intended to improve localization.

UNDISTORTED SOUND QUALITY

“It’s really annoying and it hurts my ear too” (hearing instrument user on acoustic feedback)

Since last reported in 2004, user satisfaction with hearing instruments in terms of “whistling and feedback” has shown a significant 12% improvement\textsuperscript{13}. This period of time coincides with the proliferation of feedback cancellation algorithms in digital hearing instruments, which suggests that manufacturers are on the right track to improve users’ experience with hearing instruments with this type of processing. Feedback cancellation processing can increase the amount of gain available for a particular fitting by 15 dB or more in a static situation where there are no dynamic variations in the feedback path due to client movement or changes in the acoustics of the environment. However, feedback cancellation systems are limited in their ability to operate effectively in dynamic real-world situations. Factors such as room reverberation and nonlinearities of the hearing instrument can cause the very whistling and chirping that the processing is intended to eliminate. To complicate matters further, most systems cannot distinguish between actual feedback and external sounds that may be correlated with feedback. Such sounds include tones, beeps and musical notes, and the failure of the feedback cancellation system to recognize these sounds often results in disturbing echoing or ringing artifacts. As a result, they must compromise on balancing performance in terms of gain, sound quality and critical situations such as phone usage. For example, providing the desired amplification means the wearer may have to tolerate poor sound quality as the system erroneously attacks non-feedback sound inputs.
ReSound technology has long led the field in immunity to such processing artifacts with its use of two cancellation filters, adaptive filter constraints and separate cancellation filters for dual microphone instruments. A new generation of feedback cancellation, DFS Ultra, represents a major breakthrough in feedback cancellation processing. In addition to technical enhancements that enable even more accurate feedback path modeling, a new component of the system is input signal modeling. Unlike other systems which only attempt to model the feedback path, this unique functionality also maintains a representation of the sound entering the hearing instrument (Figure 4). The advantage of this component is that the system can more easily distinguish between feedback and non-feedback sounds, vastly improving the dynamic behavior of the system. Important everyday sounds like phone rings, alarm beeps and music can be amplified to desired levels without being mistaken for feedback.

DFS Ultra also incorporates WhistleControl™ to ensure feedback-free performance in all daily life situations, including when a phone is held up to the hearing instrument. Because the feedback cancellation is constrained to not adapt to signals that are very disparate from the feedback pathway model, it is possible for intermittent feedback to occur in situations like this. WhistleControl™ restores...
the desired response when feedback is imminent (Figure 5). The combination of DFS Ultra in effect solves the most challenging dilemma of the last decades’ growth in popularity of open fittings – how to provide sufficient, undistorted high frequency gain without feedback.

CASE STUDY: DFS ULTRA

EW is an example of a client who has been challenging to fit. He has normal hearing up to 1000 Hz above which his hearing loss drops precipitously. Although he is the type of candidate who is most suited to an open fitting to avoid occlusion related issues, he had been somewhat dissatisfied with hearing instruments due to feedback. With his previous open fit devices, the maximum stable gain for EW was approximately 25 dB at 3000 Hz without any feedback cancellation processing. This is slightly higher than average for open fit miniBTE devices so EW is not atypical in this respect. The prescribed insertion gain at 3000 Hz for EW is around 30 dB for many fitting rationales. This means that a good portion of the added stable gain due to feedback cancellation would be used just to prevent feedback in a static situation, and there is less leeway for the system to handle dynamic changes in the feedback path. With his own hearing instruments, EW reported experiencing constant feedback on his left device when driving, and intermittent feedback from both instruments in other situations. Although he did not always hear it himself, his wife was quite annoyed by it and it was the cause of some embarrassment for him. EW had tried having his devices adjusted with less high frequency gain, but found that he lacked clarity and derived less overall benefit.

A “NO COMPROMISE” FITTING

When fit with the ReSound Alera, the maximum stable gain without DFS Ultra was comparable to that with his previous hearing instruments. Speech-in-noise testing showed a significant 2.1 dB signal-to-noise ratio improvement over his previous hearing instruments, most likely due to the added stable high frequency gain made possible by DFS Ultra. In addition, he reported being able to wear the devices in all daily situations without feedback occurring. In EW’s case, the robust performance of the DFS Ultra enabled a fitting with no compromises. He was provided with the appropriate gain in an open fit without the bothersome feedback issues he had to tolerate with his previous hearing instrument.

Figure 6. EW has a severe high frequency hearing loss and has been dissatisfied with open fit hearing instruments due to intermittent feedback. Adequate gain was possible without compromising on sound quality with ReSound Alera thanks to DFS Ultra and Whistle Control.
IMPROVED FEEDBACK SYSTEM CALIBRATION

An additional challenge historically faced by professionals fitting hearing instruments with feedback cancellation technology has been activating the system during the fitting. Most require a proprietary “feedback test” that necessitates the client sit quietly for a time ranging from more than 10 seconds per ear to over a minute while being subjected to loud tones, buzzing or whooshing sounds from the hearing instruments. This measurement is used to determine the feedback path for the individual fitting, but is incomprehensible, uncomfortable and sometimes even intolerable for clients. Fitting of DFS Ultra also solves this dilemma with an optimized calibration procedure. An accurate feedback path measurement requires an adequate signal-to-noise ratio (SNR) of the test stimulus at the hearing instrument microphone. Therefore, test signals used by different manufacturers for their proprietary feedback tests are presented at intense levels to ensure good SNR. The ReSound Alera is the first hearing instrument which monitors the SNR during the calibration and stops the test when an adequate level has been reached and sufficient data collected for a precise analysis of the feedback path. This results in a signal level which is an average of 9 dB lower than for ReSound legacy products. The duration of signal presentation averages only 1 second. Hearing instrument wearers clearly judge the SNR-based calibration routine as more comfortable. Figure 7 shows how subjective loudness ratings of hearing instrument wearers compare for Alera versus ReSound legacy products. Ninety-two percent of ratings for Alera DFS calibration were either “Soft”, “Comfortable” or “Loud” whereas only 64% of ratings for legacy products fell into these categories, with the remaining 36% being “Very loud” or “Too loud”.

![Figure 7. Loudness ratings of the calibration signals for ReSound Alera with DFS Ultra and ReSound legacy open fit products. The DFS Ultra calibration signal is much more comfortable for clients.](image)

NOISETRACKER II: PERSONALIZATION FOR GREATER COMFORT

“The first time I came into the street with my hearing instruments I almost passed out, all the sounds were so strong.” (hearing instrument user on experiencing different acoustic environments)

Most people encounter many dynamic listening environments throughout the day, with each offering its own unique challenges in terms of listening and communicating. The demands of hearing in the
car versus the grocery store or coffee shop are different. Some environments are favorable for a hearing impaired listener as the signal-to-noise ratio is positive and sound levels comfortable, others are much more difficult. As mentioned previously, overall hearing instrument satisfaction has been correlated to a hearing instruments ability to provide improved hearing in multiple listening environments\(^1\), which is to be expected considering that they are intended for continual wear. All hearing instrument fittings begin with some sort of prescription of settings based on client data, usually an audiogram. Yet the presumption that one set of hearing instrument parameters will meet the listening needs of an individual in all conditions is clearly not met. It is reasonable to say that the goal of fitting prescriptions is to provide amplification for optimum speech understanding while ensuring comfort for loud sounds. Even if achieved for a particular individual, this would not take into account that the wearer might want to enhance or diminish different aspects of the amplified sound in different situations. For example, a hearing instrument wearer might desire more volume than prescribed in an important meeting at work, but wish for less volume when relaxing with the newspaper on the train ride home several hours later.

INDIVIDUALLY TAILORED ADAPTIVE NOISE REDUCTION

An automatic, personalized volume control such as the Environmental Optimizer\(^\text{TM}\) solves some of the negative and impractical issues related to frequent or necessary manipulation to a manual volume control or program switch. However, this functionality combined with individually tailored adaptive noise reduction is an extraordinary solution to the complaints of hearing instrument users—both the need to adapt to multiple listening environments and comfort in noise are addressed. Environmental Optimizer II automatically adjusts both the gain and NoiseTracker\(^\text{TM}\) II settings dependent on the listening environment identified by the hearing instrument classification system. Based on the situation dependent volume preferences of hearing instrument wearers in a study at Oldenburg University\(^15\) as well as internal research studies, the Environmental Optimizer\(^\text{TM}\) prescribes volume offsets to the prescribed frequency response and optimized NoiseTracker\(^\text{TM}\) II settings for 7 different acoustic environments. Each of these settings can be personalized for the individual through the ReSound Aventa\(^\text{®}\) 3 software.

The Environmental Optimizer\(^\text{TM}\) II allows for seamless changes to hearing instrument function in order for the user to adapt to the many listening situations one could potentially encounter. Although situation dependent preferences for both volume and noise reduction have been demonstrated\(^15,16\), clinical experience with environmentally dependent changes in hearing instrument settings indicates that wearers prefer changes in hearing instrument settings to be small and gradual for acoustically similar environments. For example, the acoustical environment during a dinner at home with friends may shift from low level speech to speech-in-noise and even to noise with the ebb and flow of conversation and laughter. In this situation, large, quick changes in hearing instrument settings would probably be perceived as drastic and distracting to the wearer. The advanced classification system that steers the Environmental Optimizer II settings still uses seven categories to classify acoustic environments.
However, in the many cases where the environment does not clearly fall into one category or when the environment rapidly changes, an algorithm steers the volume and NoiseTracker II settings to a continuously changing linear combination of the prescribed settings for the three most probable categories. Because of the hearing instrument’s continuous ability to access combinations of classifications, gradual behind the scene changes to the hearing instrument function allow for the wearer to experience transparent sound transitions.

**UNIQUE USE OF SPECTRAL SUBTRACTION**

Environmentally dependent noise reduction settings make little sense unless the algorithm offers benefit in environments where speech is present. The NoiseTracker II system uses spectral subtraction, one of the most widely used methods for enhancement of noisy speech in audio applications. The concept of spectral subtraction is to subtract the short-term noise spectrum from the total signal, leaving only the speech portion. Although the concept is easy, the implementation is not. The success of this strategy hinges on being able to identify speech and to precisely characterize noise. An additional challenge is to keep up with the dynamic speech and noise make-up of real listening environments. Finally, it is important for hearing instrument users that not all noise be removed from the signal, and that the noise characteristics be preserved. If all ambient noise were removed or if the spectrum of the noise background was altered, this would create an unnatural-sounding experience. Background sounds do need to be audible to the degree that users can recognize and orient themselves in their listening environments. Ultimately, the goal is undistorted speech at the prescribed gain, and undistorted noise at lower gain.

*Figure 8. Optimized levels of NoiseTracker II are prescribed per environment type and can be further personalized in the Aventa3 fitting software.*

*Figure 9. Speech in speech babble is the most difficult situation for noise reduction systems to handle. The NoiseTracker II spectral subtraction approach can effectively reduce the level of the background noise (blue) without affecting audibility of the desired speech signal (red).*
3. CONNECTING TO ESSENTIAL COMMUNICATION DEVICES

The ReSound Alera is the first hearing instrument to implement wireless features based on 2.4 GHz. As mentioned previously, transmission at this frequency provides robust connections even at long ranges, which means simplicity, freedom and convenience for the user. Stable wireless communication directly to the hearing instruments can occur without the use of intermediate devices to boost the signal. The wireless connections which can be made with the ReSound Alera™ hearing instruments are illustrated in Figure 9. The ReSound Unite™ accessories which wirelessly interface with the hearing instruments include:

- the AirLink™ for wireless fitting,
- the Unite™ TV Streamer for use with televisions, radios, stereos, PCs or any other equipment with audio output,
- the Unite™ Phone Clip for use with Bluetooth enabled mobile phones, and
- the Unite™ Remote Control for easy management of the hearing instruments and accessories.

THE FIRST TRULY WIRELESS FITTING

The first experience a hearing instrument wearer usually has with the new devices is that they are plugged into cables and secured to a desktop programming interface. Not only is this an unnatural and somewhat intimidating situation, the cables themselves can interfere with the fitting. First and foremost, cables can fall out or be pulled out during the fitting. The client is effectively tethered in place by the cables, precluding moving around or going outside the fitting room to evaluate the sound of the hearing instrument in other surroundings. The ReSound Alera™ can be fit wirelessly via the Airlink, a device similar in size and appearance to a jump drive that plugs into the USB port of the fitting computer. Neither cables nor intermediate devices are required as the range for communication between the Airlink and the hearing instruments extends to at least 3 meters. Clients don’t need to wear anything but the hearing instruments, and if they move outside the range of the Airlink to listen elsewhere, re-establishing the connection is uncomplicated when they return.

INTUITIVE DESIGN

The ReSound Aventa® 3 fitting software for programming the ReSound Alera™ is another industry first. Drawing from cognitive psychology and the science of human-computer interface, the design of Aventa3 is the first hearing instrument fitting software that focuses on the user rather than engineering requirements or the latest computer animation techniques. The development process was based on rigorous research to understand the user’s requirements, the user’s behaviors, and how the system would be used. The design was iteratively
tested with users to ensure that it facilitated hearing instrument fitting tasks. Although the underlying software technology is state-of-the-art and the appearance sleek and modern, Aventa® 3 features no “bells and whistles” that do not serve the hearing instrument fitting process. All functionality reflects user needs and task flow.

RESOUND UNITE™ TV

"It is a problem for me – or maybe rather my wife – that I have to turn up the volume. Often she just leaves the room and that is kind of isolating me" (Hearing instrument user on television viewing with others)

As revealed by the market research that influenced product development, enhancing the television viewing situation was rated as the most desired improvement in terms of wireless capabilities. Disagreement over the television volume setting can be problematic even in families where no one has hearing loss, so it is no surprise that this is a great issue among families with one or more hearing impaired members. In a review of emerging technologies for wireless connectivity, Bloom called for direct transmission to hearing instruments from audio sources and further predicted that overcoming the obstacle of an inconvenient gateway device would represent a breakthrough for the industry and for users.

The Resound Unite™ TV Streamer is such a breakthrough – it connects to the audio output of a television or other audio device and transmits the sound directly to the hearing instruments. The hearing instrument program used for audio streaming can have the hearing instrument microphones turned on or off according to whether the user also wants to be able to hear and converse with others while listening to the streamed sound.

The delay in transmission of the sound from the Unite TV streamer to the ReSound Alera™ hearing instruments is critical for sound quality, particularly if the microphones are active or if the user can otherwise hear the direct sound from the television or audio source such as in an open fitting. The delay in the streamed sound to the ReSound Alera™ is 18 ms, which is the lowest of current technologies in hearing instruments. Delays exceeding 25 to 30 ms can be perceived as clear echoes when direct sound also is audible to the wearer. Not only is the delay between the Unite TV streamer and the
Alera instruments well below this, it is also in a range which actually can be beneficial for the wearer in terms of speech recognition. An echo occurring below 30 ms that is similar in level to the direct sound is integrated by the auditory system consistent with combining the two signal powers\(^19,20,21\). Delay is also critical for audio-visual synchronization. Disturbing “lip synch” issues occur when the difference between the audio and visual signals reaches 80 ms\(^22\). Delay of the streamed sound from the source to the hearing instruments ranges from 35 ms to more than 120 ms for other devices currently available. In addition to the short transmission range, and the inconvenience of wearing an intermediate device, the degraded sound quality and degraded audio-visual integration can easily lead to user dissatisfaction.

**CONVENIENCE AND BINAURAL HEARING ON THE PHONE**

"I really need to almost glue the phone to my ear to hear the person at the other end of the line and it actually hurts both my hand and my ear" (hearing instrument user on using the telephone)

Phone conversations are more difficult than face-to-face conversations regardless of whether or not you have a hearing loss. For one thing, visual cues to speech are not available. In addition, the transmission frequency bandwidth for the telephone is limited to the range of 300-3000 Hz, eliminating useful acoustic information for identification of fricative sounds. Additional variables such as quality of the connection, the individual telephone, and noise in both the speaker’s and the listener’s environment can make hearing on the phone even more challenging. Even individuals with relatively mild hearing losses may experience great difficulty in using both landline and cell phones.
For hearing instrument users, acoustic feedback with any phone and radio interference with the hearing instruments from cell phones can add to the frustration. Anticipated problems using the phone are also an obstacle to not acquiring hearing instruments\(^{23}\) and ReSound’s market research indicated that improved connectivity to cell phones was the second most desired improvement in terms of wireless hearing instrument features.

The ReSound Unite\(^{\text{TM}}\) Phone Clip is a tiny device that clips onto clothing or a car visor and functions just like a Bluetooth® headset. When paired with a Bluetooth\(^{\text{®}}\) compatible cell phone, the user can answer and speak on the phone as well as turn the volume up and down even if the phone is in a pocket or handbag. The Unite Phone Clip streams the sound to both hearing instruments, a critical advantage in improving hearing on the phone. Speech recognition by hearing impaired individuals has been shown to improve markedly when listening binaurally versus monaurally\(^{24}\).

**RESOUND’S LANDLINE SOLUTION**

For improved telephone performance with landline phones, ReSound Alera also incorporates PhoneNow\(^{\text{TM}}\). With this feature, a magnet placed on the telephone handset automatically activates a specially tuned acoustic telephone program when the wearer holds the phone up to their hearing instrument. The PhoneNow\(^{\text{TM}}\) acoustic telephone program is individualized according to the user’s audiogram and emphasizes the telephone transmission frequencies. Combined with DFS Ultra, PhoneNow\(^{\text{TM}}\) facilitates telephone use without interference from acoustic feedback.

**EASY ACCESS TO HEARING INSTRUMENT FUNCTIONS**

“I never know how to get back to default mode. So, in order to do that, I turn off the hearing instrument and turn it on again, that way it resets automatically. I cannot find the buttons behind my ear” (Hearing instrument user on operating the devices)

Non-auditory factors such as impaired vision and reduced manual dexterity can affect how well individuals are able to make use of their hearing instruments\(^{25,26}\). One solution that can make manipulating hearing instruments easier is via a remote control. The ReSound Unite\(^{\text{TM}}\) Remote Control provides a large, clear display and easy-to-operate buttons to change volume, program and to activate and de-activate streaming. A “home” button quickly resets the devices to the default program and volume settings. All changes in hearing instrument settings are accompanied by easily recognizable melodies or tones to help orient the user.
4. STRONG, INVISIBLE CONNECTIONS TO INDIVIDUAL NEEDS AND PREFERENCES

The ReSound Alera keeps wearers connected to their surroundings with a natural-sounding listening experience. Surround Sound by ReSound provides a full and detailed sound quality and delivers important acoustic cues for localizing sounds, which facilitates speech understanding even in challenging situations. Robust connections to essential communication devices are also enjoyed by Resound Alera users through the ReSound Unite collection of accessories. However, the story does not end there. This flexible instrument accommodates a wide range of hearing losses and client preferences with its receiver-in-the ear (RIE) style, two receiver power levels, and in-office customizable shell colors. In addition, it is available in both wireless and non-wireless versions. To ensure reliable performance over the lifetime of the hearing instrument, each device is entirely protected by iSolate Nanocoat™, a polymer finish that is one thousandth of the thickness of an average human hair. Although it is described as a coating, this technology actually changes the surface properties of the hearing instrument, which enables liquids to form into beads and roll off. This treatment makes the hearing instrument and its parts virtually impervious to the moisture, oil and cerumen that are the most frequent causes of damage. With its unique use of wireless features and comprehensive technology package, the ReSound Alera provides clients what they need to enhance connectivity in all aspects of communication.
5. REFERENCES

2. Kochkin, Marketrak VIII, HR oct 2009