

Oticon
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What's Inside



Dear Colleagues

Once again, we're honored to present all new and exciting articles in this November Edition of the 2010 Oticon Clinical Update (OCU).

We are very appreciative of the time and expertise these authors have dedicated to this task, and we thank them for their efforts. We are confident you'll find the contents interesting and stimulating.

At Oticon, we strive to create communication solutions which enable people with hearing loss to communicate freely, interact naturally and participate actively.

Kind Regards



Ravi Sockalingam, Ph.D.



Douglas L. Beck Au.D.

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Project EarMiles

The EarMiles project is being undertaken by the Eriksholm Research Centre with the aim of gaining a deeper understanding of the client journey from the time of perceiving a hearing loss to the point of using hearing aids. This Oticon Foundation-funded project is co-ordinated by the Eriksholm Research Centre with Line Knudsen and Claus Nielsen as the project members. The project leader, however, is quite a distance away from Denmark. She is Dr Sophia Kramer of VU University Medical Center, Amsterdam, Netherlands. A few weeks ago, Dr Ravi Sockalingam, in his capacity as the co-editor of the Oticon Clinical Update, had the pleasure of chatting with Dr Sophia Kramer about the EarMiles project. The following is an excerpt of his conversation with her.



Kramer



Sockalingam

Sockalingam: Good morning, Sophia. Thanks for your time. I was at the Eriksholm Research Centre two weeks ago and had the opportunity to talk briefly with Line Knudsen and Claus Nielsen about the EarMiles project. Can you tell me how it originated? And what about the strange name the project has - "EarMiles"?!

Kramer: At the Eriksholm Research Centre, there was a strong interest to look at the journey that we assume clients with hearing loss undertake in terms of help-seeking, uptake of hearing aids through the use of hearing aids to their satisfaction with the aids. Our research aim was to specifically address the non-technical, human and psychological aspects of the journey. The project name? Well, at Eriksholm they like to give projects strange names! And this one was the winner in a competition; it's a kind of pun on "Air Miles", because that relates both to journeys and to the fact that a lot of travelling is involved in the project.

Sockalingam: I learned that this is a multi-phased and multi-centred project?

Kramer: Yes, there are three phases. The first phase was done at Eriksholm Research Centre. Both Line and Claus worked with me in this phase. The second phase was a qualitative study completed across four partner sites each located in a different country. The four countries are USA (Jill Preminger of the University of Louisville), UK (Lesley Jones of York University), Australia (Louise Hickson and Ariane Laplante Levesque of the University of Queensland) and the Eriksholm Research Centre in Denmark. We are currently analysing and sorting the data col-

lected in the second phase. It's too early to say anything about the third phase as the details of that are still being worked out.

Sockalingam: This sounds like a major undertaking. What did you do in the first phase?

Kramer: We were interested to learn more about the "client journey" and had many questions. We first wanted to know what was written in the scientific literature about the client's journey. To find the answer we had to embark on a systematic review of the relevant literature. First and foremost, we wanted to know if there is such a thing as a client journey. If there is a journey, do clients recognise it? Is there any evidence that the journey as perceived by the client differs from that defined by the professional? What journeys have been evaluated in controlled studies? A search of the literature revealed that controlled studies addressing the patient journey do not exist. That was a bit disappointing. There are many published models of hearing loss and rehabilitation, but these are all designed from the perspective of the medical or hearing professional. There are no studies providing evidence regarding the impact of different journeys on the client's satisfaction with hearing aids. There is a lack of empirical data. So, we decided to focus on crucial steps in the journey instead. These steps are: *help seeking, uptake of hearing aids, use of hearing aids, and satisfaction with hearing aids*. We performed a systematic review on correlates of help-seeking behaviour for hearing loss, hearing aid uptake, hearing aid use and satisfaction with the device. Our aim was to learn more about which factors are known to be evidently important in the process of getting a hearing aid. ▶▶

Sockalingam: It certainly sounds like a very thorough literature review. How did you go about it?

Kramer: We searched electronic databases such as Pubmed, Embase and Cinahl which yielded more than 300 articles. We directed our search towards non-technical factors that influenced help seeking, uptake of hearing aids, use of hearing aids and satisfaction with hearing aids in adults with hearing impairment. By non-technical factors, we mean demographic and psychological factors as well as factors relating to the design and execution of the rehabilitation process. After applying strict inclusion criteria (for example, the study addressed one of these factors, had to be data driven, the tools to measure the outcomes were clearly defined, the statistical method was reported), only 39 papers made the cut. Two independent researchers extracted the relevant information from the articles. The results revealed that in the past 30 years, a total of 31 factors were investigated in relation to any or all of the outcomes of interest (help seeking, uptake, use or satisfaction). Factors were for instance age, gender, degree of hearing loss, expectation, motivation, attitude, personality and counselling. Many factors were documented in a few studies only. If a particular factor was examined in at least 4 studies, we summarised the results.

Sockalingam: What did you find out from this extensive and systematic literature review?

Kramer: What we found was indeed surprising. For almost all of the factors, the results were mixed which means that the studies reported contradictory findings. For instance, when looking at an individual's expectation of hearing aids, one study found a positive correlation between expectation and use of hearing aids whereas two reported no association between the two. Similar findings were observed for satisfaction. Of the 5 studies reporting on the relationship between expectation and satisfaction with hearing aids, 3 found a positive association, while 2 found no relation. There were three factors with consistent findings across all studies: age and gender and self reported hearing problems. Age and gender were not related to any of the outcome variables (help seeking, uptake, use, satisfaction).

Sockalingam: So, two factors showed consistently no relation to the outcome variables. Did you find a positive correlation between any of the factors and all four outcome variables?

Kramer: Yes, we did. Self-reported hearing loss correlated positively with all of the four outcome variables – help seeking, uptake of hearing aids, use of hearing aids, and satisfaction with hearing aids. This was quite surprising. It was the only factor with consistent findings across all studies included in our re-

view study. All studies showed a significant positive association. Audiometric measures of hearing loss didn't show such consistent correlations – at least, not with use and satisfaction.

Sockalingam: So from a clinical perspective at least, it sounds like we ought to focus more on self-reported hearing loss rather than the audiogram if we want to know who will be using a hearing aids and become satisfied with it?

Kramer: You're right! At least that's what the literature is clearly indicating.

Sockalingam: Could you please tell me what was accomplished in the second phase of the project?

Kramer: This phase of the project was done at the four partner sites as mentioned earlier and all partners are greatly acknowledged for their work. We wanted to investigate the perspectives of adults with hearing impairment on their experiences of seeking hearing help and rehabilitation. We included 24 adults with hearing impairment with a range of experience. So, we recruited a) adults who experienced hearing difficulties but never sought help, b) those who were diagnosed with hearing impairment, but decided not to pursue amplification, c) those with hearing aids, but not wearing them, d) clients using hearing aids, but not satisfied with them, e) happy hearing aid users. Semi structured face to face interviews were conducted with all of them and their responses were transcribed (and translated into English where necessary), coded and categorised.

Sockalingam: Can you tell us what you found?

Kramer: One of our main results so far is that we didn't observe a journey in the participant's responses when they talked about their hearing and rehabilitation. It seems as if potential help seekers do not think in terms of a journey. They talked about their experiences in their home environment or in the hearing care professional's clinic, but they didn't report on a logical sequence of events such that it would reflect a process or a journey.

Sockalingam: That's very interesting. I won't ask you about the next phase. I'll let you save that for another time.

Kramer: Ask me this time next year and I might have something to say.

Sockalingam: I appreciate your talking to me today. I look forward to reading more about the project from the papers you are going to publish. Thank you once again.



Eriksholm Research Centre

Severe to Profound Hearing Loss: What Do We Know and How Can We Manage?

Ravi Sockalingam, PhD Aud(C), Senior Audiologist, Oticon A/S, Smørum, Denmark

Peter Lundh, MSc Senior Audiologist, Oticon A/S, Smørum, Denmark

Donald Schum, PhD, Vice President, Audiology and Professional Relations, Oticon Inc., Somerset, NJ, USA

It is estimated that about 11% of all people with hearing loss have a severe to profound hearing loss¹. Since this percentage is not nearly as large as the percentage of people with mild to moderate hearing loss, there is a general lack of understanding of their unique audiological characteristics and rehabilitation solutions. With the growing use of cochlear implants, there has been a decrease in the attention paid to the fitting of acoustic amplification to the patients. However, since not all patients in this hearing loss group are implanted and with the growing use of bi-modal fittings (the combination of cochlear implants and hearing aids), it is important for the clinician to be aware of the modifications in standard fitting approaches that make sense for this patient group.

This paper attempts to provide an overview of the nature of severe to profound sensorineural hearing loss, unique characteristics of the patients with this disorder and the signal processing approaches that can be utilised to manage it effectively.

Characteristics of Severe to Profound Hearing loss

Sensorineural hearing loss is associated with altered loudness perception and reduced dynamic range, i.e. less distance between hearing threshold and uncomfortable loudness levels (UCLs). In other words, the UCLs do not increase at the same rate as the hearing thresholds (see Figure 1).

For people with severe to profound hearing loss this dynamic range can be as little as 30 dB or even less. And because of this extremely narrow range, providing amplification above the hearing threshold levels without exceeding the UCLs can be rather challenging.

Achieving audibility across a range of frequencies is necessary for optimal speech perception, and providing as much auditory information as possible to attain maximal speech recognition is of paramount importance to individuals with severe to pro-

Figure 1

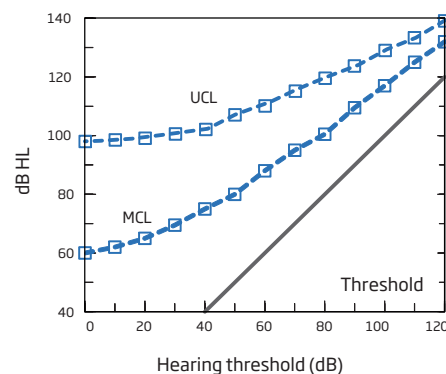


Figure 1: Uncomfortable listening level and most comfortable level for people with sensorineural hearing loss, averaged across 500, 1k, 2k, and 4 kHz. Adapted from Dillon (2001), *Hearing Aids*, Page 236, Figure 9.1, Boomerang Press, Australia.

found hearing loss. However, simply amplifying speech to supra-threshold levels may not necessarily result in better speech perception as these individuals have difficulty processing supra-threshold speech. In fact, their speech recognition may get worse with amplification².

There are two reasons for this phenomenon. First, at higher outputs, a broader region of the cochlea is stimulated and the accuracy of speech decoding diminishes³. For this reason, lower sensation levels for higher outputs are employed in DSL [i/o] and NAL-NAL1 prescriptive formulae.

Second, any hearing loss results in loss of auditory resolution. Both frequency and temporal resolution can be expected to be reduced. Loss of frequency resolution or selectivity stems from a broadening of the auditory filters which allows noise to pass through and mask speech easily. This broadening, an inherent ▶

limitation of the auditory system, is especially pronounced in individuals with severe to profound hearing loss⁴. This explains why these individuals experience significant difficulty with speech perception in noise.

The temporal resolution of individuals is often reported to be reduced in hearing loss meaning that the ability to accurately encode the timing of auditory events is disrupted. This phenomenon is marked by poorer performance on temporal tasks such as gap detection, temporal integration, temporal summation compared to people with normal hearing ability⁵. However, the performance was found to be dependent upon the presentation level of the signal and the presence of neurons in the frequency region tested. Performance is better at higher signal sensation levels and when there are neurons available to respond to the signal. Interestingly, it was found that low frequency temporal resolution in individuals with severe to profound hearing and in individuals with normal hearing was much the same. What differed between the groups was the temporal resolution in the mid and high frequencies⁶.

There is a clear and widely accepted link between the loss of temporal and frequency resolution and poor speech recognition. Speech scores have been reported to be worse in people with severe to profound hearing loss compared to what their pure-tone audiograms suggest⁷. If this is the case, what strategies do these individuals use to understand speech? For one thing, individuals with severe to profound hearing loss, compared to people with lesser degree of hearing loss, depend heavily on visual cues (such as speech lip reading) in the presence of background noise. While their ability to resolve the differences between sounds in the frequency domain is compromised, their ability to process sounds in the temporal domain is relatively intact particularly in the lower frequencies. It is this ability to utilise information from the amplitude-time waveform that helps them to decode speech. The temporal wave-

form also aids in the perception of suprasegmental cues of speech such as stress, pauses, and intonation. These features may provide additional benefit in difficult listening situations as they embody the true emotions and the intended meaning of speech⁸.


Managing Severe to Profound Hearing Loss

As mentioned earlier, the dynamic range of hearing in severe to profound hearing loss is significantly restricted. Within this narrow dynamic range, differences may exist between individuals in terms of auditory resolution. While some individuals may be able to decode speech successfully using temporal cues, others may need the extra help from visual cues⁹.

Such differences between individuals aside, careful application of amplification and automatics (directionality, noise reduction etc.) to achieve maximum comfort, audibility, speech intelligibility and sound quality is vital. These individuals are long term hearing aid users and are very conscious of the slightest change in the level or the quality of the sound from their hearing instruments.

Amplification Strategy: Compression and Prescriptive Formula

The design of any hearing instruments for severe to profound hearing losses will need to consider the psychoacoustic effect of the hearing loss. Historically, linear amplification with peak clipping was the strategy of choice for them. Even to this day, a severe hearing loss demands the highest possible power of the hearing aid, and to attain satisfactory gain the hearing aid would have to work linearly for a significant part of the frequency range.

There were, however, limitations with using a fixed amount of gain for all inputs. With linear amplification soft input sounds were not amplified loud enough, and loud input sounds were amplified too loud often exceeding the UCLs. Wide Dynamic 

Range Compression (WDRC) offered a solution to these limitations and quickly became the amplification scheme of choice for providing audibility across a range of input levels for individuals with severe to profound hearing loss. With WDRC, it was possible for all sounds to be “squeezed” into the restricted dynamic range of hearing that these individuals have. Audibility is achieved across a range of input levels but with a cost: sound quality. For severe to profound hearing loss, WDRC is typically implemented with high compression ratio and fast acting compression to maximise audibility¹⁰. Both of these parameters distort the amplitude-intensity envelope of speech, consequently degrading sound quality. Distortion is an inevitable by-product of WDRC, and for a long time wearers of WDRC aids had to contend with distortion; audibility was the main priority for them and sound quality was forced to take a back seat.

A slow acting compression with its long time constant behaves more like a linear amplification system. It protects the amplitude-time envelope of the speech signal, and preserves the dynamic phoneme to phoneme relationship that determines the fidelity of the signal. However, as with linear systems, slow acting compression may not provide adequate gain for low intensity sounds. Nor would it protect the hearing from loud sounds. However, by using fast attack and release times for sudden loud sounds, such a system can provide protection from loud transient sounds.

A novel amplification system – Speech Guard – that is currently employed in Oticon’s new super power instrument – Chili – is designed to do just that. It processes the signal in a near linear manner as long as the input signal level remains stable. When the input signal changes dramatically in level (becomes too soft or too loud), it compresses the signal. For the sudden loud sounds the very fast attack and release times help keep the signal below the UCL. This way, the output signal is always within the dynamic range (i.e. audible) and comfortable with minimal distortion. Speech Guard essentially processes speech linearly as long as possible and compresses it quickly when it has to hence combining the best of both linear and non-linear systems without the pitfalls of either¹¹. Just how the Speech Guard works has been extensively described elsewhere¹² and would be beyond the scope of this paper. Speech Guard has already been clearly demonstrated to improve speech intelligibility and reduce listening effort in noise¹³ for individuals with mild to moderate hearing loss.

Prescribing the right amount of gain is the key function of any amplification system. The fitting or prescriptive formula has to work in concert with the compression system to produce an output signal that is clear, audible and comfortable for a particular hearing loss. The amplification strategy of the hearing loss is typically based on the principle of loudness compensation. In severe to profound hearing loss, this loudness compensation is somewhat altered when every attempt is made to maintain the amplitude-time structure of the amplified speech.

Loudness modelling studies carried out at Eriksholm Research Centre have given the basis for the loudness compensation for severe to profound hearing loss¹⁴. Any gain targets for severe to profound hearing loss should take into consideration the risk of feedback since the hearing instruments for these losses are typically used at higher outputs. In view of this, a prescriptive formula known as Dynamic Speech Enhancement – Super Power (DSEsp) was developed by Oticon with the goal of prescribing sufficient sensation level of speech without reaching the feedback limit while ensuring reasonable amplitude-time envelope of the amplified speech signal.

Acoustic Feedback

Feedback is generally controlled by reducing gain in frequency channels where the risk of it occurring is high. However, this gain reduction results in undesirable loss of audibility of speech in frequency regions where feedback occurs. DSEsp minimises this drop in the speech signal by shifting the compression threshold or knee point to a higher level allowing speech to be processed without further gain reduction. As a result of this, the gain for soft sounds such as air-conditioning and ventilation noise is reduced. These are unwelcome noises that mask the target speech signal. The reduced gain for soft sounds also helps achieve another important goal in amplification: preserving the speech dynamics and hence the quality of speech by allowing the signal to be processed more linearly particularly across the speech spectrum (see Figure 2).

Directionality

Another important consideration in the management of severe to profound hearing loss is the use of directional microphones to improve speech intelligibility in noise. A significant signal to noise ratio improvement of 9 dB has been demonstrated for this group of clients¹⁵. When directionality is engaged, sounds from the sides and the back are attenuated so that the listener is able to focus and attend to the speech at the front. A side effect of

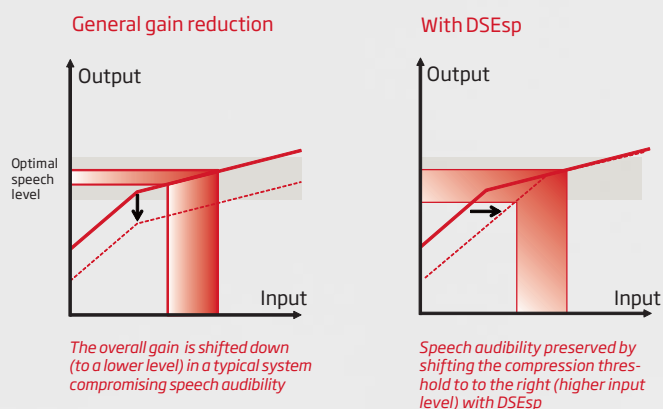


Figure 2: Input/Output function illustrating the effect of feedback management in a system without DSEsp (left) and in a system with DSEsp (right).

traditional directionality is that some of the low frequency information is lost. This can pose a serious limitation to a listener if he/she has his/her residual hearing mainly in the low frequencies. People with severe to profound hearing loss have long standing experience with hearing aids and may react negatively to the effects of directionality: reduction in audibility of low frequency sounds as well as sounds emanating from the sides and the back. These individuals may have relied heavily on these sounds for successful listening. One solution to counteract the effects of low frequency attenuation is to use a type of directional system that is used in Oticon hearing instruments: High Frequency Directionality. With such a split directional system, the hearing aid would be in the omni-directional mode in the low frequencies and in directional mode in the high frequencies.

Summary

People with severe to profound hearing loss represent a distinct group of individuals with distinct needs. There are many important considerations when managing severe to profound hearing loss: amplification strategy, feedback and directionality. Digital signal processing technology, if judiciously and carefully applied can provide many benefits in terms of audibility, speech understanding and comfort.

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Getting Through To The Reluctant Patient

Mary Porath, Au.D.
 Clinical Channel Manager, Oticon Inc.,
 Somerset, NJ, USA

Clearly one of the greatest challenges in modern hearing care is to successfully serve the needs of hearing impaired individuals who experience real life communication difficulties due to hearing loss, yet remain untreated. The global scope of this challenge is staggering. The World Health Organization reported that of the 278 million people estimated to have moderate to profound bilateral hearing loss in developing countries, only 1 in 40 uses amplification. The overwhelming lack of treatment is essentially due to unhealthy living conditions, poor access to preventive medical treatments for hearing loss, and lack of availability and/or affordability of hearing solutions (World Health Organization, 2006).

In developed countries such as the United States, despite relatively good access to medical care, the incidence of untreated hearing loss also remains high. Although the prevalence of hearing loss is increasing in baby boomer and elderly (75+) age brackets, the majority of individuals with hearing loss do not use amplification. MarkeTrak (Kochkin, 2009) recently estimated 34.25 million Americans have hearing loss. However, only about one in four (approximately 8.5 million people) owns a hearing instrument. Additionally, the ongoing use (i.e., compliance) of purchased hearing instruments is a growing concern, as use tends to worsen slowly over time (Bhatt et al, 2005).

Not only do we as professionals seek insight into patients' thought processes so as to better understand their needs and desires, but we want to encourage them to seek help sooner and ultimately improve their communication abilities.

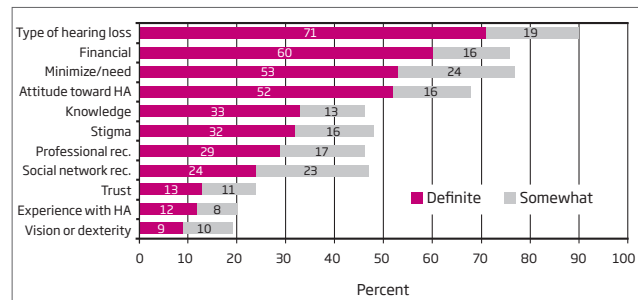


Figure 1 (from MarkeTrak VII, Kochkin, 2007) provides an overview of hearing instrument “non-adoption” factors. Our challenge is to gain a better understanding of the internal and external factors that drive a non-user’s decision to seek professional help and also to identify common obstacles. Awareness of hearing loss is not necessarily a precursor to action. Reluctance to seek professional help and avoidance or denial of hearing loss delay positive progress and misdirect the individual to adopt ineffective coping tactics. Untreated hearing loss often leads to withdrawal from social activities, depression and a reduced quality of life.

External factors can also be a roadblock on the path to better hearing. Many individuals are uncertain about how to access hearing care advice. Well-intentioned friends or family may offer cautionary tales about the amplification experience and create undue scepticism. A surprising number of people with hearing loss have visited professionals who either did not recommend hearing instruments or suggested they were not an

Turning Non-users Into First Time Users.

appropriate candidate. Nearly half of the respondents (46%) reported a professional such as a family doctor (38%), ENT (35%), audiologist (32%) or hearing instrument specialist (20%) influenced their decision not to get a hearing instrument (Kochkin, 2007).

The Path to Acceptance:

The path from hearing loss onset to self-awareness, to acceptance, to action is often a lengthy one. Progress may be delayed due to concurrent life stage events, for example when the individual is coping with multiple real or perceived diminishment of normal aging. Yet, negative consequences of hearing loss may yield a positive result, eventually motivating an individual to take action. Missing out on conversation fosters emotional reactions such as embarrassment or sadness which, in turn may provoke awareness of the hearing problem. Larger social ramifications of hearing loss, including diminished social standing, reduced employment opportunity, and a lesser quality of life (Engelund, 2006) can be the ultimate catalyst for action. Hearing care professionals who recognize the milestones along the patient journey are better equipped to intervene with appropriate measures and to effectively facilitate the rehabilitation process through appropriate, pragmatic and timely intervention.

Pre-awareness and Awareness of Hearing Loss:

Because hearing loss tends to gradually worsen over years, individuals may make subtle, even unconscious accommodations in social situations. In the pre-awareness stage, it may be an employer, friend, family member or associate who is first to suspect or notice the symptoms. The individual is more likely to consider or recognize the possibility and schedule an appointment with a hearing professional if the friend or colleague addresses these concerns in a caring and thoughtful way,

Individuals react differently once hearing loss is confirmed. Some individuals internalize this information, seek amplification and undergo aural rehabilitation. Others may get “stuck” in denial. Still others may get not know how to find professional help.

Resource planning at the pre-awareness stage:

Community programs and campaigns are effective measures to reach out to Individuals at the pre-awareness stage (i.e., before the individual realizes he/she has hearing loss). Activities can take the form of public awareness events, health fairs, and routine employment-based hearing screenings or medical check-ups. (see Figure 2).

Once the consultation is scheduled, pre-appointment educational brochures and questionnaires will help prepare the patient for the visit and set the stage for the consultation.

A well-prepared patient can get more out of the visit. The professional can more effectively direct counselling to the individual (and the significant other), better understand personal needs and desires and build greater awareness of hearing loss and treatment options. Recommendations and scheduled follow-up visits can expedite the patient’s journey from pre-awareness to awareness and eventually to acknowledgment while supporting a positive attitude toward intervention.

Acknowledgement and Acceptance:

Acknowledgement of the hearing problem is an important step on the pathway to better hearing, but does not guarantee the patient will choose to proceed with a hearing solution on their own. Gerald Zaltman, Ph.D., a Harvard professor and market researcher used the Zaltman Metaphor Elicitation Technique (ZMET) research approach to delve into the deeper motivations and reluctance to accept and wear hearing instruments (see Zaltman, 2003; Christianson et al. 2002). ZMET employs visual images, metaphors and emotions to elicit attitudes, fears, aspirations (and more) which lie below the person’s conscious awareness. Subjects are interviewed in depth and also perform tasks involving guided picture selection.

The outcome of this study revealed that despite significant hearing problems, subjects resisted amplification - fearing it would erode their self-image - essentially transforming them into the polar opposite of their “ideal sense” of self. Their resistance was further fuelled by misinformation about hearing instruments. To cope with these fears, study participants retreated into a less social world which was familiar, comfortable and protected, and they expressed high anxiety about leaving this world. They did not trust the advice of hearing care professionals that the use of amplification would help them to re-en-

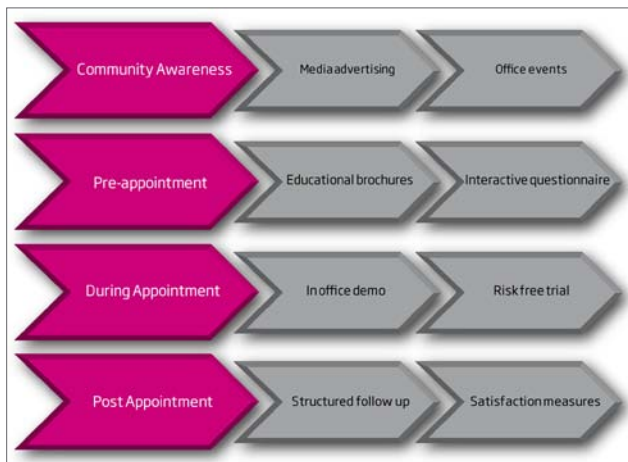


Fig 2. Resource planning to promote hearing loss awareness

ter into a “normal” or “better” world. Rather, they imagined that the outside world would be as unpleasant with hearing aids as it was without hearing aids.

Professionals are better equipped to customize their professional services to benefit patients when they understand the patient mindset. Once patients have acknowledged that they have hearing loss, they require a different professional approach than at the pre-awareness stage, even if they are still struggling with the decision to proceed with intervention. Just by experiencing the negative consequences of their hearing loss, that is, when suffering repercussions in emotional well being or social standing, a reluctant non-user can be motivated to seek a solution. Yet, additional support and encouragement are often needed. The reluctant non-users in the Zaltman study also required a more informed intervention strategy to inspire them to take action

Figure 3 summarizes the tools and approaches that support this next stage of the journey.

Resource planning at the acknowledgement stage

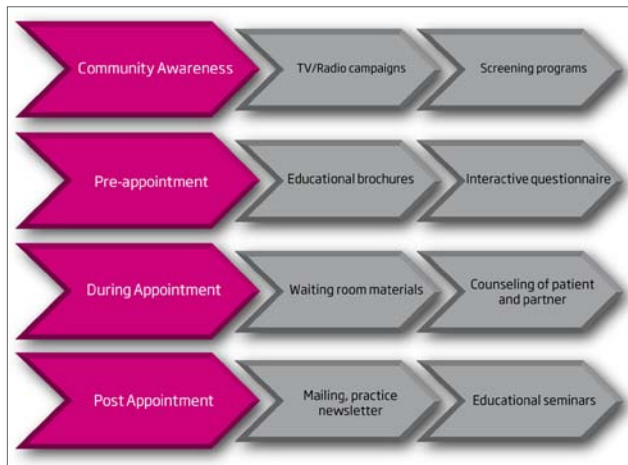


Fig 3. Resource planning to promote hearing intervention

Patients at the acknowledgement stage are more open to information about hearing loss and hearing solutions. Brochures, direct mail, media advertising, direct mail inserts, and other evocative communication directed strategically at non-users must serve to catch their attention, educate without frightening them, and present them with a call to action.

This media will be most effective without charged, anxiety-producing terminology. The offer to try hearing solutions is more attractive when described as “no or low risk” to the patient and

when avoiding any stigmatizing visuals or wording. If a hearing aid is mentioned or pictured in the ad, it should not reinforce the negative image of hearing aids (i.e., large hearing devices on older and unattractive people).

Effective and successful multimedia advertisements (see Figure 4) have been proven to motivate prospective patients. These advertisements share three key components:

1. An emotional appeal that echoes their inner conflict (“Don’t let hearing loss hold you captive”)
2. A promise of a resolution, (“Set yourself free”)
3. A visualization of a hearing solution that assuages their fears, and a solution they can see themselves wearing (“Finally a hearing device you’ll really want to wear”)

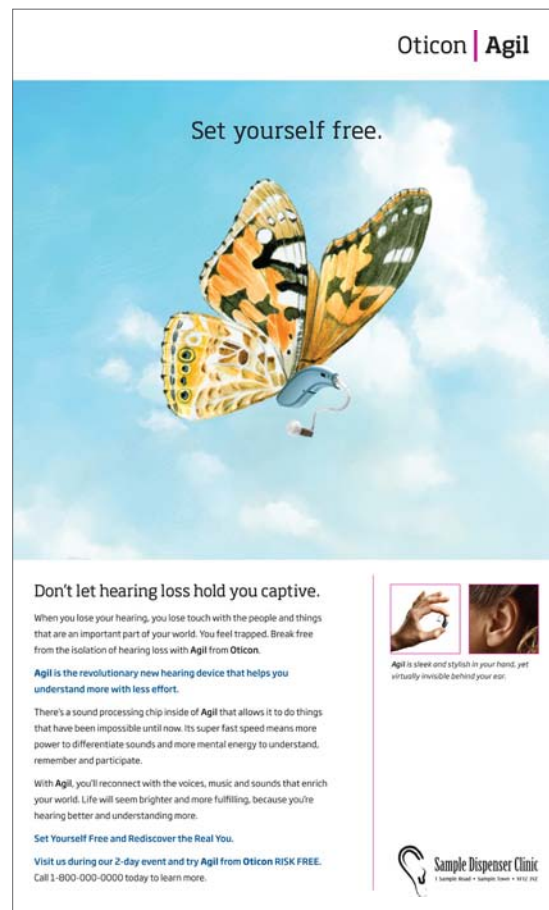


Fig 4.

For the new patient who has decided to gingerly explore hearing solutions and aural rehabilitation, measures to encourage action and reduce risk reduction can be reinforcing. A time sen- ▶

sitive deadline attached to a special event or seminar can serve as an effective call to action to schedule an appointment.

RISK-FREE TRIAL:

A listening experience in the office (or at home) is an effective approach for prospective patients and is a powerful and time-saving tool for the hearing care professional. Open receiver-in-the-ear (RITE) devices can be fit to the vast majority of prospective patients and RITE devices make same-day demonstrations possible. The transparency of operation and of acoustic performance is a tremendous boon to the new user. Keep in mind the new user wants a hassle-free, beneficial, enjoyable and natural experience. The risk-free trial reassures the patient that there is no pressure to purchase. The benefits of the experience are immediate and impact multiple environments; home, work, school and social. The patient's decision to wear risk-free trial hearing aids at home is a milestone in the path to acceptance.

Strong recommendation:

Kochkin's data support the assumption that professional recommendations to "wait" or failure to recommend at all, are among the reasons hearing aid penetration is so low. When professionals listen to patients' concerns and present strong, specific recommendations for amplification, patients are most likely to follow through. In a multi-site study, Moore et al. (2004) evaluated a sample of over 1100 adults to assess the impact of the doctor-patient relationship on treatment avoidance for a recognized medical or psychological problem. Patients who felt their physicians listened more to their concerns were most likely to seek treatment.

When counselling first time users, some professionals use the term hearing "devices" in their recommendations, and avoid using the term "hearing aid" as it's too emotionally charged. The patient's first exposure to the hearing aid is important. If the device does not look like the patient's expectation of a hearing aid, the obstacle to acceptance and purchase is lessened. Smaller sized and attractive hearing devices are clearly positives in the patient's mind, as many are concerned with aesthetics. If the hearing devices are not visible when worn and are acoustically and physically comfortable, the patient will not object and will be relieved.

Summary

Just as in-office or at-home trial protocols do not guarantee the patient will purchase hearing solutions, purchase does not guarantee long-term use or satisfaction. By working with the prospective new user and reinforcing amplification successes at regular intervals, the professional can validate the hearing

aid fitting, make modifications, and provide effective counselling to reinforce success and avoid disillusionment.

Outreach to prospective new users can be effective in moving them forward toward awareness and acknowledgement of their hearing loss and increase their readiness to take action. Once they seek professional services, reluctant non-users benefit from intervention that is sensitive to their needs and encourages their progress. Not only are reluctant non-users the greatest challenge of modern hearing care, once they become first time users they are valuable to hearing care practices. The financial success of hearing care practices depends on an ongoing stream of satisfied first-time users who develop loyal relationships with their providers, repurchase more hearing instruments over their lifetime and refer their friends.

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New Genie Feature in Oticon Hearing Aids: In-Situ Audiometry

Lisa M. Sjolander, Au.D.
Clinical Audiologist
Oticon A/S, Smørum, Denmark

Introduction:

In-situ audiometry allows the professional to measure hearing thresholds with the hearing aid located in-situ (i.e., in the patient's ear). In-situ audiometry does not replace traditional audiometry. However, in-situ measures often offer a more precise hearing aid fitting by taking into account the residual ear canal volume as well as precise vent effects and hearing aid tolerances, and in-situ audiometry can be used for quick-fit hearing aid demonstrations. A tone generator within the hearing aid generates calibrated stimuli (i.e., beeps) much like a traditional audiometer and the patient responds as they do for traditional audiometry. In-situ audiometry allows the professional to quickly and accurately tailor the fitting to the patient. This article describes some of the advantages of in-situ audiometry.¹

Gain & In-Situ Audiometry

Generally, gain values are prescribed in the fitting software using the audiogram entered in Noah. When actual physical measures of ear canal volume are not available, average ear values are retrieved from the software and used to calculate insertion gain. Thus, the accuracy of the fitting prescription depends on many physical factors such as the patient's ear canal, the ear mould depth, the specific vent selected and more. Unfortunately, hearing aid prescriptions based on average data risk over-amplification for patients with deep fitting ear moulds and/or small ear canals, and under-amplification for patients with large ear canals or shallow ear mould fittings.

In-situ audiometry reduces the risk of over-or-under fitting because the in-situ audiogram is measured with the patient's own hearing aid placed in the ear canal as it will be worn. Thus, the residual ear canal volume and the selected vent are taken into consideration via the measurement. For example, with in-situ audiometry, a smaller residual ear canal volume will result in lower thresholds and less gain will be prescribed. In this way measuring in-situ audiometry allows the gain prescription to account for individual differences in residual ear canal volume and provide an appropriate gain prescription (see Figure 1 for an example).

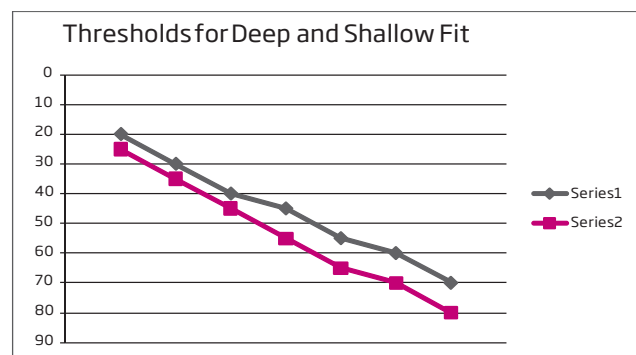


Figure 1: Shows the variance that can be expected in in-situ audiometry measurements with different hearing aid/ear mould insertion depths.

Vents & In-Situ Audiometry

When in-situ audiometry is measured then the hearing aid gain is prescribed with the individual's measured vent effect. The vent alters the amount of gain the hearing aid produces in the patient's ear. The vent effect depends on the length and width of the vent, the amount of leakage there is around the ear mould as well as the size of the individual's ear. For example, the same BTE hearing aid fit with a small vent and a large vent will result in different output in the ear. The ear mould with a smaller vent will result in a fitting that provides more low frequency gain than the ear mould with a larger vent. Sound leakage around the ear mould will affect the sound pressure in a patient's ear; the larger the leak the less low frequency gain¹. When in-situ audiometry is not used, the vent effect is calculated using the selected vent diameter and average values for the length of the vent and leakage around the ear mould.

Hearing Aid Tolerances & In-Situ Audiometry

Hearing aid tolerances are accounted for when in-situ audiometry is measured. This is possible because the exact gain prescribed is based on the measurements made with the patient's own hearing aids, ear moulds and selected vent. Thus, if the

hearing aid has a tolerance which allows it to play a few decibels louder than prescribed, this will be compensated for by the in-situ measurement because the in-situ audiogram will have lower thresholds, which will result in less gain prescribed. When measurements are made with a stand alone audiometer, the +3 dB tolerance of the audiometer and the + 4 dB hearing aid tolerance, may cancel each other or they may be cumulative resulting in an up to 7 dB error².

Ambient Noise & In-Situ Audiometry

To improve hearing aid fittings by accounting for the variances described (above), the in-situ audiogram must be accurate. To ensure an accurate in-situ audiogram measurement is accurate testing needs to be conducted in a quiet room or a sound booth. The in-situ audiometry tool in Genie has a noise level meter incorporated to provide information about the sound level while making in-situ measurements. The warning level is determined based on average values from ANSI 1991 standards for permissible ambient noise levels in the test room when conducting air-conduction screening tests³. For open fittings, in-situ audiometry testing is particularly susceptible to background noise. To reduce some of the problems with ambient noise, frequencies below 750 Hz (where no gain is provided with open fittings) cannot be tested in-situ. If ambient noise appears problematic, in-situ testing can be performed with a closed vent or for open fittings with a power dome. If one wishes to test in-situ with an occluded vent, be sure to select "occluded vent" located in the in-situ fitting software.

In-Situ Test Protocol

After selecting the appropriate vent setting and placing the hearing aid in the patient's ear, the hearing aid is detected by Genie and in-situ testing begins. The professional selects either a continuous or a pulsed tone and the mouse or the keyboard can be used to present the tone and to switch between frequencies and loudness levels. The patient is instructed to respond when they hear the beep. As noted previously, it is important to monitor the noise level to ensure accurate test results. Figure 2 shows a screen shot of the in-situ audiometry test screen with steps for testing added.

After determining the hearing thresholds through in-situ audiometry, the professional selects whether or not to use the in-situ audiogram measurements or the audiogram entered in Noah. The professional can compare the in-situ audiogram to the audiogram entered in Noah while testing (if an audiogram has been previously entered in Noah). The audiogram entered in Noah appears in the same graph with the in-situ audiogram, but the Noah audiogram appears greyed out. If the audiogram entered in Noah shows an air-bone gap in-situ audiometry is not



Figure 2: In-situ test screen with recommended steps for testing added (above) to serve as a quick guide to ensure the parameters are set correctly for in-situ testing.

recommended because the in-situ tool does not allow for bone conduction testing and bone thresholds will not be taken into account when the in-situ audiogram is selected (*Note: If an air-bone gap is present in the Noah audiogram, Genie presents a warning*). When the in-situ audiogram is selected, gain calculations are based on the in-situ thresholds. The professional can switch back and forth between the audiogram entered in Noah and the in-situ audiogram as desired. New in-situ audiograms can be measured as desired, but only one in-situ audiogram can be stored and the most recent (i.e. newest) in-situ audiograms will replace previous in-situ audiograms.

In Situ Summary:

In-situ audiometry measurements are a quick way to take into account residual ear canal volume, precise vent effects and hearing aid component tolerances in a hearing aid fitting. In-situ audiometry can be used to quick-fit hearing aids for demonstrations and it can be used for home or bedside fittings when traditional audiograms are not available. In-situ audiometry is a useful tool which provides accurate and individualized hearing aid fitting data and facilitates making appropriate individual hearing aid fittings for the patient.

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The Life Impact of Connectivity for Hearing Aids

Donald J Schum, PhD, Vice President
Audiology and Professional Relations, Oticon Inc.,
Somerset, NJ, USA

The role of amplification in the life of the patient with hearing loss is to improve access to sound. Normally we interpret this scenario as a live, face-to-face conversation, but there are many other ways that important sounds reach us as listeners. Along with the recent technical improvements in wireless transmission of sound have come new opportunities to bring important sounds to the hearing aid user. Oticon has taken the lead in creating impressive solutions for those with hearing loss over the past few years. We are now seeing how effective connectivity can positively affect the lives of our patients.

Towson Connectivity Study

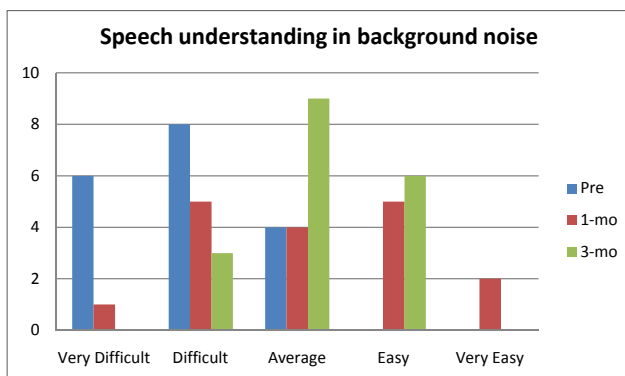
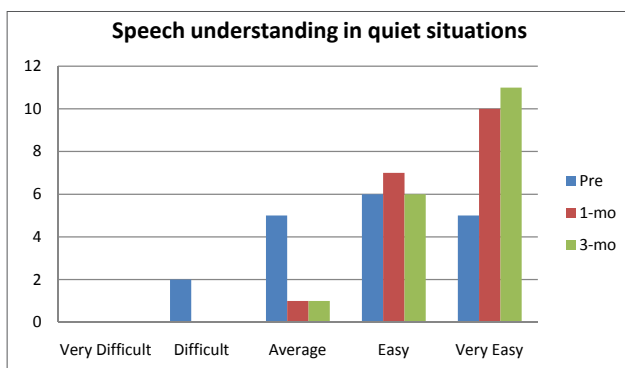
At the annual meeting of the American Academy of Audiology this past spring, Dr. Brian Kreisman at Towson University in the U.S.A. presented the findings of a study focused on quality of life impact of connectivity. Eighteen elderly (mean age 72 years) previous hearing aid users were fit with a set of Oticon Dual RITEs, Streamer, Phone Box and TV Box. The average hearing loss sloped from 35-40 dB HL below 1 kHz down to 60 - 70 dB HL at 4 kHz and above. The patients were current users of a range of mid and high level products, all using devices bilaterally.

They were assessed at 1 month and 3 months post fitting using questionnaires focused on the performance and ease of use of the Streamer, Phone Box and TV box, speech understanding and sound quality perception with the hearing aids and overall impact of the hearing aids and connectivity aids on the Quality of Life.

The results were strongly and consistently positive in favour of the fittings and, most importantly, the importance of connectivity. At one month after the fitting, 13 of the 18 subjects had connected and were using the TV Box and 11 of the 18 had connected and were using the Phone Box. All subjects were using both connectivity devices at 3 months out. The lack of use of the Phone and TV Boxes at 1 month was not due to technical or difficulty with the instructions. Rather, some patients chose to focus on experiencing the benefits of the new hearing aids before moving on to the assessment of the accessory devices. Here are the highlights of the findings:

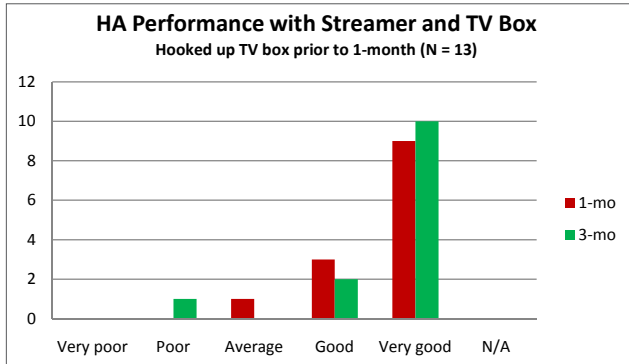
Hearing Aid Experiences

- Compared to what they used to be wearing (mid and high end technology), the Duals were judged as comfortable, stylish, providing an excellent sound quality and, most importantly, providing excellent speech understanding improvement in quiet and noise.

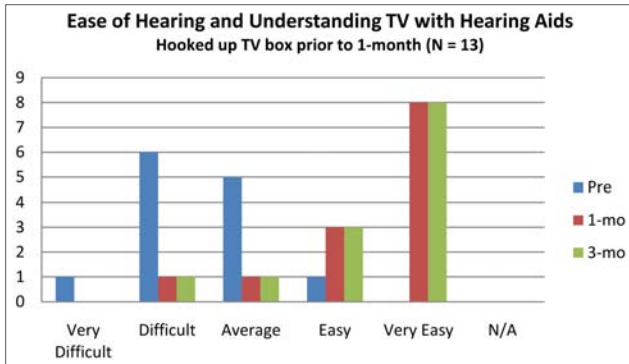


Television Viewing Experiences

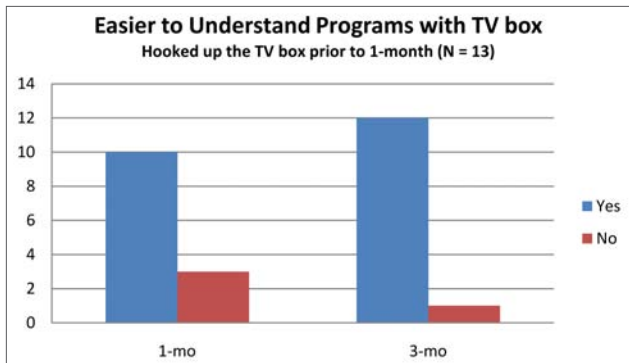
- Participants indicated that TV viewing was important to them and that they would watch more TV if it were easier to understand.
- The instructions for setting up the Phone Box and TV Box were considered to be clear and easy to follow. Set-up was easy.
- Overall, the performance of Streamer and the TV Box was rated highly.



- TV was rated as being easier to understand once the TV Box was installed and used.

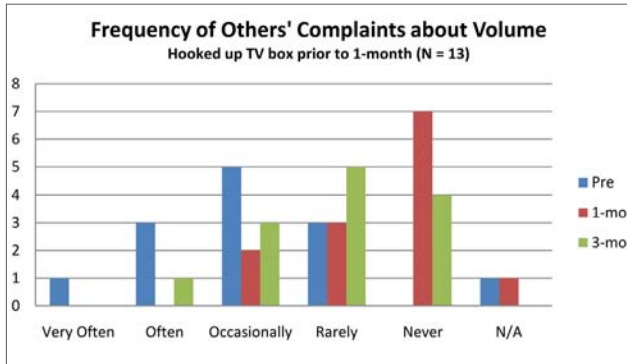


- Certain programs were identified as being hard to understand at the outset of the study (the most common mention: British Television Shows). Those identified shows were rated as easier to understand once TV Box was installed and used.



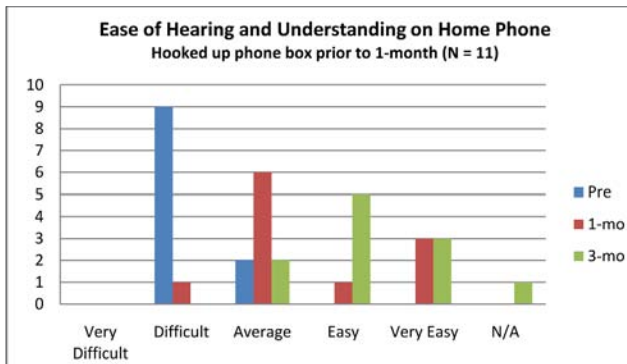
- Complaints from family members about the volume setting of the TV dropped significantly after installation of the TV Box.



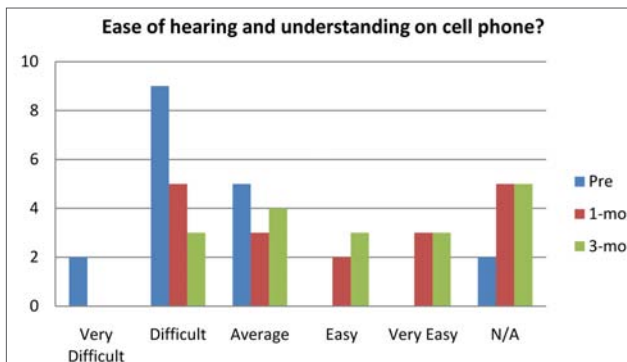


Telephone Use Experiences

- At the outset of the study, home phone used was rated as important and people would spend more time on the phone if it were easier to understand. For those who used the Phone Box, they rated listening on the phone as significantly easier.

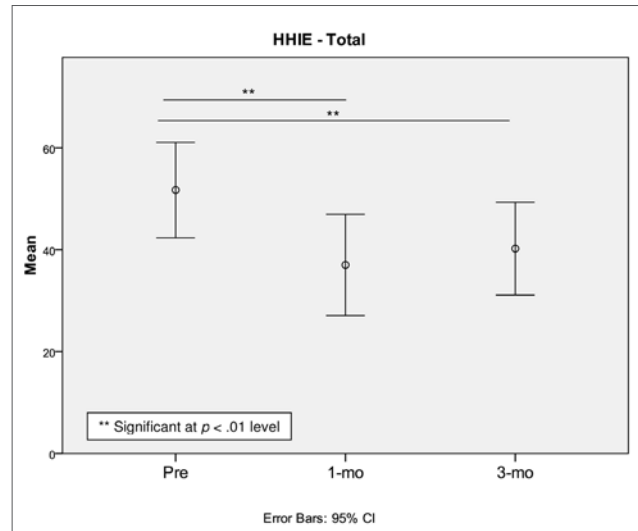


- Using cell phones was rated as important and that, if speech were easier to understand, cell phones use would increase for many. Use of Streamer and the cell improved speech understanding.

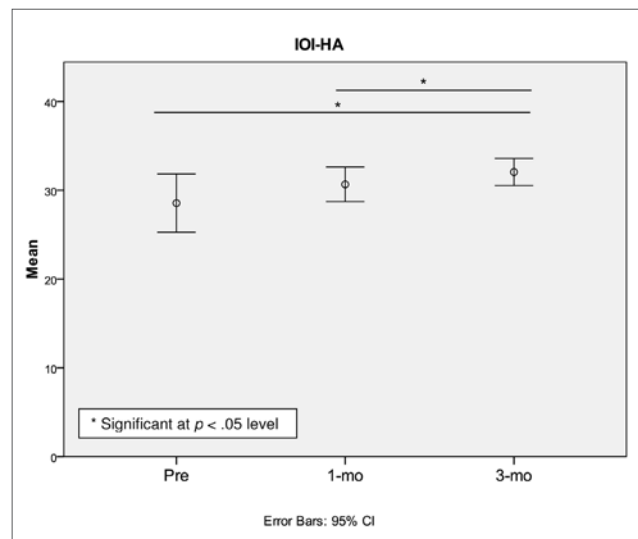


Overall Life Impact

- The Hearing Handicap Inventory for the Elderly (HHIE) (Newman & Weinstein, 1988) showed a significant reduction in perceived handicap for overall and both subscales (social & emotional).



- The International Outcome Inventory for Hearing Aids (IOI-HA) (Cox & Alexander, 2002) showed significant improvement in perceived outcome after the fitting of the hearing aids and connectivity devices.



- ▶ • 7 of 10 subscales of the Communication Profile for the Hearing Impaired (CPHI) demonstrated improvements after fitting of the devices. These included important dimensions such as Stress, Self-Acceptance, Attitudes of Others and Personal Adjustment.

Benefits of Connectivity

For many years, the only connectivity for most adult hearing aid users was to use the T-coil when speaking on the telephone. Now that there has been significant development in wireless transmission of audio signal to hearing aids, many professionals are in a position where they need to rethink the way they discuss the need for connectivity with patients. In some cases, there is a natural tendency not to bring up the topic of connectivity when fitting advanced-technology hearing aids because the professional may assume that the patient assumes that the hearing aid will solve all communication issues. Of course, this is not the case, and the significant benefits of connectivity that many, many patients have experienced over the last few years should inspire professionals to broach the topic of connectivity with most patients being fit with hearing aids.

One approach to help frame the discussion of connectivity is to describe the benefits that the patient should experience. These include:

- **Higher-quality, more intelligible speech signal**
When listening over the telephone or when listening to speech from televisions, the connectivity solutions that have been developed have been demonstrated to improve speech understanding. Since many patients continue to experience difficulties in the perception of these transmitted signals even when wearing high-quality hearing aids, connectivity can be offered as a solution to those residual communication issues.
- **Less trouble when using phones and televisions**
As discussed above, the connectivity solutions that were developed in the past tended to not be particularly elegant. Oftentimes, connectivity meant a direct-wired connection to the electronic device that was producing the audio signal. The availability of wireless connectivity, along with the very smart design of the Streamer, has made connection to these consumer electronics much more seamless. In fact, this seamless integration with consumer electronics can be used to highlight the sophistication of modern advanced-technology hearing aids.

- **Easier shared use**

It is quite common for family members to complain that the television needs to be played at excessively high volume when the hearing-impaired loved one is in the room. Wireless connectivity to hearing aids allows the hearing aid user to have independent control over the sound level of the television signal, allowing the rest of the family to listen at an appropriate and comfortable level.

- **Decreased mobility concerns**

Some patients have physical limitations on how easy it is to move around their living space. When the phone rings, sometimes it is not a trivial matter to get up and answer. The phone connectivity solutions that have been developed make access to a telephone more direct for many of these patients. Streamer makes answering calls, ending calls and the adjustment of volume easier.

- **Volume control adjustment**

An added benefit of Streamer is that they can function as a binaural volume control for the hearing aids. Again, for some patients with mobility or dexterity issues, this can be a simple yet highly useful benefit.

Our Important Role

The professional's job is to decrease the impact of hearing loss in all aspects of a patient's life. Wireless technologies have opened up new possibilities for us to address long-standing concerns that our patients present to us. Oticon has paid particular attention to designing connectivity technology that is both intuitive and effective for our patients. The professional plays a vital role in learning how these technologies can be incorporated into a patient's life. The older patient is at particular risk for becoming detached from ongoing society. We all play an important role in keeping our patients as active and involved in the modern world as possible.

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An Overview...

Using ABR Tone Burst Data in Hearing Aid Fittings

Douglas L. Beck Au.D.
 Director of Professional Relations
 Oticon Inc, Somerset, NJ, USA

Universal Newborn Hearing Screenings (UNHS) have been remarkably successful across the globe. In the USA and the UK, 95% of all children are screened for significant hearing loss at (or near) birth (White, 2008; Beck, Samsson and Moodie, 2009). The successful implementation of UNHS has dramatically increased referrals for diagnostic audiologic tests and subsequent hearing aid and cochlear implant fittings.

The importance of early hearing loss detection and intervention (EHDI) cannot be overstated. Flexer (2008) noted when children cannot clearly hear classroom instruction the entire premise of the educational system is undermined. Further, when early detection and management of hearing loss is engaged some 90 percent of identified children will be mainstreamed by the time they're in elementary school (Smaldino & Flexer, 2008). The majority of all UNHS is accomplished via otoacoustic emission (OAE) testing and/or auditory brainstem response (ABR) testing (JCIH, 2007). However, the popularity of auditory steady state response (ASSR) testing is increasing as a screening and a diagnostic tool (Beck, Speidel & Petrak, 2007; Beck, Speidel & Craig, 2009).

As UNHS and early hearing detection intervention (EHDI) have essentially become the standard of care, it is of great importance to understand how to use derived ABR tone-burst information with regard to applying the same to amplification. Importantly, many of these protocols go beyond UNHS and EHDI. Indeed, these same fitting protocols can be applied to adults unwilling or unable to undergo traditional behavioral approaches. This article will present an overview of the protocols associated with converting ABR tone-burst data into hearing aid fittings, specifically based on the Desired Sensation Level protocol (DSL m[i/o] v5.0a) applied via Interacoustics hardware and software (see <http://www.dslio.com/> for more information on DSL).

Although the standard "click-based" ABR remains the cornerstone of diagnostic ABR tests, the click is simply not sufficient to describe the hearing thresholds across the speech spectrum

or the most probable slope of the hearing loss. Thus, tone-burst ABR protocols are applied and threshold responses are used (Hood, 1998).

The ABR equipment calibration technique is a major concern (see Stapells, 2000a and Stapells, 2000b, Richter & Fedtke, 2005) and a likely source of confusion. It is important to know which ABR calibration technique was used as the results can differ perhaps up to 20 dB across calibration protocols. DSL works with two ABR data collection protocols. However, the goal is to use a behaviorally equivalent measure such as "dB estimated hearing level" ("dB eHL"). If the data is converted automatically (to dB eHL) via software or other means, no further corrections are necessary (Note - dB eHL data can be entered directly into NOAH and Genie fitting software systems via the Interacoustics Affinity 2.0.).

However, if the ABR tone burst threshold data was collected in normal hearing level (dB nHL), as is often the case, corrections and conversions must be applied (Bagatto, 2005) to facilitate hearing aid selection and fitting. Converting ABR tone burst thresholds at 500, 1000, 2000 and 4000 Hz (respectively) from dB nHL into dB eHL is actually a simple matter. Bagatto et al (2005) recommends subtracting 20, 15, 10 and 5 dB (respectively) from nHL value to give the best estimate (eHL) of the audiogram. However, because DSL is founded in sound pressure level (SPL) as measured in the ear canal, thus a conversion from HL to SPL is required. This too, is simply a matter of adding and subtracting - and is accomplished via software. The result is referred to as the "estimated hearing level" in Sound Pressure Level (SPL). For an in-depth and step-by-step explanation of these same corrections and conversions, see Beck, Samsson and Moodie (2009).

Additionally, it is of paramount importance to determine and use the Real-Ear-to-Coupler-Difference (RECD) to accommodate the specific child's ear canal (Bagatto, 2001). RECD is simply the difference in amplitude (across the speech spectrum) between ▶

the actual "real ear" canal measurement and the measurement obtained in the standard 2 cc coupler - because pediatric ears are most often smaller than adult ears. Thus, if one were to not correct for the child's ear canal volume, it is very likely the prescribed fitting would "over fit" the hearing loss and could potentially cause additional damage. If a physical measure of the ear canal is not possible due to behavioral or other issues, estimates of RECD are available in the fitting software.

Once corrections and conversions (above) have been applied to the ABR tone-burst thresholds, selection and fitting of appropriate amplification can begin. The specific hearing aids and options chosen are based on the needs and requirements of the individual child with respect to their hearing loss, their educational requirements and the concerns and needs of the parents/caregivers.

After the hearing aids have been programmed via the target criteria provided in DSL m[i/o] v5.0a with RECD values (measured or estimated), verification can be initiated (Beck & Duffy, 2007; Pumford & Sinclair, 2001). The Interacoustics Affinity2.0 real-ear measurement (REM) system verifies the electro-acoustic parameters of the hearing aid fitting based on real-ear measurements or predicted real-ear measurements in the form of an "SPL-0-gram" and assures speech audibility for soft, average and loud sounds.

Term	Definition	Comment
peSPL (Peak equivalent Sound Pressure Level)	0dB peSPL is a standardized physically defined acoustic stimulation level as measured in a coupler.	This is what is calibrated when an ABR instrument is calibrated to its transducers
	For each type of stimulus, the normal threshold of hearing (0dBnHL) is at a particular value of peSPL. Therefore, a set number of dBs can be subtracted from the peSPL to arrive at the nHL.	peRETSPL values to use for this are specified for tone bursts in the ISO 389-6 standard (2007).
nHL (normal Hearing Level)	0 dB nHL is the behavioral hearing threshold for normal-hearing young adults for the stimulus in question.	
ABR threshold is given in nHL	This is the outcome of the ABR threshold test.	
	ABR slightly overestimates threshold (greater hearing loss). Thus, ABR thresholds are "corrected" to estimated behavioral-equivalent thresholds in dB HL.	The amount of correction depends on e.g., the ABR stimulus. DSL v5.0a values are 5 dB at 4000 Hz, 10 dB at 2000 Hz, 15 dB at 1000 Hz, and 20 dB at 500 Hz.
Estimated behavioral threshold is often called eHL (Estimated Hearing Level)	This is then our best guess at the actual audiogram.	
	For optimal hearing aid fittings, the ear canal must be considered. Therefore, eHL level to dB SPL in the ear canal is needed.	
dB SPL TM	Used by DSL 5.0 to calculate gain requirements.	

"Road Map" from: "Facilitating a Smooth Transfer From ABR to Hearing Aid Fittings". Beck, Samsson & Moodie (2009).

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The Role of Connectivity and Direct Audio Input in Limiting Exposure to Hazardous Music Levels

George Lindley, Ph.D., Au.D.
 Manager, Oticon Pediatrics Oticon, Inc.
 Somerset, NJ, USA

Background

According to a recent survey, 76% of 8-18 year old children own a portable music player (e.g. MP3 player, iPod). As a group, they reportedly listened to music an average of 2.19 hours per day¹. Listening to music a few hours daily is not inherently dangerous from a noise exposure standpoint unless volume levels routinely exceed recommended exposure limits. For example, according to United States National Institute for Occupational Safety and Health (NIOSH) guidelines, most individuals can be exposed to continuous noise levels of 91 dBA or less for two hours daily with low risk of acquiring significant noise induced hearing loss. A large proportion of the time, however, music is listened to via earphones and personal listening devices that are capable of producing sound levels in excess of 110 dBA². At listening levels of 110 dBA, an individual would exceed recommended exposure limits in 90 seconds. Thus it becomes apparent that many individuals, both with normal hearing and pre-existing hearing loss, are at risk of acquiring noise-induced hearing loss if high volume levels are routinely chosen for excessive periods of time.

It is also important to consider that music is just part of the daily noise dosage for most children and adults. Noise exposures from other activities including shooting, motorsports, power tools, occupational settings, etc. also contribute. Not surprising, in today's noisy world, studies have shown a significant number of children will acquire a noise induced hearing loss before adulthood. Niskar et al. (2001), for example, reported data that suggested 12.5% of a population of 6-19 year old children had noise-related hearing loss in at least one ear³.

Recently, investigators have focused on preferred listening levels when using personal music systems. Snowden and Zapala (2010) found that 53% of a group of middle-school students chose iPod listening levels that were unsafe in a binaural listening condition⁴. Notably, 31% of the participants wanted to set the iPod at the maximum (110 dB A) level. Fligor and Ives (2006) found that only 6% of normal hearing college-age students chose unsafe listening levels in quiet. However that number increased to 80% when listening in a simulated airplane environ-

ment. By using occluding earphones that effectively reduced the level of background noise, the number of participants choosing an unsafe listening level dropped to 20%.

Taken together, the results of these studies and others indicate that many children and adults are exposed to excessive noise levels from listening to music and other activities on a daily basis. When listening to music, the amount of background noise and the type of transducer are factors that contribute to the listening level chosen by the user. For individuals with hearing loss using amplification, an additional factor enters the picture namely the coupling or non-coupling of hearing instruments with the personal music player.

Options for Controlling/Reducing Preferred Listening Levels

Education remains a critical aspect of reducing risk of noise exposure for both normal hearing individuals and individuals with hearing loss. Counselling on effective volume control strategies and the risks associated with listening to music at excessively loud levels should be reviewed. Importantly, individuals with hearing loss need to realize there is potential for acquiring additional hearing loss as a result of noise exposure.

Beyond the education component, there are additional strategies that can be employed to reduce the potential for music-induced hearing loss. The output of some devices can be limited. The popular iTunes software used with iPods allows one to limit the maximum volume under the settings tab. Usage of an occluding earphone can reduce the negative impact of background sounds on the enjoyment of music and therefore lead to listening at lower volume levels. This will have an impact on environmental awareness, however, and safety needs to be considered when using this type of transducer for certain activities such as running outdoors.

For individuals with hearing loss, use of traditional earphones poses additional difficulties as these transducers generally provide a fairly flat frequency response. Therefore the music will not be shaped according to the degree and configuration of hearing loss. An individual with a sloping hearing loss, for example, may be inclined to increase the volume in order to achieve some degree of audibility for the higher frequency aspects of music. Without appropriate output limiting, however, this can lead to potentially dangerous listening levels. Another concern when using occluding earphones would be an even further decrease in environmental awareness due to the combined effects of sound isolation by the earphones on top of audibility deficits ▶

resulting from the hearing loss. Ideally, individuals with hearing loss would listen to music while wearing their hearing instruments. This can be accomplished in a number of ways including direct audio input (DAI), usage of a neckloop and telecoil, or through usage of a connectivity device such as Streamer. When using one of these connection options, music will be better shaped to reflect the user's hearing loss and the compression/output settings of the hearing instruments provide additional assurance that the music levels reaching the ear canal will not be excessive.

Figure 1 shows the real-ear music output measured when using an iPod with earbuds on KEMAR (Knowles Electronic Manikin for Acoustic Research) thus reflecting average adult head, torso, and ear canal characteristics. In this example, a mild to moderately severe sensorineural hearing loss was created. Note that both output curves demonstrate a peak at 2600 Hz that is associated with an average real-ear-unaided response indicating that the typical iPod earbuds are non-occluding in nature. The green curve is the output obtained with the iPod volume set to $\frac{3}{4}$ volume while the pink curve is that obtained with the volume at the highest setting. In order for high frequency audibility to be provided, this individual would need to use the iPod at or near full volume level. Figure 2 shows the same setup except this time, the music is routed from the iPod (at $\frac{3}{4}$ volume) to the hearing instruments before presentation to the ear. In this example, the hearing aid was programmed to match DSL 5.0 targets for this hearing loss. The orange line shows the real-ear output obtained using the Streamer gateway device with the iPod while the purple line was obtained using a DAI connection between the iPod and hearing aid. In both cases, the output falls more appropriately within the user's dynamic range. An additional bass boost is provided by Streamer to enhance the quality of the music signal and reduce the impact of venting on low frequency output.

There are several advantages of using one's hearing instruments to listen to music and other signals. The response is shaped to reflect the individual's hearing loss. In our hypothetical example, high frequency audibility is provided at lower volume settings reducing the risk of noise induced hearing loss. The Streamer device can also reduce the impact of venting on low frequency output by providing a bass boost.

For both Streamer and DAI connections, the hearing aid user is able to mute or engage the hearing instrument microphones while listening to music depending on the need for environ-

mental awareness. There is no need to switch between occluding versus non-occluding earphones depending on the listening environment. For a DAI connection, different hearing aid programs can be created to reflect a DAI only versus DAI plus microphone condition. With Streamer, the user simply presses a button on the device in order to toggle between hearing aid microphone "off" versus "on" settings.

In summary, individuals with normal hearing and individuals with hearing loss are at risk of acquiring hearing loss when routinely listening to music at excessive volume levels. Strategies are available to help reduce this risk and include both educational and technological options. For individuals with hearing loss, routing of the signal through the hearing instruments provides a convenient and safe method for reducing the potential for noise induced hearing loss. Verification measures can be used to not only document safe listening levels, but also for counselling purposes.

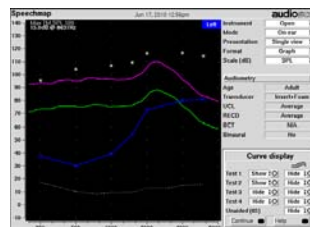


Figure 1. Real-ear output measured on KEMAR with an iPod set to $\frac{3}{4}$ volume (green line) and at full volume (purple line).

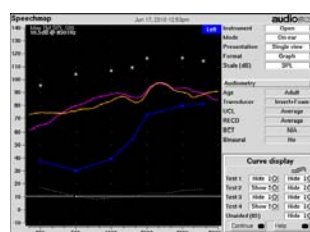


Figure 2. Real ear aided output obtained when the music signal is routed from the iPod to the hearing instruments. The purple line was obtained using a DAI input while the orange line was obtained using Streamer.

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