Quantifying and Responding to Patient Needs and Expectations

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Abstract

Comprehensive audiometric testing serves as the cornerstone of adult hearing aid fittings for many clinicians. The data will serve to define the degree, configuration, and site of lesion of the hearing loss. The data will be used in prescriptive formula to preset the hearing aid and may be entered into probe microphone or hearing aid test box equipment to provide verification targets. Clinicians are comfortable obtaining audiometric data, have an accepted way of obtaining these data, and are comfortable discussing these data with patients and other professionals. The patient, however, is not a walking audiogram and may bring all sorts of interesting nuances to the process.

Just as part of the clinician’s comfort with using audiometric data comes from the standard process of obtaining and reporting these data, the clinician who chooses to go beyond the audiogram in terms of data collection with a patient must have a means for gathering and quantifying additional information. The following case describes a method of obtaining and quantifying the patient’s listening and communication needs. The case illustrates the use of these measures in recommending appropriate communication and safety solutions.

Key Words: Assistive listening devices, communication needs, expectations, hearing aids, telephone, television

Abbreviations: ALD = assistive listening device; APHAB = Abbreviated Profile of Hearing Aid Benefit; AV = aversiveness; BN = background noise; EC = ease of communication; FM = frequency modulated; QuickSIN = Quick Speech in Noise Test; RV = reverberation; SNR = signal-to-noise ratio; STS-SPLITS = simulated telephone sensitivity—sound pressure level for inductive telephone simulation; UCL = uncomfortable listening level

Sumario

La evaluación audiométrica integral es la piedra angular para muchos clínicos en la adaptación de auxiliares en adultos. Esta información servirá para definir el grado, la configuración y el sitio de la lesión de la pérdida auditiva. Los datos serán utilizados en una fórmula de prescripción para configurar el auxiliar auditivo y pueden ser introducidos en equipos de micrófono de sonda o de caja de evaluación de audífonos, para conseguir mediciones de verificación. Los clínicos se sienten a gusto obteniendo esta información audiométrica, disponen una forma aceptada para obtenerla y se sienten cómodos al discutir estos datos con pacientes y con otros profesionales. El paciente, sin embargo, no es un audiograma móvil y puede traer todo tipo de interesantes variantes al proceso. Esta comodidad del clínico cuando utiliza información audiométrica, proviene de la forma estandarizada de obtener y reportar dichos datos. Igualmente, el clínico que escoge ir más allá del audiograma al obtener datos del paciente, debe disponer de medios para recolectar y cuantificar la información adicional. El siguiente caso describe un método para obtener y cuantificar las necesidades de audición y comunicación del paciente. El caso ilustra sobre el uso de estas medidas en la recomendación de soluciones apropiadas de seguridad y comunicación.
Comprehensive audiometric testing serves as the cornerstone of adult hearing aid fittings for many clinicians. The results from this testing reveal the degree and configuration of hearing loss as well as recognition of monosyllabic words in quiet at a comfortable listening level. In most cases, the site of lesion can be defined from these findings, or further testing will be indicated to define the site of lesion. Based on the results, the clinician will determine the style of hearing aid, which often is recommended based on degree of hearing loss, and whether the individual needs one or two hearing aids. Special features including multiple channels and directional microphones may be recommended based on the configuration of the hearing loss and the results of word-recognition testing, respectively. For instance, if the shape of the loss provides different average thresholds across three frequency areas on the audiogram, a three-or-more-channel hearing aid may be needed to fine-tune the gain and compression characteristics across frequencies. If the hearing loss has a sharp slope into the high frequencies, the audiologist may want a greater number of frequency channels in order to shape the response and control feedback. If a speech-in-noise task is employed in the evaluation, the results may suggest that the individual has great difficulty in noise even when sound is presented audibly, and this may warrant the selection of directional microphones or other special features. These decisions will be discussed in detail later.

These same audiometric results provide the data used by current hearing aid fitting algorithms (e.g., NAL-NL1 [Byrne et al, 2001]; DSL[i/o] [Cornelisse et al, 1995]). Thresholds are entered, and a series of mathematical calculations provide the clinician with the gain or output required for soft (50 dB SPL), moderate (65 dB SPL), and loud (85–90 dB SPL) input levels to match a prescriptive target. During verification, these same thresholds can be entered into real ear probe microphone systems to provide a variety of prescriptive target responses. Clinicians are comfortable obtaining audiometric data, have an accepted way of obtaining these data, and are comfortable discussing these data with patients and other professionals. The patient, however, is not a walking audiogram and may bring all sorts of interesting nuances to the process.

Just as part of the clinician’s comfort with using audiometric data comes from the standard process of obtaining and reporting these data, the clinician who chooses to go beyond the audiogram in terms of data collection with a patient must have a means for gathering and quantifying additional information. Consistent methods are essential for clinics with multiple practitioners and from a quality control perspective. Is it enough that clinicians interview patients and use that information to inform their amplification and treatment decisions, or is it necessary to implement a more standard approach to insure consistent, quality care? What do audiologists need to ask in order to accurately and efficiently define the patient’s needs and
expectations related to all hearing concerns? The following case is offered as an example where a nondirected interview, widely accepted self-report techniques, and audiometric data would not have lead to appropriate solutions for this patient.

**PATIENT DESCRIPTION**

Mrs. X is an 88-year-old woman who arrived at the clinic with her daughter. The patient was ambulatory with a cane and engaged in conversation with multiple requests for repetition. The appointment was listed as a hearing test with possible hearing aid discussion. The standard patient history revealed that Mrs. X’s chief complaint was not hearing well, and she indicated that she had come to the clinic to purchase a new hearing aid if needed. She indicated that her current hearing aid did not always sound good when there were loud sounds, and it sometimes squealed. Her history was negative for ear surgery, ear pain or drainage, dizziness, and tinnitus. When asked about her general health, Mrs. X indicated that she was not on any medications and was in good health. Mrs. X indicated that she had purchased the one behind-the-ear hearing aid that she was wearing for her right ear approximately three years ago near where her daughter was living at the time. She did not choose to go back to that clinic since the daughter was no longer located there. The daughter revealed that they had traveled over 60 miles that morning to get to the clinic and that there were no audiologists closer to where her mother was living. Otoscopic examination revealed clear ear canals and an intact eardrum. Mrs. X removed her hearing aid so it could be cleaned and tested while she was having her hearing test.

**AUDIOMETRIC EVALUATION**

Audiometric evaluation revealed a sloping moderate to severe-to-profound sensorineural hearing loss bilaterally (Figure 1). Word recognition in quiet (recorded CID W-22 female talker, 50 word list) at a comfortable listening level (100 dB HL and 104 dB HL) produced scores of 32 and 30%

<table>
<thead>
<tr>
<th>SNR Loss</th>
<th>Degree of SNR Loss</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 dB</td>
<td>Normal/near normal</td>
<td>As good as, or better than, normal-hearing individuals</td>
</tr>
<tr>
<td>2-7 dB</td>
<td>Mild SNR loss</td>
<td>As good as many normal-hearing individuals</td>
</tr>
<tr>
<td>7-15 dB</td>
<td>Moderate SNR loss</td>
<td>Directional microphones are recommended</td>
</tr>
<tr>
<td>&gt;15 dB</td>
<td>Severe SNR loss</td>
<td>Maximum SNR improvement is needed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consider an assistive listening device (e.g., FM system)</td>
</tr>
</tbody>
</table>

*Source: Adapted from Etymotic Research, 2001.*
in the right and left ear, respectively. Although the signal-to-noise ratio (SNR) required to achieve 50% correct on the sentences in noise (QuickSIN; Etymotic Research, 2001) is routinely evaluated when patients are pursuing amplification, the QuickSIN is not performed if the individual displays poor word-recognition results in a quiet signal presentation. The rationale for this is that the patient is going to continue to have marked difficulty in noise if he/she already has difficulty in quiet, and measurement will not inform the treatment recommendations. Conversely, there are individuals who do quite well in quiet but have greater difficulty in noise. It is not possible to predict this from the audiogram, so a speech-in-noise test is used to assist in recommending hearing aid features (e.g., directional microphones) and assistive listening device solutions.

**UNDERSTANDING SPEECH IN NOISE**

Table 1 provides the guidelines for matching technology with QuickSIN results (Etymotic Research, 2001). These recommendations are published by Etymotic Research and are based on a compilation of data from other studies revealing potential directional microphone advantage. There are not empirical data to match exact level of SNR loss to technology recommendations. The clinician, however, may find the QuickSIN results to be a helpful counseling tool. If the patient is scoring at 7 dB SNR loss, it may be helpful to let the patient know that he or she is functioning similarly to a normally hearing individual when the signal is presented at a comfortable level. This means the patient needs amplification but that he or she can sort out the signal and noise fairly well without any remarkable technological manipulations. It is easy for a patient to lose sight of the fact that everyone has difficulty hearing in noise some of the time. This does not mean that an individual with an SNR of less than 7 dB could not benefit from a directional microphone; it simply means that this technology may not be a requirement for reasonable amplification success. If the patient’s score is greater than 7 dB SNR, it is appropriate to indicate that he or she has more difficulty than would be expected once the signal has been made audible.

There are no data to indicate an exact level of SNR loss that will benefit most from directional microphones and/or assistive listening devices. Currently, these numbers simply support clinical decision making. The more difficulty (greater the SNR), the more signal enhancement the individual needs to perform well in noise. If directional microphones are recommended, the clinician needs to take the time to train the user in correct positioning within the listening environment in order to take advantage of the signal-to-noise ratio enhancement (Cord et al., 2002). If a room is highly reverberant, the benefits of a directional microphone will be diminished because the noise from behind the person is reaching both microphones due to reflections in the reverberant environment. An assistive device will always provide the best signal enhancement because the microphone is located by the speaker and the signal is delivered directly to the listener overcoming any noise or distance problems. Users of assistive listening devices have to be comfortable placing the microphone in the desired location whether that is by a lecturer or on a companion at a restaurant. The success of either solution, directional microphones or assistive devices, is dependent on patient education. Clinicians would welcome well-controlled research that might provide predictive measures for recommending these technologies.

In Mrs. X’s case, her word recognition in quiet was diminished to a point that it can be assumed that her hearing in noise also would be compromised. According to the data provided by Thornton and Raffin (1978), Mrs. X’s true (95% confidence) word-recognition scores could be anywhere between 16% and 50% in the right ear and 14% and 48% in the left ear. Even with this range, due to the poor reliability of word-recognition testing, it is safe to say that Mrs. X has poor recognition of single words in quiet. Dubno et al. (1995) provided data for the comparison of pure-tone average (PTA) and word recognition. According to these data, Mrs. X’s word-recognition results are disproportionately low compared to average results, meaning that one would expect better (approximately 44% or higher) word recognition given the average level of Mrs. X’s thresholds. Based on the symmetry of the test results and the lack of any other signs and symptoms along with age, Mrs. X was not referred for further
testing based on her disproportionately low word-recognition scores.

**SELF-REPORTED HEARING ABILITY**

Patients are provided with a paper and pencil version of the Abbreviated Profile of Hearing Aid Benefit (APHAB, Cox and Alexander, 1995) when they check in at the front office. They complete the survey while waiting to be called in for their appointment. The APHAB is scored using a computerized scoring tool by one of the front office staff while audiometric testing is being completed so the audiologist will have the APHAB results and audiometric results when discussing possible treatments with the patient. Patients who currently wear hearing aid(s) are asked to complete the APHAB in the “currently aided” condition. It is unlikely that full-time users of amplification can respond accurately to the APHAB statements in the unaided condition because responses would be based on the memory of how they heard before they started using hearing aids. Therefore, Mrs. X was asked to respond to the APHAB statements as if she were wearing her current hearing aid (right ear BTE). The instructions on the APHAB indicate that “if you have not experienced the situation we describe, try to think of a situation that you have been in and respond for that situation. If you have no idea, leave that item blank.”

The computerized scoring program of the APHAB provides several pieces of data. There is a chart of the distribution of responses (from A to G). The response for each of the 24 items is noted. Ideally, responses will range from A to G without a particular pattern. If all of the responses are in the middle, it generally means the individual has put very little effort into reading and answering the questions accurately. If the responses are all at the top (G) or all at the bottom (A) it means the individual has not carefully read the questions because a number of questions are purposefully reversed and a consistent demonstration of difficulty (similar to other questions) would require the individual to answer on the opposite end of the scale for reversed questions.

Mrs. X responded to all of the APHAB statements, and her response pattern indicated the majority of responses were on either end of the scale (always or never), with a few responses toward the middle. Upon a brief inspection of individual items, it was clear that Mrs. X perceived great difficulty in most communication situations addressed on the APHAB (i.e., shopping, lectures, small groups, large groups, car, dinner table, offices, theaters, doctors’ offices, and worship) and had little problem with loud (averse) sounds (i.e., sirens, traffic noise, smoke detector, running water, construction work, fire engines, and screeching tires). Her self-report regarding the perception of loud sounds appears to be in contradiction to her earlier report during the case history. At that time she reported that her current hearing aid did not always sound good when there were loud sounds. This

![Figure 2](image1.png) **Figure 2.** Abbreviated Profile of Hearing Aid Benefit (APHAB) results from the patient compared with normal-hearing elderly individuals.

![Figure 3](image2.png) **Figure 3.** Abbreviated Profile of Hearing Aid Benefit (APHAB) results from the patient compared with users of linear amplification.
apparent contradiction will be discussed later in the paper.

COMPARISONS TO NORMATIVE DATA

The composite aided scores for the Ease of Communication (EC), Reverberation (RV), Background Noise (BN), and Aversiveness (AV) subscales are plotted in Figure 2. Mrs. X’s results are represented by A’s (aided condition), and the 5th to 95th percentile for elderly individuals reporting no hearing loss are displayed for comparison purposes. These are normative data that allow comparison of a patient to a representative group of people (e.g., other older adults). Based on Figure 2, it would be correct to indicate that Mrs. X perceives more problems in quiet, reverberant, and noisy situations than 95% of a population of older adults. Only about 5% of the population experience as little difficulty as she does with aversive sounds. Most of the population experiences much more difficulty with these loud noises.

In Figure 3, Mrs. X’s results are compared with data from individuals of all ages wearing linear amplification, which also can be considered a comparable population since Mrs. X wears a linear hearing aid. Compared to other users of linear technology, Mrs. X is at about the 95th percentile for communication situations. This means that approximately 95% of this population perceives fewer problems than Mrs. X. Although this is acceptable performance (she is within the population data between the 5th and 95th percentile), this is not ideal since she is at the upper edge of what is considered normal for this population. She is within the 5th percentile for aversiveness (meaning that she has very little problem with aversive sounds). Only 5% of this population perceives fewer problems than she does.

EVALUATING CURRENT AMPLIFICATION

If an individual currently uses amplification, electroacoustic and real ear aided response measures are performed to evaluate the amplification the individual currently is using. The treatment options include knowledge of what the individual already owns in case the current technology can be used in the recommended solution. The assessment used for current amplification includes measures that relate to the basic goals of a hearing aid fitting: providing audible and comfortable sound for soft, moderate, and loud input signals with low distortion (i.e., less than 10% total harmonic distortion) across a variety of input levels. Additional hearing aid features are evaluated (e.g., telecoil, directional microphones, etc.). The worksheet presented in Appendix A (Palmer, 2003) provides the list of parameters measured. The worksheet presented in Appendix A has been filled out for Mrs. X, and the measurement process will be described briefly below. A full description of this type of evaluation can be found in Palmer (2003).

SIGNAL PROCESSING IN THE CURRENT HEARING AID

Mrs. X is wearing an Oticon Personic 425 hearing aid in her right ear. The hearing aid is attached to a skeleton style acrylic earmold by an undamped earhook. The Personic provides linear gain (same gain regardless of input level) until limiting. A review of the specifications for the Personic 425 reveals “active output limiter” (or “AOL”) as the output limiting. This is a manufacturer-specific term. There is no easily available electroacoustic measure that will differentiate types of output limiting (peak clipping versus output compression limiting). A call to the
company revealed that output compression limiting is employed. An input/output graph from the ANSI (1996) test verified a linear response through 70 dB input and then output limiting with a maximum output of approximately 130 dB SPL. This hearing aid has two potentiometers for response manipulation: UCL (uncomfortable loudness level) and “AGram.” The UCL potentiometer controls maximum output and was set to “full on” (allowing maximum output). The “AGram” control serves as a low-frequency tone control. The current setting provided maximum gain for low frequencies.

REAL-EAR PROBE MICROPHONE RESPONSE WITH THE CURRENT HEARING AID

Real-ear aided response measures are used to address the first three items on the worksheet in Appendix A. The reliability and validity of real-ear aided response measures have been established and repeatedly reported in the literature (Hawkins and Mueller, 1986; Dirks and Kincaid, 1987; Hawkins, 1987; Tecca et al, 1987; Killion and Revitt, 1993; Scollie et al, 1998). The individual’s thresholds are entered into the real-ear probe microphone system, and the system converts these HL data to SPL data using average conversions. The display (see Figure 4) presents right-ear thresholds as circles and UCL (either average or measured if those have been entered) as asterisks. For Mrs. X, average UCLs were used. The plus signs reveal the DSL \[i/o\] (Cornelisse et al, 1995) target for average input levels. The target does not have to be used, but it is displayed. The three curves on the plot represent the results for a soft input (50 dB SPL), moderate input (65 dB SPL), and loud input (85 dB SPL). A speechlike signal was used to obtain these curves (Stelmachowicz et al, 1996; Scollie and Seewald, 2002). The curve for the soft input should be at or slightly above threshold. The moderate input should be above UCL, and the loud input should be above the moderate response but below UCL. As indicated on the worksheet in Appendix A, the hearing aid achieves these goals, although the loud input could provide a higher output in the low frequencies.

These judgments must be made in the context of what is realistically achievable with the individual’s hearing loss. For example, soft and moderate sounds are not audible in the higher frequencies, but given thresholds of 85 to 100 dB SPL, there is no fitting that will achieve audibility at these levels, and there are data to suggest that audibility will not be useful to the patient at these levels (Turner and Cunningham, 1999; Baer et al, 2002). Even if audibility could be achieved, it certainly would cause sounds to be uncomfortably loud. It is within this context that bandwidth is examined as well. For this patient, the bandwidth of this hearing aid is appropriate. In addition, there are no data to suggest “how audible” a signal should be for an adult listener. Should soft be just above threshold; should moderate be at the halfway point, and so forth? Currently, the rationale that the patient cannot use a signal if it is not audible and will not use a signal that is uncomfortable are followed. David Pascoe said it eloquently, “although it is true that mere detection of a sound does not ensure recognition. . . . It’s even more true that without detection, the probabilities of correct identification are greatly diminished” (Pascoe, 1989).

THE IMPORTANCE OF AUDIBILITY

The question of audibility has been fairly well defined for the pediatric population. Stelmachowicz et al (2000, 2002) provide convincing data that for the child with little language context, audibility across a wide bandwidth is essential for speech understanding. Adults may have different requirements and preferences than children because of previous listening experience and ability to rely on context. Sousa (2000) compared the articulation index (an audibility measure) after matching the hearing aid fitting to an NAL-R target to self-perceived performance after a year of use. The correlations were very low, indicating that audibility alone is not sufficient to produce self-perceived benefit. In fact, adults’ self-perceived benefit appears to decrease as audibility increases past a certain level (presumably comfort; Leijon et al, 1990; Stelmachowicz et al, 1998). Discrepancies about just how audible sound should be for the adult patient may stem in part from a lack of data related to the role of binaural summation (amplification in both ears), and the use of signal summation (warble tone to broad-band stimuli) transforms from normal-hearing individuals.

Lindley et al (2001) reported loudness
growth data for both normal-hearing and moderately hearing-impaired individuals. The normal listeners had the greatest loudness summation (from warbles to speech) for comfortable level stimuli and less for soft and loud stimuli. For the hearing-impaired subjects, loudness summation was greatest for loud stimuli rather than for moderate stimuli. A prediction of loudness summation from warble tones to speech is important because hearing aid fitting algorithms and verification are based on tonal inputs, but the individual will be listening to speech. Current hearing aid fitting algorithms are based on the expected loudness summation of normal listeners. As more is understood about the damaged system and its impact on perception, these assumptions may need to be modified. These findings may help explain some dissatisfaction with varying amounts of audibility even when the clinician has “met a target.”

Although data suggest that new hearing aid wearers adjust to newly audible soft sounds over time (Mueller and Powers, 2001), the data related to adaptation to loud sounds suggest that adults do not experience increased tolerance (Schmitz, 1969; Walden et al, 1977; Berger and Hagberg, 1982; Byrne and Dirks, 1986). The clinician will want to verify that loud sounds are not uncomfortable prior to the patient leaving the hearing aid fitting. The clinician indicate that there should not be an expectation that the patient will adjust to being uncomfortable, and further, this discomfort may preclude use of the hearing aid. In fact, Kochkin (2003) reported that only 42% of hearing aid users in his survey of approximately 11,000 hearing aid users are satisfied regarding comfort for loud sounds. When asked what improvements they would like to have in new hearing aid technology, 58% indicated that having “loud sounds be less painful” would be a highly desirable improvement.

LOUDNESS JUDGMENTS WITH THE CURRENT HEARING AID

As part of the assessment of current technology, the patient’s response to loud sounds is elicited to ensure that the current hearing aid fitting is not uncomfortable. A 60 dB SPL and 80 dB SPL broad-band speech signal are provided, and the patient is asked to rate each signal using the 7-point rating scale from Cox’s (1994) Contour Test (very soft to uncomfortably loud). A rating of 3–5 for the 60 dB SPL signal and a rating of 5–6 for the 80 dB SPL signal is the goal. If the rating is a 7 for the 80 dB SPL signal, the gain for loud sounds or the maximum output to ensure comfort for the individual has to be decreased. Soft sounds are not rated because this perception will change over time since these are the sounds the patient has not been hearing (Mueller and Powers, 2001). Mrs. X rated the moderate sound as a 4 and the loud sound as a 6.

SOUND QUALITY OF THE CURRENT HEARING AID

Sound quality is examined through an objective measure and patient interview. In taking the original history, the patient indicated that she did not like the sound of her hearing aid when there was loud sound around her. An electroacoustic analysis of her hearing aid with its current settings is displayed in Figure 5. This is the gain curve for an 85 dB input signal. This test provides harmonic distortion bars (not displayed on this figure)

Figure 5. Electroacoustic analysis of the gain and frequency response of the hearing aid with a moderate (50 dB SPL) input signal. The dash/dot line illustrates the response without a damped earhook, and the dashed line illustrates the response with a damped earhook.

Figure 6. Total harmonic distortion is illustrated by the bars along the x-axis and by percent on the right y-axis. The total harmonic distortion across frequency is less than 10%.
that reached greater than 30% across frequencies. Ten percent distortion is considered to be the greatest allowable distortion for reasonable sound quality (Nielsen et al, 1990) and is easily achievable in hearing aids available today. Unlike the ANSI (1996) recommendation, an input signal of 85 dB SPL is used in order to test the harmonic distortion of the hearing aid. Most hearing aids have reasonably low distortion at the ANSI input levels (60 to 70 dB SPL), and it is not until they are driven into saturation that distortion is revealed. An 85 dB SPL signal is a common input level at the hearing aid microphone including the user’s own voice.

The distortion measure is viewed in light of the frequency/gain response since this sometimes provides insight into the cause of the distortion. In Mrs. X’s case, the frequency response curve does shed light on the possible cause of distortion at high input levels. Mrs. X’s behind-the-ear hearing aid had an undamped earhook when she arrived. The two resonant peaks due to sound channel length and receiver characteristics can be seen on the plot in Figure 5, one at 1500 Hz and one at 3000 Hz. Her earhook was replaced with a 1500 Hz damped earhook. The dashed line on Figure 5 reveals the new frequency response curve. The harmonic distortion test was rerun with the new earhook, and the results are depicted in Figure 6. The distortion is now at 10% or lower across frequencies.

These harmonic distortion measures at high input levels are in agreement with the reported use of output compression limiting. When peak clipping is employed, high distortion generally is noted at levels intense enough to drive the instrument into saturation. The detrimental effects of peak clipping on speech recognition ability and sound quality have been established (Preves and Newton, 1989; Hawkins and Naidoo, 1993). Output compression limiting is the appropriate way to limit the hearing aid signal, and this is what is employed in Mrs. X’s current hearing aid.

The real-ear aided response measures reported in Figure 4 were conducted with the new earhook at user volume control settings. Mrs. X may find that she can increase her volume control position now that the distorting peak has been removed. If she does this, she may achieve better audibility in the low and midfrequencies without discomfort in the high frequencies since output limiting will restrict the overall output. In addition, the undamped peak may have made the hearing aid more susceptible to feedback, which was one of Mrs. X’s original concerns.

**USING THE TELEPHONE WITH THE CURRENT HEARING AID**

The electroacoustic analysis is used to evaluate the function of the telecoil circuitry as well. The Simulated Telephone Sensitivity—Sound Pressure Level for Inductive Telephone Simulation (STS-SPLITS) is measured (Figure 7). As can be seen from the graph, the telecoil has a flat frequency response that is appropriate for the telephone. The STS-SPLITS value provided indicates the change in volume control that would be required to achieve a similar response to the microphone setting at the measured volume control. When the SPLITS was measured at user volume control setting (approximately a VC setting of 2 with a range of 1–4), the measured response was -14 dB. This result indicated that the patient would have to increase the volume control (VC) to obtain the same response on the telephone as she obtained through her microphone at use gain setting. At full-on VC position, the STS-SPLITS was -4 dB (Figure 7), which indicated that even at full-on setting, the telecoil response was weaker than the microphone response that one would presume to be the correct response for the individual.

**Figure 7.** The telecoil response plotted as output across frequency.
The last portion of the worksheet presented in Appendix A (unresolved issues based on patient interview and observation) is completed during the patient interview. Some of these issues are raised by the patient, and others must be presented as questions to the patient.

**DESCRIBING RESULTS**

At this juncture in the evaluation, the patient’s self-report of communication difficulty as assessed by the APHAB (the complete audiometric evaluation that provides insight into degree, configuration, and site of lesion of hearing loss as well as word recognition in quiet) and the current status of the individual’s hearing aid is known. All results thus far point to the patient having significant communication difficulty in a wide variety of communication situations (as evidenced by the APHAB) using her current hearing aid. This is consistent with moderate-to-severe hearing loss with very poor word recognition.

At this point, it would be tempting to provide a recommendation consistent with the philosophy of the clinic. This would include binaural instruments staying with the behind-the-ear style due to the degree of hearing loss. It is reasonable to recommend the same signal processing for both ears, and it also would be reasonable to improve the technology that the patient is using rather than matching her current technology in the second hearing aid. The improvement might consist of wide dynamic range compression allowing the patient to differentiate the audibility for moderate and high input levels and multiple channels that would allow fine-tuning of the audibility response considering the patient’s very poor high-frequency hearing, transitional midfrequency hearing, and moderate hearing loss in the low frequencies. Given the telecoil response of the current hearing aids, it would be reasonable to include a programmable telecoil in the new instruments in order to provide an optimum setting for telephone listening. An automatic telecoil (switches automatically when the magnet from the telephone is in close proximity to the hearing aid) might be considered if that would make telephone communication easier (no switching needed). The automatic telecoil does not work with assistive listening devices so the need for these would have to be ruled out or an automatic telecoil with an optional telecoil switch would have to be selected.

Considering the results of the BN and RV subscale of the APHAB and the very poor word-recognition results, directional microphones would be a reasonable recommendation. There are no data indicating if degree of hearing loss and degree of word-recognition difficulty interact with ability to benefit from directional microphone technology. There are data to indicate that the laboratory advantage of directional microphones does not predict the real-world benefit of directional microphones (Surr et al, 2002). Walden et al (2003) indicate that directional microphones are an environmental manipulation and the patient must be taught how to position themselves and how to identify appropriate listening situations for beneficial directional microphone use. The signal must be in front of the listener with the noise behind with a fairly low level of reverberation in the room so the noise truly is coming primarily from behind.

**FORMALIZED PATIENT INTERVIEW**

Rather than proceed with what might be considered expected recommendations, the patient was interviewed in order to complete two forms used in the clinic. In order to better communicate during this process, the individual’s current hearing aid(s) are worn. If the patient does not have hearing aids, an assistive listening device may be used so a comfortable conversation can be conducted with the patient. If the patient has hearing aids, he/she inserts the hearing aid(s) so the clinician can see if the patient is able to do this easily and how the patient manipulates the hearing aid(s). An individual may report daily hearing aid use, but when the patient attempts insertion, he/she does not know which ear the hearing aid(s) so the clinician can see if the patient is able to do this easily and how the patient manipulates the hearing aid(s). An individual may report daily hearing aid use, but when the patient attempts insertion, he/she does not know which ear the hearing aid goes in or how to put it in the ear. In other circumstances, the patient may have difficulty with insertion just because of manual dexterity challenges. This was the case for Mrs. X. It quickly became apparent that Mrs. X knew how to put her hearing aid in, but her hands were not cooperating. She had the greatest difficulty getting the upper portion of the skeleton mold tucked into the concha. She finally got the hearing aid seated and was asked if the clinician’s voice was...
comfortable or if she needed to turn the hearing aid volume control up or down. She indicated that she always set it in the middle prior to putting the hearing aid in because she could not feel the wheel or switches (the microphone/telecoil setting) on the hearing aid. She did indicate that voices were at a comfortable level. Due to these difficulties, Mrs. X was asked how she handles replacing batteries, and she indicated that the helper that comes to her home once per week changes the battery at that time. The simple action of handing Mrs. X the hearing aid to place in her ear will later influence several decisions in the recommendation process.

A SYSTEMATIC APPROACH

The use of the forms described below should encourage consistent practice by multiple clinicians at a primary clinic and/or satellite locations. The Hearing Demand, Ability, and Need Profile (HDAN; Palmer and Mormer, 1997 [see Figure 8]) provides a systematic interview format and data collection sheet. This process was implemented in response to retrofitting/remaking instruments, instrument returns, and the ability to provide complete hearing health care to patients. By asking specific questions about alerting situations, communication situations, and “other” activities (see Figure 8), the clinician can avoid costly remakes and returns as well as provide more comprehensive hearing health care to patients. This sheet delves into all of the types of signals to which an individual may need to respond and helps inform the final instrument(s) selection. Often, assistive listening devices (ALD) are not initially considered by clinicians; however, if the results of the various tests and questionnaires described above indicate poor word recognition and problems in noise, then the need to recommend ALDs and hearing aids compatible with ALDs would become clear.

HEARING DEMANDS AND NEEDS

The HDAN (Figure 8) is created so the clinician can quickly ask about each situation (left-hand column) in each
environment that applies to the patient (home, work, travel) with the hearing aids on and off ("off" applies to night time or if a nonuser is being interviewed). If the cause of the difficulty can be identified, it is indicated in the column under "The Problem is Due to..." If the patient currently uses technology or strategies, these are indicated to the far right. Indicating current compensation methods assists the audiologist in designing solutions that work well with or even make use of current solutions being employed by the patient. The alerting and personal communication categories are self-explanatory. The "Other Activities" section is very helpful in finding out needs peculiar to specific patients (e.g., the need to use a stethoscope with hearing aids, the participation in particular sports or other hobbies that may require special solutions).

The use of the HDAN was particularly enlightening with Mrs. X. She does not have difficulty hearing her telephone ringer, doorbell, or smoke detector with her hearing aid on or off. Mrs. X does not work and indicated that she does not travel except to doctor’s appointments when her daughter or son visit. When asked about hearing sirens or turn signals, Mrs. X indicated that she no longer drives. Under “Personal Communication,” Mrs. X indicated she has great difficulty on the telephone and uses it exclusively to communicate with both of her adult children, neither of whom live near her. Further, she indicated that she needs to rest on and off all day, and when she is awake she likes watching the news. She has always enjoyed keeping current with world events. She indicated she has significant difficulty understanding the television with or without her hearing aid. When asked if she had tried looking at the captioning, she said it was very confusing to try to listen and read, and her preference would be to listen if possible.

When asked about difficulty in one-to-one, group, or large room communication, Mrs. X indicated that she had no difficulty in these situations because she was never in them. This, of course, is in direct conflict with the results of the APHAB that was completed earlier. Upon further discussion, Mrs. X and her daughter indicated that Mrs. X’s mobility is such that she never leaves her home now. A service does her shopping and cleaning weekly. She communicates with the individual from this service in the quiet of her home. She has no living friends where she is and only communicates by telephone to her children who live at a great distance (over 500 miles each). She has no plans of moving nearer to her children; they have no plans to move nearer to her; and she has no plans of entering any type of retirement or partial care community at this time.

The discussion that was prompted by the questions on the HDAN made it clear that Mrs. X needs to be able to hear the telephone ringer, doorbell, smoke detector, television, and understand the captioning on the television. The use of the HDAN was particularly enlightening with Mrs. X.

Patient Expectation Worksheet

<table>
<thead>
<tr>
<th>Goal (list in order of priority)</th>
<th>Hardly Ever</th>
<th>Occasionally</th>
<th>Half the Time</th>
<th>Most of the Time</th>
<th>Almost Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To hear my adult children on the telephone.</td>
<td>C</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. To enjoy television while I am sitting at my table.</td>
<td>C</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
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<tr>
<td>4.</td>
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<tr>
<td>5.</td>
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<td></td>
</tr>
</tbody>
</table>

C = how the patient functions currently (pretreatment or with current technology/strategies)

E = how the patient expects to function postintervention (HA, ALD, strategies, etc.)

✓ = level of success that the audiologist realistically targets

! = how the patient actually perceives level of success postintervention

**Figure 9.** Patient’s current performance and expected performance recorded on the Patient Expectation Worksheet.
that Mrs. X was living alone, had very limited mobility, was no longer socializing, and was in great need of adequate telephone communication for safety and enjoyment, and in need of television listening for her enjoyment. None of this had been apparent from the brief history prior to the audiometric evaluation or from the APHAB. Indeed, the APHAB results were misleading in this particular case. Mrs. X took the instructions “If you have not experienced the situation we describe, try to think of a situation that you have been in and respond for that situation” very literally. She was responding as if she were still doing these things and knew that she would have great difficulty in them. A reasonable interpretation of her APHAB scores would have been that she had difficulty in a variety of social situations and did not mind loud sounds although in her initial case history she reported that loud sounds did not sound good. In reality, she was never in any of these situations (social or aversive). Interestingly, the two difficult situations that the HDAN identified are not situations that are investigated by the APHAB (telephone use and television viewing). Mrs. X was questioned further about her reaction to loud sounds, and she indicated that she did not like the sound quality when there were loud segments on television. Sound quality has already been addressed and most likely would resolve this problem.

**EXPECTATIONS**

Identifying two expectations from the patient is the next step. The “Patient Expectation Worksheet” (Figure 9) is used for this purpose (Palmer and Mormer, 1997). Although in Mrs. X’s case, only two areas of need were identified on the HDAN, many patients will have multiple issues (hearing various alerting devices, telephone listening, television listening, group communication, etc.). The expectation worksheet is used to define what the patient cares most about in terms of improving performance through whatever treatment is recommended. Only two expectations are solicited because Mormer and Palmer (2002) found that patients recall no more than two goals over time reliably. Mrs. X had no difficulty identifying telephone communication with her adult children and television viewing as primary goals of whatever solution we would offer. The “C’s” on the worksheet indicate how Mrs. X feels she currently is functioning, and the “E’s” illustrate how she expects to function after intervention. The audiologist may want to provide a check mark where the patient will most likely function given the treatment that is chosen. This can help create realistic expectations for the patient.

In Mrs. X’s case, she should be able to communicate well on the telephone most of the time and understand the television most of the time (as opposed to almost always). The expectation worksheet provides a posttest measure after intervention for which the patient is asked to mark how he or she is functioning now. This also is a good reminder to the patient of what was expected from the amplification. It is very rewarding for a patient to find that his/her expectations have been met or exceeded. It also helps keep the patient focused on realistic goals.

**RECOMMENDATIONS**

The initial audiometric results, APHAB, and case history had the audiologist considering recommending binaural amplification. The findings from the HDAN and “Expectations Worksheet,” however, forced the audiologist to consider other recommendations. Mrs. X communicates in the quiet of her own home with one helper, with her children on the telephone, and potentially with emergency personnel on the telephone, and she listens to the television in order to stay informed about current events. With her helper, her current hearing aid is sufficient. It provides audibility for soft, moderate, and loud sounds across frequencies where she has enough hearing to benefit from an amplified signal. Her complaints of distortion and feedback have been resolved by simply adding a damped earhook. It is unlikely that the addition of a second hearing aid will add significant benefit to this specific communication situation.

**THE TELEPHONE SOLUTION**

As for the telephone, Mrs. X’s current telecoil has a reasonable response (4 dB lower than the microphone response) when the volume control is set to full on. However, Mrs. X has indicated that she cannot manipulate the volume control due to dexterity problems, so this is not helpful. A
new hearing aid with a programmable telecoil could provide a stronger response without manipulating the volume control. This assumes that Mrs. X can manipulate the telecoil switch without having to remove her hearing aid to see where the switch is. It became clear in the patient interview that Mrs. X does not have the dexterity to use the telecoil switch well. Another option would be to replace her current hearing aid with a hearing aid with an automatic telecoil. A third option would be to provide Mrs. X with an amplified stand-alone telephone. The decision regarding telephone use was impacted by a solution to listening to the television. The intertwining need for communication on the telephone and listening to the television had an impact on the final recommendation. This is described in the next section.

THE TELEVISION SOLUTION

Mrs. X has indicated that television viewing is her primary enjoyment in life and her way of keeping in touch with world events. It is evident that Mrs. X is well educated and well informed and would like to continue this activity. She revealed significant frustration at no longer being able to understand what was being said on television. She describes becoming exhausted and exasperated while trying to listen to television with her current hearing aid. Considering Mrs. X's hearing ability and her desire to sit across the room from the television, it is unlikely that binaural amplification of any type will greatly enhance Mrs. X's television listening ability.

An ALD (infrared or frequency modulated [FM]) that places the transmitting microphone directly at the television loudspeaker and sends the amplified signal directly to Mrs. X's hearing aid (via telecoil or direct audio input) or ear (use of external receiver) will likely provide the greatest benefit. To receive a signal with high signal-to-noise ratio, Mrs. X would need to either wear the earphones that go with these devices or purchase new hearing aids with direct audio input or programmable telecoils with a switch. Again, the manual dexterity difficulty in either plugging in a direct audio input or switching to telecoil is encountered. For these reasons, it was decided that Mrs. X would use an assistive listening device with a headset (independent from hearing aids) with the television. An infrared device was chosen because Mrs. X is always in line of sight of the television, and the cost is reduced compared to an FM system. There also is less chance of interference from other nearby signals. If she were more mobile while watching television, an FM system would be a better choice.

Since Mrs. X will not be wearing her hearing aid while watching television (which she does during the majority of her day), it was decided to provide a stand-alone amplified telephone. The patient would not want to have to remove the television headset and insert her hearing aid(s) with automatic telecoils in order to answer the telephone. This would create an unmanageable situation. Now the only complication was that when the helper comes to the house once per week, Mrs. X would need to put in her hearing aid. She indicated that she was comfortable with switching from the television device to her hearing aid and she could continue to use the amplified telephone on the unaided ear during these times. To improve Mrs. X's comfort in inserting her hearing aid, a canal earmold was made to replace the skeleton earmold. This fit eliminates the need to tuck any part of the earmold into the concha and allows for an easier insertion. The other one-to-one communication Mrs. X engages in is when her children come to visit. This is in the quiet of her house, but she indicated that she enjoys speaking with them while they watch television programs. For this purpose, the headset that was ordered for the television device was equipped with an environmental microphone that can be turned up or down. This allows the television device to function as a hearing aid for listening to individuals nearby.

UNRESOLVED ISSUES

At this point, the section of the worksheet titled “Unresolved issues based on patient interview and observation” (see Appendix A) was reviewed, and it was found that difficulty in noise, difficulty in localizing sounds, and difficulty understanding when sounds originate from one particular side are not of consequence to Mrs. X because of her lifestyle. Feedback had been a problem but was resolved when the 1500 Hz peak was reduced. Mrs. X also may have been experiencing feedback because of insertion problems with her earmold. This was resolved.
by supplying a new, canal-style earmold. Mrs. X does not have a problem with the sound quality of her own voice.

Mrs. X’s disappointment in sound quality of outside signals was resolved through damping the earhook of her hearing aid and by providing excellent sound quality devices specifically for the telephone and television. Mrs. X had difficulty communicating on the telephone and understanding the television (under “Other” in Appendix A), and these situations were resolved with specific devices.

Most clinicians appreciate the ability of wide dynamic range compression signal processing to produce audible sound at soft, moderate, and loud input levels in an automatic fashion. Data suggest that this type of signal processing works as well or better than linear signal processing (Jenstad et al, 1999; Jenstad et al, 2000; Marriage and Moore, 2003), which eliminates the concern that the compression itself might distort the signal in a detrimental way. Conversely, a linear response is designed to provide appropriate gain for moderate input levels while soft sounds generally are too soft and loud sounds are too loud without manipulation of the volume control.

In the case of more severe hearing losses such as Mrs. X, the fact remains that well-fit linear and WDRC hearing aids perform in a similar manner. Because of the high amount of gain needed to make soft and moderate sounds audible, the linear hearing aid is operating in compression (output limiting compression) most the time anyway. A wide dynamic range compression instrument might be able to employ slightly less compression for soft inputs, but it too would be at fairly high compression ratios for moderate and loud input levels in order to keep the signal within the severely reduced dynamic range. For this reason and all of the other specific patient needs described above, new hearing aids were not pursued for this patient. In Mrs. X’s well-defined communication situations, there is no reason to believe that binaural amplification will be of significant benefit, so a second hearing aid with similar signal processing was not pursued.

Mrs. X left the clinic with a new telephone amplifier with large print and large buttons along with a volume control wheel. She also left with an infrared device. It was ideal to have these items in stock so Mrs. X’s daughter could install them for her when they returned home.

**FOLLOW-UP VISIT**

Mrs. X received her new earmold two weeks after her initial visit and immediately inserted it with ease. Because the trip to the clinic is a hardship for Mrs. X and her children, the postassessment measures were collected at this time rather than scheduling another visit. Normally, a second version of the APHAB is provided, and the change revealed by the benefit scores is examined. Although this can inform further treatment or counseling needed by the patient, this is largely used for quality control data. In Mrs. X’s case, no change was expected in her responses because she would still be thinking back to how she used to do in all of these activities. For this reason, the APHAB was deemed an inappropriate posttreatment measure for this patient.

Mrs. X did complete the postassessment on the “Patient Expectation Worksheet” (Figure 9). She indicated that she now heard well on the telephone almost always and understood television most of the time. A final result within one category of the patient’s expectation is considered a good outcome. In addition, Mrs. X indicated that she enjoyed the television solution because she naps periodically throughout the day and it is simple to remove the headset, nap, and then replace the headset when she is up again. Previously, she had found it very frustrating to go through the process of removing and replacing her hearing aid.

The rechargeable battery needed in the infrared system was large enough that Mrs. X did not have difficulty inserting it for use or inserting it into the recharging space. An added benefit to this particular set of solutions for a patient with extremely limited mobility and an inability to make the trip to the clinic is that the devices are sturdy and rarely need repair compared with traditional hearing aids. If repair is needed, it could be done by mail with the assistance of her weekly helper. There is no need to see the patient if a standalone television or telephone device is not working. In addition, if Mrs. X’s hearing loss worsens, she can compensate by turning up the volume control on her telephone and television device. She would not need to come into the clinic for any type of “retuning.” A
patient’s access to the clinic has to be one consideration in formulating a solution.

With the assistance of an organized method to examine Mrs. X’s specific listening and communication needs in the context of her particular lifestyle, a set of appropriate and cost-effective solutions were offered. Rather than starting with a new hearing aid or binaural hearing aids, Mrs. X’s specific listening needs were addressed. This included solutions for the telephone, television, and occasional one-to-one visiting. The protocol suggested in this report allowed Mrs. X’s hearing demands, needs, and expectations to be viewed prior to making recommendations. Mrs. X is comfortable with these solutions, and she and her family perceive significant benefit. The clinic has documented the success of this process through the postexpectations worksheet.

REFERENCES


## Appendix A. Evaluation of Current Hearing Aids

Name: Mrs. X  Date: 10/10/04

<table>
<thead>
<tr>
<th>Right Hearing Aid:</th>
<th>Left Hearing Aid:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company</td>
<td>Oticon</td>
</tr>
<tr>
<td>Model</td>
<td>Personic 425</td>
</tr>
<tr>
<td>Serial #</td>
<td><em>XXXXXXXX</em>________</td>
</tr>
</tbody>
</table>

Circle Style: BTE ITE ITC CIC

### Sound is audible for quiet inputs

| R | L |  | Yes |  | No: |  |  |  |  |  |  |  |  |  |  | modification to current hearing aid response |  |  | new hearing aid circuitry would be required to achieve this goal |  |  | new hearing aid style would be required to achieve this goal |  |  | new earmold would be required to achieve this goal |  |  | patient must attempt new wearing habits to achieve this goal |  |  | degree of hearing loss precludes audibility to soft sounds in some frequencies |

### Sound is audible for moderate inputs

| R | L |  | Yes |  | No: |  |  |  |  |  |  |  |  |  | modification to current hearing aid response |  |  | new hearing aid circuitry would be required to achieve this goal |  |  | new hearing aid style would be required to achieve this goal |  |  | new earmold would be required to achieve this goal |  |  | patient must attempt new wearing habits to achieve this goal |  |  | degree of hearing loss precludes audibility to moderate sounds in some frequencies |

### Sound is audible for loud inputs

| R | L |  | Yes |  | No: |  |  |  |  |  |  |  |  |  | modification to current hearing aid response |  |  | new hearing aid circuitry would be required to achieve this goal |  |  | new hearing aid style would be required to achieve this goal |  |  | new earmold would be required to achieve this goal |  |  | patient must attempt new wearing habits to achieve this goal |  |  | degree of hearing loss precludes audibility to loud sounds in some frequencies |

Loud sound is at or just below uncomfortable loudness level

| R | L |  | Yes (yes for higher frequencies) |  | No: (no for lower frequencies) |  | modification to current hearing aid response |  |  | new hearing aid circuitry would be required to achieve this goal |  |  | new hearing aid style would be required to achieve this goal |  |  | new earmold would be required to achieve this goal |  |  | patient must attempt new wearing habits to achieve this goal |
Bandwidth is adequate for communication, patient's environment, and any special requirements

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<td>_</td>
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</table>

- Yes
- No:

- _x_ __ modification to current hearing aid response
- __ new hearing aid circuitry would be required to achieve this goal
- __ new earmold would be required to achieve this goal
- __ degree of hearing loss precludes audibility across some of the frequency range

Good sound quality while the hearing aid is providing audible sound across input levels

<table>
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<th>L</th>
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<tbody>
<tr>
<td><em>x</em></td>
<td>_</td>
<td>_</td>
</tr>
</tbody>
</table>

- Yes
- No:

- _x_ __ new hearing aid circuitry would be required to achieve this goal
- _x_ __ modification to current hearing aid response

Unresolved issues based on patient interview and observation:

- **Difficulty in noise**
  - _ _ binaural hearing aid use
  - _ _ modification of hearing aid response
  - _ _ patient must attempt new wearing habits to achieve this goal
  - _ _ different circuitry/signal processing recommended (e.g., directional microphones and/or assistive listening devices)

- **Difficulty localizing sounds**
  - _ _ binaural hearing aid use
  - _ _ patient must attempt new wearing habits to achieve this goal
  - _ _ modification of current hearing aid response
  - _ _ new hearing aids required

- **Difficulty when sound originates from one particular side**
  - _ _ binaural hearing aid use
  - _ _ routing of signal to opposite ear (e.g., CROS, BICROS, transcranial CROS, BAHA)
  - _ _ patient must attempt new wearing habits to achieve this goal
  - _ _ modification of current hearing aid response

- **Feedback**
  - _x_ __ modification of earmold or shell
  - _x_ __ modification of hearing aid response
  - _x_ __ different circuitry/signal processing recommended (e.g., feedback cancellation)

- **Disappointment in sound of own voice**
  - _ _ modification of hearing aid response
  - _ _ modification of earmold/shell (lengthen canal portion)
  - _ _ modification of vent (open venting if possible)
  - _ _ different circuitry/signal processing recommended

- **Disappointment in sound quality**
  - _x_ __ modification of hearing aid response

- **Difficulty communicating on the telephone**
  - _ _ reinstruction
  - _ _ modification of telecoil response
  - _ _ addition of telecoil circuitry
  - _x_ __ other phone solution
  - _x_ __ different circuitry/signal processing recommended
Difficulty coupling to ALDs

- Reinstruction
- Change hearing aid style
- Modification to current hearing aid (e.g., add t-coil or DAI, enable DAI, etc.)
- Equipment addition (e.g., neckloop, DAI cord, etc.)

Other (describe problem and solution below)

OVERALL RECOMMENDATIONS: