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## A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate For This Individual?

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After reading news of exciting advances in hearing aid technology many patients, parents, and educators are asking the question "Is this hearing aid appropriate for me/my child?" The audiologist is challenged with answering this question from four constituencies: 1) patients or parents of children seeking an appropriate hearing aid solution; 2) a physician posing the question about one of his/her patients; 3) educational audiologists guided by legislation or guidelines that recommend testing of each child's hearing aid once per year resulting in a report documenting the adequacy of the fitting; and 4) health professionals such as speech-language-pathologists, occupational therapists, and physical therapists whose treatment may depend on or be modified by the individual's ability to hear. Four primary hearing aid fitting goals are identified and a test protocol is suggested to evaluate whether these goals have been met by an individual's current hearing aids. A case is presented to illustrate the protocol and provide discussion related to the possible results of the assessment and subsequent actions that might be recommended.

**Key words:** hearing aids, advanced technology, sound quality, audibility, verification

**Abbreviations:** dB: decibel; SPL: sound pressure level; ANSI: American National Standards Institute; DSL[i/o]: Desired Sensation Level [input/output]; VC: volume control; WDRC: wide-dynamic-range-compression; RECD: real-ear-to-coupler-difference; 2 cc: two cubic centimeters; RE: real ear; UCL: uncomfortable loudness level; REAR: real ear aided response; APHAB: Abbreviated Profile of Hearing Aid Benefit; SHARP: situational hearing-aid response profile.

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### Is this hearing aid appropriate for this individual?

With the advent of remarkable changes in hearing aid technology in the past few years and the subsequent attention that has been given through media, advertising, and professional meetings, many physicians, patients, educators, and parents are asking whether the hearing aid that is currently being used by an individual is adequate. More and more of our "hearing aid discussion" appointments are turning into a fairly successful hearing aid user asking if his/her current hearing aids are providing the most benefit that can be expected or if there is something new that will offer more communication help. Four scenarios have been identified in which the audiologist is challenged with this question: 1) directly from a patient or parent seeking an appropriate hearing aid solution or verification of the appropriateness of a currently used hearing aid arrangement, 2) from a physician posing the question about one of his/her patients, 3) from legislation or guidelines that guide an educational audiologist to "test" each child's hearing aids once per year and report on the adequacy of the fitting, and 4) from other healthcare professionals whose treatment may depend on or be modified by the individual's ability to hear (e.g., voice specialists who need

to know what level of self-monitoring can be expected from a particular patient given his/her ability to hear across the frequency/intensity range).

Audiologists often receive well meaning requests from a third party to provide functional gain measurements across frequency to evaluate whether an individual's hearing aids are "adequate." For a variety of reasons, this type of testing is inadequate to answer the question that actually is being posed "Is this hearing aid appropriate for this individual?" The protocol presented in this paper has been developed in order to answer the question and provide valuable information to the patient, health care professional, parent, and/or educational professional.

The answer to the question, "Is this hearing aid appropriate for this individual?" depends on the original goals of the hearing aid fitting and a variety of individual limiting factors that may have impacted the final fit and response of the hearing aids. Although one cannot always go back and reconstruct the original goals of a hearing aid fitting (especially if you are working with an individual that you did not fit originally which often is the case for the educational audiologist), there are several reasonable goals that could be assumed. These would include:

- 1) soft, moderate, and loud sounds are audible (within reason as compared to degree of hearing loss),
- 2) sounds are comfortable,
- 3) recent data from Stelmachowicz et al (2002) indicate that audiologists may want to be more critical and insist on audibility through 8000 Hz (as opposed to through 5000 Hz) whenever possible for children, and
- 4) good sound quality

Table 1 matches the above goals with possible objective clinical measurements. The focus of the proposed assessment is on audibility (e.g., Humes, 1991), comfort, bandwidth (e.g., Skinner & Miller, 1983; Stelmachowicz et al, 2002), and sound quality (e.g., Agnew, 1988;

**Table 1. Verification of hearing aid fitting goals.**

Goal	Verification Technique	
	Hearing Aid User Present	Hearing Aid Only
Soft, moderate, and loud sounds are audible	REAR plotted on DSL[i/o] SPLogram	Coupler data converted to DSL[i/o] SPLogram*
Loud sounds are comfortable	REAR plotted on DSL[i/o] SPLogram with 90 dB SPL input	90 dB SPL Coupler data converted to DSL[i/o] SPLogram*
Wide bandwidth	REAR from above measures	Frequency/Gain measure from above coupler data
Good Sound Quality	Measure THD with an 85 dB SPL input level at 500, 800 and 1600 Hz (instead of the 65-70 dB SPL input recommended by ANSI, 1996). It should be < 10%.	

REAR = real ear aided response

DSL[i/o] = Desired Sensation Level [input/output] algorithm (Cornelisse, Seewald, & Jamieson (1995)

SPLogram = graph of the individual's dynamic range in sound pressure level

\*This can be accomplished manually through data entry into the DSL [i/o] software program or automatically through converted coupler measurements in the AudioScan (see text for description).

Gabrielsson & Sjogren, 1979) because there are data to indicate that these are essential components of an adequate hearing aid fitting. These also comprise components of a hearing aid fitting that can be objectively and reliably measured with or without the individual present. Although

a patient rarely will express the need for any of these particular parameters, meeting these objectives leads to the more obvious goal of improved communication in quiet and noise. Audibility must be viewed in light of sound quality and comfort. An audible signal that is distorted and/or uncomfortable is not useful to the listener.

The following description presents one case and three clinical protocols for assessing each of the four general hearing aid fitting goals. The first two protocols assume that the audiologist only has access to the hearing aids and the audiogram. Only having access to the hearing aids and not the hearing aid user, although not ideal, is often the situation for educational audiologists who may not have the ability to test each child in person but rather are supplied with the child's amplification system and hearing records. There also may be cases when a patient is present, but the equipment to make real ear measurements is not available. The third protocol assumes that the individual is present for the evaluation and that probe microphone equipment is available. All three protocols will allow the audiologist to evaluate the four hearing aid fitting goals outlined above. The results of the evaluation are recorded on the worksheet supplied in Appendix A. The worksheet allows a systematic evaluation of an individual's hearing aids and results in suggestions as to whether the hearing aid is adequate across the evaluation categories and if not, if the problem can be resolved with changes to the current hearing aid or if new hearing aids are needed.

### A Word About Test Signals

It is not the goal of this paper to go into a detailed description of possible test signals in hearing aid test boxes and probe microphone systems. It is important to mention that the selection of test stimuli has become more important with the advent of advanced signal processing that attempts to identify "noise" and process it differently from "speech." The majority of these noise management systems analyze the signal as it comes into the hearing aid and if the signal appears to be steady state (no large peaks and valleys that would be expected in speech) then the hearing aid may reduce gain in some fashion. Many of the signals in hearing aid test boxes and probe microphone systems look like noise to the hearing aid. If this is the case, the hearing aid will reduce gain when these signals are presented and an accurate assessment of output will not be obtained. In order to avoid this, the audiologist can turn off the noise management feature of the hearing aid prior to testing. This is not very practical for the educational audiologist who may not have the programming cables, software, etc. to do

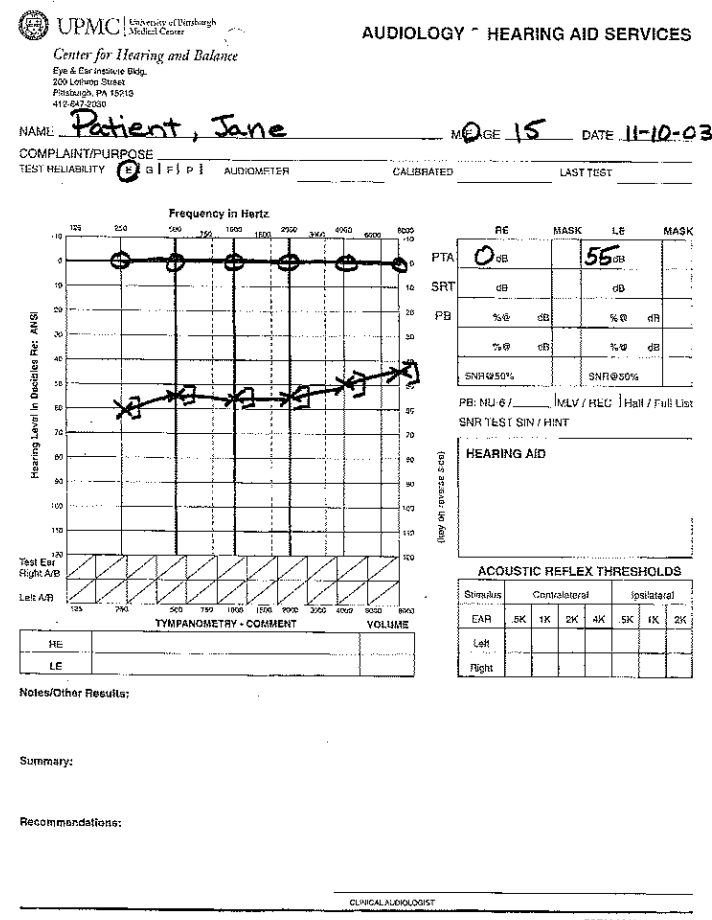
## A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate For This Individual?

this with every hearing aid they encounter. Scollie and Seewald (2002) and Scollie, Steinberg, and Seewald (2002) tested a variety of hearing aids with noise management systems and recommend speech weighted and temporally modulated signals for use with these hearing aids. If you do not have one of these signals available on your hearing aid testing equipment, you can often add the signal as an upgrade. If this is not possible, the second best solution is to make sure that you present the test signal for as brief a time as possible to get the measurement, thereby testing faster than the noise management can start to react. The best solution is to have the right signal.

### General Patient Information to be used in each of the following protocols

The left in-the-ear (ITE) hearing aid from a 15 year old girl was evaluated for school purposes. The student was not available. You have information related to the teenager's hearing loss (Figure 1) and complaints of

**Figure 1. Air conduction results. The patient has a sensorineural hearing loss in the left ear.**



avoiding loud sounds and finding her own voice unpleasant. The hearing aid was a conventional model with a screw set volume control (VC). Hearing in the right ear was normal. Although the student indicated that she can use the telephone with her normally hearing right ear, she would like to use the telephone on her left ear because she does volunteer work at the local library where she needs to write (she is right handed) while she listens on the telephone. She says the telephone is not loud enough when she uses her telecoil switch. The child has been using amplification in the left ear for five years. The current hearing aid was purchased eleven months ago because of the child's desire to switch from her four year old behind-the-ear (BTE) hearing aid to an ITE hearing aid.

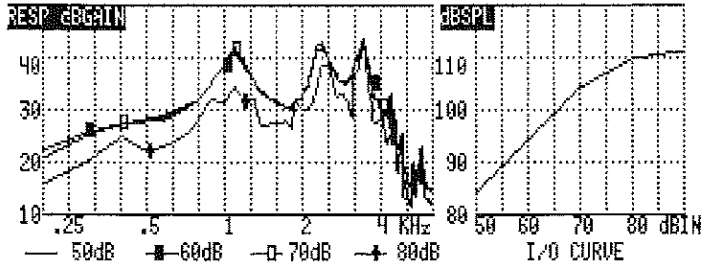
### Protocol 1: student is not present and/or a real ear probe microphone system is not available

The following procedure answers the question "Is this an adequate hearing aid for this child?" when the student is not available to participate in the evaluation. The entire procedure takes approximately 15 minutes. Equipment needed consists of a hearing aid test box that allows for the measures described below, a computer, and the DSL[i/o] software program (Cornelisse et al., 1995).

1. If the hearing aids have volume controls, establish the use gain setting of the volume control by presenting average conversational speech to the patient or by reviewing the patient records. Set the hearing aid to this volume setting. For this case, the screw-set VC position was used.
2. Use a hearing aid test box to obtain gain (or output) curves for a variety of input levels. This can be achieved by selecting "ANSI 1992" (provides curves at 50, 60, 70, and 80 dB SPL automatically) or by running a "multi-curve" and selecting 50, 70, and 80 dB SPL input levels. Print the curves or select "data" and print the digital output (table with values at each frequency). Printing the data makes it easier to enter these numbers in the DSL[i/o] program (described later). Figure 2 shows gain curves corresponding to four input levels (50, 60, 70, 80 dB SPL) for the right hearing aid.
3. Use a hearing aid test box to obtain an output curve for a 90 dB input signal (OSPL90). Running a standard ANSI (1996) test will provide these data. Once again, print the curve or data. This test also will provide an estimate of the usable bandwidth of the hearing aid. Figure 3 presents the ANSI (1996)

data for the individual's left hearing aid. The response for the 90 dB SPL input can be read from the right vertical axis. Bandwidth is defined as F1 to F2 in Figure 3. Since the student has a complaint related to the telecoil response, it will save time if you use the ANSI (1996) test protocol and

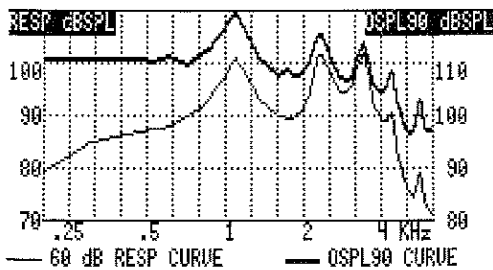
**Figure 2. ANSI S3.42-1992(R 2002) hearing aid test box evaluation (Protocol 1) (Frye electronics 6500-CX Hearing Aid Test System).**



ANSI S3.42-1992  
 NSPL90: 111.8 dB SPL  
 FULL-ON NOISE GAIN: 50.7 dB  
 TARGET REFERENCE GAIN: 34.8 dB  
 ACTUAL REFERENCE GAIN: 34.3 dB

TEST SPECIFICATIONS:  
 HEAR. BANDWIDTH: 200-8000 Hz  
 NOISE TYPE: PSEUDO-RANDOM  
 CREST FACTOR: 10 dB  
 ANALYSIS METHOD: SNGL CH FFT  
 FILTER BANDWIDTH: 100 Hz  
 ANALYSIS WINDOW: RECTANGULAR  
 FILTER SMOOTHING: NONE  
 MEASUREMENT AVERAGING: 8X

**Figure 3. SSPL90 response for the hearing aid (ANSI, 1996)(Protocol 1)(Frye Electronics 6500-CX Hearing Aid Test System.)**

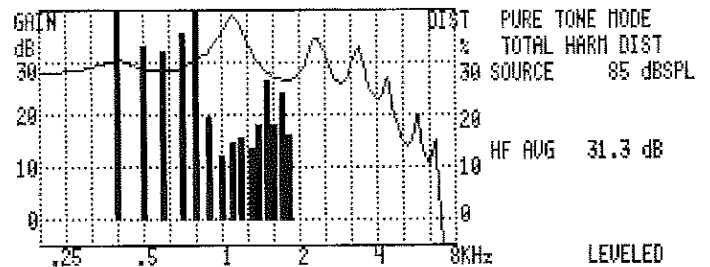


MAX OSPL90: 119.9 dB  
 AT: 1100 Hz  
 HF AVG: 112.5 dB  
 HF AVG FULL ON GAIN: 2.2%  
 AT 50 dB IN 60.3 dB  
 REFERENCE TEST GAIN:  
 TARGET: 35.5 dB  
 MEASURED: 35.6 dB  
 RESP LIMIT: 75.6 dB  
 F1= 200 Hz F2=5900 Hz  
 THD FREQ SRC  
 0.9% 500Hz 70 dB  
 0.4% 800Hz 70 dB  
 0.4% 1600Hz 65 dB  
 E0 INP NOISE: 26.9 dB  
 BAT (1.5 V) 0.00 mA  
 ANSI S3.22-1996  
 AID TYPE LINEAR  
 F.O.G. AT 50 dB

measure the telecoil sensitivity at this time. The telecoil information (Figure 8 and 9) will be described later.

4. Select the Total Harmonic Distortion (THD) test to be conducted separately from the standard ANSI (1996) test. Select an 85 dB SPL input level (Bentler & Niebuhr, 1999). A graph like the one in Figure 4 will be displayed. Total harmonic distortion is represented by the vertical bars on the graph.

**Figure 4. Total harmonic distortion for an 85 dB SPL input (Protocol 1, 2, and 3) (Frye Electronics 6500-CX Hearing Aid Test System).**



5. Armed with the above data, the audiologist now uses the Desired Sensation Level (DSL[i/o], Cornelisse, et al., 1995) program in order to assess whether the hearing aid is making soft, moderate, and loud sounds audible, but not uncomfortable. It is important to note that the DSL[i/o] program is being used because it features the ability to transform audiometric data into dB SPL and predict uncomfortable loudness levels from threshold and age data thus providing a graph of the individual's estimated dynamic range. In addition, the DSL[i/o] program transforms coupler data in order to plot the hearing aid response against the dynamic range of the individual using an age-appropriate estimated real-ear-to-coupler difference (RECD). The RECD is a correction applied to the threshold and UCL data based on the difference expected from a child as compared with a coupler. The plot allows for visual inspection of what levels and frequencies are audible to the hearing aid user. It is not the purpose of this procedure to calculate and/or use the actual DSL[i/o] targets in the assessment of the hearing aid's function. Therefore, the original goal of the hearing aid fitting does not have to be based on the DSL[i/o] fitting algorithm in any way. Table 2 provides a detailed description of the necessary set-up of the DSL [i/o] parameters for this evaluation.

## A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate For This Individual?

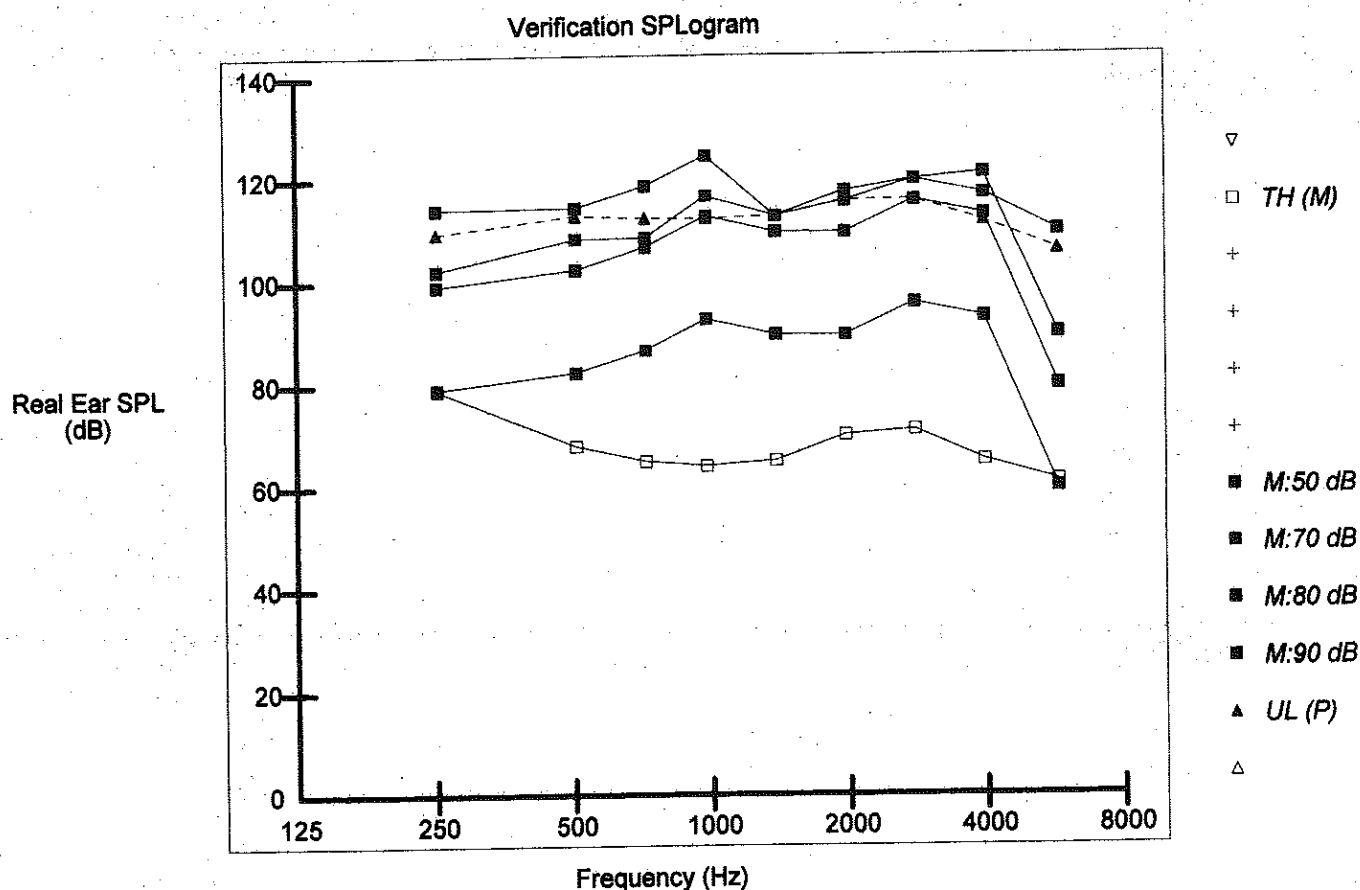
6. There is an icon bar near the top of the screen that leads the user through the DSL[i/o] data entry and verification screens. In order to enter the audiometric data, select the icon depicting earphones. At a minimum, threshold data must be entered. If data related to uncomfortable loudness levels (UCLs,

e.g., Mueller & Bentler, 1994) and/or real-ear-to-coupler-difference (RECD, e.g., Westwood & Bamford, 1995) are available, these may be entered as well. Remember, these data are not used in calculations unless they are chosen in the menu selections described below. If these data are not available, leave the corresponding boxes empty and the program will make an age-appropriate estimate.

**Table 2. Parameter set-up in the DSL[i/o] fitting software.**

1. Open the DSL4.1[i/o] fitting software.
  2. The first screen requires that patient ID and birth date are entered.
  3. Under the menus at the top of the screen, make appropriate choices based on the data that are available to you and the hearing aid that is being evaluated.
  4. The ear to be considered is chosen under the Edit menu.
  5. Under the Assess menu, the audiologist chooses the transducer that was used to produce the audiogram.
  6. In addition, the mechanism for transforming HL to SPL is chosen. In the type of assessment being described, it will be rare to have the individual's real-ear-to-coupler-difference (RECD) so the choice would be "predicted." If current RECDs are available, these can be used to make an even more accurate assessment of the individual's dynamic range and hearing aid response.
  7. Under HA Fit on the main menu bar the hearing aid circuit type (linear, wide-dynamic-range-compression with fixed compression ratio, or wide-dynamic-range-compression with variable compression ratio) is chosen. A linear circuit implies that gain does not change as a function of input level until saturation. If "linear" is selected as the circuit type, the Mid-Level verification screen will display only one level along with the 90 dB SPL input level supplied in the High-Level verification screen. Since the goal of this verification is to plot the response of soft, moderate, and loud signals in order to compare them to the individual's dynamic range, WDRC with fixed compression ratio always should be chosen even if the hearing aid actually provides a linear response. In this way, the response for several input levels can be plotted and evaluated. This "deception" would only matter if one were trying to use the DSL[i/o] target and ordering data which is not the purpose of this procedure.
  8. The Style of hearing aid must be indicated since the microphone location will have some impact on the overall response of the hearing aid.
  9. The RE (real ear) to 2cc transform will be predicted unless RECD data are available.
  10. If uncomfortable loudness level (UCL) data are available, Maximum Output should be selected as "measured" and these data should be entered along with the threshold data. In many cases, UCL will not be available and "predicted" should be selected.
  11. The Speech Spectrum should be selected based on whether the hearing aids of a child (UWO Child, data from University of Western Ontario) or an adult are being evaluated.
  12. The HA Fit menu provides a choice of compression thresholds. This choice does not matter for the purpose of this evaluation.
  13. Under the Verify menu, select "coupler output" for the High-Level Input and either "coupler output" or "coupler gain" (depending on how you measured the hearing aid) for the Mid-Level Input. You also must select either "constant-level" or "speech-weighted" as the signal type for the Mid-Level Input. Make this selection based on the type of signal that was used in testing the hearing aid.
  14. All of the selections made will be displayed below the menu bar.
7. Select the "Mid-Level Input" icon (middle of three bars is highlighted). Set the three levels provided to the levels that match the input levels used in the coupler testing that was performed (e.g., 50, 70, 80 in Figure 2). Data do not have to be entered for every level that was tested. The goal is to enter data for a soft, moderate, and loud sound. The DSL[i/o] targets are displayed with empty boxes below for the actual coupler data to be entered. The targets are not important for the purposes of this evaluation. Enter the coupler results (Figure 2) for all three levels. Make sure that the coupler data being entered (gain or output) match the title on the screen (Coupler Gain or Coupler Output). Go under Verify (top menu) to select gain or output.
  8. Select the "High-Level Input" icon (first and third bars are highlighted). Enter the coupler data that was determined earlier (Figure 3) into the spaces under the 90 dB SPL target values. These data always will be in coupler output.
  9. All of the data are entered and verification of the hearing aid fitting is now possible. Select the second "Graph" icon which is the SPLogram (graph with a sine wave). A screen with a graph appears. To the right of the graph are the data choices. Highlight the "measured thresholds and the predicted upper limits" in order to view the patient's estimated dynamic range. Verification consists of plotting the hearing aid results (whether coupler or real ear) in this format so the soft, moderate, and loud input levels can be compared to the lower and upper levels of hearing. Anything falling between the two lines representing threshold and discomfort can be considered audible and are judged to be comfortable unless patient interview indicates otherwise. Four "measured" input level choices appear to the right of the graph and represent the three levels chosen in the "Mid-Level Input" data entry screen and the 90 dB SPL input level from the "High-Level Input" data entry screen. Click on each of these boxes and the corresponding responses will be graphed. Figure 5

Figure 5. Verification SPLogram for the hearing aid (Protocol1).



illustrates the completed graph of the patient's hearing aid response measured in a coupler and converted to SPL re: a real ear. Visual inspection now allows the audiologist to determine what input levels as a function of frequency are audible and presumably comfortable to the patient.

- Repeat for the other ear if you are working with a binaural user.

The results of the evaluation will be discussed after each protocol is discussed.

**Protocol 2: student is not present but an AudioScan® (model RM500 series or unit with comparable capabilities) with a test box and probe microphone system is available**

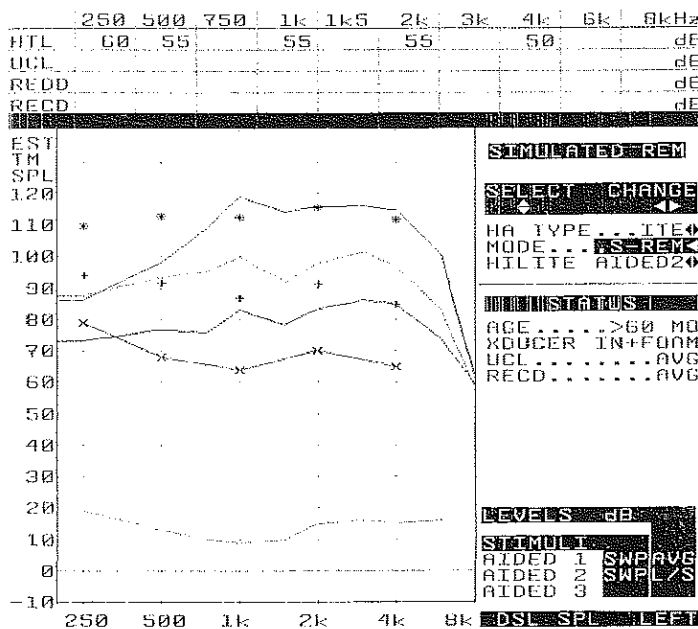
The method described below should produce similar results to the protocol described above, but it is faster (about 10 minutes). In this procedure, the AudioScan® is taking the threshold, age, and test box data and creating the SPLogram. This saves the step of entering all of the

coupler data into the computer version of DSL[i/o] in order to obtain the SPLogram.

- Turn on the AudioScan® equipment.
- Connect the probe microphone and calibrate (follow the directions on the screen). Press continue. Now connect the coupler microphone and calibrate (follow the directions on the screen). Press continue. Place the hearing aid on the coupler connected to the microphone and position this correctly in the test box. Select Aided 1 on the probe microphone side of the equipment (this just lets the equipment know that you are using the probe microphone features, not the coupler features at this point). Select Advanced Features and continue. Select the Audiogram (Agram) and enter the student's age. If uncomfortable loudness level data and/or RECD are available, select the option to enter these data. If these data are not available, the system will use age appropriate corrections. Now enter the audiogram and select continue. If you chose to enter RECD, the screen for this data

entry would appear at this point. On the main testing screen, use the arrow key to go from "REM" to "S-REM" (simulated real ear measurement Figure 6). You now will see the dynamic range (threshold to UCL) displayed on the screen. Press Aided 1 to start and stop the first measure-

**Figure 6. Simulated SPLogram from test box measures (Protocol 2) (AudioScan RM 500 Series).**



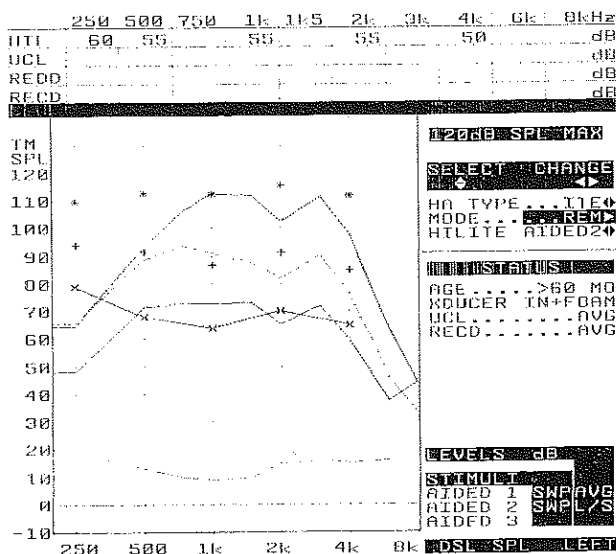
ment. When you press Aided 1 either "moderate" or "loud/soft" will be displayed. You will see a line added to the graph where dynamic range is displayed. Collect the data and then go on to Aided 2 and change the selection to whatever was not measured in Aided 1 (e.g., loud/soft or moderate). Depending on the signal and test parameters that you have selected in your AudioScan® you will see lines on the graph or ranges of responses (shaded areas) for a soft, moderate, and loud input (Figure 6).

3. In the routine test box mode, you will select the Total Harmonic Distortion (THD) test to be conducted separately from the standard ANSI (1996) test. Select an 85 dB SPL input level (Bentler & Niebuhr, 1999). A graph like the one in Figure 4 will be displayed. Total harmonic distortion is represented by the vertical bars on the graph.
4. Repeat for the other ear if you are working with a binaural user.

**Protocol 3: student is present and a real ear probe microphone system is available**

1. The following procedure is designed to answer the question "Is this hearing aid appropriate for this individual?" when the student is available to participate in the evaluation. The entire process takes less than 15 minutes. If the probe microphone system you are using allows you to use DSL[i/o] as part of the fitting verification or some other method to display the patient's dynamic range, enter the patient's thresholds and UCLs (or generate the UCLs automatically) into the appropriate screen in your system. For instance, if the portable Fonix FP40 were being used, Probe and then Target would be selected in order to get to the appropriate data entry screen. Enter the individual's age as well in order to make use of age appropriate estimations of RECD and UCL for transforming the data.
2. Whether you can complete step one or not, enter the probe microphone screen and obtain real ear aided responses (REAR) at three input levels representing soft, moderate, and loud input signals (e.g., 50, 70, and 90 dB SPL). If your system allowed you to select DSL[i/o] as a fitting rationale, it may default to these levels. If the hearing aid has a volume control, it should be set at the level used for listening to an average speech signal.
3. If you were able to enter threshold data into the DSL[i/o] fitting algorithm or used some other means of displaying the individual's dynamic range, the probe microphone display will now display the three REAR curves on top of the individual's estimated dynamic range. In Figure 7 the "X's" represent the patient's thresholds across frequency for the left ear and the "\*"s" represent the upper level of discomfort, thus providing the dynamic range. The "+"s" are the target for average speech as calculated by the DSL[i/o] fitting algorithm and as stated earlier are not of interest for the verification purposes outlined in this process. What is of interest is what portion of each REAR curve falls within the individual's dynamic range.
4. If the probe microphone equipment is unable to provide a graphic display of the individual's estimated dynamic range, the real ear probe microphone data at the three input levels are entered into the DSL[i/o] fitting software just as they were for

**Figure 7. Real ear aided responses for three input levels plotted against the dynamic range (Protocol 3) (AudioScan RM 500 Series)**



the coupler data example (work through steps 5-9) in the first protocol. The only difference is in the menu selections for verification where “real ear aided response” should be selected for the Mid-Level Input and High-Level Input menu. If only three input levels were tested (50,70, and 90 dB SPL), one set of data will be left empty in the Mid-Level Input screen (the third level can only be set as high as 85 dB SPL so the 90 dB SPL data must be entered into the High-Level Input screen).

5. Bandwidth can be evaluated using the REAR curves displayed against the dynamic range.
6. The objective measure of sound quality is performed in the same manner whether the patient is present or not. See step 4 from the first protocol for hearing aid test box instructions that allow for the assessment of total harmonic distortion at a high input level. Figure 4 is the graphic display of total harmonic distortion for this patient’s left hearing aid.
7. Repeat for the other ear if you are working with a binaural user.

**Applying Protocol Results to Determine Appropriateness of Hearing Aids**

The findings from the measures described in the three protocols will be discussed as a function of completing the worksheet in Appendix A which summarizes each of the four goals (audibility, bandwidth, comfort, and sound quality) as well as specific complaints that the patient may present. Table 3 summarizes the worksheet (Appendix A) responses as a result of evaluation of the 15-year-old female’s hearing aid. For each section of the worksheet in Appendix A, the data collected in any one of the three proposed protocols are used to answer each question (heading). If the answer is YES, then go on to the next item. If the answer is NO, then check off the recommended solution based on the test results and information in Tables 4 and 5. Items are checked for each ear since results may vary between ears. There is space at the end of the worksheet for a summary of the overall recommendation (e.g., reinstruction, reprogramming, new hearing aids needed, etc.).

**Table 3. Results of the evaluation using the described procedures.**

Components of Evaluation	Where data are obtained	Patient
Sound is audible for quiet inputs	SPLogram (50 dB SPL)	Yes
Sound is audible for moderate inputs	SPLogram (70 dB SPL)	Yes
Sound is audible for loud inputs	SPLogram (80 or 90 dB SPL)	Yes
Loud sound is at or just below uncomfortable loudness level	SPLogram (90 dB SPL)	No*
Bandwidth is adequate for communication, patient’s environment, and any special requirements	SPLogram (all inputs)	Yes
Good sound quality while the hearing aid is providing audible sound across input levels	THD at high input level	No*
Patient Interview Points		
Difficulty in noise	Patient Interview	No
Difficulty localizing sounds	Patient Interview	No
Difficulty when sound originates from one particular side	Patient Interview	No
Feedback	Patient Interview	No
Disappointment in sound quality	Patient Interview	Yes*
Disappointment in sound of own voice	Patient Interview	Yes*
Difficulty communicating on the telephone	Patient Interview	Yes**
Difficulty coupling to ALD’s	Patient Interview	No

\* In each case, modification of the current hearing aid response was not adequate to overcome these problems and new hearing aid circuitry was required. Her own voice would be reaching the hearing aid microphone at about 85 dB SPL which produces poor sound quality (see Figure 4).  
 \*\* See the text for a description of the patient complaint, measurement, and solution for the telephone.



## A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate For This Individual?

**Table 4. Problems, causes, and solutions to hearing aid responses that are not audible across frequency and/or do not provide adequate sound quality.**

Description	Possible Causes	Solution/Recommendation
Not audible because patient does not wear VC at adequate setting	Class A Receiver Peak Clipping Output Limiting	Replace with Class D Receiver Replace with Compression Output Limiting
	Patient Preference	No solution, Counseling
Not audible because patient cannot wear VC at adequate setting due to feedback	Poor fitting earmold Inappropriate style for degree of hearing loss	New earmold Change style, patient willing
	Class A Receiver Peak Clipping Output Limiting	Replace with Class D Receiver Replace with Compression Output Limiting
Sound quality is poor*	Unknown	Try more advanced technology
	Restriction of microphone Restriction of receiver	New microphone New receiver
Bandwidth is limited	Restriction of digital sampling	Decide if digital features are worth the compromise in bandwidth
	Conscious choice due to hearing thresholds (Ching, et al., 1998; Hogan & Turner, 1998; Oticon Ski fitting algorithm)	Leave as is

\*Caution: although your measures may say that the sound quality is poor, the hearing aid user may be used to this sound quality and may not appreciate your attempt to provide "better" sound quality (Ovegard, Lundberg, Hagerman, Gabrielsson, Bengtsson, & Brandstrom, 1997; Palmer et al., 1995).

Figure 5, 6, or 7 (depending on the protocol you used) illustrate that sound is audible across a wide frequency range of input levels. Loud sounds are above the upper limit of comfort in the mid-to-high frequencies. Moderate sounds are not uncomfortable, but are at the upper half of the dynamic range. Soft sounds which might be expected to come in just above threshold are approximately 15 – 20 dB above threshold. Figure 3 indicates that the Total Harmonic Distortion (THD) is low (< 10 %) for a moderate input level (65-70 dB SPL) while Figure 4 indicates that THD is unacceptable (>10%) at moderately high input levels likely producing a perception of poor sound quality. When this student is speaking up in class or calling to friends, her own voice will produce this input level and create a distorted sound.

This evaluation revealed that the gain for high input levels should be reduced in the mid-to-high frequencies. In addition, the gain for soft and moderate input levels should be reconfigured in a way that would produce a more normal

perception of sound (e.g., soft sound should be perceived as soft and moderate sounds should be comfortable but not loud). This could be achieved through manipulation of the locked volume control. A 15-year-old individual should be capable of manipulating the VC if a VC is to be included in a hearing aid (as opposed to a WDRC hearing aid that would not require a VC). Adjustments to the current hearing aid were attempted but because of the conventional nature of the hearing aid, the mid-to-high frequencies could not be altered without losing audibility in the low frequencies. Even if these adjustments could have been made, the circuit contained a Class A receiver and

output limiting was achieved through peak clipping (see Table 4 and 5 for details) which likely was the cause of reduced sound quality at high input levels (Palmer, Killion, Wilber, & Ballard, 1995).

There are many instances where problems identified through this evaluation and patient interview can be solved through modification of the current hearing aid response (the educational audiologist may not make the modification but he/she would forward the recommendation) or counseling regarding use and wearing habits. The worksheet that is completed as part of this evaluation (Appendix A) provides check boxes for various recommendations so there is a record of the recommendations and a clear description of what was evaluated in order to make these recommendations.

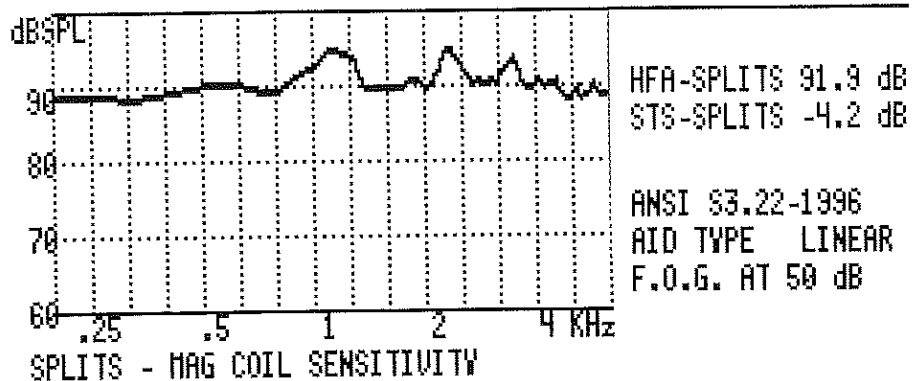
The last section of the worksheet in Appendix A lists unresolved issues that are based on patient report. These include difficulty in noise, difficulty localizing sounds, difficulty when sound originates from one particular side,

**Table 5. Red flags for achieving hearing aid fitting goals.**

Circuitry	Issue
Class A amplifier	The Class A amplifier is known to produce reduced sound quality as intensity of the input signal increases (Palmer, et al., (1995).
Peak clipping output limiting	Peak clipping is known to produce poor sound quality as soon as the input signal is intense enough to drive the hearing aid into saturation (Hawkins & Naidoo, 1993).
Linear response	A linear response indicates that all input levels receive the same amount of gain until saturation is reached. The goal in linear fittings is to make moderate sound comfortable. If this goal is achieved, then soft sounds will be inaudible and the individuals will operate in saturation for many louder sounds. It is virtually impossible to make soft, moderate, and loud sounds all audible and comfortable using a linear hearing aid response with a patient with sensorineural hearing loss.
Single channel	Reduced ability to make low and high frequency sounds audible across input levels (quiet to loud) in sloping hearing losses due to the need to compromise compression characteristics between the low and high frequencies.
Patient Driven Volume Control	The patient has the ability to make signals inaudible. This is especially a problem when coupled with Class A receivers, peak clipping output limiting, and/or a peaky frequency response because the patient will turn down the volume control at the expense of audibility in order to avoid distortion or feedback associated with high level inputs that receive full gain.

Palmer and Mormer (1999) presented the Developmental Index of Audition and Listening (DIAL) which illustrated that children as young as one to two years interact with the telephone. The telephone may impact the student's ability to participate in extracurricular activities and certainly has an impact on socialization. Thus, an evaluation of the student's telecoil coupling is warranted. This student indicated that she is not getting enough power from her telecoil setting. Figure 8 illustrates the telecoil test that was conducted using ANSI (1996). The test is called SPLITS (sound pressure level for inductive telephone simulation). The graph provides the response of the telecoil across frequency. The STS-SPLITS data on the printout indicate the difference between the telecoil and microphone response at the same volume control setting. In Figure 8, the telecoil response was tested at use VC setting (2 on the VC). The results indicate that the telecoil response is 4 dB below the microphone response (-4.2 dB). This would explain why the student has the impression that the telecoil response is not adequate. The VC was increased to 3, and the test results are displayed in Figure 9. Now the telecoil actually is stronger than the microphone response. Therefore, the student needs to be allowed to manipulate the volume control (currently it is locked) and should be instructed in the independent use of volume control when in microphone setting versus telecoil setting. If a new hearing aid is recommended based on the results related to audibility and sound quality, a pre-amplifier and/or separate telecoil program may be selected in order to insure that the telecoil will be adequate for her needs in the future. Further measurement may be required if difficulty coupling to ALDs is reported as well, but this was not a problem for this student. Measurement of the response of the ALD coupled to the hearing aid is essential and a protocol for this type of measurement was described by Nelson (2001) and Lewis (2000).

**Figure 8. Telecoil response with the volume control at 2 (Frye Electronics 6500-CX Hearing Aid Test System)**



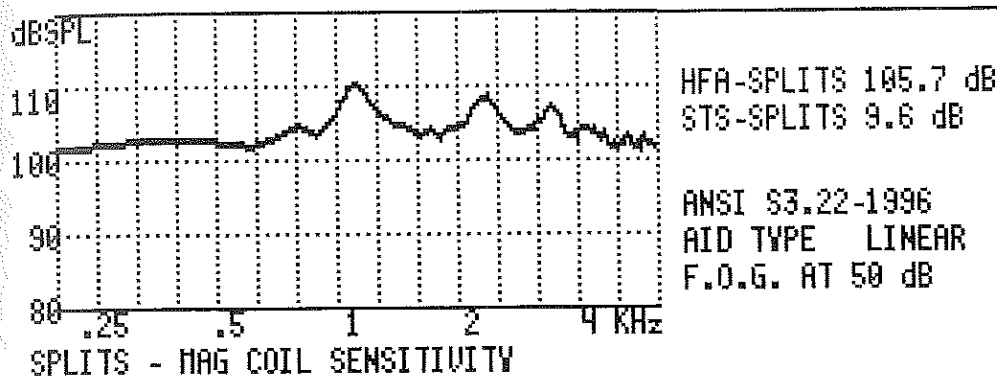
feedback problems, disappointment in the sound of one's voice, disappointment in sound quality, difficulty communicating on the telephone, difficulty coupling to ALDs. Although all of these issues are based on self report, the telecoil on the hearing aid can be measured using the ANSI (1996) coupler method that produces a measure of the telecoil response relative to the microphone response.

The resulting recommendation was for programmable, two-channel circuitry that would allow manipulation of the gain as a function of frequency and input level (wide dynamic range compression). A Class D amplifier/receiver combination was included and provided good sound quality at various input levels. A separate telecoil program was

ear shape, surgery, etc.), and e) degree of hearing loss. After presentation of the results of the evaluation and counseling, the patient may continue to limit the hearing aid fitting by his/her choices and this should be documented on the worksheet provided in Appendix A.

The hearing loss itself may be the limiting factor and

**Figure 9. Telecoil response with the volume control at 3 1/2 (Frye Electronics 6500-CX Hearing Aid System).**



this too should be documented so that the patient and/or health care provider will understand that the patient is receiving the most benefit possible even though this may not meet each of the general hearing aid fitting goals. Clinical experience and recent data provided by Ching, Dillon, and Byrne (1998) and Hogan and Turner (1998) indicate that although audibility may be achieved for moderately-severe to severe regions of hearing loss

obtained so the response of the telecoil could be manipulated independently of the microphone response. The student is now a happy, full-time user of an ITE hearing aid with no VC.

(often in the high frequencies), the resulting sound may not be of use to the individual.

### Making Use of Assessment Results

As illustrated in this case, if the evaluation reveals that one or more of the hearing aid fitting goals have not been met, the audiologist must identify the cause of the problem. For instance, there are a variety of reasons why the hearing aid may not be audible at soft, moderate, and loud levels. The reason must be identified in order to provide the solution to the patient, parent, and/or health care provider. Table 4 provides descriptions of problems, possible causes, and the recommended solutions. It is important to note that two of the problems and solutions for inaudible sounds (patient preference and inappropriate style for degree of hearing loss) are based on patient limiting factors. Every hearing aid fitting is a combination of advice from the hearing aid provider and patient preferences. Certain patient preferences may severely limit the functionality of the hearing aid. Common patient limiting factors include: a) cosmetics (style, monaural versus binaural amplification), b) finances/funding sources (may dictate monaural amplification or inferior technology), c) ability to tolerate background sounds, newly returned high frequencies, and/or the individual's own voice, d) earmold fit (challenging

There may be such severe damage to the inner hair cells that useful information is not transmitted to the VIIIth nerve. Appendix A includes "degree of hearing loss precludes audibility of soft (moderate, and/or loud) sounds in some frequencies" to indicate that the goal was not achieved on purpose. There are no data to indicate that children do not benefit from high frequency sounds and audibility should be attempted whenever possible until data indicate otherwise. Stelmachowicz, et al. (2002) found that hearing-impaired children needed an audible signal between 2000 and 8000 Hz in order to perceive a female talker saying "s" and none of their subjects had a degradation in performance with high frequency audibility.

If the hearing aids are not making sound audible across frequency while bandwidth and sound quality are good, resetting/reprogramming the hearing aid should be attempted prior to recommending new circuitry. This may consist of increasing the user volume control setting and re-running the test box or real-ear measurements in order to see if this change increases audibility across input levels and frequencies. The hearing aid parameters can be manipulated through potentiometers and/or computer programming in order to try to achieve audibility. Once again, the coupler or real ear measurements should be repeated and the verification data should be plotted to evaluate the effectiveness of these changes. If these

modifications allow the hearing aids to provide audible sound across input levels and frequencies while maintaining good sound quality, then the patient should be encouraged to start the adaptation period that may be required to get used to a new hearing aid response. The educational audiologist may not be the individual making these changes, but he/she certainly is in the position to make these recommendations for the benefit of the student listener.

The patient may not be wearing the volume control at an adequate setting because of the sound quality that is achieved for higher input levels. For instance, hearing aids with Class A receivers do not sound distorted until input levels are over approximately 80 dB SPL (Palmer, et al., 1995). The user may have a good reason for limiting the volume control. In addition, an instrument that limits with peak clipping will sound distorted when inputs drive the hearing aid into saturation (Hawkins & Naidoo, 1993). Again, the user may limit the volume control in order to preserve sound quality at the expense of audibility. As indicated in Table 4, the circuitry in these hearing aids would have to be replaced in order to guarantee adequate sound quality for intense signals.

If the bandwidth is not adequate considering the individual's hearing loss, new circuitry and/or earmolds are most likely required. Poor sound quality generally will require new circuitry.

Table 5 lists five "red flags" in hearing aid circuitry that often preclude audibility and adequate sound quality across input levels. When dealing with a hearing aid that was not dispensed by the verifying audiologist, spec books and/or a call to the manufacturer may be necessary in order to determine what type of circuitry and output limiting is used in a particular hearing aid. A patient with a volume control always has the option of making various input levels inaudible. Although the obvious solution would be re-fitting individuals with hearing aids that no longer require user volume controls (instruments with low compression thresholds), many previous users will not happily relinquish their volume controls and the power that comes with them. One can still pursue "automatic" hearing aids that also have the user volume control and encourage patients to allow the hearing aids to regulate sounds as much as possible and use the volume control only as a manual override.

## **Providing Record Keeping and Solutions**

A form to record results of the hearing aid verification procedure is provided in Appendix A. This document may be used for record keeping purposes, patient counseling, and communicating with other individuals concerned with the welfare of the patient (primary care physician, otolaryngologist, other health care provider, educator, parent). The various options under each of the areas assessed in this procedure allow the reader to understand the status of the hearing aid and what corrective actions might be required including a modification of the patient's habits (e.g., VC setting) or preferences (e.g., style, monaural versus binaural use).

## **Limitations of Functional Gain in Assessing Hearing Aids**

Hawkins, Montgomery, Prosek, and Walden (1987) provided data that questioned the use of functional gain in the assessment of audibility provided by hearing aids. Test-retest data illustrated that functional gain measures were likely to vary by more than 15 dB between test sessions with no change in hearing and/or hearing aid response. This much variability is unacceptable if one is trying to quantify audibility for various input levels received by a hearing aid. In addition, functional gain, by definition, comes from threshold measures using quiet sounds. Therefore, even a reliable functional gain measure only provides information about the audibility of very quiet sounds and not moderate and loud sounds. With wide-dynamic-range-compression, the individual is receiving the most gain for very quiet sounds and less gain as signals increase. With three dimensional hearing aid fittings (where gain is varying as a function of both input level and frequency), one must document audibility for at least three levels of input (quiet, moderate, and loud) in order to tell the entire story. Noise reduction circuitry and automatic feedback management systems also may impact measures of aided threshold or functional gain. Stelmachowicz, et al. (2002) provide an excellent summary of the difficulties associated with relying on functional gain in any type of hearing aid verification procedure.

### Comments

This procedure answers the four objective questions related to the original goal of the hearing aid fitting, but it leaves many questions unanswered. These would include:

- 1) Would digital signal processing be superior for the patient who is currently using analog technology (potentially a sound quality issue)?
- 2) Would an advanced algorithm be superior for this patient (e.g., ASA or SKI algorithm by Oticon, Senso or DIVA algorithm by Widex, etc.)?
- 3) Would directional microphones provide significant benefit in noisy situations?

There are not adequate empirical data published at this time to answer any of these questions unequivocally. The audiologist must rely on patient interview in terms of the individual's communication needs, abilities, demands, and expectations (Palmer and Morner, 1997) in order to determine if a change in technology level and/or features will benefit the patient. The last section of Appendix A is a check list of potentially unresolved issues for the hearing aid user even if the four basic goals of the hearing aid fitting have been achieved. Problems in any of these areas should motivate the individual to try technology developed to provide solutions to these problems. Until more sophisticated and specific clinical measures are developed and implemented, many of these advanced solutions must be worn by the patient in his/her own environment in order to determine benefit. In order to continue the process of assessment with the adult patient, it is well worth administering the Abbreviated Profile of Hearing Aid Benefit (APHAB, Cox & Alexander, 1995) or some reliable measure of hearing aid benefit to the patient as a pre-test (wearing his/her current hearing aids) and as a post-test (several weeks of using advanced technology) in order to document perceived differences in communication and sound quality. This will assist the clinician in documenting the recommendation and may assist the patient in making a final decision regarding updating the hearing aid technology. Observations from the communicators in a child's environment (teachers, sibling, parents, and the child) may provide the best measure of whether the technology level and/or features are making a difference (e.g., Functional Listening Evaluation, Johnson & Von Almen, 1997; the Screening Instrument for Targeting Risk, Anderson, 1989; or the Listening Inventory for Education, Anderson & Smaldino, 1996).

One must examine the entire situation. For instance, there may be an older child who would appear to be a perfect candidate for directional microphones, but upon

further examination it may become evident that the type of hearing aid required to couple to the child's classroom assistive listening system is not a hearing aid that can be outfitted with directional microphones. It becomes a balancing act of which is more important for this particular individual: assistive listening technology or a particular hearing aid feature.

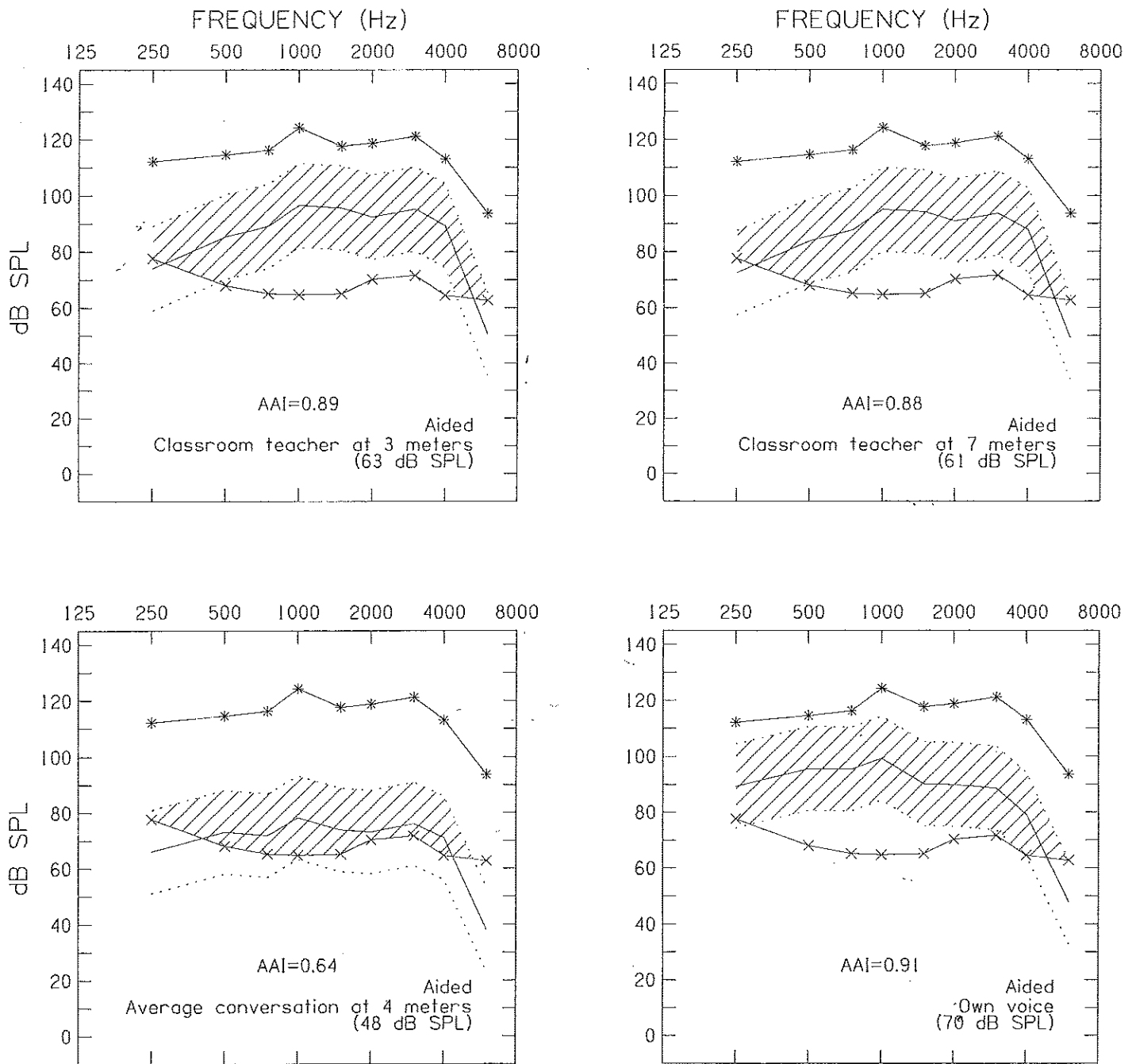
Although the recommendation of hearing aid technology and features continues to contain elements of both art and science and is accepted as a very complicated procedure involving the audiologist's knowledge base and experience as well as the patient's preferences, this protocol attempts to objectify the minimum set of hearing aid fitting goals that audiologists generally agree combine to make an adequate hearing aid fitting. These data can be used to educate hearing aid users and the professionals or relatives who are trying to help them obtain the most appropriate hearing aids given any acknowledged limitations (e.g., degree of hearing loss). Although new hearing aids are not always an option, the results of the recommended assessment can lead to hearing aid modifications to meet as many of the goals as possible and to supply criteria for future hearing aid purchases.

The proposed protocol provides a way to systematically evaluate components of a hearing aid fitting that generally are accepted as reasonable goals. A systematic approach does not imply that these are simple questions. The audiologist must use this protocol with caution and apply the breadth of knowledge expected of an audiologist. Examples of where the protocol could be misleading for less knowledgeable users include prescribing low frequency gain in order to reach audibility for soft sounds when this may simply increase background noise and cause upward spread of masking; assuming that 90 dB input measures falling below estimated UCL are definitely comfortable for every individual; and assuming that total harmonic distortion tests all types of possible distortion. With this said, the knowledgeable audiologist should be able to implement this protocol in order to answer the basic questions related to appropriateness of a hearing aid fitting and to produce a detailed, systematic record of this assessment.

### Audibility of Specific Listening Situations

The educational audiologist may find him/herself in need of quantifying specific listening situations in terms of audibility. The Situational Hearing Aid Response Profile (SHARP, Stelmachowicz, Lewis, Kalberer, & Creutz, 1994) provides an excellent tool for quantifying audibility as a function of specific listening situation. The audiologist

Figure 10. SHARP plots for specific communication situations.



Patient #1234 11/10/2003

collects either coupler or real ear data at 50, 60, 70, 80, and 90 dB input levels (as described in the protocols in this paper). Appendix B provides detailed instructions related to using the program with the data collected in any of the protocols described above. Figure 10 illustrates the data from the case described in this paper plotted for four specific listening situations (the classroom teacher at 3 meters, the classroom teacher at 7 meters, average conver-

sation at 4 meters, and the student's own voice). These graphs provide information about audibility. In our student's example, audibility is adequate in the louder communication situations (the teacher is projecting his/her voice and the student's own voice reaches the hearing aid microphone at an intense level), but suffers in the softer input levels (average conversation at 4 meters which might be consistent with group class work with other students).

Considering the discussion above, audibility is only part of the picture since our data illustrated that the audibility for moderate and loud sounds came with a compromise in sound quality. The SHARP data can be very helpful when trying to illustrate to administrators, funding agencies, and parents the impact of distance on audibility when a hearing aid is used alone (as opposed to in conjunction with an assistive listening device in the classroom).

The tools and techniques described in this paper are meant to assist the educational audiologist with the difficult task of assessing the amplification of children with a variety of hearing losses and hearing aid technologies. The protocols focus on primary elements that can be considered part of an adequate hearing aid fitting. Audiologists must use their expertise and knowledge of the individual students in order to fully evaluate the adequacy of any amplification system.

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### **Acknowledgments**

Carol Bostick from the Pittsburgh Public Schools was the first audiologist to pose this question to me in her quest to provide the best possible care to the children entrusted to her expertise. I would like to thank her for asking me a question that has taken me three years to finally answer in an organized manner. In those three years, countless audiologists have heard me describe this protocol and have asked me to provide a final written document – I am pleased that they kept pushing and that there is a mechanism for this type of material. Thanks also to the variety of patients and health care providers who have participated in the process of refining this procedure. Thanks to Randall Kesterson and Stacey Karn for their assistance in finalizing the figures for this manuscript.



**A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate For This Individual?**

**Appendix A  
Evaluation of Current Hearing Aids**

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Right Hearing Aid:

Left Hearing Aid:

Company \_\_\_\_\_

\_\_\_\_\_

Model \_\_\_\_\_

\_\_\_\_\_

Serial # \_\_\_\_\_

\_\_\_\_\_

Circle Style: BTE ITE ITC CIC

BTE ITE ITC CIC

Sound is audible for quiet inputs

R L

\_\_\_ \_\_\_ Yes

\_\_\_ \_\_\_ No:

R L

\_\_\_ \_\_\_ 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:

R L

\_\_\_ \_\_\_ 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:

R L

\_\_\_ \_\_\_ 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

\_\_\_ \_\_\_ No:

R L

- \_\_\_ \_\_\_ 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

R L

\_\_\_ \_\_\_ Yes

\_\_\_ \_\_\_ No:

R L

- \_\_\_ \_\_\_ 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

R L

\_\_\_ \_\_\_ Yes

\_\_\_ \_\_\_ No:

R L

- \_\_\_ \_\_\_ new hearing aid circuitry would be required to achieve this goal
- \_\_\_ \_\_\_ 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

**A Checklist/Protocol for Audiologists: Is This Hearing Aid Appropriate For This Individual?**

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- \_\_\_\_\_ **Feedback**
  - \_\_\_ modification of earmold or shell
  - \_\_\_ modification of hearing aid response
  - \_\_\_ 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**
  - \_\_\_ modification of hearing aid response
  - \_\_\_ different circuitry/signal processing recommended
- \_\_\_\_\_ **Difficulty communicating on the telephone**
  - \_\_\_ reinstruction
  - \_\_\_ modification of telecoil response
  - \_\_\_ addition of telecoil circuitry
  - \_\_\_ other phone solution
  - \_\_\_ different circuitry/signal processing recommended
- \_\_\_\_\_ **Difficulty coupling to ALD's**
  - \_\_\_ 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:

Audiologist: \_\_\_\_\_ Date: \_\_\_\_\_

### **Appendix B**

Instructions for using the SHARP to estimate audibility in specific listening situations.

1. Open the program and select New under File. Use the top tabs to navigate the program.
2. Select General and enter name, birth date, hearing aid configuration, and transducer.
3. Select Hearing Aid Information. Indicate whether the hearing aid is linear or WDRC. If you select linear, the change in output vs change in input is not highlighted (these compression ratio data only apply to WDRC signal processing).
4. Enter the nonlinearity point (this comes from the input/output graph in Figure 2). Indicate the type of data you will be entering (real ear or 2cc coupler gain for inputs between 50 and 80 dB and output for 90 dB).
5. A table is supplied for the real ear or coupler data. Mid-levels will be grayed out if you indicated that this is a linear hearing aid (since gain will be the same for all inputs until the nonlinearity point).
6. Enter the threshold data and any individual RECD data that you may have (otherwise the program will use an age appropriate correction).
7. Under Spectra, choose which particular listening situations are of interest. The educational audiologist may be particularly interested in some of the classroom situations depending on where the child sits or on data related to the audibility of the child's own speech for purposes of advising the speech-language therapist.
8. The Spectra choices include:
  - a. Average conversation at 1 meter
  - b. Raised voice at 1 meter
  - c. Classroom teacher at 1 meter
  - d. Classroom teacher at 2 meters
  - e. Classroom teacher at 3 meters
  - f. Classroom teacher at 4 meters
  - g. Classroom teacher at 7 meters
  - h. Average conversation at 4 meters
  - i. Shout
  - j. Own voice
  - k. Head shadow at 1 meter
  - l. Cradle position, near ear
  - m. Hip position, near ear
8. Close the screen at the X  
Select Plot and select preview. If you want a printed copy of this information, select close and then Print under the Plot menu (see Figure 8 for an example of a printout of 4 listening situations).