MEETING HEARING AID FITTING GOALS

Catherine V. Palmer, Ph.D.

The goal of a hearing aid fitting is to make the range of sounds one encounters throughout a day audible, while ensuring comfort and good sound quality. Further, we attempt to address a patient's communication goals with hearing aids (e.g., understanding or comfort in noise) through special features that may include directional microphones, noise suppression programs, coupling to assistive devices, etc. In addition, we must ensure safety in the patient's auditory environment by providing appropriate coupling to both landline and mobile telephone devices. The individual's ability to hear doorbells, telephone ringers, and smoke detectors, among other warning signals also must be addressed. Table 1 lists this common set of goals. Our goal of returning audibility to the entire input range of sounds (soft, moderate, and loud input levels) is tempered by the degree of hearing loss which may prevent audibility for certain sounds. Of course, the challenge is to do all of this without having the hearing aids produce feedback, while maintaining physical comfort for the patient wearing the hearing aids, and while providing a style of hearing aids that the patient finds acceptable.

TABLE 1: Hearing Aid Fitting Goals
1. Audibility
2. Comfort
3. Sound quality
4. Addressing patient communication goals
5. Safety in the environment

Hearing Aid Fitting Goals

The first goal, audibility, is the underpinning for all of the other goals. As David Pascoe (1980) once eloquently stated, "Although it is true that mere detection of a sound does not ensure its recognition…it's even more true that without detection, the probabilities of correct identification are greatly diminished." Although this statement is self-evident, there also are data-based articles that show repeatedly that signals must be audible for a listener to understand speech (e.g., Skinner, 1979; Skinner and Miller, 1983; Humes, 1996). Therefore, our primary goal for the individual with hearing loss who is pursuing amplification must be audibility for the widest possible input range and across the widest possible frequency range without discomfort (goals 1 and 2). Today's hearing aids generally provide good sound quality (goal 3); and goals 4 and 5 are inextricably linked to the goal of audibility.

The primary goal of amplification (audibility) requires verification. The verification technique should be focused on measuring whether audibility has been achieved while providing an efficient method for repeat measurements to show and verify changes as the hearing aid parameters are manipulated. The goal is to measure audibility at the eardrum of the individual, not in a coupler.

First Fit and/or Best Fit

The first step in hearing aid fitting is to enter threshold data into the manufacturer fitting program and select "first fit" or "best fit" from the computer software. Unfortunately, this is often misunderstood as the "final step" when it is most definitely the "first step." The software program does not know anything about the acoustics of the individual ear or the contributing acoustics of the specific hearing aid. The fitting software uses data from an average hearing aid and an average person to provide a starting measurement point.

Failure to measure audibility in the ear canal implies that the hearing health care professional believes the manufacturer's hearing aid settings provide audibility across various input levels and across a broad frequency range for the individual patient and that, therefore, there is no need for verification. The evidence clearly indicates that this is a false assumption as shown by Hawkins and Cook (2003), who reported that manufacturer-simulated values overestimate the output provided by the hearing aids they tested with differences of as much as 20 dB. Keidser et al (2003) documented that the variety of proprietary fitting algorithms used by manufacturers produce significantly different "first fit" settings which do not ensure audibility. Mueller et al (2008) showed that there are significant differences between manufacturers in terms of the prescribed maximum output of hearing aids. In addition, Seewald et al (2008) showed that manufacturer settings generate substantial variation in output in hearing aid fittings for a group of infants. Clinicians must be aware that hearing aid under-fitting leaves sound inaudible and over-fitting can potentially harm an individual. Both of these hearing aid fitting results are unacceptable and are avoided when the actual output of the hearing aid in the individual's ear is measured.

Assessing Audibility

To map audibility across the patient's dynamic hearing range, the clinician needs an accurate graph of threshold and uncomfortable loudness level (UCL) displayed in sound pressure level. Hearing Level (HL) in dB, is, of course, a conversion of sound pressure level to a convenient graphing technique that equalizes minimal audible pressure to 0 dB HL across all test frequencies. The output of a hearing aid is measured in dB sound pressure level (SPL) and therefore must be compared to hearing thresholds and UCLs displayed in dB sound pressure level.

The first step in having an accurate measurement of audibility is to establish an accurate dynamic range against which to assess the audibility that has been achieved. Assuming hearing thresholds and UCLs are displayed on the audiogram in dB HL, these data need to be converted into sound pressure level accurately. This can be achieved by measuring the real-ear-to-coupler difference (RECD) for the particular individual. This measurement provides corrections for each frequency to accurately convert the HL data to SPL. In fact, RECD is one of the most powerful sets of data used in the accurate fitting of hearing aids. With these correction factors, all other verification of the hearing aid can be conducted in the coupler if desired. The RECD can be applied to these measurements in order to simulate the sound levels that will be achieved in the ear canal of the individual. Indeed, this is the recommended process for fitting infants and small children since there is an assumption that they will not sit still for real-ear probe microphone verification procedures. For adult, cooperative patients, it is faster to verify with a real-ear probe microphone in the ear canal at the time of fitting, and the measurement process provides face validity for the patient.

The patient should be made aware of the importance of this measurement. Additional value of the measurements is in their use for patient education illustrating that the goal of audibility has been achieved (e.g., the output of the hearing aid is above threshold and below UCL on the graph). Patients need to understand why they often are not asked about their opinion of how the hearing aids sound on the day of fitting since their brain needs time to adapt to these new inputs. Accurate measurement is valuable on the day of fitting, while subjective patient impressions are valuable during the fine-tuning follow-up visit after at least two or three weeks of full-time use.

Case Presentation

In Figure 1 a graph of an individual's dynamic range (from threshold to UCL) is shown. The sound pressure level data have been achieved by applying the measured RECD to the dB HL results from the hearing evaluation (threshold and UCL). Figure 2 displays a graph of the outputs for soft, moderate, and loud input speech signals after selecting "first fit" for a new hearing aid. These measurements were achieved with a probe microphone and hearing aid in the ear canal and a free field loudspeaker. It is clear that audibility has not been achieved for soft or moderate high frequency sounds for this individual. Figure 3 displays the second set of probe microphone measurements after the hearing aid was adjusted to meet prescriptive targets shown as "+" marks.

Prescriptive targets are a starting place in any fitting and should be used as guidelines. The dynamic range, however, provides clear data – sounds below the threshold will not be audible and sounds above UCL will be uncomfortable for this individual. Audibility still has not been achieved for frequencies above 4000 Hz. As can be seen by the dramatic drop off in output for all input signals after

4000 Hz, this is a limitation of the bandwidth of the hearing aid being used. Unfortunately, hearing aids continue to have limited bandwidths compared to the bandwidth needed to achieve improved speech perception for high frequency sounds (e.g., Horwitz et al, 2008; Ricketts et al, 2008; Stelmachowicz, 2002). Real-ear probe microphone measures can assist the clinician in comparing various hearing aids so they can choose hearing aids that have the widest possible bandwidth.

Audibility and Real-Ear Probe Microphone Measurements

There is a great deal of momentum behind evidence-based practice. An evidence base related to real-ear probe microphone measurements is not needed. The evidence indicates that sounds must be audible and comfortable to ensure that the best possible speech understanding is obtained for an individual patient. Real-ear probe microphone measurement is simply a tool to verify that audibility has been achieved. The use of real-ear probe microphone measurement itself does not ensure audibility; however, it is an objective measurement of audibility. The clinician must use these measurements to guide the fine-tuning adjustments in the hearing aid software that will then produce audibility.

A question such as, "Will patients who are tested with real-ear probe microphone measurements report greater satisfaction with their hearing aid fittings than patients who are not tested in this manner?" is misguided. Real-ear probe microphone measurements are not a treatment; audibility is the treatment, and we know with certainty that audibility is essential for speech understanding. Providing audibility provides patient benefit (understanding speech) but not necessarily satisfaction. As Mead Killion (2004) points out, the relationship between hearing aid satisfaction and benefit has not been established. Despite all of the technological advances in hearing aids, there has not been a significant increase in self-reported hearing aid satisfaction. The focus of returning audibility to patients with hearing loss and verifying audibility with an appropriate measurement tool, such as real-ear probe microphone measures, helps to ensure benefit from amplification. Satisfaction with hearing aids is dictated by many other factors that go into successful hearing aid fittings.

Conclusion

Real-ear probe microphone measures are currently our most accurate and most efficient method of verifying that the essential goal of audibility has been achieved. Verification techniques should always be dictated by the goal of the hearing aid fitting. Audibility across input levels and across the appropriate frequency range is the goal of amplification, and real-ear probe microphone techniques provide an objective measurement of audibility.

About the Author

Catherine V. Palmer, Ph.D., is the Director of Audiology at the Eye and Ear Institute, and Associate Professor, Department of Communication Science and Disorders, School of Health and Rehabilitation Science at the University of Pittsburgh. She also serves as Director of Audiology, University of Pittsburgh Medical Center. Dr. Palmer is the Editor-in-Chief of *Seminars in Hearing*.

References

Hawkins, D., Cook, J. (2003). Hearing aid software predictive gain values: How accurate are they? *The Hearing Journal*, 56(7), 26-34.

Horwitz, A., Ahlstrom, J., Dubno, J. (2008). Factors affecting the benefits of high-frequency amplification. *Journal of Speech, Language, and Hearing Research*, 51, 798-813.

Humes, L. (1996). Speech understanding in the elderly. *Journal of the American Academy of Audiology*, 7, 161-167.

Keidser, G., Brew, C., Peck, A. (2003). How proprietary fitting algorithms compare to each other and to some generic algorithms. *The Hearing Journal*, 56(3), 28-38.

Killion, M. (2004). Myths about hearing aid benefit and satisfaction. *Hearing Review*, 11(9), 14-20, 66.

Mueller, H.G., Bentler, R. (2008). Prescribing maximum hearing aid output: Differences among manufacturers found. *The Hearing Journal*, 61(3), 30-36.

Pascoe, D. (1980). Clinical implications of nonverbal methods of hearing aid selection and fitting. *Seminars in Hearing*, 1, 217-229.

Ricketts, R., Dittberner, A., Johnson, E. (2008). High-frequency amplification and sound quality in listeners with normal through moderate hearing loss. *Journal of Speech Language Hearing Research*, 51, 160-172.

Seewald, R., Mills, J., Bagatto, M., Scollie, S., Moodier, S. (2008). A comparison of manufacturer-specific prescriptive procedures for infants. *The Hearing Journal*, 61(11), 26-34.

Skinner, M. (1979). Audibility and intelligibility of speech for listeners with sensorineural hearing loss. In Rehabilitative Strategies for Sensorineural Hearing Loss, P. Yanick (Ed). Grune and Stratton, Inc.

Skinner, M., Miller, J.D. (1983). Amplification bandwidth and intelligibility of speech in quiet and noise for listeners with sensorineural hearing loss. *Audiology*, 22, 253-279.

Stelmachowoicz, P., Pittman, A., Hoover, B., Lewis, D. (2002). Aided perception of /s/ and /z/ by hearing-impaired children. *Ear and Hearing*, 23, 316-324.

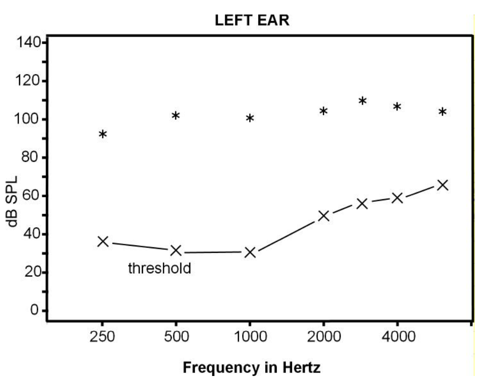

Figure 1
The dynamic range of a patient converted into dB SPL using RECD is displayed.

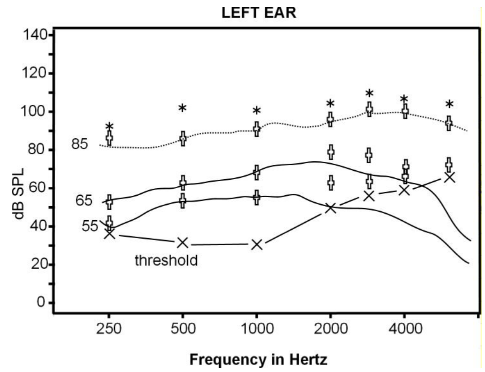

Figure 2
The lines (from bottom to top of the graph) represent the output measured from input speech signals of 55, 65, and 85 dB SPL. The "+" signs indicate the targets for the various input levels. Targets are met across frequencies for the 85 dB SPL input, but are not met for the high frequencies for the 55 and 65 dB SPL input. High frequency quiet sounds will not be audible for this patient.

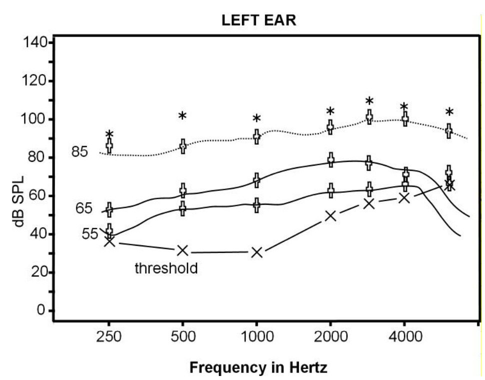

Figure 3
After viewing the results displayed in Figure 2, the clinician has increased the gain for quiet and moderate input levels in order to achieve audibility. Signals are now audible but not uncomfortable through 4000 Hz. The limitations of the hearing aid's bandwidth makes audibility past 4000 Hz impossible in this case (note the sharp drop off in response after 4000 Hz).