Choosing hearing aid technology for older adults: examination of user outcomes

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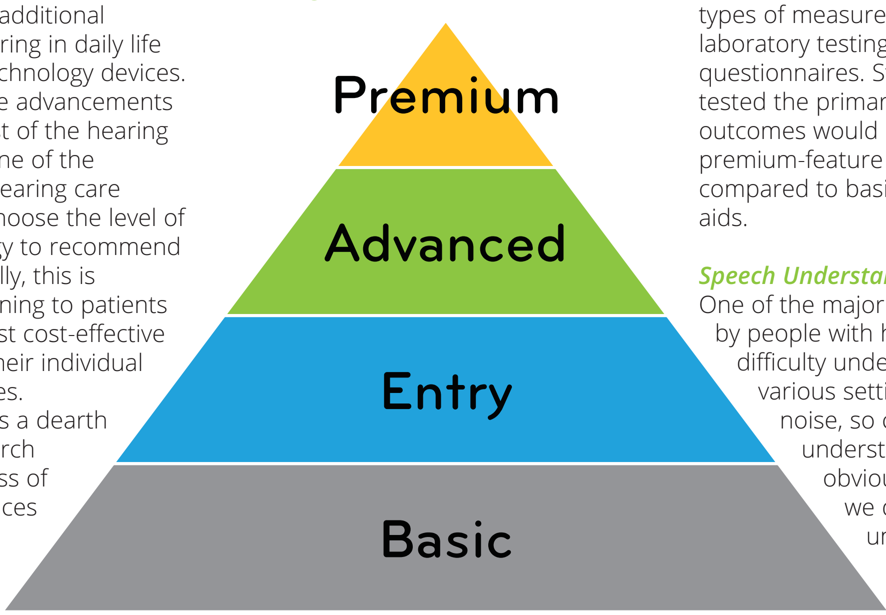
Modern hearing aids possess complex features that are intended to improve hearing in a variety of listening environments. Major manufacturers market families of hearing aids that are described as spanning the range from basic technology to premium technology. Premium technology hearing aids include features that are not found in basic technology instruments. These premium features are intended to yield additional improvements to hearing in daily life compared to basic technology devices. Not surprisingly, these advancements add to the overall cost of the hearing aids, often by a lot. One of the challenges faced by hearing care providers is how to choose the level of hearing aid technology to recommend to their patients. Ideally, this is accomplished by listening to patients and choosing the most cost-effective technology to meet their individual needs and preferences. Unfortunately, there is a dearth of independent research about the effectiveness of premium feature devices compared to basic feature devices. As a result, practitioners are forced to rely mostly on unverified manufacturer claims about feature benefits when they decide which hearing aid(s) to recommend to patients. This, of course, is not an evidence-backed basis for recommending these important healthcare devices. To meet patients' needs, hearing aid providers should have access to scientifically based evidence about the real world improvements that can be delivered by the premium-feature and basic-feature instruments they recommend. This paper summarizes results of research designed to address this lack of evidence.

We compared the effectiveness of premium-feature and basic-feature hearing aids in four real-world listening challenges that modern hearing aids claim to address: speech understanding, listening effort, localization, and acceptability of everyday sounds. For each topic the following question was asked:

Do premium-feature hearing aids yield better outcomes than basic-feature hearing aids for older adults with mild to moderate sensorineural hearing loss?



Research Participants and Procedure
Forty-five older adults (30 males and 15 females) with essentially symmetrical mild to moderate sensorineural hearing loss were included in this study. Participants wore four different pairs of commercially available mini behind-the-ear thin-tube hearing aids in their daily lives for one month each. These hearing aids exemplified basic-level and premium-level technology from each of two major manufacturers, released in 2011 and still in use. Basic and premium devices from the same manufacturer were identical in appearance, but there were substantial differences in advertised features and functions, such as number of compression channels, function of directional technologies, and types of noise reduction strategies. More details are given in Cox et al. (2014). Participants were not aware of the technology differences among the hearing aids or the primary purpose of the study. Outcomes were evaluated at the end of each one-month trial.

The strategy for outcome measurement was designed using two types of measures for each domain: laboratory testing and standardized questionnaires. Statistical analyses tested the primary hypothesis that outcomes would be better for premium-feature hearing aids compared to basic-feature hearing aids.

Speech Understanding.
One of the major problems reported by people with hearing impairment is difficulty understanding speech in various settings with background noise, so comparing speech understanding outcomes was obviously important. Briefly, we quantified speech understanding in the laboratory using an American dialect version of the Four Alternative Auditory Feature test (AFAAF; Foster & Haggard, 1987; Xu & Cox, 2014) in three listening environments (soft, average, and loud). Quadrant A of Figure 1 depicts mean speech understanding in the average listening environment in unaided and aided conditions. Results of statistical analyses showed that aided listening yielded significantly better speech understanding scores than unaided listening for all three environments. However, scores were not significantly different for premium and basic hearing aids for any of the 3 test environments.

We also measured speech understanding in the real world by asking participants to respond to questionnaires. The Abbreviated Profile of Hearing Aid Benefit (APHAB; Cox & Alexander, 1995); the Speech, Spatial, and Qualities of Hearing Scale - Benefit (SSQ-B; Gatehouse & Noble, 2004; Jensen et al., 2009) and the Device-Oriented Subjective Outcome Scale (DOSO; Cox, Alexander, & Xu, 2014) all have subscales that assess real-world speech understanding. To provide a single comprehensive benefit/deficit score for each hearing aid, data were combined from the speech understanding subscales of each questionnaire. Quadrant A of Figure 2 depicts the resulting composite benefit scores for basic-feature and premium-feature hearing aids. On average, participants reported significant improvements in real-world speech understanding with the research hearing aids, but benefit was not perceived to be significantly different between basic-level and premium-level hearing aids.

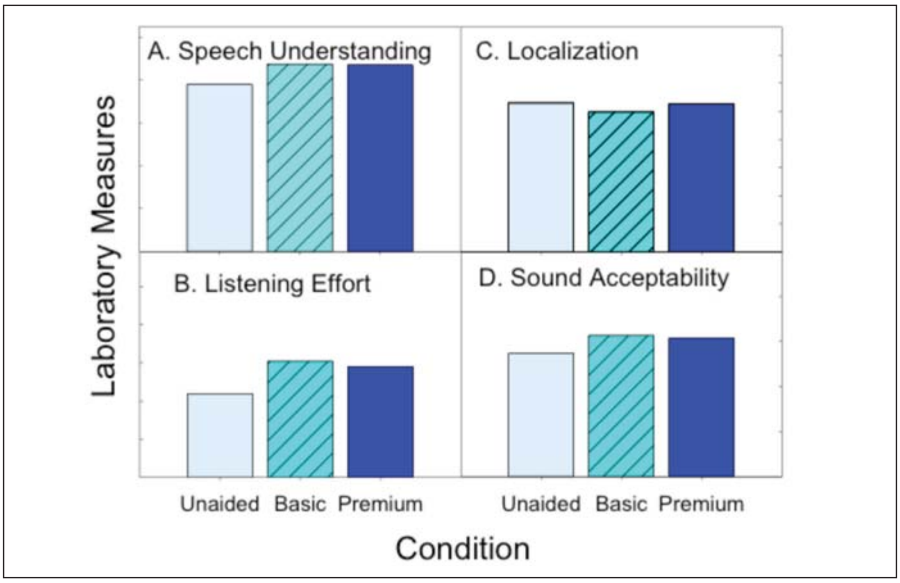


Figure 1/ *Mean performance on four laboratory measures for unaided and the two aided conditions. The following test conditions represent performance on each measure: A & B: average listening environment; C: quiet environment/high frequency stimuli; D: stimuli with average intensity/transient duration. Scales for localization and listening effort were reversed so that taller bars indicate better performance for all measures.*

Listening Effort.

Improved hearing is not limited to better speech understanding. It has been proposed that advanced processing applied by high-technology premium hearing aids might reduce the amount of mental effort that is required for listening even when improvements in hearing are not captured using speech recognition scores (e.g., Bentler et al. 2008). We measured listening effort in the laboratory alongside the speech understanding test in the three listening environments. After groups of speech understanding test words were presented, participants were asked to rate the effort it took for them to understand the group. They based their answers on a 7-point scale of listening effort. Quadrant B of Figure 1 depicts the mean listening effort rating in the average listening environment. Listening with hearing aids yielded significantly reduced listening effort compared to unaided listening for the soft and average environments. However, as above, ratings were not significantly different for premium and basic hearing aids in any of the three environments.

Participants responded to two questionnaires that contained questions about listening effort in daily life: the SSQ-B and the DOSO. Listening effort subscales from these two questionnaires were combined. Quadrant B of Figure 2 shows the average composite benefit scores for the two aided conditions. Although listening effort was significantly lower when using the research hearing aids compared to unaided listening, once again, scores were not significantly different between the premium and basic hearing aids.

Localization.

An additional important function of hearing is the ability to accurately detect the direction from which sound is coming. Using hearing aids, especially behind-the-ear (BTE) style hearing aids, is known to have a negative effect on natural localization cues. Current hearing aids, especially premium-feature hearing aids, have technologies that are designed to target improved sound localization. Localization performance was measured in both quiet and noisy environments in the laboratory. Briefly, low-frequency and high-frequency filtered speech utterances (approximately 1.33 seconds in duration) were presented from loudspeakers placed in a circle surrounding the participant. For the noisy environment, high and low frequency masking noises were presented from 2 additional loudspeakers from the back of the participant. After each test stimulus, participants indicated which speaker that they believed the utterance originated from. We scored localization performance using a method in which a larger number indicates more localization errors. Quadrant C of Figure 1 shows the mean scores for the unaided and the two aided conditions with high and low frequency test stimuli in quiet and noise. Unaided and aided localization performance was not significantly different in any test condition. However, premium-feature hearing aids outperformed the basic-feature hearing aids when high frequency stimuli were used and the test environment was quiet. It can be seen in Figure 1 that the difference, though statistically significant, was small.

Real-world localization data included two SSQ-B subscale scores for spatial hearing. The mean scores for the two aided conditions are shown in Quadrant C of Figure 2. Statistical results showed that localization performance was significantly improved when using the research hearing aids. However, once again, the amount of improvements with the premium and basic hearing aids were not significantly different in the real-world.

Acceptability of Everyday Sounds.

Acceptability of every day non-speech sounds has been found to relate to hearing aid use and satisfaction. Several advanced hearing aid features have been developed to improve

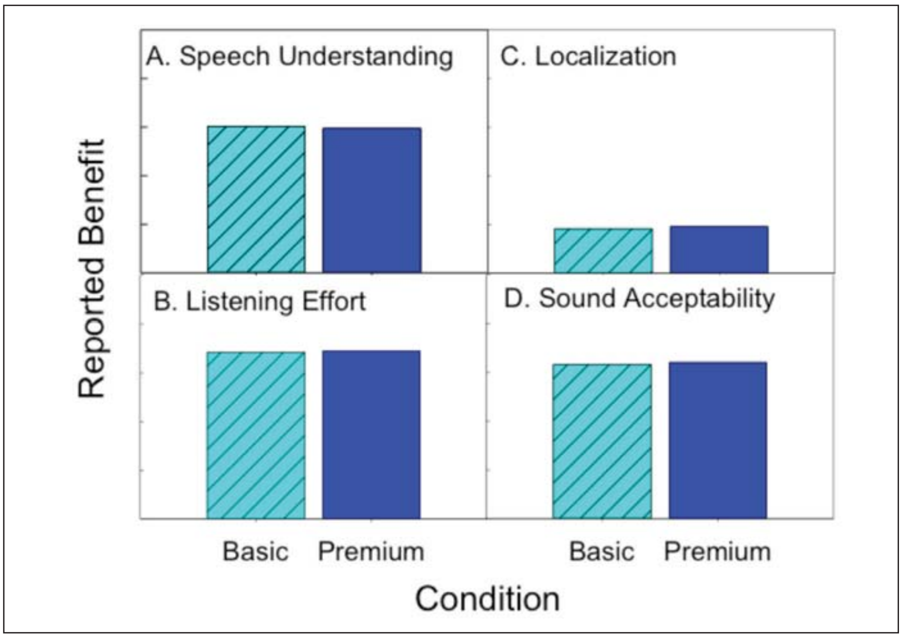


Figure 2/ *Mean real-world aided benefit outcome scores for the two aided conditions. Taller bars indicate more benefit.*

acceptability of non-speech sounds of varying intensity and duration. We quantified acceptability of everyday sounds in the laboratory using a method we developed called the Sound Acceptability Test (SAT). In the SAT, acceptability is based on an individual's total impression of a sound. Although related to aversiveness, annoyance, and loudness tolerance, acceptability also comprises aspects of individual experience, preferences, emotional reaction to sound, and perceptions of sound quality, naturalness, clarity, etc. For this measure, we presented 21 everyday sounds (e.g., cleaning with an upright vacuum cleaner, hitting wood with a hammer, rattling silverware in a metal pan) with varying durations (transient, episodic, continuous) and intensities (soft, average, loud) for each participant in each condition. Sounds were presented in real-time. After each presentation, participants were asked to rate the acceptability of each sound. They based their answers on a 0-10 scale of acceptability. Quadrant D of Figure 1 presents an example of the mean rating scores computed for each listening condition for average intensity/transient duration sounds. Results of statistical analyses showed that aided listening yielded significantly more acceptable average/transient non-speech sounds compared to unaided listening, but significantly less acceptable average/continuous and loud/episodic sounds. As was observed for the other laboratory measures, scores were not significantly different for premium and basic hearing aids for any of the intensity/duration categories.

Participants responded to questionnaires that contained items about sound acceptability in daily life: they indicated how much benefit (or deficit) in sound acceptability that they observed from the hearing aids by responding to the APHAB Aversiveness subscale and the DOSO Quietness subscale. Scores from these two questionnaires were combined. Quadrant D of Figure 2 shows the average composite sound acceptability score for each of the four aided conditions. As above, these scores were not significantly different for premium and basic conditions.

We also administered the Profile of Aided Loudness (PAL; Palmer et al., 1999) to assess loudness and loudness satisfaction for soft, average, and loud sounds. Aided soft and average non-speech sounds were significantly louder than unaided sounds, and all categories of sounds were reported as more satisfactory when aided. However, the loudness ratings and loudness satisfaction scores from the PAL were not significantly different for premium and basic hearing aids.

Discussion and Comments

Our results support the assertion that hearing aids are beneficial in multiple real-world domains for older adults with hearing loss. For these participants, hearing aids effectively improved speech understanding, reduced listening effort, maintained localization performance, and improved acceptability of some everyday non-speech sounds. Additional details about the procedures used in this study have been provided in recent presentations and publications that are available for download on the Hearing Aid Research Lab's website at www.harlmemphis.org. In addition, our team is working on a series of articles that will discuss in depth the methods and results summarized above. These will be available over the next year.

It might be surprising that, despite the broad scope of outcomes that were evaluated, and the careful attention that we paid to optimizing all the hearing aid fittings, there was minimal evidence of greater improvements in hearing when older individuals with mild to moderate sensorineural hearing loss used hearing aids with premium technology versus basic technology. In fact, only one contrived situation (localization of high frequency filtered speech in a quiet laboratory) demonstrated better performance with premium hearing aids compared to basic and this incremental improvement did not translate to perceived benefit in the real-world.

When choosing which hearing technology to recommend for an older patient, hearing care providers need to consider the patient's individual needs and then help the patient perform a cost-benefit analysis of the products that are available. Because basic-feature hearing aids are less costly than premium-feature hearing aids, the amount of perceived benefit per unit cost would likely be higher for the basic devices. Therefore, it would be expected that patients will find them to have higher value than premium-feature hearing aids.

However, it is important for practitioners to keep in mind that the knowledge and skills required for hearing rehabilitation with hearing aids are highly specialized. Although patients might like their new hearing aids, they don't automatically know how to get the best use of them. Audiologists know more than any other professionals about how to help individuals with hearing loss. It is important that practitioners stop focusing on technology minutia and refocus on patients, listening to them and teaching them about communication and how hearing devices can be helpful, or not, and why. Professional services that follow best-practice, patient-oriented protocols can be time-consuming, but they are essential to obtaining an optimal outcome for each patient, no matter which feature level is recommended. Although the results of this research are clear, further research is needed on this topic with other hearing aids and other manufacturers. To make valid, cost-effective recommendations about hearing healthcare devices to patients, hearing care providers cannot rely solely on manufacturer marketing claims. Instead, practitioners must insist on timely, independent, scientifically credible research that demonstrates the effectiveness of those hearing technologies that they recommended.

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Acknowledgement: This research was funded by a grant to the third author from the U. S. National Institute on Deafness and other Communication Disorders (R01DC011550).

References

Bentler, R., Wu, Y. H., Kettel, J., & Hurtig, R. (2008). Digital noise reduction: outcome from laboratory and field studies. Int J Audiol, 47(8), 447-460.

Cox, R. & Alexander, G. (1995): The Abbreviated Profile of Hearing Aid Benefit. Ear & Hearing;16:176-186.

Cox, R., Alexander, G., & Xu, J. (2014). Development of the Device-Oriented Subjective Outcome (DOSO) Scale. J Am Acad Audiol, 25(8), 727-736.

Cox, R., Johnson, J., & Xu, J. (2014). Impact of advanced hearing aid technology on speech understanding for older listeners with mild-to-moderate, adult-onset, sensorineural hearing loss. Gerontology, 60 (6), 557-568.

Foster, J. & Haggard, M. (1987). The four alternative auditory feature test (FAAF) linguistic and psychometric properties of the material with normative data in noise. Br J Audiol, 21, 165-174.

Gatehouse, S. & Noble, W. (2004). The Speech, Spatial and Qualities of Hearing scale (SSQ). Int J Audiol, 43, 85-99.

Jensen, NS., Akeroyd, MA., Noble, W. & Naylor, G. (2009). The Speech, Spatial and Qualities of Hearing scale (SSQ) as a benefit measure. Fourth NCRAR International Conference. Portland, OR, USA.

Xu, J. & Cox, R. (2014). Recording and evaluation of an American dialect version of the four alternative auditory feature test. J Am Acad Audiol, 25(8), 737-45.

CRCA Excellence in Innovation Award recognises HEARnet

The HEARing CRC was one of only two recipients of an Excellence in Innovation Award, presented by the Minister for Industry and Science the Hon Ian Macfarlane at the 2015 Cooperative Research Centres Association Conference Dinner at Parliament House.

The HEARing CRC received the Award in recognition of its HEARnet Online and HEARnet Learning website initiatives, that have proven effective in connecting the public, hearing health professionals and researchers with the latest independent research findings and information about hearing loss, the clinical treatment of hearing loss and available hearing technologies solutions, such as the cochlear implant.

HEARnet Online (www.hearnet.org.au) has a wealth of independent information about different types of hearing loss together with commercially-available technologies that are applicable to each respective type. There is also practical information for hearing health professionals to help provide assistance in the personal management of hearing loss.

HEARnet Learning (www.hearnetlearning.org.au) was specifically established to ensure that HEARing CRC evidence-based, research outcomes are translated into clinical practice by hearing health professionals. At the same time, these modules assist them with their ongoing professional development and help deliver better outcomes to their patients.

Above/ *Greg Lawrence, Helen Goulios and Bob Cowan receive the Awards from Hon Ian McFarlane.*

Working closely with Audiology Australia, HEARing CRC has developed clinical training modules that provide up-to-date information on an expanding array of specialist topics such as cochlear implant and hearing aid fitting, patient-centric rehabilitation for managing hearing loss in infants, adults and the elderly, as well as diagnosis of Central Auditory Processing Disorders in children and the elderly.

As end-user members of the HEARing CRC, Audiology Australia and the National Acoustic Laboratories (the research division of Australian Hearing) have played an important role in developing and accrediting the modules for continuing professional development.