

# Strategies of adult hearing aid selection

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## Introduction

There is little doubt that the most helpful treatment for persons with hearing impairment are personal amplification instruments – better known as hearing aids. For more than 40 years I have marveled at the evolution of hearing aids and the concurrent development of various fitting procedures. The advances in personal amplification to help those with hearing loss have been nothing less than amazing. During these four decades, we have moved from simple basic analog hearing aids fit through subjective behavioral assessments to fitting today's advanced digital devices through computerized and automated protocols. Reflective of those early years, there were substantial differences between the various manufacturers' hearing aid products and it was, accordingly, necessary for patients to listen and judge between a number of hearing aid choices to select the device that sounded best to them. In more recent years, however, all digital hearing aids generally provide appropriate output, gain and frequency responses to fit nearly any person's hearing loss regardless of degree or threshold configuration. In fact, the numerous specialized features of today's modern hearing aids have expanded utilization of personal amplification far beyond anyone's expectations. Unfortunately, the technologies of new hearing aids always arrive far earlier and faster than our abilities to develop accurate fitting methods for our patients – a statement that is true even today.

In our early naïveté, many of us even questioned the value and need for binaural hearing aid fittings as we had no empirical evidence in those days that binaural fittings provided better hearing than monaural fittings. Today, with more than twenty years of strong scientific support, binaural hearing aid fittings have become the standard of care, and in the United States, binaural hearing aid fitting for adults is approximately 80% (Kochkin, 2010). As James Jerger (2010) recently pointed out, in those early years when we were concerned with frequency response and gain, controversy raged over whether it was bet-

ter science to fit a flat frequency response hearing aid or to try a frequency response and gain pattern that mirrored the patient's threshold audiogram. Over the years we have seen a plethora of fitting formulae beginning with the infamous half-gain rule, the one-third gain rule, and POGO, growing in numbers to today's more sophisticated NAL and DSL needed for fitting more complex non-linear hearing aids. Comparing those early procedures to today's standard of care, it is a salute to the art of our early clinical skills that we were at all successful in fitting hearing aids to patients with hearing losses.

When I began working with hearing aids in the mid-1960s, they were all analog circuit body-type instruments – each with ragged and peaked frequency responses, multiple distortions, limited acoustic response choices, attached to a long cord and a large external button receiver coupled to full hard acrylic earmold. During the 1970s, the first behind-the-ear (BTE) models were introduced. Since the early BTE hearing aids were rather large and unattractive, it was a only a short time before BTE aids were popularized by being hidden in the temples of eyeglasses. With a continued focus on making hearing aids smaller and less visible, the in-the-ear (ITE) hearing aids appeared in the 1980s, followed by the very small in-the-canal aids (ITC) that were the products of the 1990s. The introduction of digital signal processing (DSP) algorithms in 1996 created opportunities for advanced signal processing to be implemented in all styles and models of hearing aids.

Over the last decade, we have seen a major market return to the BTE styles of hearing aids that take advantage of today's mini-models that disappear behind the pinna. In fact, Kirkwood (2009) reports data from the Hearing Industries Association (HIA) showing that BTE style hearing aids compose 65% of sales last year in the US. A new model of BTE hearing aid, with the receiver-in-the-canal (RIC) (separated from the BTE case creating a micro-BTE), has been very successful and now makes up more than 60% of BTE sales. These BTE hearing aids can be fitted with thin tubing leaving the ear canal open to natural sounds. The open-canal RIC hearing aids eliminate occlusion created by traditional earmolds, and they are an easy and instant fitting that the patient can wear out the door at the end of the first office visit. The RIC hearing aids are particularly useful for aiding the common high-frequency sensorineural hearing loss.

The current era of technology explosion has not left hearing aids behind. Where audiologists used to make decisions for gain and output with analog hearing aids on a hit-or miss method, we now have precise prescription formulae to guide us; where we used to use a small screwdriver to turn tiny potentiometers to some unknown values, we now configure our hearing aids to absolute decibel values through elaborate and complex software. We used to counsel patients to use the volume control to modulate incoming signal levels; we now have hearing aids that automatically adjust gain as a function of input levels; where we had a set of limited adjustments to make in terms of filter settings and output controls, we now have an almost infinite range of computerized hearing aid gain and frequency settings that have revolutionized amplification adjustments. These innovative developments speak volumes for the engineers who designed these hearing instruments.

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## Adults with hearing loss

Over the years, the adult hearing aid candidate has also evolved with the times. Contemporary digital hearing aids have, by and large, answered many of the complaints commonly associated with hearing aids. According to Kochkin (2000) the key complaints from dissatisfied users about their hearing aids included lack of noticeable benefit, poor fit with discomfort, whistling feedback, plugged up sensation due to occlusion of the earmold, and continued difficulties understanding speech in noise. In his 2010 MarkeTrak VIII paper, Kochkin points out that there is no doubt that hearing aids have improved and benefited significantly from the digital revolution to reduce these early complaints. He argues that now the weak link in the system is the dispenser and confusing dispensing systems.

Today's hearing aid consumers are not spontaneous or impulsive buyers who follow the general rules of retail purchasing. In fact, today's adult purchasers of hearing aids are thorough, thoughtful, informed persons who seek and respect professional expertise and quality services. They are more inquisitive, better educated, sophisticated and technically savvy, with high product performance expectations and they demand to be involved in the decision-making process. They often arrive at the hearing aid office well armed with information gleaned from the internet and from friends and relatives who are current hearing aid wearers. In a recent editorial, David Kirkwood of The Hearing Journal, stated that he honestly tells consumers that *...hearing aids are much better than they were, even as recently as 2000. Today, most hearing-impaired people can be fitted with hearing aids that will give them better speech understanding and more natural sound, even in environments with background noise.*

The demographics of new hearing aid owners have changed ever so slowly over the past 25 years as reported in the MarkeTrak VIII survey (Kochkin, 2010). In the United States, 4 out of 10 people with moderate-to-severe hearing losses, and 1 out of 10 with mild hearing losses, own hearing aids. The typical new user is about 69 years of age and retired. The factors influencing that first time purchase included the perception that their hearing loss was getting worse, or that growing admonitions from family members and friends were a driving force to seek help for their hearing. Survey respondents reported waiting 8 to 12.4 years to obtain hearing aids after determining that they had a hearing loss. It is interesting, however, that the survey showed that the family physician, the price of the hearing aids, and personal safety concerns played only a minor role in their decision to move forward with hearing aids.

## The hearing aid evaluation

Back in 1971, the noted auditory psychologist, JD Harris, stated that our goal is to *present to the ear as faithful a representation of the acoustic world as if the hearing aid were not present.* David Pascoe (1980) poignantly observed, *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!* Catherine Palmer (2010) put a more succinct spin on the hearing aid fitting by stating the goals as making sure that the sounds patients want to hear are audible, comfortable, and of good sound quality. However, in spite of all the changes and advancements in hearing aids in over the years, the recommended hearing aid fitting protocol has not changed that much. Mueller and Hall (1998) described a six-step procedure for organizing hearing aid fittings for adult patients with hearing loss.

## Step #1: hearing assessment

Obviously, the success of hearing aid fittings depend on an accurate and in-depth hearing evaluation conducted by a licenses or certified hearing professional. The assessment must be sufficient to determine the extent and cause of the hearing loss and to reflect the patient's candidacy for hearing aid use. I remember the early days when we followed the guideline that a person needed to have more than a 30 dB hearing loss to benefit from hearing aids. Finally, an angry patient correctly pointed out to me that this artificial decibel boundary made no sense at all and that anyone who had reported difficulties in hearing should be offered the opportunity to use hearing aids. The decision about candidacy for hearing aids requires both auditory and non-auditory considerations and it is agreed by most audiologists that audiometric information alone is insufficient to predict success with hearing aids. Speech recognition tests conducted in a background of noise may come as close as any procedure for predicting aided outcomes. But, aging factors as well as personality features also play a big role in hearing aid candidacy including the patient's motivation to hear better, emotional levels, willingness to learn how to use the hearing aids, and acknowledgement of their hearing loss and the associated communication difficulties in business and everyday living situations. Dillon (2001) concludes that unless the patient is actually motivated and wants some form of hearing rehabilitation, there is little point in pursuing a technological solution.

## Step #2: treatment planning

The obvious goal of any hearing aid fitting is to improve the patient's communication abilities by maximizing their hearing potential through personal amplification devices. The audiologist, the patient and family members often want to focus only on the device itself, but they need to understand results of the hearing assessment, identify areas of patient hearing difficulties, and agree on a path of rehabilitative procedures – of which the hearing aid fitting is just the initial step. Sweetow (2009) points out that to properly establish the treatment plan requires the use of a tests from a communication needs assessment battery (Table 1). This approach shifts the focus from being purely product-oriented (i.e., centered around the hearing aids) to one that is process-oriented (centered around enhancing the patient's communication). Previous hearing aid users will no doubt require less treatment planning time than new users. In addition to discussions and demonstrations, the new user should be sent home with printed materials to review as necessary. This approach to a treatment plan provides counseling for realistic expectations as well as a time-based estimate of when to expect results.

**Table 1. The communication needs assessment battery\*.**

Objective procedures
QuickSIN <sup>2</sup>
Hearing in noise test <sup>3</sup>
Acceptable noise levels <sup>4</sup>
A test of binaural interference <sup>5</sup>
Listening span <sup>6</sup>
Subjective measures
Hearing handicap inventory for the elderly – Screening HHIE-S <sup>7</sup>
The hearing handicap inventory for adults <sup>8</sup>
Communication scale for older adults <sup>9</sup>
Characteristics of amplification tool <sup>10</sup>
The client oriented scale of improvement <sup>11</sup>
Expected consequences of hearing aid ownership <sup>12</sup>
Communication confidence test <sup>13</sup>
Combined methods
Performance perceptual test <sup>14</sup>

\*From Robert Sweetow (2009)

### Step #3: hearing aid selection and fitting

The audiologist needs to carefully and thoughtfully assess the life-style and hearing needs of the patient prior to making hearing aid recommendations. Although the audiologist's role is to fairly present the options available and provide guidance, the final decisions should be made by the patient, or the patient's family. The style of hearing aid chosen will likely depend on degree and configuration of hearing loss as well as the patient's cosmetic concerns, battery life and external ear geometry. Decisions will be influenced by the patient's manual dexterity, visual abilities, desired advanced features, amplification characteristics, including the style and technology of the hearing aids, and of course, ability to pay the required cost which can be expensive for both unilateral and binaural fittings. There may be a divergence between the audiologist's knowledge of what styles and features are suitable for a successful fitting outcome versus the appropriateness of the patient's desires. The goal in hearing aid selection and fitting is to provide comfortable hearing instruments that will meet the life-style needs of the patient while easing the patient's communication difficulties and maximizing performance in different listening environments. Too often the patient still puts invisibility at the top of the desirable list!

### Step #4: verification

The verification process is conducted to determine that the hearing aids meet standardized judgments that include documenting basic electroacoustic performance, ensuring cosmetic appeal and acceptance, as well as comfortable fit. The accepted goals for verification are to confirm that soft sounds are audible, that speech recognition is maintained or improved, and that loud sounds are limited to a comfortable level. The current standard of care procedure used during the verification process is real-ear measurement - obtained through a probe-microphone from the ear canal with the hearing aid in place and turned on. Unfortunately, recent clinical surveys confirm that less than one-third of all dispensers use real-ear measurement to verify their fittings (Kirkwood, 2006; Strom, 2006). Apparently, most dispensers today depend on the manufacturer's first-fit protocols which automatically set the hearing aid output parameters based primarily on the patient's auditory threshold values and configuration. However, numerous studies have shown that the manufacturer's simulated output values, based on coupler responses, often over- or under-fit patients with amplification (Hawkins and Cook, 2003; Keidser *et al.*, 2003; Aarts and Caffee, 2005; Mueller *et al.*, 2006). Palmer (2010) warns audiologists to be aware of the broad differences between manufacturers' first-fit algorithms, and that under-fitting leaves sound inaudible and over-fitting can potentially create hearing damage. Palmer points out that both of these unacceptable outcomes can be avoided when the actual output of the hearing aid in the patient's ear canal is determined with real-ear measurements.

### Step #5: orientation and counseling

The counseling piece of the hearing aid fitting is often the poor overlooked stepchild in the total process. Orientation and counseling refers to time spent with the patient and family helping them adjust to amplified sounds and to obtain the utmost benefit out of their hearing aids. Although most hearing care professionals pay homage to the necessity for aural rehabilitation measures and treatments, many audiologists forgo counseling and feel that the initial hearing aid orientation and the use and care of the hearing aid demonstrations are sufficient for patients. There are a myriad of ways to provide this information and education service including individual or class lessons, self-help books, CD or video presentations, auditory therapy or referral to a support group composed of other adults with hearing impairment. There certainly abundant materials available to provide aural rehabilitation services that do not require significant professional time, and the value is

apparent in a reduction of returned hearing aids, increased usage and greater patient satisfaction (Wayner and Abrahamson, 1996; Sweetow and Henderson-Sabes, 2006; Sweetow, 2009). Most manufacturers of hearing aids include in their fitting software various innovative and even interactive counseling tools to supplement the hearing aid fitting. In a detailed survey of nearly 2,000 new and experienced hearing aid wearers with hearing aids less than 4 years of age, Kochkin (2010) found that on average, respondents received 1.2 hours of counseling during the first two months of the hearing aid fitting process and required 2.5 office visits. He also reported that in his overall large sample that so few patients actually received aural rehabilitation or auditory retraining therapy, it was not possible to determine accurately the statistical significance of these protocol procedures with real-world amplification success. Northern and Beyer (1999) showed that patients who are provided ample opportunity through group classes for help adjusting to and utilizing their hearing aids, prove to be more satisfied and have fewer hearing aid returns.

### Step #6: validation

Validation involves determining the impact of the hearing aid fitting by way of various outcome measures and may be a dynamic and ongoing process with each return visit of the patient throughout the life of the hearing aids. The outcome measures can be subjective which use self-assessment tests to determine the hearing aid performance in terms of patient benefits and satisfaction, or objective in terms of using standardized speech recognition measures to ascertain the patient's abilities to understand speech in a standardized test conditions (Boney, 2007). The validation process also incorporates re-programming or fine tuning of the hearing aids as necessary to ensure the patient's preferred sound quality. Re-programming or fine-tuning may call for a new probe-microphone real-ear measurement to validate the hearing aid output changes. The audiologist should routinely perform a physical examination of the hearing aid and earmold to ensure patient comfort and proper aesthetics. The validation period provides opportunity for discussion of the effects of amplification intervention on the patient's daily living and improvement in communication abilities.

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## Real-ear measurements

Along with the development of new hearing aid technologies, came the most important clinical tool in our armamentarium: the real-ear hearing aid analyzer. In North America, the initial development of the clinical use of real-ear probe-microphone measurements for hearing aid fittings is attributed to Earl Harford (1982). The first clinical real-ear probe microphone instrument, housed in an early Apple McIntosh SE Computer, was developed by Steen Rasmussen in Denmark in 1983 and the procedure immediately added a new dimension to hearing aid fittings. For the first time, a simple clinical procedure could accurately verify the acoustic characteristics of the entire hearing aid amplification system as measured from the patient's ear canal. The real-ear probe system accurately measures and displays the final acoustic output of the hearing aid and ear coupling system as the amplified sound is directed to the patient's tympanic membrane. This revolutionary tool has had tremendous impact on the improved fitting of hearing aids (Mueller, Hawkins and Northern, 1992).

In today's professional hearing aid delivery settings no hearing aid fitting should be completed without verification from real ear-probe microphone measurements. The recommended hearing aid management protocol includes real-ear measurements to verify and the output of all hearing aid fittings ensuring that they will provide adequate benefit for every patient (Amer Acad Audiol, 2006). Probe microphone real-ear measures should be used routinely to evaluate, adjust, and verify



the amplification fittings specifications required by the audiometric configuration. Unfortunately, surveys of clinical practices continue to show that the majority of audiologists still do not routinely use real-ear measures for verifying their hearing aid fittings citing reasons of time limitations, equipment expense and lack of credibility.

An innovative idea to make probe-microphone measurements easier, quicker and more accurate resulted in the design of a real-ear measurement (REM) system integrated into the hearing aid itself and driven by files in the fitting software. In this system, the hearing aid is delivered with a flexible probe tube attached to the microphone to measure the sound pressure level in the ear canal. The hearing aid's digital processing system generates a complex signal through the hearing aid receiver and determines the individual's real-ear aided response (REAR). The system then uses this information to automatically adjust the hearing aid based on ear canal acoustics to achieve a precise best-fit match to the selected prescriptive target in a matter of seconds (Yanz, *et al.*, 2007; Galster and Galster, 2010a).

## The digital hearing aid revolution

Digital hearing aids have provided a true revolution in hearing aid processing and given us tools for precise fitting strategies as well as opened doors for numerous advances yet to come. Digital signal processing (DSP) can provide multi-core, open architecture platforms that can process multiple incoming acoustic signals instantaneously while making adjustments to achieve faster and more transparent parallel processing actions. The earliest digital hearing aids were designed used about 2000 lines of code; in contrast, today's digital hearing aids might have over 4,000,000 lines of code – all the while getting smaller, faster and smarter with more powerful chips. Currently, it is estimated that more than 98% of all hearing aids operate on digital processing platforms.

Who could have predicted the versatility of today's digital hearing aids with nearly infinite acoustic configurations programmed through powerful software to meet the needs of nearly every person with hearing loss? Digital processing has made available a dazzling array of advanced features than would never have been possible in the old analog days. Top level advanced technology hearing aids now routinely include integrated systems such as adaptive directional and omnidirectional microphones, feedback cancellation with enhanced stable gain, automatic volume control, real-time acoustic environment analyzers that make simultaneous decisions and seamlessly change programs, variable noise suppression programs automatically driven by the environmental, data logging, male or female voice indicators, low battery notification, self-diagnostic checks, remote adjustment capabilities, touch technology which eliminates buttons, switches and dials, and improved direct audio input for FM use, to name just a few features.

Other innovative improvements include waterproofing the hearing aid and enabling remote programming by the use of an ordinary cell phone. And, of course, stylish new cases, tubing and earmold in various colors and designs help make today's hearing aids a true fashion statement. All of these features, along with the highest level of personal comfort and very wide dynamic range frequency responses for optimal speech clarity, reflect the dramatic change in hearing aids achieved during the past few years. Powerful software programs not only allow for personalized record keeping and fine tuning adjustments for fitting individual hearing losses, but often include a speech mapping tool and synthetic hearing loss demonstrations which are valuable tools for fitting and counseling patients (Moore, 2006).

The advent of feedback canceling algorithms has been especially valuable for reducing many of the common hearing aid user com-

plaints. In addition to eliminating the irritating squeal of hearing aid associated with yesterday's hearing aids, complex feedback cancellation makes listening more comfortable, helps with telephone compatibility, eliminates the need for uncomfortable tight-fitting earmolds and provides better speech understanding without sacrificing high-frequency gain. Being able to prevent feedback was essential for the development of higher gain open-canal fittings and the current highly popular receiver-in-the-canal instruments.

Especially promising is the shift in the mentality of the hearing aid industry. Routine delivery of evidence-based research is now the expectation. Hearing professionals expect that the benefits of new technology will be supported by relevant data rather than simple marketing claims alone. Of note are recent evidence-based published studies of improved stable gain with feedback cancellation (Merks, *et al.*, 2006; Galster and Galster, 2010b) and digital noise management algorithm improving patient listening comfort without degrading speech intelligibility (Mueller, *et al.*, 2006; Pisa, *et al.*, 2010).

## Future directions

Looking forward to see what might develop in the future is difficult propositions judging from the innovative technologies that are continually introduced to the marketplace. Although it is recognized that digital signal processing has revolutionized the hearing aid industry in ways no one might have imagined, the door for future applications is wide open. There will no doubt be continued improvements in hearing aid invisibility, re-chargeability, connectivity, disposability, as well as hearing aids that learn and automatically adjust to personal listening preferences, long distance remote programming to permit tele-audiology applications, and continued advances in developing new algorithms for recognizing and clarifying speech in various backgrounds of noise, etc, etc.

Brent Edwards, (2007) writing about the future of hearing aids, predicts that digital wireless technology will be the next big wave of development. Digital wireless transmits a higher-fidelity signal than the old wireless analog systems. Although there is much talk and interest in Bluetooth wireless technology, and even though we have some limited applications already in the hearing aid arena, Bluetooth is a low-frequency system that requires too much power to operate (increased power goes hand in hand with increased size – which is basically unacceptable in hearing aids) and is limited to short-distance applications. A promising wireless future lies with utilization of a high-frequency system that has less power requirements and can thereby be imbedded in a small hearing aid. But even digital wireless will not be successful until ease-of-use and end-user benefit are fully developed and proven. When wireless technology in hearing aids is successful, as it no doubt will be in the very near future, the aids will automatically and easily connect with all other wireless-capable devices such as cell phones, television, free-field FM systems, ear-to-ear amplification adjustments, video games, etc.

Recognizing that auditory perception requires much more than simple audibility, Edwards (2007) calls into question the traditional audiometric evaluation procedures that depend on threshold determination and speech recognition. He maintains that additional patient factors including cognition, attention, and listening effort are areas that need to be included in the pre-hearing aid evaluation. Edwards states that in the future, hearing aids will be designed to take into account the effect of peripheral auditory processing on signal representation, as well as the impact of amplified auditory processing on cognitive function. Edwards concludes that methods of assessing the function of the complete auditory and cognitive systems need to be developed to determine hearing aid benefit.

## Conclusions

In our field of audiology, historically replete with obviously biased and subjective decisions, conclusions regarding hearing aid performance, fitting strategies, and rehabilitative approaches must be thoroughly researched with evidence-based methods. The rapid evolution of advanced fitting procedures has provided us with numerous opportunities to properly fit each and every patient's hearing loss with maximum success. We now have complete control over every aspect of the hearing aid's output and the performance of every special feature. We understand that it takes time for adults to adjust to amplification and that it is a complex cognitive process and we have numerous ways to enhance the patient's education and learning. By accurately determining the proper characteristics of the patient's hearing loss, and applying the appropriate adjustments to the hearing aid's output performance, verifying the fitting with real-ear measurements, followed by helpful and empathetic counseling and rehabilitative measures, we will continue to improve the satisfaction rates and overall acceptance of amplification for each of our patients.

## References

- Aarts, N., Caffee C. 2005. Manufacturer predicted and measured REAR values in adult hearing aid fitting: Accuracy and clinical usefulness. *Int J Audiol*, 44:293.
- American Academy of Audiology. 2006. Guidelines for the Audiologic Management of Adult Hearing Impairment. [http:// www.audiology.org/resources/documentlibrary/Documents/haguidelines.pdf](http://www.audiology.org/resources/documentlibrary/Documents/haguidelines.pdf).
- Boney S. 2007. Adult Amplification. In: *An Essential Guide to Hearing and Balance Disorders* (Ackley, R., Decker, T., Limb, C., (Eds). New Jersey: Lawrence Erlbaum Associates, Mahwah.
- Edwards, B., 2007. The future of hearing aid technology. *Trends in Amplif* 11(1).
- Galster, J., Galster, E., 2010a. Recording the real-ear aided response through a hearing instrument. *Hear J*. 63(2).
- Galster, J., Galster, E., 2010b. How to compare feedback suppression algorithms in open-canal fittings. *Hear Rev*, 17(11), 39-41.
- Harford, E., 1982. Real ear measurements for prescribing a hearing aid. In Paparella, M., Goycoolea, M (Eds.), *Ear clinics international*. Baltimore, MD: William and Wilkins.
- Harris, J., 1971. Summary of the symposium on amplification for sensorineural hearing loss. In: *Harris on Audiology*. W. Shilling Co.: Groton, CT.
- Hawkins, D. and Cook, J., 2003. Hearing aid software predictive gain values: How accurate are they? *Hear J*, 56(7).
- Keidser, G., Brewer, C., Peck, A., 2003. How proprietary fitting algorithms compare to each other and to some generic algorithms. *Hear J*, 56(3).
- Kirkwood, D., 2006. Survey: Dispensers fitted more hearing aids in 2005 at higher prices. *Hear J*, 59(4).
- Kirkwood, D., 2010. Editorial: Yes, hearing aids have improved – a lot! *Hear J*, 63(2).
- Kochkin, S., 2000. MarkeTrak V: Why my hearing aids are in the drawer – the consumer's perspective. *Hear J*, 53(3).
- Kochkin, S., 2010. MarkeTrak VIII: Consumer satisfaction with hearing aids is slowly increasing. *Hear J*, 63(1).
- Mueller, H., Hall, J., 1998. *Audiologists' Desk Reference* (Vol. 11). San Diego: Singular Publishing Group, Inc.
- Mueller, H., Hawkins D., Northern, J., 1992. *Probe Microphone Measurements*. San Diego: Singular Publishing Group, Inc.
- Mueller, H., Weber, J., Hornsby B., 2006. The effects of digital noise reduction on the acceptance of background noise. *Trends in Amplif*, 10(1).
- Moore, B., 2006. Speech mapping is a valuable tool for fitting and counseling patient. *Hear J*, 59(8).
- Northern, J., Beyer, C., 1999. Reducing Hearing Aid Returns through Patient Education. *Audiol Today*, 11(2).
- Palmer, C., 2010. Meeting Hearing Aid Fitting Goals. *Starkey Audiology Series*, 2(1).
- Pascoe, D. 1980. Clinical implications of nonverbal methods of hearing aid selections and fitting. *Sem Hear*, 1(4).
- Pisa, J., Burk, M., Galster, E., 2010. Evidence-based design of a noise-management algorithm. *Hear J*, 63(4).
- Rasmussen, S., 1984. How insertion gain measurements can take the guess work out of hearing aid fittings. *Hear Instrum*. 34:1.
- Strom, K. The HR 2006 dispenser survey. *Hear Rev*, 13(6).
- Sweetow, R., Henderson-Sabes, J., 2006. The Need for and Development of an Adaptive Listening and Communication Enhancement (LACE) Program. *J Am Acad Audiol*, 17(6).
- Sweetow, R., 2009. Time-based expectations and the communication needs assessment. *Starkey Audiology Series*, 1(3).
- Wayner, D., Abrahamson, J., 1996. *Learning to hear again: an audiologic rehabilitation curriculum guide*. Hear Again, Austin, TX.
- Yanz , J., Pisa, J., Olson,L., 2007. Integrated REM: Real-ear measurement from a hearing aid. *Hear Rev* 14(5).