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The effect of cost, benefit, and level of technology on patient preference and satisfaction with hearing aids

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THE EFFECT OF COST, BENEFIT, AND LEVEL OF TECHNOLOGY ON PATIENT PREFERENCE AND SATISFACTION WITH HEARING AIDS

by

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Abstract

The present double blind study sought to determine if experienced hearing aid users can differentiate between different levels of hearing aid technology. Specifically, the following research questions were addressed: (1) Are HINT scores affected by level of hearing aid technology for experienced hearing aid users?; 2) Is benefit/satisfaction of hearing aids affected by level of technology for experienced hearing aid users?; and (3) How do hearing aid users rank different levels of technology? If a perceptual difference in hearing aid technology is identified by hearing aid users, participants were asked to identify how money much they would be willing to pay for the difference in perceived benefit. Therefore, ten experienced, adult hearing aid users with bilateral symmetrical sensorineural hearing loss were fit binaurally with three levels of hearing aid technology (i.e., entry-level, mid-level, and premium-level) and underwent one-week trial periods with each set of hearing aids. Participants were asked to answer three questionnaires (i.e., International Outcomes Inventory for Hearing Aids [IOI-HA], Post-Fitting Questionnaire adapted from the Marketrak Survey [Kochkin, 2010], and the Cost and Preference Questionnaire) after each hearing aid trial period to rate level of satisfaction and benefit with hearing aids. Participants completed the Hearing in Noise Test (HINT) to determine speech understanding ability in noise conditions.

HINT results revealed no difference between hearing aid technology level and the ability to improve speech discrimination in noise abilities in participants. Results from the Post-Fitting Questionnaire, displayed greater satisfaction with entry-level hearing aid compared to mid-level hearing aids, but no difference in mid and high-end hearing aids. Results comparing entry-level and high-end technology approached significance. Further investigation identified the overall benefit and comfort in loud sounds subscales as providing greater satisfaction when using entry-level hearing aids over mid-level hearing aids. Results from the IOI-HA indicated no substantial difference between technology levels. Furthermore, level of technology did not affect speech understanding in noise abilities and showed a minimal effect on satisfaction and benefit with hearing aids, depending on the questionnaire used. Results were variable across testing methods; therefore, no superior level of hearing aid technology was identified. Clinical implications/application will be discussed.

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Dedication

I dedicate my dissertation work to my family and friends; without each of you, some of my life's achievements would be or will continue to be possible.

Table of Contents

Abstract iii

Dedication vi

List of Tables ix

List of Figures x

Acknowledgments xi

Chapter I Introduction 1

Chapter II Review of Literature 5

Prevalence of Hearing Loss and Hearing Aid Use 5

Hearing Aid Selection 7

ASHA's guidelines for hearing aid fittings. 7

AAA guidelines for hearing aid fittings 9

Acclimation to Hearing Aids 11

Evaluation of Success with Hearing Aids 16

Satisfaction 16

Benefit 21

Comparison of Technology Levels 27

Chapter III Methods and Procedures 33

Participants 33

Materials 34

Qualification procedures 34

Hearing aids 35

Speech understanding in noise 35

Post-fitting questionnaire 36

International outcomes inventory for hearing aids questionnaire 36

Procedures 37

Qualification procedures 37

Experimental procedures 38

Chapter IV Results 41

HINT Results 41

Subjective Benefit and Satisfaction with Hearing Aids 42

Hearing Aid Preference 46

Chapter V Discussion 49

HINT Results 49

Subjective Benefit and Satisfaction with Hearing Aids 50

Hearing Aid Preference 51

Limitations and Future Research 52

Clinical Implications 53

Appendix A Case History 54

Appendix B IRB Consent Form 57

Appendix C Fitting Protocol and Outline of Topics for Hearing Aid Orientation 61

Appendix D Post-Fitting Questionnaire 64

Appendix E International Outcomes Inventory for Hearing Aids 66

Appendix F Cost and Preference Questionnaire 68

References 70

List of Tables

Table 1. Friedman's test results for the ten subscales adapted from the Knowles MarkeTrak Questionnaire (Kochkin, 2010) to evaluate hearing aid satisfaction/benefit. 45

List of Figures

Figure 1. Mean pure tone thresholds of participants for octave frequencies 250 to 8,000 Hz for the left and right ears. 34

Figure 2. Mean HINT scores and standard deviations as a function of three levels of hearing aid technology. 42

Figure 3. Median (variance) scores for subjective ratings for three hearing aid technology levels as taken from The Post-Fitting Questionnaire (i.e., adapted from the Knowles MarkeTrak Questionnaire). 43

Figure 4. Median (variance) scores for subjective ratings for three hearing aid technology levels as taken from the IOI-HA. 46

Figure 5. Rank of hearing aid technology levels as determined by the Cost and Preference Questionnaire. 47

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Chapter I

Introduction

According to Kochkin, (2010), the population of individuals with hearing loss in the United States has reached 34.25 million with hearing aid adoption rates of approximately one in every four people. With yearly increases in the prevalence of hearing loss, the number of persons wearing hearing aids is increasing; however, this number continues to be much less than the number of people with reported deficits. This is, in part, due to a disconnect between the patient's need for hearing aids and their desire to purchase them. Factors such as cost, extent of benefit, cost effectiveness and level of hearing aid technology affect patients' desire for amplification (Newman and Sandridge, 1998).

Hearing aid manufacturers typically market hearing aid product lines based on level of technology (i.e., basic, advanced, and premium). Basic products are typically considered entry level products with reduced fitting channels, memories, fitting bands and limited connectivity to accessory devices. Additionally, basic products offer features such as basic directional microphones, feedback management, and noise suppression at a more affordable price point. Advanced level hearing aids, also called mid-level products, possess a larger number of fitting channels and memories, have added programs/ identifies for various listening environments, and more sophisticated directional microphones, feedback cancellation technology, and noise suppression algorithms. However, these added features come at a higher cost. Lastly, premium hearing aids have the highest cost while possessing the greatest number of fitting channels, memories, and programs/identifies and the most sophisticated directional microphones, feedback cancellation technology, and adaptive noise reduction algorithms (Cox, Johnson, & Xu, 2014). Furthermore, many hearing aid manufactures claim that premium levels of technology offer the greatest improvement in understanding in noisy situations (Cox et al., 2014).

To determine effectiveness of a hearing aid fitting with any level of hearing aid technology, benefit, satisfaction, and use are commonly assessed formally and informally. According to Newman and Sandridge (1998), benefit is described as an improvement in audibility and speech discrimination ability with a decrease in communication disability and psychological handicap; likewise, satisfaction is described as meeting a person's personal expectations with relation to sound quality and performance in many listening environments. Furthermore, according to Kochkin (2010), satisfaction with amplification is dependent upon ten factors; (1) overall benefit, (2) clarity of sounds, (3) value (performance of the hearing aid relative to price), (4) naturalness of sounds, (5) reliability of the hearing aid, (6) richness or fidelity of sound, (7) use in noisy situations, (8) ability to hear in small groups, (9) comfort with loud sounds, and (10) sound of own voice. Knowing a patients amount of hearing aid use, level of benefit, and level of satisfaction regarding hearing aid technology can provide useful information into the effectiveness of basic, advanced, and premium hearing aid levels to determine if there is truly an advantage in purchasing higher levels of technology.

Moreover, Cox et al., (2014) states that most individuals would assume that when purchasing a higher the level of hearing aid technology, greater benefit will be received;

however, there is little evidence to support this claim. To this end, Cox et al., (2014) investigated whether premium-feature hearing aids yielded better speech understanding scores than basic-feature hearing aids for adults with mild-to-moderate sensorineural hearing loss. Participants were given a one month trial period with each set of hearing aids (i.e., one basic-feature and one premium-feature) and were unaware as to which set they were wearing at any given time. Participants collectively found improvement when wearing hearing aids compared to not hearing them; however, no difference was noted by participants between basic and premium hearing aids, indicating participants had no specific preference of basic versus premium devices. This study implies that it may not be necessary to fit patients with the highest level of hearing aid technology in order to see the most subjective benefit.

In summary, currently manufacturers have different product lines/levels of hearing aids (i.e., basic, advanced, or premium). The difference within a level of products is the sophistication of the technology within the casing with the premium products having the most sophisticated features and the highest cost and the basic hearing aid having the least sophisticated features at a cheaper cost. Likewise, the patient and audiologist often assume that the higher the level of hearing aid technology, the greater the benefit received from the hearing aid. There is, however, little evidence to support this theory. To this end, the purpose of this study is to determine if experienced hearing aid users can differentiate between different levels of hearing aid technology. The following specific research questions will be addressed:

1) Are Hearing in Noise Test scores different when experienced hearing aid users utilize different levels of hearing aid technology?
2) Is the benefit//satisfaction of hearing aids different when experienced hearing

aid users utilize different levels of hearing aid technology?

3) If a perceptual difference in hearing aid technology is identified by hearing aid users, how much more money would each participant be willing to pay for the difference in perceived benefit?

Chapter II

Review of Literature

Prevalence of Hearing Loss and Hearing Aid Use

It is estimated that 34.25 million people in the United States have some degree of hearing loss (Kochkin, 2010). Furthermore, according to Lin, Thorpe, Gordon-Salant, and Ferrucci (2011), hearing loss in older adults is exceedingly prevalent, and poor hearing leads to communication difficulties, social isolation, and can exacerbate other conditions such as dementia. Specifically, Lin et al. (2011) investigated the prevalence of hearing loss and hearing aid adoption rates in adults 70 years or older based on the 2005 – 2006 National Health and Nutritional Examination Survey (NHANES). The study yielded the following results. First, the prevalence of hearing loss in adults 70 years or older was 63.1%. Furthermore, the results showed that the prevalence of hearing aid use in participants who wore hearing aids more than five hours a week was 19.1%. Specifically, only 3% of hearing aid users with mild hearing loss utilized amplification; whereas, 41% of those with moderate to profound hearing loss used amplification. These results suggest that while there are large populations of individuals over 70 years who have hearing loss, a small percentage of those over 70 years are using hearing aids.

Lin, Niparko, and Ferrucci (2011) further discussed the prevalence of hearing loss in the Unites States. To complete this study, a review of pure-tone audiograms for 7,490 participants 12 years and older was completed. The results estimated that there were 30.0 million people in the U.S with hearing loss. Furthermore, 12.7% of U.S. citizens 12 years or older have bilateral hearing loss. This rate increases to 20.3% if individuals with unilateral hearing losses are included. These results indicate that the incidence of hearing loss continues to increase over time not only due to an aging population, but also due to an increase in the ways hearing loss can occur. With the increases in hearing loss, it has become increasing important to analyze the acceptance of hearing aids among those with hearing loss.

Lastly, Chien and Lin (2012) assessed hearing aid use in older adults. Participant's ages ranged from 50 to 70 years (N = 1,888 for those 50-60 years; N = 717 for those more than 70 years). Furthermore, a questionnaire which identified if participants from 1999 – 2004 reported wearing the hearing aids at least one time a day was completed. It also sought to identify if participants from 2005 – 2006 identified wearing the study hearing aids five hours per week. Results from this study revealed that 3.8 million Americans (14.2%), 50 years or older wear hearing aids. It was also found that as age increases by decade, the prevalence of hearing aid use increases as does the incidence of hearing loss. Specifically, this study showed that 4.3% of people 50 – 59 years wear hearing aids while 22.1% of people greater than 80 years of age wear hearing aids. Based on these results, the authors indicated that despite the number of people in the United States with hearing loss, adoption rates are still incredibly low. They further explain that the lack of amplification use is likely due to the stigma of hearing aids despite the trend of making hearing aids more discreet and stylish. Another factor in the lack of use of hearing aids is that health insurance agencies predominantly do not reimburse for amplification, making out of pocket costs for patients extremely high (Chien & Lin, 2012).

Hearing Aid Selection

The usual treatment for hearing loss when it cannot be medically resolved is the use of hearing aids. One of the main questions to be answered in this selection is whether or not a patient needs a specific level of hearing aid technology. Furthermore, hearing aid manufacturers market their hearing aids as having different levels of technology, each with three to four models (i.e., budget, entry level, advanced, and premium) that function from lower to higher levels based on the addition of features. No matter which level of technology is selected, the fitting process is somewhat standardized by several organizations. These guidelines are suggestions for the treatment of hearing loss and are discussed below.

ASHA's guidelines for hearing aid fittings. The American Speech Language and Hearing Association Ad Hoc Committee on Hearing Aid Selection and Fitting (ASHA, 1998) developed guidelines for audiologists to follow when fitting patient's with hearing aids. The guidelines presented are recommendations for procedures that should be followed to appropriately fit patients with hearing aids. In this document, there are six categories outlined to aid in hearing aid fittings and patient rehabilitation.

First, an *assessment* must occur to determine the type and degree of hearing impairment as well as to aid in the determination of hearing aid candidacy. It is suggested that the assessment should produce specific outcomes including: (a) documentation of hearing impairment; (b) documentation of the need for medical/surgical intervention or referral to licensed physician; (c) recommendations and counseling; (d) determine eligibility and motivation for amplification/rehabilitation; and (e), indicate medical clearance for hearing aids. Non-audiological assessments regarding patient perception should also be completed prior to fitting amplification to assess patient motivation, perspective, and activity level. An informal physical assessment should also be completed to assess dexterity, health, physical status of the ear, visual acuity, cognitive status, communication needs, and level of independence.

Next, *treatment planning* should occur in order to counsel the patient and family members/caretakers as well as to determine areas of strain for patients. This will allow goals to be made for the rehabilitation process. Patient's and family members/caretakers should be allowed to partake in the selection of hearing aids in terms of style and color options, but the electroacoustic properties of the hearing aid should be determined by the audiologist. Realistic expectations of amplification are also explained to patients in this phase of the hearing aid fitting process through counseling.

The *selection of amplification* will follow treatment planning. Electroacoustic characteristics of the hearing aid should be determined based on the patient's specific needs and their hearing loss. Non-electroacoustic characteristics such binaural or monaural hearing aid selection, style (BTE, ITE, ITC, and CIC), earmold/shell choice, user controls, microphones (directional or omnidirectional), volume control, telecoil, assistive listening device (ALD) compatibility, programming, remote control, hearing aid memories, color, and additional features should also be considered during the selection process.

Upon receipt of the selected hearing aids and after all goals have been decided upon for the patients rehabilitation plan, *verification* of hearing aids should be completed. Verification of hearing aids ensures that the physical fit, cosmetic appeal, basic electroacoustic standards, comfort, and probe microphone measurements are appropriate. Next, the hearing aid *orientation* process begins and involves explaining the use, care, and maintenance of the devices with patients and their family members/caretakers.

Subjects that should be discussed include battery use/ safety, landmarks of the device (microphones, volume control, receiver, etc.), insertion/removal, telephone use, storage, and routine maintenance. Patients or their family members/caretakers are recommended to perform hands-on tasks before leaving the orientation appointment to show some level of competency before leaving with their hearing aids.

The last step in ASHA's guidelines for fitting adults with hearing aids is *validation*. To identify the effect of hearing aids on a patient's quality of life, there are several formal measures that may be used in validation. Such measures include the Abbreviated Profile of Hearing Aid Benefit (APHAB), the Hearing Handicap Inventory for Adults (HHIA), and the Hearing Handicap Inventory for the Elderly (HHIE), and the Client Oriented Scale of Improvement (COSI). Validation can also occur through aided and unaided speech recognition and/or speech in noise testing (ASHA, 1998).

AAA guidelines for hearing aid fittings. Similar to ASHA, as a part of the American Academy of Audiology Task Force for Guidelines for the Audiologic Management of Adult Hearing Impairment, recommendations were developed for providing a complete treatment plan for the audiological management for adults with hearing impairment. These guidelines are recommendations by AAA for best practices in hearing aid selection, fitting, verification, and validation (Valente et al., 2007).

The first step in the AAA guidelines is *audiologic assessment* and diagnosis of type, degree, and severity of hearing loss. It was suggested that this portion of the evaluation should include: (1) medical referral to a licensed physician; (2) determination of candidacy for amplification; (3) provide adequate counseling on proper amplification; (4) determination of needs based on lifestyle assessments; and (5) determination of medical clearance based on Federal Drug Administration Standards (FDA).

The next portion of the hearing aid fitting process suggested by AAA involves *determining the patient's self-perception of communication needs and the selection of goals for treatment.* This is also the portion of the assessment where realistic long-term goals are established. Tools such as the COSI and APHAB are recommended to determine these patient specific goals. These tools can also be used as a post-fitting method to show satisfaction and benefit with amplification. A non-auditory needs assessment is also suggested to determine factors that might affect successful treatment of hearing loss. A visual examination of all patients could include issues related to general health, manual dexterity, vision, support systems, motivation, and prior experience with amplification.

Thirdly, the actual *hearing aid selection* is discussed in that style and features based on auditory and non-auditory assessments are determined. Furthermore, factors such as style, occlusion, volume control, monaural versus binaural fitting, direct audio input (DAI), telecoil, multiple memories, etc. are determined. Another factor to consider during the selection process is if is special technologies such as bone-anchored hearing aids (BAHAs), CROS/BICROS hearing aids, or referrals for cochlear implantation are needed.

The next step is *fitting and verification of hearing aids*. Verification occurs through real-ear electroacoustic measures to determine that hearing aids meet prescriptive targets. Hearing Assistive Technology (HAT) is also explored to further aid in the communication needs of patients who may be having difficulty hearing in specific situations. Such situations include phone conversations, watching television, face-to-face communication, and sensitivity to alerting signals and environmental stimuli. Examples of HAT include: FM systems, infrared systems, induction loop systems, telephone amplifier systems, alerting alarms, etc.

Next, *orientation to hearing aids, counseling, and follow-ups* are recommended. Topics discussed in a hearing aid orientation include insertion/removal, batteries (size, type, and insertion/removal), hearing aid features, care and cleaning, comfort, feedback, telephone use, and warranty information. Comprehensive counseling beyond the initial fitting helps patients learn to wear and use their hearing aids.

According to AAA, the final step in the hearing aid fitting process is *assessing patient outcomes*. Areas typically assessed via questionnaires are benefit, satisfaction, and quality of life. As previously stated, the APHAB and COSI are adequate validation questionnaires that can be utilized in post fitting assessments. Other measures include Glasgow Hearing Aid Benefit Profile (GHABP) and the International Outcome Inventory – Hearing Aids (IOI-HA). Furthermore, the AAA found that the above key factors in the hearing aid fitting process can improve treatment efficacy, efficiency, and effectiveness and ultimately improve an individual's health related quality of life (Valente et. al, 2007).

Acclimation to Hearing Aids

Auditory acclimatization is the concept of a systematic change in auditory performance occurring over time as acoustic information becomes accessible to the listener, creating an improvement in performance that is related to task, procedural, or training effects (Reber and Kompis, 2005). This lends to the question of how long it takes for hearing aid users to acclimatize to their hearing devices. To this end, in 2005, Reber and Kompis investigated the auditory acclimatization of 28 new, adult hearing aid users who were fitted with custom advanced digital hearing aids, while using three different fitting protocols over a six month period. Fitting protocols were labeled as audiologist driven, patient driven, and set-to-target, and each participant was placed in one of these three groups.

During the first fit appointments, the audiologist driven group was allowed to select their entry gain level using the prescriptive formula NAL-NL1. At each follow-up appointment, if patients allowed, the audiologist increased insertion gain in the participants' hearing aids until the prescriptive formula was met. If feedback occurred, insertion gain was then decreased. The patient driven group of participants also chose their entry gain level using the prescriptive formula NAL-NL1, but during follow-up appointments, each participant's insertion gain was increased or decreased based on their hearing preference. The set-to-target group received the total NAL-NL1 prescription at the first fit appointment. During follow-up appointments, the prescription was only decreased if the participants were not able to tolerate the level. After the initial fitting, all participants received follow-up appointments at two weeks, four weeks, eight weeks, and three and six months post-fitting. Each appointment consisted of aided and unaided speech recognition testing in quiet and noise and real-ear measurements to verify insertion gain. A questionnaire was distributed to analyze hearing aid use at two weeks and three months post-fitting.

The results indicated that all three groups experienced improvement in speech understanding ability in quiet and noise conditions after six months of hearing aid use, indicating acclimatization to hearing aids over time in new users. After wearing their hearing aids, some participants also had increased speech perception ability without the use of hearing aids in quiet conditions only. These results indicate that it takes time to acclimate to hearing aids for improvement in speech recognition ability and that amplification has the ability to cause increased performance of the central auditory system over time (Reber & Kompis, 2005).

Similarly, Kuk, Potts, Lee, Valente and Picirrillo (2003) investigated the effects of acclimatization to hearing aids in persons with severe-to-profound hearing loss. A secondary purpose was to compare participants' personal hearing aids to hearing aids provided for this study. The hearing aids provided were digital non-linear power hearing aid with a low compression threshold and expansion. Twenty experienced hearing aid users (i.e., participants who had worn hearing for approximately 20 years) participated in this study and wore hearing aids for a three month time period. Objective and subjective outcome measures were used to evaluate performance with participants own hearing aids and the study hearing aids. These measures included (1) aided soundfield thresholds, (2) speech recognition testing, (3) the APHAB questionnaire, (4) the Washington University Questionnaire, (5) Knowles MarkeTrak questionnaire, (6) and screening version of the Hearing Handicap Inventory for the Elderly. All participants were seen for four appointments. At Visit 1, performance of participants own hearing aids was verified/ examined via electroacoustic measures, aided soundfield thresholds, the SPIN test, and the APHAB. During Visit 2, the study hearing aids were fit binaurally and general instructions on use, care, and maintenance were given. Aided soundfield thresholds and SPIN tests results were obtained at this visit. The third session occurred after participants had worn the study hearing aids for one month. At this visit, hearing aid settings were modified based on subjective concerns. Speech recognition scores were also obtained, and the APHAB, MarkeTrak, HHIE-S, and the WUQ questionnaires were completed. This procedure was also completed at the final/fourth appointment.

Results from the SPIN test revealed an improvement in performance between the initial fitting and the one month follow-up while using study hearing aids, supporting the hypothesis of acclimatization between initial fit and one-month post-fitting. Results from the WU Questionnaire also showed that participant's level of satisfaction with study hearing aids did not increase from one to three months post-fitting, further indicating acclimatization between initial fit and one-month post-fitting Furthermore, the MarkeTrak survey was used to compare variables between one month and three months post –fitting. There was no improvement in SPIN scores or MarkeTrack survey results between the one month follow-up and the three month follow-up. This supports the theory that acclimatization related to subjective tasks take approximately one month to occur. Results from the WU questionnaire and HHIE-S indicated that overall more participants preferred the study hearing aids when compared to their personal hearing aids. Specifically, the study hearing aids were reported as having better performance in areas of audibility, sound quality, and moderate noise and reverberant environments. Moreover, in this study, it took participants approximately one month to acclimatize to hearing aids; this is evidenced by the improvement in SPIN scores by one month of wear followed by a plateau effect (Kuk et al., 2003).

Lastly, Prates and Iorio (2006) investigated the acclimatization to hearing aids through the use of objective and subjective test measures. Sixteen new hearing aid users with symmetrical slight to moderately-severe sensorineural hearing loss (i.e. PTA = 70 dB HL) participated in this study. Each participants wore digital compression hearing aids and was evaluated on the first day of participation and then monthly for three months. Each evaluation consisted of speech perception tests including the Perceptual Index of Speech Recognition (PISR) and Sentence Recognition in Noise tests; these were completed at each visit along with the International Outcome Inventory for Hearing Aids (IOI-HA), which was completed at the one and three month follow-up visits.

Day One of testing included selection and electroacoustic measurement of hearing aids, measurement of functional gain, and administration of the PSIR and Speech Recognition in Noise tests. At the one month follow-up, participants completed all speech recognition tests and the IOI-HA questionnaire. Next, participants returned at two months post-fitting and completed the same speech recognition tests as well as list 4B of the Speech Recognition in Noise testing. Finally, at the three month follow-up, the speech recognition tests and the IOI-HA were repeated. The results showed a significant improvement in the speech test scores over three months, indicating acclimatization to hearing aids over a three month period. Furthermore, the amount of time in which improvements occurred was analyzed and it was found that improvements in speech recognition occurred after one month and after two months of adaptation. However, there was no significant difference in scores between the first day of the trial and one month of adaptation, indicating that acclimatization occurs after the first month of hearing aid use. A continued improvement in speech test results was seen over the three month period, indicating improvement in speech recognition in the presence of noise for up to 90 days. No significant changes were noted subjectively in the IOI-HA questionnaire between the first and third month of adaptation. Furthermore, it was also determined that acclimatization occurs progressively over time as long as access to sound is available (Prates & Iorio, 2006).

In conclusion, auditory acclimatization is an important aspect of the hearing aid fitting process. Research has shown that acclimatization leads to increased performance by the central auditory system over time causing improvements in speech recognition abilities. Research has also shown that auditory acclimatization in some individuals reaches a plateau in performance approximately one month after hearing aid use; whereas, in other individuals, performance in the area of speech recognition continues to improve over a three month period of hearing aid use.

Evaluation of Success with Hearing Aids

Success with hearing aids is typically documented in one of three ways using questionnaires through assessment of satisfaction, benefit, and use of hearing aids. These are effective validation measures that can improve treatment efficacy, efficiency, and effectiveness no matter which level of hearing aid technology a person may be wearing.

Satisfaction. As previously stated one way to document hearing aid success is through satisfaction. The following section describes studies which document hearing aid success through the evaluation of satisfaction. First, Uriarte, Denzin, Dunstan, Sellars, and Hickson (2005) examined hearing aid outcomes using the Satisfaction with Amplification in Daily Life (SADL) questionnaire. A total number of 1,572 ears were fitted with several different hearing aid styles (i.e., BTE's, ITE's, CIC's, or FM systems). Each participant received the SADL questionnaire. Fitting procedures took place over three separate appointments: (1) initial assessment- which entailed the audiological evaluation, counseling on hearing loss, discussion of rehabilitation options, exploring daily listening difficulties, and a hearing aid evaluation; (2) fitting appointment- where probe mic measurements were obtained and participants were educated on use, care, and maintenance of the hearing aids; and (3) a follow-up appointment to fine tune the hearing aid(s). Then, three to six months post-fitting, the participants were asked to rate their experience and satisfaction using the SADL and the Client Satisfaction Survey. The results revealed that the global satisfaction score for the SADL showed a large level of participant approval with 70% of participants having a *very satisfied* rating total. The positive effect subscale revealed *high satisfaction* for items regarding improvement in understanding familiar conversation, reduction in number of repetitions, naturalness of sound as well as a *medium level of satisfaction* for items regarding whether or not hearing aids were in their best interest. Furthermore, participants indicated *great satisfaction* with the services they received during the fitting process. Negative features such as extraneous sounds amplified by the hearing aid received a *considerable satisfaction* rating. Likewise, participants reported they were only *somewhat satisfied* with the ability to use their hearing aids on the phone. These results indicated overall satisfaction with hearing aids for 75% of participants, indicating that their amplification helped a moderate amount or greater (Uriarte et al., 2005).

To further examine satisfaction with amplification, Kochkin (2010) researched hearing aid user's experiences and overall satisfaction with hearing aids using the Knowles MarkeTrak VIII survey. The survey was mailed to hearing aid users with devices that were at least four years old. The survey asked participants to indicate hearing aid experience using a 7-point Likert scale to rate their experience using the following responses: *Very Dissatisfied, Dissatisfied, Somewhat Dissatisfied, Neutral, Somewhat Satisfied, Satisfied, and Very Satisfied.* Areas discussed in this survey included overall satisfaction, satisfaction with hearing aid features, performance, and satisfaction in 19 different listening environments. Specifically, there are ten factors that relate to satisfaction with hearing aids on the MarkeTrak survey. These factors included: (1) overall benefit, (2) clarity of sounds, (3) value (performance of the hearing aid relative to price), (4) naturalness of sounds, (5) reliability of the hearing aid, (6) richness or fidelity of sound, (7) use in noisy situations, (8) ability to hear in small groups, (9) comfort with loud sounds, (10) sound of own voice (occlusion). Also participants were asked to identify if they would recommend hearing aids to friends, how many hours a day hearing aids were worn, and whether or not they would repurchase the same brand as their current model.

Results from the survey indicated the average age for hearing aid users was 71 years. First, the results showed that since the 2004 MarkeTrak survey, hearing aid ownership increased from 68% to 74% while hearing aids being placed in a drawer decreased from 16.7% to 12.4%. Also, participants with new hearing aids reported satisfaction that increased from 77.6% to 80.3%, but new hearing aid users who put hearing aids in the drawer increased 5.2%. It was also believed that an indicator of user satisfaction was if participants recommended amplification to friends. Furthermore, 82% of respondents would recommend hearing aids to friends. Benefit from hearing aids was found to have a score of 86% and 67% of participants were either *satisfied or very satisfied,* respectfully. Reportedly, 91% of consumers are satisfied with the ability of their hearing aids to improve communication in one on one listening situations. Approximately three out of four people who participated in this survey found that they were satisfied with hearing aids in a place of worship (75%), a restaurant (75%), and on the phone (73%). In conclusion, overall consumers are more satisfied with their hearing aids than they were in 2004, and factors such as hearing aid benefit, value, and sound quality greatly affect this increase in satisfaction (Kochkin, 2010).

Next, Kaplan-Neeman, Muchnik, Hildesheimer, and Henkin (2012) examined the level of satisfaction of adult hearing aid users who used advanced digital hearing aids. One hundred and seventy-seven participants were included in this study. Part One of the study consisted of a preliminary counseling session where hearing aid options were discussed and a hearing aid was decided upon. In Part Two, a hearing aid fitting was completed, where each of the selected hearing aids was programmed with a reputable prescriptive formula. During this session, each participant underwent functional gain testing and aided word recognition testing at normal conversational speech levels. Additionally, real ear measurements were employed for fine tuning purposes, and each participant received instructions on hearing aid use, care, and maintenance. Part Three of the study included a trial period with hearing aids, which lasted four to six weeks. Part Four involved a brief follow up appointment, where any adjustments were made, and Part Five consisted of long term follow up (6-12 weeks). The SADL as well as a non-use questionnaire were used as self-report measures to determine satisfaction with hearing aids as well as determine variables that led to a small group of participant's non-use of their devices. Questionnaires were administered to participants through mail prior to a designated telephone conversation conducted by six students with no affiliation to any fitting process.

Furthermore, of the 177 participants initially fit with amplification, 131 subjects partook in the telephone survey. Participants received further designations as users or non-users. Out of the 133 participants, 109 were identified as users of hearing aids (i.e., 22 non-users). Nonusers reported that due to over amplification of background noise, lack of necessity, unpleasant feelings, maintenance, cost, and negligible functional gain, they were unsatisfied with their hearing aids and opted not to wear them. These results indicated that 8% of participants were unsatisfied with their hearing aid fitting whereas 92% reported some level of satisfaction. Furthermore, participants reported high satisfaction in areas regarding service and care by the audiologist, style and appearance, and low satisfaction in areas pertaining to telephone use, feedback, and difficulties with background noise. It was also noted that increased satisfaction correlated with participants who wore their hearing aids for more hours per day. Lastly, level of hearing aid technology was not a predictor of degree of satisfaction in this study, but this was attributed to the irregular dispersal of levels of hearing aid technology among participants. It was, however, indicated that there were obvious improvements in the area of satisfaction when comparing analog hearing aids to digital hearing aids (Kaplan-Neeman et al., 2012).

Furthermore, Kozlowski, Almeida, and Ribas (2014) researched hearing aid user satisfaction using the International Outcomes Inventory for Hearing Aids (IOI-HA). One hundred eight adult with sensorineural or mixed hearing loss served as the participants for this study. Each participant had hearing aids for at least two weeks. Using the IOI-HA questionnaire, seven areas including hearing aid use, benefit, residual limitation of activity, satisfaction, residual restriction of participation, impact on others, and quality of life were evaluated using a 5-point Likert scale. The IOI-HA questions were analyzed individually and grouped (i.e., using a total score from all seven questions). Then to further analyze data, questions were broken down by two factors. Factor one consisted of an analysis of the relationship between the participants and their hearing aids, and factor two consisted of an analysis of the relationship between the participants and their environment.

Results of this study revealed that 52.8% of people had an improved quality of life after two weeks of hearing aids use. Overall user satisfaction increased as participants wore amplification. It was discovered that 85% of participants used their hearing aids between four and eight hours per day while only 3% wore hearing aids less than one hour per day, indicating that the majority of participants grew to find hearing aids helpful. Furthermore, the results showed that 35% of individuals thought hearing aids helped in a situation where they wanted to hear better while only 3% of people found that hearing aids did not help. Results further showed that 51% of users had high to moderate difficulty hearing in situations where they most wanted to hear better while 47% had little to no difficulty while wearing hearing aids in situations where they most wanted to hear better. Likewise, it was found that 78% of participants found that wearing hearing aids was advantageous over not wearing them, and 53% of participants felt that hearing aids had changed their lives in a positive way. Furthermore, results of the factor analysis (i.e., Factor one- relationship of user to hearing aid and Factor two - relationship of user to environment) showed that there was a stronger relationship between the participant and the hearing aid compared to the participant and the environment, indicating good adaptation to hearing aids over a two week time span. In conclusion, participants were found to have satisfaction with amplification over a two week time period with use of the IOI-HA (Kozlowski et al., 2014).

Benefit. As previously stated one way to document hearing aid success is through benefit. The following section describes studies which document hearing aid success through the evaluation of benefit. First, Mendel (2007) conducted a study to assess several word recognition assessments and their sensitivity as objective measures in the process of hearing aid verification to determine benefit. He also sought to determine if these objective measures qualified as subjective measures to document speech understanding improvement with hearing aids. Twenty-one hearing aid users who had worn amplification for more than six months served as the participants in this study. All participants had normal tympanograms and symmetrical sensorineural hearing loss, which varied in degree. Digital hearing aids used in this study were and were fit with the

NAL-NL1 prescription formula. Three separate speech recognition in noise tests were conducted on participants in aided and unaided conditions; these tests included the Revised Speech Perception in Noise test (R-SPIN), Quicksin, and the Hearing in Noise Test (HINT), which was completed in both quiet and noise. Test participants also completed the Hearing Aid Performance Inventory (HAPI), answering questions in five categories; these areas included perception of environmental sounds in quiet and noise, speech perception ability in quiet situations with familiar speakers, speech in quiet with unfamiliar speakers, speech in noisy situations with familiar speakers, and speech in noisy situations with unfamiliar speakers.

Aided and unaided performance scores on sentence recognition were used to measure objective hearing aid benefit. Later those objective scores were compared to subjective impressions of benefit using the HAPI questionnaire. The results revealed that aided scores were significantly greater than unaided scores for the R-SPIN, QuickSIN, and HINT in quiet tests; however, there was no difference in aided and unaided HINT scores in noise. Additionally, aided responses on the HAPI were significantly greater than unaided scores. Lastly, correlations between subjective (i.e., questionnaire data) and objective (i.e., speech measures) data showed similar trends especially in the aided condition. For example, generally, participants who improved on subjective measures (i.e., HAPI scores) also improved on both speech in quiet and in noise tests. Based on these results, the author suggests that both objective and subjective outcome measures should be used as measurements of hearing aid verification. Likewise, it was found that objective measures are effective in determining hearing aid benefit; however, subjective measures are also an important way to validate subjective impressions (Mendel, 2007).

To further assess hearing aid benefit, Meister, Rahlmann, Walger, Margolf-Hackl, and KieBling (2015) examined the relationships between cognitive function and age with clinically assessed hearing aid benefit in older hearing impaired listeners. This study is based on the premise that patients with slower cognition may not benefit as greatly from advanced processing schemes in hearing aids as those with higher cognitive performance. Instead, those with slower cognition may benefit more from slower compression to improve speech understanding abilities. Participants included 30 individuals with mild to moderate sensorineural hearing loss who had hearing aids from a variety of manufacturers and had worn hearing aids for at least six months. Hearing aid benefit was described as improvement in aided speech scored as compared to unaided scores. Speech recognition was assessed using hearing aids in quiet (e.g., SRT) and noise (e.g., sentences in noise) conditions. For the noise conditions, two types of noise was utilized a speech-shaped steady-state noise and a speech shaped noise with amplitude fluctuations. Subjectively, performance was assessed using the IOI-HA questionnaire. Furthermore, six different tests which assessed cognitive functions as related to the perception of speech were completed to assess cognitive function. Areas assessed within these tests included crystallized intelligence (i.e., knowledge), short-term memory, cognitive processing speech, and attention.

The results showed an increase in aided scores in quiet when compared to unaided scores. When comparing conditions with different types of background noise, it was found that scores obtained with fluctuating noise were greater than those with steady-state noise. Subjective outcomes of the IOI-HA showed hearing aids are worn more 8 hours a day; hearing aids help quite a bit, and hearing aids increase the enjoyment of life. On the other hand, results showed moderate difficulty with hearing aids, and hearing aids are quite a lot for the trouble. Overall, results indicated satisfaction with hearing aids. Furthermore, in terms of the cognitive assessments, a relationship between fluid intelligence and objective hearing aid benefit was noted. Additionally, lower cognitive functioning was found to be associated with greater amounts of hearing loss. Also no correlation was found between level of cognition and overall outcome on the IOI-HA. In conclusion, this study found that neurophysiological cognition tests did not seem to have an association with speech perception. This is dissimilar to what previous research has shown; stating that faster processing strategies should be left for those who have higher cognition and those with slower cognition may need slower compression schemes. Furthermore, this study found that level of hearing aid technology did not appear to be a limiting factor in the success of hearing aids (Meister et al., 2015).

Alternatively, Humes, Wilson, Barlow, and Garner (2002) investigated the use of objective and subjective measures of hearing aid benefit over a two year period in participants (age range = 60-89 years) with flat or gently sloping sensorineural hearing loss. The hearing aids used in this study were full-shell ITE output compression limiting circuits. All hearing aids were verified electroacoustically to the NAL-R prescriptive fitting formula. Participants also received a hearing aid orientation where the following topics were parts of the device, battery size, insertion and removal, realistic expectations, and communication strategies were discussed. All participants were instructed to wear their hearing aids minimally for four hours per day and to report their experience in a hearing aid usage diary. Next, participants returned for a two week follow-up appointment were usage diaries were photocopied, and participants were instructed to increase usage to a minimum of six hours per day. Unaided speech recognition testing was completed at this appointment; each participant completed four speech tests in three conditions (left ear, right ear, and binaurally) for a total of 12 unaided measurements. The conditions included: (1) CUNY Nonsense Syllable Test presented at 65 dB SPL at a +8 dB signal to noise ratio (SNR), (2) Connected Speech Test (CST) presented at 50 dB SPL in quiet, (3) CST presented at 65 dB SPL at a +8 dB SNR, and (4) CST presented at 80 dB SPL at a 0 dB SNR. It was noted, however, that the CST presented at 80 dB was more difficult and was not reliable; therefore, the data collected for that condition was not considered further. Binaural unaided speech recognition testing was repeated at one year and two years post-hearing aid fitting. Two weeks later, participants retuned for the one month follow-up where hearing aids were examined and adjusted to meet targets. The four speech recognition conditions were performed in the aided condition. The HAPI and HHIE questionnaires were also administered. These measures of benefit were also completed at six months, one year, and also at two years post-fitting.

The results of this study which relate to hearing aid acclimatization and benefit attempted to determine the long-term stability of hearing aid gain. As for measures of aided speech recognition, it was found that CST scores were overall higher than NST scores in all conditions (unaided left, right, and binaural and aided). Also, there was evidence of improvement between unaided and aided test scores with the greatest benefit on the CST in quiet. Furthermore, for the aided CST in quiet and in noise, a significant improvement was seen six months and one year post hearing aid fit. There was also a decrease in unaided performance for the CST in noise from one month to one year post-fitting. Furthermore, a decrease in aided performance was noted from one to six months post fitting followed by an improvement in scores from six months to one year post fitting for the NST, and unaided performance on the NST decreased over the one year data period. These results suggest that acclimatization to hearing aids may take up to one year post-fitting (Humes et al., 2002).

Lastly, Andrade' and Blasca (2005) researched the effects of digital hearing aid technology in daily situations as well as participant's expectation level of their digital hearing aids. Fifteen participants were placed into two groups: Group one (N = 9) were experienced hearing aid users while Group two (N = 6) were non-hearing aid users. All participants (age range = 16-95 years) had bilateral sensorineural hearing loss. The COSI questionnaire was used to determine participant satisfaction with their hearing aids in everyday situations. The questionnaire was administered at the initial fitting of hearing devices and at the three month check-up. During the initial fitting, each participant was asked to identify five listening situations where they currently felt they experienced the most difficulty hearing. At the three month follow-up appointment, participants were asked to denote how often they continued to have difficult in the five chosen listening environments (choices included - *never, seldom, occasionally, frequently*, and *always*). Participants were also asked to report if changes occurred in their identified listening situations – choices included *no modification slightly better, better, and much better.*

The results indicated that participant expectations were primarily focused on improvements in speech recognition ability. It was noted that participants sought to obtain improvements in situations such as conversation in the presence of background noise (i.e., in meetings, in theaters, and in church), while listening to the television, radio, and on the phone, and in quiet listening situations. Results related to occurrence of modification revealed that experienced hearing aid users showed improvements ranked as *better* in conversation in noise, talking on the phone and in the car, as well as improvements that were ranked as *much better* for watching television and listening to the radio. The non-user group revealed *better* results in conversation in noise, meetings, talking on the phone, in theaters, and church, as well as a *much better* rating in classrooms. The results showed consistent improvements in all everyday listening situations identified by participants. Results presented a score of *always* in areas related to identifying a sounds source, watching television, and listening to the radio for 100% of participants in experienced hearing aid user group. A score of *frequently* was identified for 100% of participants for situations related to talking on the phone. For the non-users of hearing aids, 100% of participants reported a score of *always* for situations related to conversation in quiet, meetings, classrooms, and hearing light sounds. Also, 100% of participants gave scores of *frequently* to hearing situations in meetings, conversation in quiet, classrooms, and hearing light sounds. These results indicated that with the use of digital hearing aids, experienced and non-experienced users both achieved improvements in previously identified difficult listening situations and over time, adapted to their hearing aids. This study also displayed that the COSI is a subjective measure that is effective in identifying gains in the area of hearing aid benefit based on pre- and-post test data collection (Andrade' & Blasca, 2012).

Comparison of Technology Levels

Hearing aid features increase the cost of the device, meaning the more technology applied inside the hearing aid casing, the more money the product will cost. In premium devices, these features typically include multichannel compression, automatic-adaptive directional microphones, and complex noise reduction and feedback algorithms; hearing aid manufacturers claim these features will increase performance with hearing aids. It has also been suggested by manufacturers that premium levels of hearing aid technology offer better processing of speech in the presence of background noise (Cox, Johnson, and

Xu, 2014). The following research documents the literature available comparing different levels of technology.

First, Newman and Sandridge (1998) investigated the cost effectiveness of three different levels of hearing aid technology from a single hearing aid manufacturer. Twenty-five adult hearing aids users participated in this study. Each was fitted with three commercially available behind-the-ear (BTE) hearing aids; fourteen participants were fitted bilaterally while monaural fittings occurred on 11 participants. The devices included Hearing Aid A – the Personic 410/420, a one channel analog, linear mini-BTE (cost = $1,192); Hearing Aid B – the Multi-focus Compact or Compact Mild mini-analog-BTE (cost = $1,660), and Hearing Aid C – the Digifocus, a seven-band, two-channel digital hearing aid (cost = $3,732). Objective experimental measures used included the Audibility Index (AI) and the Speech Perception in Noise (SPIN) test. Subjective self-report measures were used to obtain patient pre- and post-fitting satisfaction data. Questionnaires and surveys used included (1) the APHAB; (2) the HHIE-A; (3) the Knowles Hearing Aid Satisfaction Survey; (4) daily hearing aid log sheets; and (5) preference ratings at the end of hearing aid use, without knowledge of hearing aid cost.

Test hearing aids were fit on subjects during a minimum of five sessions. Session one included a full audiological evaluation and completion of the HHIE and APHAB, which were completed to gather pre-fitting baseline data. An unaided SPIN test was also conducted and custom earmold impressions were taken for earmolds. In the second session, the first set of hearing aids was issued. Each set of hearing aids was first fitted based on the manufacture's recommended protocol. Each participant was instructed on insertion/removal, use, care, and maintenance of hearing aids and the daily logs were explained. Session Three included aided testing of Device One and the fitting of the second set of hearing aids. Session Four involved aided testing of Device Two and the fitting of the third set of hearing aids. The final session included aided testing of Device Three. Furthermore, Sessions Two through Five included aided versions of the HHIE-A, the APHAB, and the Knowles Satisfaction Survey.

First, objective results showed that aided AI scores for each device were significantly higher than unaided AI scores; however, there was no difference between AI scores for the three hearing aids. Furthermore, aided SPIN scores were higher for all three hearing aids than the unaided condition. Also, HA-C (i.e., the digital, two-channel device) showed significant improvement on the SPIN tests when compared to the other tested hearing devices, indicating improvement in speech in noise when a digital, two-channel hearing aid is used compared to a linear, analog hearing aid. APHAB results, results from the Knowles Hearing Aid Satisfaction Survey, and the HHIE-A results showed aided results in all three hearing aids were higher than unaided test results; however, no difference in benefit was seen for the three hearing aids. Moreover, subjects were asked to state their preference of hearing aids in two conditions. The first condition was without knowledge of cost or any indication of level of technology. Almost half (48% or 12 subjects) chose HA-C, 24% chose HA-A, and 28% chose HA-B. The second condition where preference was indicated was done with the patient's knowledge of price. The subjects who selected HA-A and HA-B did not change their preference when cost was known. Four subjects who selected HA-C changed their preferences (two selected HA-A and two selected HA-B). Furthermore, when test participants were given the opportunity to purchase test hearing aids at a reduced price, 33% of participants initially chose HA-C but upon knowing the cost of HA-C, preferences changed. In the end, only six participants (24%) purchased HA-C, the more expensive, digital hearing aid. Based on these results, it was determined that cost was an underlying factor in the selection of personal hearing aids. In conclusion, no pattern was indicated to determine a superior hearing device. Furthermore, despite one device (HA-C) having superior processing, it was found that upon knowing cost, participants decided to purchase lower levels of hearing aid technology (Newman & Sandridge, 1998).

Furthermore, in recent research, Cox, Johnson, and Xu (2014) investigated whether premium-feature hearing aids yielded better speech understanding than basic-feature hearing aids for persons with uncomplicated, stable, adult-onset, and mild-to-moderate sensorineural hearing loss. They also examined if the previous question differed between the devices of two different hearing aid manufacturers. The study consisted of 25 participants (age range = 61-81 years; 8 female and 17 male). Products utilized in this study included four sets of commercially accessible mini-BTE hearing aids with thin tubes. They consisted of basic and premium-level hearing aids that had no distinguishing features besides the advertised features from the manufacturer, which patients were unaware of. Participants were given a one month trial period with each set of hearing aids and were unaware as to which set they were wearing at any given time. This study's hearing aid fittings consisted of five steps including: (a) programming of hearing aids based on manufacturer's proprietary fitting formula; (b) verification using real-ear measurements based on National Acoustic Laboratories Non-Linear version 1 (NAL-NL1); (c) fine-tuning using bilateral loudness balancing, loudness of average conversational speech, loudness comfort, and quality of own voice; (d) follow-up interview by telephone after first week of use with any needed fine tuning; and (e) the activation of the remote control and hearing aid learning abilities in the devices that possessed them. Participants in this study completed four questionnaires at the end of each one month trial period including: (a) the APHAB, (b) the Speech, Spatial and Qualities of Hearing Scale (SSQ-B), (c) the Device-Oriented Subjective Outcome Scale (DOSO), and (d) a questionnaire that rated change in overall quality of life related to hearing during each trial.

Results from this study indicated that participants had no specific preference of basic versus premium devices. Furthermore, aided speech recognition scores yielded higher scores than unaided scores in a laboratory setting for all basic and premium hearing aids; however, aided conditions using the premium devices did not show a significant improvement when compared to using the basic devices, indicating no major difference in speech understanding between basic and premium hearing aids. On the APHAB questionnaire, results revealed a significant difference in aided and unaided scores, but no significant difference between basic and premium hearing aids. In a soft listening environment, the SSQ-B did not show a difference between basic and premium listening devices, whereas on the DOSO, the basic featured hearing aids yielded better results than the premium hearing aids. Furthermore, in average and loud listening situations, no difference was noted between basic and premium hearing aids on the SSQ-B and DOSO. Overall, 96% of participants indicated that hearing aids in general made their life "a good deal better" when compared to not having them. The ending quality of life survey also revealed that there was no difference in quality of life between the use of basic and premium hearing aids. In summary, participants collectively found improvement when wearing hearing aids compared to not hearing them; however, no difference was noted by participants between basic and premium hearing aids throughout the length of this study (Cox et al., 2014).

In conclusion, research regarding the effectiveness of basic, advanced, and premium level digital hearing aids is still scarce. One research study related to level of hearing aid technology indicated that patients could not notate a difference between basic and premium technology levels. Another study found that patients could not tell a difference in technology levels, but once given the option to purchase, about one fourth of the patients chose the hearing aid with higher processing. Therefore, due to limited research in this area, the purpose of the present study is to determine if experienced hearing aid users can differentiate between different levels of hearing aid technology.

Chapter III

Methods and Procedures

Participants

Ten experienced adult hearing aid users (i.e., at least 18 years or older) participated in this study (mean age = 66.8 years, range 52-77 years). Each subject was recruited from The Emerge Center for Communication, Behavior, and Development (Baton Rouge, Louisiana). The inclusion criteria were as follows: (1) bilateral sensorineural hearing loss with normal to near normal low frequency hearing (i.e., participants had thresholds of 35 at 250 and 500Hz, hearing loss no greater than 55 dB HL at 1000Hz, and hearing loss no greater than 75 dB HL at 6,000 or 8,000 Hz) in each ear (see Figure 1 for audiometric data); (2) full-time (i.e., wears hearing aids during most waking hours) wearers of open fit BTE hearing aids for at least six months to one year; (3) native English speakers; (4) word recognition scores better than 60% in the right and left ears; and (5) no known cognitive, psychological, or neurological deficits as determined by the case history (see Appendix A). Participants were recruited via flyers and telephone calls from the client roster at the Emerge Center for Communication, Behavior, and Development (Baton Rouge, Louisiana).

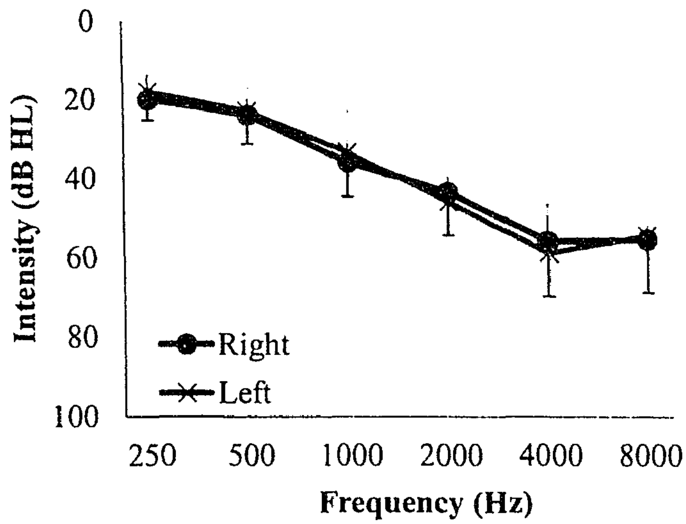

Figure 1. Mean pure tone thresholds of participants for octave frequencies 250 to 8,000 Hz for the left and right ears.

Materials

Qualification procedures. Upon arrival, each participant was given a verbal description of the study and required to read and sign an informed consent (see Appendix B for informed consent and IRB approval memo). Prior to inclusion in this study, participants were administered a case history form to determine (1) date of purchase of current personal amplification, (2) hearing aid hours of use daily, (3) daily listening situations that are difficult, (4) serious illnesses or hospitalizations, (5) recent ear related surgeries, (6) limitations of activities in daily life due to hearing loss, and (7) overall communication handicap. All audiometric testing was conducted at the Emerge Center for Communication, Behavior, and Development in a sound treated booth (Acoustic Systems - 8 m x 8 m). A Grason Stadler (GSI) AudioStar Pro audiometer (serial # GS0051967) was used to perform air and bone conduction testing and was confirmed to be acceptable for testing unoccluded ear via current calibration and daily biologic checks (ANSI S3.6, 2004). Otoscopy was performed using a Welch Allyn otoscope to confirm no outer ear abnormalities in each participant. Spondee words were used as the stimuli to obtain speech recognition thresholds (SRT) with the use of monitored live voice to compare with the audiometric pure-tone average to confirm reliability. The Northwestern University Auditory Test No. 6 (NU-6) was used as the stimuli to measure word recognition ability. The NU-6 word list was administered using the GSI AudioStar Pro routed through the audiometer via integrated recorded materials.

Hearing aids. Six sets of hearing aids from a single manufacturer (i.e., two sets of basic, two sets of advanced, and two sets of premium) were used for the experimental testing. The manufacturer utilized in this study was Oticon, and hearing aids used were the Alta Pro (premium), Nera Pro (advanced), and Ria Pro (basic) BTEs with corda tubing and open domes. Identifying labels indicating each hearing aid model were removed prior to patient fittings; the hearing aids were identified by serial number alone. The audiometric data of each participant was used to program each hearing instrument using the NAL-NL1 fitting strategy. Hearing instruments were programmed using the manufacturers "first fitting" method; all devices were set at adaptation level three. Additional programs were not added. Volume controls in each hearing instrument were activated (see Appendix C for fitting protocol for each hearing aid). After the "first fitting," hearing aid overall gain only was adjusted based on participants perception of the level of the hearing aids (i.e., too loud or too soft). Furthermore, directional microphone functioning was verified upon receipt of the hearing aid manufacturer by using the Audioscan Axiom testbox prior to any fittings were scheduled.

Speech understanding in noise. The Hearing in Noise Test (HINT) (Nilsson, Soli, and Sullivan 1994) was utilized to evaluate understanding in noise. The HINT consists of 250 sentences that are separated into groups of either 25 lists of ten sentences. The standard HINT procedure was presented via soundfield speakers. The HINT sentences and speech spectrum noise were presented at ear level from 0 and 180 ° azimuth, respectively. The HINT was conducted as identified by the test instructions. Specifically, noise was presented at a constant noise level (65 dBA), and the level of speech was varied. Furthermore, for the first four sentences, the speech presentation level was increased by 4 dB HL for every sentence stated wrong. For correct answers, the presentation level was decreased by 4 dB HL. The presentation level for sentences five through ten was increased by 2 dB HL for incorrect answers and decreased by 2 dB HL for correct answers. The level of speech was recorded for each sentence presentation, and a sentence recognition threshold was obtained for each HINT sentence list. The sentence lists on the HINT were chosen at random for each subject.

Post-fitting questionnaire. First, the top ten predictors of consumer hearing aid satisfaction from the Knowles MarkeTrak Questionnaire (Kochkin, 2010) were used to evaluate satisfaction with hearing aids. The top ten predictors of satisfaction with amplification according to Kochkin, (2010) include: (1) overall benefit, (2) clarity of sounds, (3) value (performance of the hearing aid relative to price), (4) naturalness of sounds, (5) reliability of the hearing aid, (6) richness or fidelity of sound, (7) use in noisy situations, (8) ability to hear in small groups, (9) comfort with loud sounds, (10) sound of own voice (occlusion). This questionnaire is typically based on a five-point ranking scale; however, for the purposes of this study, the scale was modified into a 10-point ranking scale of 1 – 10 (i.e., 1 meaning "very dissatisfied" and 5 meaning "Neither Satisfied nor Dissatisfied and 10 meaning "very satisfied"). This was referred to as the Post-Fitting Questionnaire for the purposes of this study (see Appendix D).

International outcomes inventory for hearing aids (IOI-HA) questionnaire. Second, a modified version of the International Outcomes Inventory for Hearing Aids

(IOI-HA) questionnaire (Cox, Hyde, Gatehouse, & Noble, 2000), was assess overall satisfaction and experience level with each set of hearing aids (see Appendix E). The IOI-HA is a seven question, questionnaire used in identifying the effectiveness of hearing aid treatments. This questionnaire was modified from its original version to reflect one week trial periods with three separate levels of hearing aid technology. It addresses parameters related to daily use, satisfaction, and benefit. Furthermore, participants circled answers to each question that best described their experiences with each set of hearing aids.

Third, a self-developed cost and preference survey, which asked questions related to cost and overall satisfaction was also completed (referred to as the Cost and Preference Questionnaire, see Appendix F). The Cost and Satisfaction survey addressed factors such as (1) rank order of participant preference of hearing aids between trials, (2) estimation of price of hearing devices (by participant's), and (3) actual cost (MSRP) of hearing devices provided by primary researcher.

Procedures

Qualification procedures. Upon arrival, each participant was given a verbal description of the study and was required to read and sign an informed consent in accordance with the institutional review board procedures at Louisiana Tech University (see Appendix B). Then, each participant underwent a full audiological evaluation consisting of (a) case history (see Appendix A), (b) otoscopy, (c) pure-tone air and bone conduction threshold testing, (d) speech recognition thresholds testing and (e) word recognition testing. Furthermore, an air conduction pure-tone screening was completed/checked at each visit (N = 3) to ensure no significant change in hearing occurred between technology trials (see below for trial explanation).

Experimental procedures. This was a double blind study; neither the primary investigator nor the participant received any information as to the level of technology that was being fit at any given time. Participants included in this study were required to appear at the Emerge Center for Communication, Behavior, and Development for four separate appointments (Visits 1, 2, 3, and 4), where randomized hearing aid fittings occurred. At Visit 1, a complete audiological evaluation including otoscopy, pure-tone audiogram (air and bone conduction), speech recognition thresholds, and word recognition testing was obtained. Furthermore, at this visit, a hearing aid fitting and orientation including proper use, care, and maintenance of the device were reviewed. A pure-tone air-conduction screening was performed at Visits 2 and 3 to ensure that no significant change in hearing occurred between technology trials. If a change in the pure-tone air-conduction audiogram greater than ± 10 dB HL occurred at any frequency, participants were dismissed from the study.

Prior to each participant's hearing aid fitting (Visits 1, 2, and 3), a secondary researcher chose the set of hearing aids that were fitted on the participant, but did not allow the primary researcher to have knowledge of the level of technology of the given hearing aids (i.e., basic, advanced, or premium technology). The secondary researcher then verified that the hearing aids were functioning appropriately and programmed the hearing aids using the current participant audiogram and NOAH software. The secondary researcher programmed all amplification devices according to a pre-set first fitting protocol (see Appendix C for fitting protocol). Specifically, the secondary researcher programmed each set of hearing aids using the NAL-NL1 prescriptive formula with volume controls activated.

Each participant received a one week trial period with each level of amplification (basic, advanced, and premium), resulting in a total of three weeks of time wearing selected amplification. Then, at Visits 2, 3, and 4, the HINT and outcome questionnaire were administered. First, the HINT was administered after participants wore each set of hearing aids for one week trial periods. Participants were seated in the center of a sound treated booth with loudspeakers located at 0° and 180° azimuth. HINT sentences were presented through an ear-level loudspeaker located at 0° azimuth, and the HINT background noise was presented from another ear-level loudspeaker positioned at 180° azimuth. Each participant was given the following instructions for each HINT tests completed: "You will listen to ten sentences with background noise through the loudspeakers. I want you to repeat the sentences you hear back to me."

Furthermore, upon completion of each trial (i.e., at Visits 2, 3, and 4), each participant completed the Post-Fitting Questionnaire (see Appendix D) and the IOI-HA (see Appendix E). Lastly at Visit 4 only, an exit questionnaire called the Cost and Preference Questionnaire was presented to each participant in an interview format (see Appendix F). On this exit questionnaire, the participants were instructed to rank order their preference for hearing aids. Patients were also allowed to note if they had no preference between the three sets of hearing aids. If no preference between devices was noted, questioning ended. If a preference in amplification was noted, participants were then asked to identify what factors made the first choice (top ranked) the best set of hearing aids (i.e., clarity, sound quality, performance in background noise) to them. Furthermore, participants were instructed to determine how much more money they would be willing to pay for the perceived difference between the following: (1) the third rated set and the second rate set of hearing aids and (2) the second rated set and the first rated set of hearing aids. Finally, participants were asked to identify which set of hearing aids they would be most willing to purchase at the conclusion of the questionnaire.

Chapter IV

Results

The present study sought to determine the effect of hearing aid technology level on HINT score and perceived benefit/satisfaction of hearing aids as measured by a questionnaire adapted from the categories of the MarkeTrak Survey and the IOI-HA. Lastly, the present study sought to determine the ranking of hearing aid technologies, and if a perceptual difference in hearing aid technology was identified, how much more money would participants be willing to pay for the difference in perceived benefit. Participants in this study were required to appear for four separate appointments (Visits 1, 2, 3, and 4), where hearing testing, hearing aid fitting/orientation, and the completion of questionnaires on hearing aid satisfaction/benefit occurred. Moreover, each participant received three, one week trial periods with three different levels of hearing aid technology: entry-level, advanced, and premium. At the completion of each trial, the participant was asked to complete the HINT as well as the two questionnaires (i.e., Post-Fitting Questionnaire adapted from the MarkeTrak Survey and the IOI-HA Questionnaire) on benefit/satisfaction with the given hearing aids. Furthermore, at Visit 4, an exit questionnaire called the Cost and Preference Questionnaire was administered to rank overall preference of level of technology.

HINT Results

As stated previously, one purpose of the present study was to determine the effect of level of hearing aid technology on HINT scores. A total of six HINT scores were obtained for each participant. For each hearing aid trial, participants completed a practice HINT list and a test HINT list. Test HINT scores were averaged across participants for each level of hearing aid technology to get an overall HINT score for that hearing aid trial (see Figure 2).

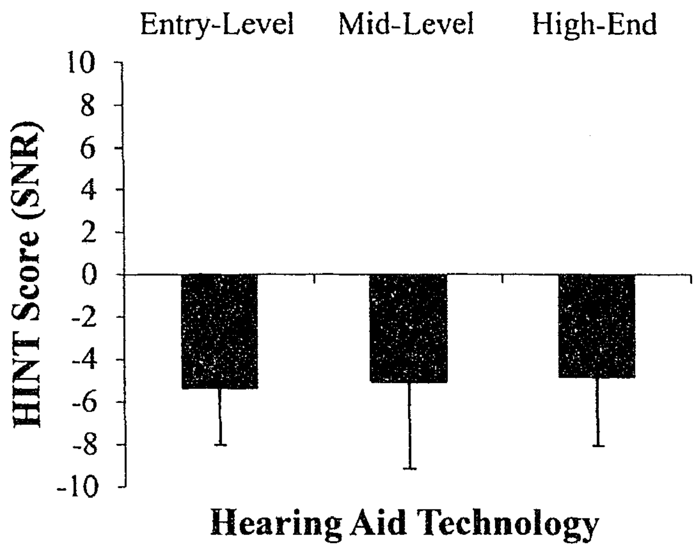

Figure 2. Mean HINT scores and standard deviations as a function of three levels of hearing aid technology.

A one-way repeated measures analysis of variance (ANOVA) was completed to determine the effect of level of hearing aid technology on HINT scores. The within subject variable was hearing aid technology with three levels (high-end, mid-level, and low-end). The results showed no significant main effect for hearing aid technology ($F(2,18) = 0.08$, $p = 0.93$). These results indicate that level of hearing aid technology does not affect speech understanding in noise ability, at least not in an audiometric booth in the manner in which we completed the testing.

Subjective Benefit and Satisfaction with Hearing Aids

Another purpose of the present study was to determine the effect of level of hearing aid technology on perceived benefit/satisfaction of hearing aids. To this end, the

Post-Fitting Questionnaire (see Appendix D) as well as the IOI-HA Questionnaire (see Appendix E) were used to assess overall satisfaction/hearing aid experience with each level of technology. Each questionnaire was completed with each level of hearing aid technology, and the scores were totaled across participants. As a review, the Post-Fitting Questionnaire is composed of the top ten predictors of consumer hearing aid satisfaction as determined by the Knowles MarkeTrak Questionnaire (Kochkin, 2010). The ten subscales included are: overall benefit, clarity of sounds, value, naturalness of sounds, reliability, richness/fidelity of sound, use in noisy situations, ability to hear in small groups, comfort with loud sounds, and sound of own voice. Each subscale score was rated from 1-10 (i.e., very dissatisfied to very satisfied). The average of all subscales was added for each participant, and then across participants to create a median/variance score for each level of hearing aid technology (see Figure 3).

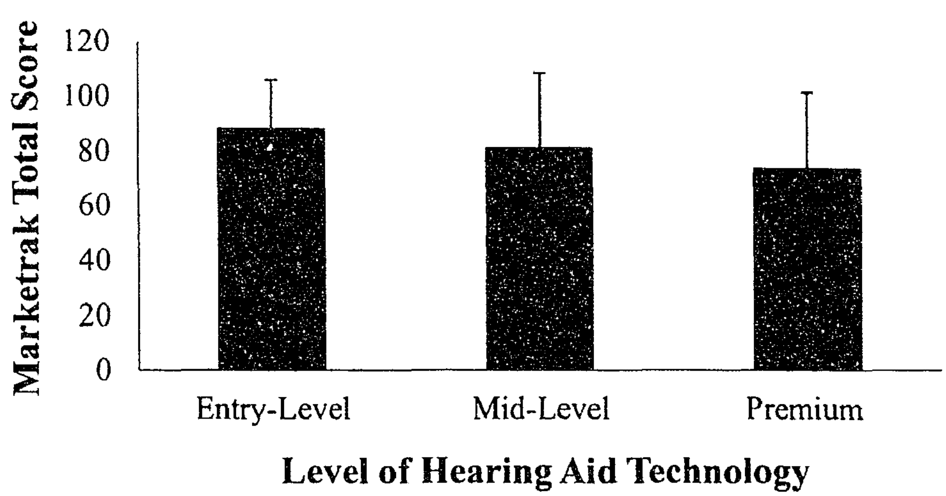

Figure 3. Median (variance) scores for subjective ratings for three hearing aid technology levels as taken from The Post-Fitting Questionnaire (i.e., adapted from the Knowles MarkeTrak Questionnaire).

The Friedman's test was used to determine the effect of level of hearing aid technology on subjective ratings of hearing aids. The within subjects variable was hearing aid technology level with three levels (high-end, mid-level, and low-end). The results showed a significant effect for technology level (Z = 8.10, $p = 0.02$), indicating that a difference in satisfaction with hearing aids based on level of technology. Three Wilcoxon signed ranks tests were completed to further investigate the results of the Friedman's test; a Bonferroni adjustment was completed for multiple comparisons (0.05/3 = 0.016). The results showed a significant difference in subjective ratings when comparing the low-end and mid-level levels of technology (Z = -2.55, $p = .011$); but no significant difference in subjective rating when comparing the high-end to the mid-level technology (Z = -0.71, $p = 0.48$) or the high-end to the low-end technologies – along the later approached significance (Z = -1.66, $p = .097$). These results indicate greater satisfaction with hearing aids when comparing the entry-level hearing aid to mid-level hearing aids, but no increased satisfaction when comparing mid-level to high-end hearing aids. Furthermore, when comparing high-end hearing aids to entry-level, it seems there was a slightly more satisfaction with the entry-level hearing aids. Lastly, because significant was noted on the total score for all subscales on the Post-Fitting Questionnaire, the 10 subscales were evaluated individually using Friedman's tests, one for each subscale. The results of these ten tests showed significance for two: overall benefit and Comfort with Loud Sounds (see Table 1). Specifically, through the use of three paired Wilcoxon, significance was identified in the Overall Benefit subscale when comparing high-end versus entry-level technologies (Z= -2.20, p = 0.03) as well as in the Comfort with Loud Sounds subscale when comparing high-end to entry-level technologies (Z= -2.38, p= 0.02).

Table 1. Friedman's test results for the ten subscales adapted from the Knowles MarkeTrak Questionnaire (Kochkin, 2010) to evaluate hearing aid satisfaction/benefit.

Subscale	Z-value	p-value
Overall Benefit	**8.40**	**0.02**
Clarity of Sound	4.87	0.09
Value	1.58	0.45
Naturalness of Sound	2.30	0.32
Reliability	5.83	0.05
Richness of Sound	5.15	0.08
Use in Noisy Situations	2.96	0.23
Ability to Hear in Small Groups	3.38	0.19
Comfort with Loud sounds	**8.60**	**0.01**

*Bold indicates significance.

The IOI-HA Questionnaire also was used to assess satisfaction level with each level of hearing aid technology. Participants answered eight questions related to their experiences with each level of hearing aid technology; those scores were added for each participant, and then averaged across participant to obtain medians and variance scores (see Figure 3). Again, Friedman's test was used to determine the effect of level of hearing aid technology on subjective ratings of hearing aids. The within subject variable was hearing aid technology level with three levels (high-end, mid-level, and entry-level). The results showed no significant effect for technology level ($Z = 2.0$, $p = 0.37$), indicating that there was no substantial difference between technology levels as related to participants overall experiences. The results are displayed in Figure 4.

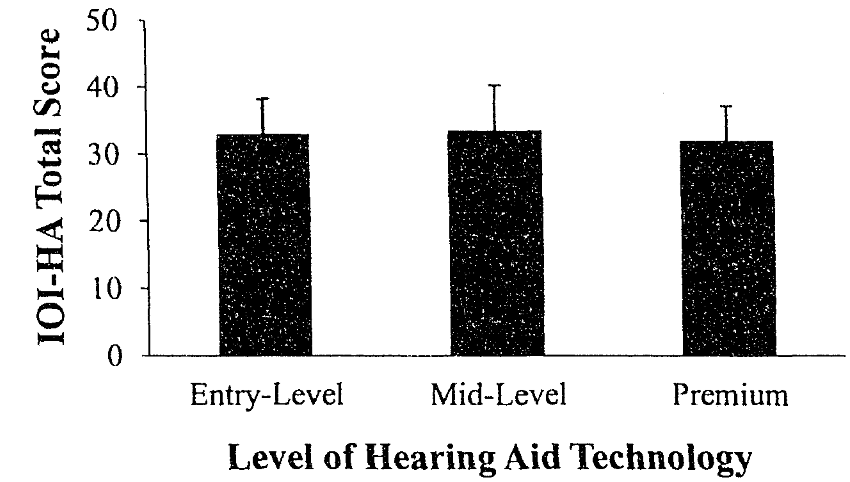

Figure 4. Median (variance) scores for subjective ratings for three hearing aid technology levels as taken from the IOI-HA.

Hearing Aid Preference

The last purpose of this study was to identify if experienced hearing aid users could identify a perceptual difference in hearing aid technology and if so, how much more money would each participant be willing to pay for the difference in perceived benefit. This was determined through the administration of the Cost and Preference Questionnaire at the conclusion of the research study. Specifically, participants were asked to rank order the three sets of hearing devices worn (Trial 1, Trial 2, and Trial 3) in order of preference based on perceived benefit and satisfaction or to indicate if no obvious differences were noted between devices. The results are displayed in Figure 5.

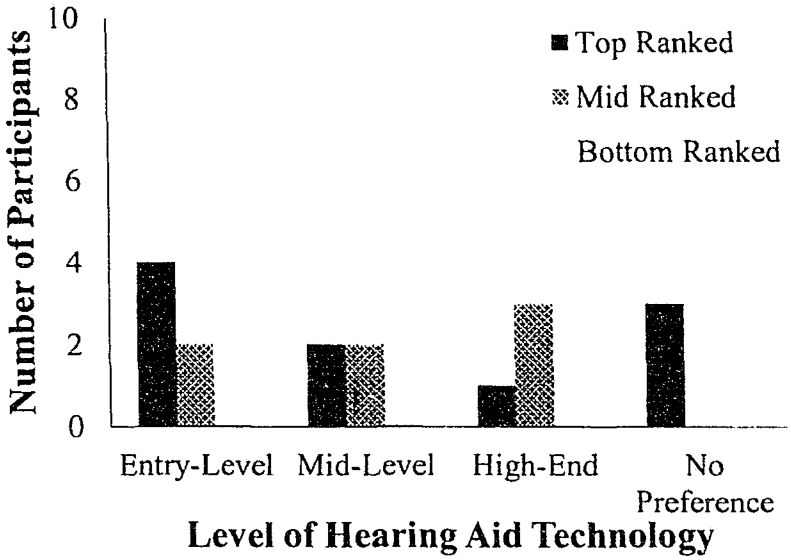

Figure 5. Rank of hearing aid technology levels as determined by the Cost and Preference Questionnaire.

Overall, results revealed that the entry-level set of hearing aids was identified as "Top Ranked" the greatest number of times (N = 4), followed by the mid-level product (N = 2) and then the high-end hearing aid technology (N = 1). The premium-level product was identified as the "Mid Ranked" set of hearing aids (N=3), leaving the mid-level product as the "Bottom Ranked" set of hearing aids (N=2). Three out of ten participants also indicated that "No Preference" was observed between technology trials. Moreover, it seems that results for preference were generally spread across the hearing aid technologies or no preference.

Lastly, participants were asked to indicate how much money they would be willing to pay for the difference in perceived benefit between their "Bottom Ranked" and "Mid Ranked" hearing aids and "Mid-Ranked" and "Top Ranked" hearing aids. Participant results from this parameter of the Cost and Preference Questionnaire were variable. The amount of money participants were willing to pay for the difference between their "Bottom" and "Mid Ranked" hearing aids ranged from \$0 to \$3,500, and the amount for "Mid" to "Top Ranked" ranged from $0 to $7,000. Specifically, four participants stated that they would not pay any money ($0) towards the difference in benefit they perceived from their "Bottom" to "Mid Ranked" choices of hearing aids. Only two participants continued this pattern and stated that they would not pay any money for the difference in perceived benefit for the "Mid" to "Top Ranked" levels of hearing aids. Moreover, results indicate that patients do not have a frame of reference in relation to price of levels of hearing aid technology; however, some participants did indicate that they would pay greater amounts for the difference in benefit they perceived between "Bottom, Mid, and Top Ranked" hearing aids.

Chapter V

Discussion

The purpose of this study was to determine if experienced hearing aid users can differentiate between different levels of hearing aid technology. More specifically, the following specific research questions were addressed: (1) Are HINT scores affected by level of hearing aid technology for experienced hearing aid users?; 2) Is benefit/satisfaction of hearing aids affected by level of technology for experienced hearing aid users?; and (3) How do hearing aid users rank different levels of technology? As a follow-up to the last question, if a perceptual difference in hearing aid technology is identified by hearing aid users, how much more money would participants be willing to pay for the difference in perceived benefit?

HINT Results

The comparison of HINT scores across technology levels revealed no difference between hearing aid technology and its ability to improve speech discrimination in noise abilities. This is a surprising finding given that hearing aid manufacturers suggest that the higher the level of hearing aid technology, the greater the device will perform in different situations (i.e., background noise, small groups, speech discrimination) due to high end features that typically include multichannel compression, automatic-adaptive directional microphones, and complex noise reduction and feedback algorithms (Cox et al., 2014). The results comparing HINT scores across participants suggest that it is not always true that people will have greater performance with premium level devices. These findings were consistent with previous data by Cox et al. (2014), who investigated whether premium-feature hearing aids yielded better speech understanding than basic-feature hearing aids. Results from Cox et al. (2014) indicated that aided speech recognition scores yielded higher scores than unaided scores in a laboratory setting for all basic and premium hearing aids; however, aided conditions using the premium devices did not show a significant improvement when compared to the use of basic devices, indicating no major difference in speech understanding between basic and premium hearing aids in the laboratory. The present study also showed that speech discrimination ability is not greatly affected by level of hearing aid technology in a laboratory setting.

Subjective Benefit and Satisfaction with Hearing Aids

The next purpose of this study was to determine if benefit or satisfaction of hearing aids is different when experienced hearing aid users utilize different levels of hearing aid technology. First, the ten subscales of the Knowles MarkeTrak Survey (Kochkin, 2010) were used to form the Post-Fitting Questionnaire that sought to determine overall benefit and satisfaction after a one-week trial period with each level of hearing aid technology. The results showed greater satisfaction with entry-level hearing aids as compared to mid-level hearing aid technology, but no difference in mid- and high-end hearing aids. The results comparing entry-level and high-end hearing aids approached significance. When further investigated, the overall benefit and comfort in loud sounds subscales were identified as being providing greater satisfaction when using entry-level hearing aids over mid-level hearing aids. Next, the IOI-HA was used to assess satisfaction/benefit with each level of hearing aid technology. The results indicated no substantial difference between technology levels as related to participants' overall experiences. These results agreed with past research by Kaplan-Neeman et al. (2012) and

Kozlowski et al. (2014). First, Kaplan-Neeman et al. (2012) examined the level of satisfaction of adult hearing aid users who used advanced digital hearing aids. Results from that study determined that level of hearing aid technology was not an overall predictor of degree of satisfaction with hearing aids. Similarly, Kozlowski et al. (2014) researched hearing aid user satisfaction using the IOI-HA. Unlike the present study, Kozlowski et al. (2014) examined the use of a single set of hearing aids over a two-week time period. Their results indicated that participants experienced satisfaction with amplification over a two-week time period. The present study sought to utilize the IOI-HA differently, as a tool to compare satisfaction across technology levels over multiple trial periods. When used in this manner in the current study, the IOI-HA did not reveal any preference towards a specific level of hearing aid technology.

Hearing Aid Preference

The last purpose of this study was to identify if experienced hearing aid users could identify a perceptual difference in hearing aid technology, and if so, how much more money would each participant be willing to pay for the difference in perceived benefit. Results indicated that the entry-level set of hearing aids was identified as "Top Ranked" while the premium-level product was identified as the "Mid Ranked" set of hearing aids, leaving the mid-level product as the "Bottom Ranked" set of hearing aids. Participants also indicated that "No Preference" was observed between technology trials a third of the time. Overall, these results indicate preference for hearing aid technology was highly variable.

Furthermore, when participants were asked about how much money they would be willing to pay for the difference in benefit they perceived, these results were also highly variable, ranging from $0 to $7,000. Some participants indicated they were willing to pay more money for the difference in benefit that they perceived from the Mid-Ranked to Top-Ranked hearing aids than when comparing Bottom-Ranked to Mid-Ranked." In a similar study, Newman and Sandridge (1998) attempted to examine the cost effectiveness of three different levels of hearing aid technology from a single hearing aid manufacturer. It was determined that cost was an underlying factor in the selection of personal hearing aids; however, Newman and Sandridge (1998) found no pattern indicated a superior hearing device among the hearing aids used in their study. Furthermore, despite one device in their study having superior processing, it was found that upon knowing cost, participants decided to purchase lower levels of hearing aid technology (Newman & Sandridge, 1998). This somewhat contradicts the results of the present study, where some participants indicated they would be willing to pay for the advantages in signal processing that they perceived.

Limitations and Future Research

The present study was limited by the sample population, which only consisted of ten individuals. Data collection is still in process in order to obtain a full population size of 15 participants. Future research should have a greater sample size and should utilize several different hearing aid manufacturers` hearing aids in order to further validate claims regarding level of hearing aid technology. Furthermore, future research into the effectiveness of levels of hearing aid technology should focus on different styles of hearing aids including traditional behind-the-ear (BTE) hearing aids, receiver in the ear (RITE) hearing aids, and/or custom hearing aids as the present study focused only on open-fit BTE hearing aids coupled to the ear using slim tubing. Traditionally, people who are fit with hearing aids using slim tubing and domes have normal or near-normal low frequency hearing. These hearing aids allow low frequency sounds to enter the ear naturally through the large venting versus artificially through the hearing aid; this allowance of low frequencies causes a low-cut, potentially decreasing the performance of advanced features such as directional microphones, noise reduction, and expansion. Researching an alternate style of hearing aid will allow future participants to fully utilize advanced hearing aid technology, which may make it easier for participants to determine differences between the levels of hearing aid technology.

Clinical Implications

For individuals with hearing loss that are seeking hearing aids, this study and future research in the same area, can help audiologists appropriately fit hearing aids based on patients actual need rather than fitting hearing aids based on the audiologists perceived need. If potential hearing aid users can benefit from entry-level hearing aids as much as they could benefit from premium-level hearing aids, this could potentially save purchasers money as well as make hearing aids seem more appealing due to having a lower price point. However, more research should be done in this area to further determine the effectiveness of hearing aid technology levels.

Appendix A

Case History

Case History Form

Participant Name______________________ DOB_____________

List your current medications:

____

Have you had any recent ear related surgeries?

T&A________Mastoidectomy________Stapes
Mobilization________Myringotomy________

Fenestration________Tympanoplasty________Other________

Serious Illnesses/Hospitalizations:

____

____
______

Have you experienced any changes or fluctuations in your hearing loss in the last 2 years?

____

When did you receive your current set of hearing aids?

________________________ Current HA Make/Model;_______________
______

How many hours per day do you wear your current hearing aids?

____

In which situations do you find your hearing aids most effective?

Phone_____	Individuals_____	T.V./Radio______
Groups____	Church________	Localization_____
Home_____	Quiet________	Movies_________
Work______	Noise________	

How much does your hearing loss limit your activities in daily life?

A lot –1 2 3 4 5 6 7 8 9 10—Not at all

How would you rate your overall communication ability?

A lot of problems –1 2 3 4 5 6 7 8 9 10—No problems

How much of a problem do you have understanding conversation in noisy situations?

____

Do you have any visual impairment that would limit or prohibit you from signing an informed consent form or any hearing aid questionnaires (Check one)?

______Yes ______No

Appendix B

IRB Consent Form

HUMAN SUBJECTS CONSENT FORM

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: The Effect of Cost, Benefit, and Level of Technology on Patient Preference and Satisfaction with Hearing Aids

PURPOSE OF STUDY/PROJECT: To determine if experienced hearing aid users can differentiate different hearing aid technology.

PROCEDURE: Prior to inclusion in this study, you will be asked to complete a case history form to ensure that no known cognitive, psychological, or neurological deficits are present and to verify that you are a native English speaker. Also prior to inclusion, you will be required to verify the wearing of previous personal behind-the-ear hearing aids for at least six months to one year. If included in this study, you will be required to appear at the Emerge Center for Communication, Behavior, and Development for four separate appointments (Visits 1, 2, 3, and 4), where hearing testing, hearing aid fitting/orientation, and the completion of questionnaires will occur. Specifically, at Visit 1, a complete audiological evaluation including otoscopy, pure-tone testing (air and bone conduction), speech recognition thresholds, and word recognition testing will be obtained. Furthermore, at this visit, a hearing aid fitting and orientation including proper use, care, and maintenance of the device will occur. A pure-tone air-conduction screening will be performed at Visits 2 and 3 to ensure that no significant changes in hearing occurred between technology trials. If a change in the pure-tone air-conduction audiogram greater than ± 10 dB HL occurs at any frequency, you will be dismissed from this study. At Visits 1, 2, and 3 a selected set of hearing aids will be programmed to your hearing loss. You will receive a one week trial period with each set of hearing aids. Then, at Visits 2, 3, and 4, the Hearing in Noise Test (HINT) and two questionnaires will be completed (the Post-Fitting Questionnaire and the International Outcomes Inventory for Hearing Aids Questionnaire). Lastly at Visit 4 only, an exit questionnaire called the Cost and Preference Questionnaire will be administered to you.

INSTRUMENTS: The IOI-HA the Post-Fitting Questionnaires will be administered to assess overall experience and satisfaction with hearing aids. A self-developed cost and preference survey which addresses cost and overall satisfaction with hearing aids will also be administered. All information collected will be held confidential and reviewed only by the primary researchers. At the conclusion of the research study, all materials and hard copies of data will be placed in a locked filing cabinet in room 214 in Robinson Hall at Louisiana Tech University.

RISKS/ALTERNATIVE TREATMENTS: There are no known risks to subjects associated with these procedures. These procedures do not vary from routine audiometric practices. Participation is voluntary with written consent. Furthermore, the participant understands that neither Louisiana Tech nor the Emerge Center is able to offer financial compensation or to absorb the costs of medical treatment should you be injured as a result of participating in this research.

EXTRA CREDIT: Does not apply to this project.

BENEFITS/COMPENSATION: You will receive free hearing examinations consisting of otoscopy, pure-tone testing, and speech discrimination testing. You will also receive free three hearing aid trial periods as a participant in this study. Also, the scientific and clinical communities will benefit from a better understanding of the effect of cost, benefit, and level of technology on patient preference and satisfaction with hearing aids.

SAFEGUARDS OF PHYSICAL AND EMOTIONAL WELL-BEING: This study requires minimal contact (i.e., placing of earphones, fitting of domes and hearing aids) with the subject, all of which are routine clinical audiologic measures.

I, ____________________, attest with my signature that I have read and understood the following description of the study, " The Effect of Cost, Benefit, and Level of Technology on Patient Preference and Satisfaction with Hearing Aids ", and its purposes and methods. I understand that my participation in this research is strictly voluntary and my participation or refusal to participate in this study will not affect my relationship with Louisiana Tech University or The Emerge Center for Communication, Behavior, and Development or my grades in any way. Further, I understand that I may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my survey will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative. I have not been requested to waive nor do I waive any of my rights related to participating in this study.

______________________________　　　____________

Signature of Participant or Guardian　　　**Date**

CONTACT INFORMATION:The principal experimenters listed below may be reached to answer questions about the research, subjects' rights, or related matters.

Lindsay M. Young, B.S.	EMAIL: lam058@latech.edu PHONE: (225) 614-4775
Matthew D. Bryan, Au.D., CCC-A	EMAIL: mbryan@latech.edu PHONE: (318) 257-3102

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:

Dr. Stan Napper (257-3056)

Dr. Mary M. Livingston (257-2292 or 257-5066

LOUISIANA TECH
UNIVERSITY

MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO: Ms. Lindsay Young and Dr. Matthew Bryan

FROM: Dr. Stan Napper, Vice President Research & Development

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: September 15, 2015

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"The Effect of Cost, Benefit and Level of Technology on Patient Preference and Satisfaction with Hearing Aids"

HUC 1344

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. ***This approval was finalized on September 15, 2015 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond September 15, 2016.*** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Dr. Mary Livingston at 257-2292 or 257-5066.

Appendix C

Fitting Protocol and Outline of Topics for Hearing Aid Orientation

Fitting Protocol

1. **Open Noah**
2. **Open Genie**
    a. Detect Hearing Aids (Wireless or w/ cords)
    b. Once detected press "continue"
    c. **Ensure hearing loss is within fitting range**
3. Press **"Selection"** at top of page
    a. Select **"Personal Profile"** (Left side of page)
        i. Verify gender (M/F)
        ii. Verify appropriate age range
        iii. Set experience level as **Long-Term**
        iv. Do **NOT** change anything under **Preference Manager** – leave all questions on default.
    b. Select **Program Manager** (Left side of page)
        i. **Change** fitting Rationale to **NAL-NL1**
        ii. **Ensure** personal profile is on **"Default"** setting
    c. Select **Acoustics** (Left side of page)
        i. Select **Corda Minifit**
        ii. Select **domes based on default setting (i.e., based on hearing loss and Genie default settings)…ensure that either <u>OPEN OR BASE DOMES</u> <u>ARE default</u> (NOTE: We are NOT using patients that DEFAULT to POWER domes.).**
        iii. Ensure that the EXACT dome that is the default in Genie is the domes that is ON THE participant (i.e., open, base –single dome, base – double dome).
            1. Lock acoustics
4. Press **"Fitting"** (top of page)
    a. Select **Automatics**
        i. **Verify** that default personal profile is selected.
    b. Select **"Automatic Adaptation Manager"**
        i. Verify that hearing aid is on **Adaptation Level Three**
            1. If it is not, activate automatic adaption manager, and select Adaptation Level Three
5. Press "End Fitting" (top of page)
    a. Press "Buttons and Indicators"
    b. Select Operate Push Button
        i. Activate Volume Control for both aids
    c. Select Beeps
        i. Check the following:
            1. Beep at preferred volume
            2. Beep at min/max level
            3. Emit Clicks
            4. Pre-warning
            5. Turn on battery warning
6. Save Program and Exit
7. Save to Noah and Hearing Instrument

Outline of Topics for Hearing Aid Orientation

1. Parts of the HA:
    a. Have one HA in their ear and the other out so they can look at it.
    b. Show them how the HA fits and where the electronics are on it.
        i. Volume control
            1. Turn it towards the nose to turn it up and away from the nose to turn it down if it's a wheel
            2. What different beeps mean
        ii. Other things
            1. Mic/Receiver – Where they are and what they do
            2. Right vs. Left
2. Insertion and Removal
    a. Show them how to hold it and put it in
    b. Don't pull them out by tubing
    c. Show them how, then help them, then they do it themselves
3. Battery Size
    a. Zinc Air
        i. Open battery door at night to preserve life
    b. Battery size and color
    c. Hazardous if ingested
        i. Keep away from pill bottles
        ii. Poison control
4. Care/Maintenance
    a. Warn them about wax, moisture dropping, and extreme heat
    b. Do not wear in the shower or getting their hair done
    c. Show them how to clean wax off
        i. Clean them over a surface in case they are dropped
    d. Do not wear around loud noise
5. Cleaning
    a. Take them out of ears at night and open battery door.
        i. Wax will dry overnight
        ii. Brush wax off in the morning
        iii. Make sure wax falls out and not in
6. Wearing Schedule
    a. Wear as many hours as they can each day.

Appendix D

Post-Fitting Questionnaire

Post-Fitting Questionnaire

Satisfaction with Hearing Aids Questionnaire	Trial 1 / 2 / 3
Overall benefit	1 2 3 4 5 6 7 8 9 10
Clarity of sound	1 2 3 4 5 6 7 8 9 10
Value (performance of hearing aid relative to price)	1 2 3 4 5 6 7 8 9 10
Natural sounding	1 2 3 4 5 6 7 8 9 10
Reliability of the hearing aid	1 2 3 4 5 6 7 8 9 10
Richness or fidelity of sound	1 2 3 4 5 6 7 8 9 10
Use in noisy situations	1 2 3 4 5 6 7 8 9 10
Ability to hear in small groups	1 2 3 4 5 6 7 8 9 10
Comfort with loud sounds	1 2 3 4 5 6 7 8 9 10
Sound of voice (occlusion)	1 2 3 4 5 6 7 8 9 10

Kochkin, (MarkeTrak, 1999)

1	Very Dissatisfied
5	Neither Satisfied nor Dissatisfied
10	Very Satisfied

1. Overall, how satisfied are you with these hearing aids?
    a. Extremely satisfied
    b. Satisfied
    c. Neither satisfied or dissatisfied
    d. Dissatisfied
    e. Extremely dissatisfied

Kochkin, S. (2010). MarkeTrak VIII: Consumer satisfaction with hearing aids is slowly increasing. Hearing Journal, 63 (1): p. 19-27.

Appendix E

International Outcomes Inventory for Hearing Aids

International Outcomes Inventory for Hearing Aids Questionnaire

Please circle the answers that best describe your experience

1. Think about how much you used your present hearing aid(s) over the past week. On an average day, how many hours did you use the hearing aid(s)?

none	less than 1 hour a day	1 to 4 hours a day	4 to 8 hours a day	more than 8 hours a day

2. Think about the situation where you most wanted to hear better, before you got your present hearing aid(s). Over the past week, how much has the hearing aid helped in those situations?

helped not at all	helped slightly	helped moderately	helped quite a lot	helped very much

3. Think again about the situation where you most wanted to hear better. When you use your present hearing aid(s), how much difficulty do you STILL have in that situation?

very much difficulty	quite a lot of difficulty	moderate difficulty	slight difficulty	no difficulty

4. Considering everything, do you think your present hearing aid(s) is worth the trouble?

not at all worth it	slightly worth it	moderately worth it	quite a lot worth it	very much worth it

5. Over the past week, with your present hearing aid(s), how much have your hearing difficulties affected the things you can do?

affected very much	affected quite a lot	affected moderately	affected slightly	affected not at all

6. Over the past week, with your present hearing aid(s), how much do you think other people were bothered by your hearing difficulties?

bothered very much	bothered quite a lot	bothered moderately	bothered slightly	bothered not at all

7. Considering everything, how much has your present hearing aid(s) changed your enjoyment of life?

worse	no change	slightly better	quite a lot better	Very much better

8. How much hearing difficulty do you have when you are not wearing a hearing aid?

affected very much	affected quite a lot	affected moderately	affected slightly	affected not at all

Appendix F

Cost and Preference Questionnaire

Cost and Preference Questionnaire

1. Overall, please rank order the three sets of hearing devices worn (Trial 1, Trial 2, and Trial 3) in order of preference based on perceived benefit and satisfaction, or indicate if no obvious differences were noted between devices. Basically, which device was your favorite or the best in your opinion?

Top Ranked______________________ No Preference__________________

Mid Ranked ______________________

Bottom Ranked ____________________

2. In your opinion, what made your first choice the best set of hearing aids (i.e., clarity, sound quality, performance in background noise)?

____

____

____

____

____

____

3. How much more money would you be willing to pay:

Bottom Ranked vs. Mid Ranked _________________

Mid Ranked vs. Top Ranked ____________________

4. If you were going to buy a set of hearing aids, which would you choose?

Trial Number _____________ None______________

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