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TEST-RETEST RELIABILITY AND CLINICAL UTILITY OF THE MULTIMEDIA HEARING HANDICAP INVENTORY

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Sara Louise Shogren

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By

Sara Louise Shogren

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ABSTRACT

TEST-RETEST RELIABILITY AND CLINICAL UTILITY OF THE MULTIMEDIA HEARING HANDICAP INVENTORY

By

Sara Louise Shogren

A new multimedia version of the Hearing Handicap Inventories (MHHI) was recently developed by Punch and Weinstein based on the original screening versions of the Hearing Handicap Inventory for the Elderly (HHIE - S) and the Hearing Handicap Inventory for Adults (HHIA-S). The MHHI is comprised of two separate programs: a short program (SP) and a long program (LP). The purpose of this study was to determine the clinical utility of the MHHI, including its test-retest reliability, acceptability and ease of use, and preliminary clinical validity.

Thirty-six normal-hearing and hearing-impaired subjects completed the MHHI during two separate test sessions conducted three weeks apart. Audiometric data and case history information were collected in both sessions. Each subject was randomly assigned to one of three test-retest sequences (LP/SP, SP/SP, or SP/LP).

Results revealed the MHHI to have high test-retest reliability and high internal consistency reliability. Statistical properties were shown to be highly consistent with those of the original screening versions of the HHI. Overall, the MHHI exhibited good clinical utility. Its full validation as a screening measure of hearing impairment will require testing with a larger number of subjects than included in this study.

This is dedicated to Kenneth Shogren, Daniel Shogren, Jennifer Rise, and most especially David and Virginia Shogren. They have always given their love and support and never let me lose sight of my dreams.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Background

Hearing *disability* has been characterized as encompassing the primary communication consequences of a hearing loss, and a *handicap* as encompassing the secondary consequences of a hearing loss. In recent years, distinctions have been drawn among the terms *disorder*, *impairment*, *disability*, and *handicap*:

> "A hearing ***disorder*** occurs as a result of some type of disease process or malformation of the auditory system.
>
> A hearing ***impairment*** is any loss or abnormality of psychological, physiological, or anatomical structure or function.
>
> A hearing ***disability*** is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range that is considered normal for a human being.
>
> A hearing ***handicap*** is a disadvantage for a given individual, resulting from impairment or disability, that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual."
>
> (World Health Organization, 1980)

A disorder, impairment, or disability can be characterized or reasonably predicted by use of audiological measures such as pure tone audiometry, speech recognition thresholds, acoustic reflex thresholds (ART), otoacoustic emissions (OAE), and auditory brainstem responses (ABR), but the handicapping, or secondary, effects of a hearing loss need to be measured with different tools. One way to quantify handicap is to use a formula developed by the American Academy of Otolaryngology (AAO) Committee on Hearing and Equilibrium (1979). The AAO formula classifies people as either *handicapped* or *not* *handicapped* according to a formula based on thresholds for the frequencies 500 Hz, 1000 Hz, 2000 Hz, and 3000 Hz, with a cutoff of 25 dB HL.

Self-assessment scales, inventories, or questionnaires provide another way to measure hearing handicap. Self-assessment data reveal important insights about individuals' responses to hearing impairment that cannot be gleaned from audiometric data (Weinstein and Ventry, 1983). Hearing handicap represents the non-auditory problems resulting from hearing disorder, impairment, or disability. While the degree of hearing handicap generally increases with increased hearing impairment, hearing handicap may vary, depending on the attitudes and perceptions of the affected individual and those with whom he or she interacts, as well as with the demands placed on one's ability to hear and understand speech in everyday life. Individual response is based on personality, psychosocial adjustment to a hearing impairment, age, and general health (Ventry and Weinstein, 1982).

Self-assessment inventories have been designed to assess hearing handicap in the young adult and elderly adult populations. They assess various aspects of a hearing loss, including attitudes, general communication abilities, communication in various environments or situations, emotional aspects of a hearing loss, and the effects of hearing loss on social functioning. As many as 158 items and as few as 5 items have been used to evaluate the various consequences of hearing loss on everyday life. A comprehensive listing of self-assessment inventories is given in Table 1.1. This listing describes the target population, the author/developers(s), the year the inventory was published, the number of items in the inventory, the factors measured, and (if available) the approximate time required to complete the inventory.

Self-assessment scales in audiology have evolved from pencil-and-paper versions in the mid-1960s to current scales that are administered through computer technology. A similar transition to computer technology has been seen in the field of psychology. Psychological questionnaires were computerized for two reasons: 1) for ease of scoring and 2) to elicit more-honest responses from subjects than are likely to occur on written questionnaires or in face-to face interviews. Neal, Fox, Carroll, Holden, and Barnes (1997), in a study involving a computerized version of a personality disorder screening test, indicated the need for greater ease in scoring questionnaires. They noted that "computerized tests based on self-report questionnaires should be independently validated because reliability between the two forms cannot automatically be assumed" (Neal et. al, 1997, p. 352). Skinner and Allen (1983) speculated while analyzing a computer version of a self-assessment questionnaire that more-accurate information would be provided about sensitive areas. In their study of alcohol, drug, and tobacco use, they found no difference in reliability, level of problems reported, or consumption patterns among a computerized version, a pencil-and-paper version, and a face-to-face version. Pouwer, Snoek, van der Ploeg, Heine, and Brand (1998) found no differences in computerized and pencil-and-paper versions of the Well-being Questionnaire (WBQ) and the Diabetes Treatment Satisfaction Questionnaire (DTSQ) and thus considered the versions to be equivalent. However, Duijsens, Eurelings-Bontekoe, and Diekstra (1996) found only a moderate agreement between the computerized Vragenlij voor Kenmerken van de Persoonlijkheid (VKP), an instrument for determining personality disorders, and their gold standard scale.

The Multimedia Hearing Handicap Inventory (MHHI) is one of the newest self-assessment scales in Audiology. It is a computerized, multimedia questionnaire based on paper-and-pencil screening questionnaires. The purpose of this study was to evaluate the test-retest reliability and overall clinical utility of the MHHI.

Self-assessment scales serve multiple purposes beyond the measurement of hearing handicap. They may be used to screen directly for hearing handicap; screen indirectly for hearing impairment; evaluate the need for aural rehabilitation, including hearing aid candidacy; measure outcomes of audiological interventions, such as hearing aid benefit; and market and promote one's clinical practice.

When self-assessment scales are used to screen for hearing handicap or impairment, it can generally be presumed that patients who score on one side of a specified cutoff value will not exhibit a hearing impairment, while patients scoring on the other side of that cutoff value will exhibit hearing impairment. To the extent that this is true, the scale may be said to be a valid screening measure of hearing handicap or hearing loss. If a patient's score on such a scale suggests no handicap, it may also be presumed that hearing aids and other forms of aural rehabilitation are not necessary. On the other hand, if the score of a patient who does not wear amplification suggests hearing handicap, aural rehabilitation (probably hearing aids) will likely need to be considered.

Ideally, predictions of who will pursue amplification and actually use it may also be gleaned from self-assessment scales. If a patient demonstrates a low handicap score, despite audiometric evidence of hearing impairment, the patient is not perceiving a hearing handicap. Because that individual does not regard hearing to be a problem, he or she is not likely to seek assistance, and is also unlikely to comply with specific recommendations to do so. On the other hand, the patient who demonstrates both audiometric hearing loss and a high handicap score perceives hearing to be handicapping and is likely to comply with recommendations to explore amplification or other forms of audiologic rehabilitation.

Given a high test-retest reliability and validity, a self-assessment scale may be used effectively as an outcome measure. If a handicap score on such a scale decreases substantially over a time period in which the patient undergoes some rehabilitation process, then it may normally be assumed that the process is largely responsible for the patient's perception of diminished handicap.

Self-assessment scales may be utilized in various settings. If the scales are relatively easy to use, easy to score, have validity and high test-retest reliability, and provide a basis for determining candidacy for—and benefit from—rehabilitation, they may be used to promote one's clinical practice. For example, a potentially powerful strategy for the use of self-assessment questionnaires would be their use in offices of primary-care physicians to refer patients to audiologists for diagnostic services and follow-up care.

Due to the wide variety of uses for self-assessment scales, the development and improvement of these scales is a highly worthwhile task. The present study focused on a preliminary evaluation of the MHHI. Because the Hearing Handicap Inventory for the Elderly-Screening Version (HHIE-S) and the Hearing Handicap Inventory for Adults-Screening Version (HHIA-S) are important components of the MHHI, these two scales, their parent scales (HHIE and HHIA), and the MHHI itself will be the major topics addressed in the *Review of Literature* in the next chapter.

Table 1.1: History and scope of Hearing Handicap Inventories.

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Hearing Handicap Scale (HHS)	Adults	High, Fairbanks, and Glorig	1964	20	Speech communication, awareness of environmental sounds, ability to hear warning signals	5
Rating Scale for Each Ear (RSEE)	NA	Schein, Gentile, and Haase *	1970	NA	Hearing status for each ear and whether the perception is rated as good, as having little trouble hearing, as having considerable trouble hearing, or deaf	NA
Hearing Measurement Scale (HMS)	Adults	Noble and Atherly ⊗	1970	53	Ability to hear speech, non-speech hearing acuity, localization ability, speech distortion, tinnitus, social effects of a hearing loss, individual's response to a hearing loss	10-40
Test of Actual Performance	NA	Koniditsiotis ⊗	1971	7	Relationship between audiometric hearing loss and disability experienced by the person; assessed by the clinician, not the patient	NA

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Social Hearing Handicap Index (SHHI)	Adults	Ewertson and Birk-Nelsen	1973	21	Specific listening situations	5
Denver Scale of Communication Function (DSCF)	Seniors	Alpiner, Chevrette, Glascoe, Metz, and Olsen $^{\lambda}$	1974	25	Family, social, vocational, and general communication issues	15
Denver Scale of Communication Function for Senior Citizens Living in Retirement Centers	Seniors in retirement centers	Zarnoch and Alpiner $^{\lambda}$	1977	7	Family, emotions, other persons, general communication, self-concept, group situations, and rehabilitation (interview format)	15
Nursing Home Handicap Index (NHHI)	Seniors in nursing homes	Schow and Nerbonne	1977	20	General communication, attitudes towards peers, socialization, specific hearing situations (half completed by senior, half by nursing-home staff)	NA
Denver Scale of Communication Function - Modified	Seniors	Kaplan, Feeley, and Brown	1978	34	Peer and family attitudes, socialization, communication, specific hearing situations (interview format)	NA

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Hearing Performance Inventory (HPI)	Adults	Giolas, Owens, Lamb, and Shubert	1979	158	Ability to understand speech, intensity, social, personal and occupational communication, hearing-impaired person's response to auditory failure	30-55
Quantified Denver Scale (QDS)	NA	Schow and Nerbonne *	1980	25	Estimate of hearing disability	NA
Self-Assessment of Hearing	Elderly	Manzella and Taigman[∅]	1980	16	Determination of need for a hearing aid	NA
Performance Inventory for Profound and Severe Loss	Adults with severe-to-profound hearing loss	Owens and Fujikawa	1980	74	Ability to understand speech with and without visual cues, intensity, response to auditory failure, environmental sounds awareness, personal response to a hearing loss	50
Hearing Problem Inventory	Adults	Hutton [λ]	1980	51	Perception of a hearing problem, the benefit of hearing aids, and the use of hearing aids	NA

Table 1.1: (continued)

Hearing Handicap Inventory	**Target Population**	**Author/Developer(s)**	**Year**	**No. Items**	**Factors Measured**	**Time (min)**
Communication Assessment Procedure for Seniors (CAPS)	Seniors in extended care facilities	Alpiner and Baker [λ]	1981	35	General communication, group situations, self concept, other person's concept, and family communication	20-40
Profile Questionnaire for Rating Communication Performance	Adults	Sanders	1982	22	Home, business, and social environments for communication success	15
Self-Assessment of Communication/Significant Other Assessment of Communication (SAC/SOAC)	Elderly and spouse	Schow and Nerbonne	1982	10/10	Communication situations, feelings, and perception of others' attitude toward hearing handicap (both SAC and SOAC)	NA
Hearing Handicap Inventory for the Elderly (HHIE)	Elderly	Ventry and Weinstein	1982	25	Social-situational and emotional aspects of hearing loss	NA
McCarthy-Alpiner Scale of Hearing Handicap (MA-Scale)	NA	McCarthy and Alpiner[λ]	1983	34	Psychological, social, and vocational effects of hearing loss; diagnostic data for audiological rehabilitation (given to hearing-impaired person and family)	NA

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Hearing Performance Inventory – Revised (HPI- Revised Form)	Adults	Lamb, Owens, and Schubert	1983	90	Ability to understand speech; intensity, social, personal and occupational communication; hearing-impaired person's response to auditory failure	20
Hearing Handicap Inventory for the Elderly - Screening Version (HHIE-S)	Elderly	Ventry and Weinstein	1983	10	Social-situational and emotional aspects of hearing loss	NA
Hearing Performance Inventory for Severe to Profound Hearing Loss (HPI-SP)	NA	Owens and Raggio $^{\lambda}$	1984	NA	To be used in conjunction with use of hearing aids, cochlear implants, and vibrotactile aids	NA
Hearing Aid Performance Inventory (HAPI)	Adults	Walden, Demorest, and Hepler	1984	64	Hearing aid benefit in daily life	NA
Communication Profile for the Hearing Impaired (CPHI)	Adults	Demorest and Erdman	1986	145	Communication performance, communication importance, communication environments, communication strategies, and personal adjustment to hearing loss	20-40

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Feasibility Scale for Predicting Hearing Aid Use (FSPHAU)	Adults	Chermak and Miller	1988	11	Four factors that may influence the probability of successful hearing aid use: audiometric, psychosocial, economic, and medical factors	NA
Hearing Aid User's Questionnaire (HAUQ)	NA	Forster and Tomlin ∞	1988	11	Assesses hearing aid use, benefit, problems, and satisfaction	NA
Attitudes Toward Loss of Hearing Questionnaire (ALQH)	NA	Brooks	1989	39	Six scales: personality, attitude/acceptance, motivation/expectation, quality of life, relationship with significant others, and hearing aid stigma	10
Communication Skill Scale	Adults	Kaplan, Bally, and Brandt ⊗	1990	NA	How hearing loss affects daily life: different communication situations, communication strategies, and attitudes (used at Gallaudet University)	NA
Hearing Handicap Inventory for Adults (HHIA)	Adults	Newman, Weinstein, Jacobson, and Hug	1990	25	Social-situational and emotional aspects of hearing loss	NA

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Profile of Hearing Aid Performance (PHAP)	Elderly	Cox and Gilmore	1990	66	Self-assessment of hearing aid benefit, familiar talkers, ease of communication, reverberation, reduced cues, background noise, aversiveness to sounds, and distortion of sounds	NA
Profile of Hearing Aid Benefit (PHAB)	NA	Cox and Gilmore	1990	66	Self-assessment of hearing aid benefit	NA
Intelligibility Rating Improvement Scale (IRIS)	NA	Cox, Gilmore, and Alexander	1991	NA	Estimation of proportion of speech that can be understood in various situations	NA
Alpiner-Meline Aural Rehabilitation Screening Scale (AMAR)	Adults	Alpiner, Meline, and Cotton $^{\lambda}$	1991	17	Assesses need for aural rehabilitation; consists of combination of questions from 3 other hearing handicap inventories	NA
Hearing Handicap Inventory for Adults - Screening Version (HHIA-S)	Adults	Newman, Weinstein, Jacobson, and Hug	1991	10	Social-situational and emotional aspects of hearing loss	NA

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Shortened Hearing Aid Performance Inventory (SHAPI)	NA	Schum [#]	1992	38	Benefit of hearing aids in each of the 38 situations questioned	NA
Wichita State University (WSU) Communication Appraisal and Priorities Profile (CAPP)	Adults and elderly	Hull	1992	16	Determination of most important communication situations to address	NA
Gothenburg Profile (used in Sweden and Germany)	NA	Ringdaht, Eriksson-Mangold, and Karlsson*	1993	NA	NA	NA
Hearing Disability and Handicap Scale (HDHS; English and French versions)	NA	Hétu, Stephans, Noble, Getty, Philibert, and Désilets *	1994	20	Ten questions assessing disability and 10 questions assessing handicap	NA
Abbreviated Profile of Hearing Aid Benefit (APHAB)	NA	Cox and Alexander	1995	24	Four subscales: ease of communication (in quiet), reverberation, background noise, and aversiveness to harsh or loud sounds	NA

Table 1.1: (continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Multimedia Hearing Handicap Inventory (MHHI)	Adults and elderly	Punch and Weinstein	1996	10/10	Social-situational and emotional aspects of hearing loss	SP- 2 LP - 15-20
Client Oriented Scale of Improvement (COSI)	NA	Dillon, Alison, and Ginis	1997	Up to 5	Client nominates and ranks up to 5 critical situations, and indicates for each situation how good hearing was before and after intervention	NA
Hearing Aid Needs Assessment (HANA)	NA	Schum	1999	11	Four subscales: speech in quiet, speech in noise, nonspeech signals, and speech without visual cues	NA
Glasgow Hearing Aid Benefit Profile (GHABP)	NA	Gatehouse	1999	Up to 8	Six topics addressed: preintervention disability, handicap, reported hearing aid use, reported benefit, satisfaction, and residual disability	NA

Table 1.1: (Continued)

Hearing Handicap Inventory	Target Population	Author/Developer(s)	Year	No. Items	Factors Measured	Time (min)
Hearing Disability and Aid Benefit Interview	NA	Gatehouse	1999	Up to 126	Client is asked 7 questions each for 14 common listening situations and 4 listener-specified situations to assess relevancy of situation, pre-intervention disability and handicap, hearing aid use, and hearing aid benefit	NA

*NA = not available. * Cited in Schow and Nerbonne, 1996; ⊗ cited in Hull, 1992; λ cited in Alpiner and McCarthy, 1993; ∅ cited in Giolas, 1994; # cited in Weinstein, 1997; ∞ cited in Dillon, Birtles, and Lovegrove 1999 .*

Chapter 2

Review of Literature

Hearing Handicap Inventory for the Elderly

Ventry and Weinstein (1982) developed the Hearing Handicap Inventory for the Elderly (HHIE; Appendix A) to assess the emotional and social adjustment of elderly people (age 65 years or older) to a hearing loss. It is comprised of two subscales: emotional reactions to a hearing loss (emotional subscale) and how social situations are affected by a hearing loss (social-situational subscale) to conform to their hypothesis that a hearing impairment becomes a hearing handicap “when it affects behavior and when it affects the emotional well-being of the hearing-impaired person.” (Ventry and Weinstein, 1982, p. 129). Thirteen of the 25 questions assess social-situational reactions (abbreviated S), and the remaining 12 assess emotional reactions (abbreviated E). Respondents are to answer *Yes*, *Sometimes*, or *No* to each question. A hearing handicap score is calculated by summing all responses, where each *Yes* response is worth 4 points, each *Sometimes* response is worth 2 points, and each *No* response is worth 0 (zero) points. Scores for each subscale (S and E) can be calculated separately and/or conjointly. A *Not Applicable* category is not included as a possible response. Although all emotional questions would be applicable, not all situations may be applicable to every individual. Respondents are encouraged to answer even those questions involving situations that they either avoid or do not experience. In essence, they are encouraged to respond as if they were to engage in those specific activities. The maximum score on the HHIE is 100 points. The higher the patient's score, the more the patient perceives a hearing handicap. An HHIE score of 16 or less, or 16% or less, is taken to indicate no handicap, 17%-42% represents a mild handicap, and a score of 43% or greater indicates a significant handicap (Weinstein and Ventry, 1983). A score of 18 or greater, therefore, is indicative of a substantial self-perceived hearing handicap.

The Hearing Handicap Inventory for the Elderly—Screening version (HHIE-S; Appendix B) is an abbreviated version of the HHIE (Ventry and Weinstein, 1983). It consists of 10 questions, compared to the 25 questions of the HHIE. The two sub-categories, emotional and social-situational reactions to a hearing loss, are still represented in the screening version, and scoring is performed in essentially the same way as for the HHIE. The highest possible score on the HHIE-S, however, is 40. A cutoff of 8 is used to distinguish those who do not have a hearing handicap from those who do. Scores of 0-8 represent no perceived handicap, while scores of 10-40 represent proportionally higher degrees of perceived handicap. In a study of the validation of screening tools by Lichtenstein, Bess, and Logan (1988b), subjects with an HHIE-S score of 0-8 had a 13% probability of having a hearing impairment, scores of 10-24 were associated with a 50% probability of having a hearing impairment, and scores of 26 or more were associated with an 84% probability of having a hearing impairment. The *sensitivity*, the degree to which a measure correctly identifies impairment, and the *specificity*, the degree to which a measure correctly identifies the absence of impairment, were evaluated against Ventry and

Weinstein's (1982 and 1983) pure tone criteria. Those pure tone criteria were defined as follows: a subject had a hearing impairment if the subject had a hearing loss of 40 dB HL or greater for either 1000 or 2000 Hz in both ears, or the subject had a hearing loss of 40 dB HL or greater at 1000 and 2000 Hz in the same ear. With a score of 8 as a cutoff point, the HHIE-S had sensitivities ranging from 53 - 72% and specificities ranging from 70 - 84% (Lichtenstein, Bess, and Logan, 1988a).

Ventry and Weinstein (1982) found the HHIE to be a highly reliable measure of hearing handicap, with reliability coefficients (alphas) ranging from 0.88 to 0.95. For subjects 65 years old and older, the mean HHIE score was about 30, with a range between 0 and 98. This range indicates that the degree of hearing handicap cannot be measured directly from audiometric data and that individuals react very differently to hearing impairment. Ventry and Weinstein (1983) found that pure tone sensitivity measures accounted for 31-38% of the variance in the total HHIE score, as well as in the emotional and social-situational subscales. Speech recognition ability accounted for only 14-20% of the variance in HHIE scores. Matthews, Lee, Mills, and Schum (1990) also found a low correspondence between audiometric measures of hearing handicap and self-reported hearing handicap as measured by the HHIE. The correlations between pure tone thresholds and self-reported hearing handicap ranged from 0.39 to 0.63. Audiometric pure tone thresholds were found to account for approximately 40% of the variance in HHIE scores.

Ventry and Weinstein (1983) studied the relationship between audiometric data (pure tone sensitivity and word recognition ability) and HHIE scores. They found that as hearing loss increased, as measured by pure tone sensitivity, the HHIE score also increased. Results, however, were extremely variable. Listeners who had pure tone averages between 26 dB HL and 40 dB HL (a mild hearing loss) in the better ear had the most variable response on the HHIE. Of those listeners, 54% perceived little or no handicap, 46% perceived some degree of hearing handicap, and 16% of that 46% perceived significant hearing handicap. The degree of perceived handicap was defined by the HHIE score. A score of 0-16% was considered *no handicap*, a score of 18-42% was considered a *mild to moderate handicap*, and a score of greater than 42% was considered a *significant handicap*. Pure tone averages greater than 40 dB HL were associated with a sharp increase in HHIE scores. As the pure tone averages approached the normal range, there was a sharp decrease in HHIE scores. There was an even weaker correlation between word recognition scores and HHIE scores than was found between pure tone averages and HHIE scores. These results are not unexpected given the poor reliability of word recognition scores based on a tradeoff between measurement error and sample size, as described by Thornton and Raffin (1978).

Weinstein, Spitzer, and Ventry (1986) further assessed the test-retest reliability of the HHIE. The original HHIE can be administered by two methods: either face-to-face or via a pencil-and-paper version. The face-to-face administration involves the clinician's asking the HHI questions verbally in an interview situation. The pencil-and-paper version is given to the patient for him or her to read and complete, either in the clinic or at home. Both methods were found to have high test-retest reliability. For the face-to-face administration approach, the reliability coefficients for the total score and the two subscales ranged from 0.92 to 0.96. For the pencil-and-paper administration approach, the reliability coefficients for the total score and the two subscales ranged from 0.79 (just below a value considered to be acceptable) to 0.84. The reliability of the total score for the pencil-and-paper method was 0.84. The high test-retest reliability for both administration approaches indicates that the self-assessment scale can be used to assess outcomes of aural rehabilitation.

In clinical settings, the possibility exists that the clinician might verbally ask the HHIE questions, with the subsequent HHIE being completed by the pencil-and-paper administration approach. Newman and Weinstein (1989), therefore, studied the test-retest reliability of the HHIE when these two administration methods were used in combination. They found that the HHIE was highly reliable across administration approaches. The test-retest reliability for the total score was 0.94, with the two subscales having reliability coefficients of 0.91 (emotional) and 0.94 (social-situational). This finding supports the use of the HHIE as an outcome measure, even when test and retest are administered by different approaches.

Malinoff and Weinstein (1989) studied the use of the HHIE as a measure of hearing aid benefit in the elderly population. They found a significant reduction in HHIE scores after a three-week period of hearing aid use. Due to the high test-retest reliability of the HHIE, the reduction in scores was indicative that the fitting of hearing aids had a positive effect on the elderly population tested, and consequently on measured HHIE scores.

Taylor (1993) also found that after three weeks of hearing aid use, patients' HHIE scores decreased significantly. Weinstein (1991) found a similar decrease in HHIE-S scores after a three-week period. These studies suggest that the decrease in HHIE and HHIE-S scores reflects a reduction in self-perceived hearing handicap, and that, given the high test-retest reliability of these self-assessment scales, the perceived changes in hearing handicap could be attributed to successful aural rehabilitation.

Bess (1995) reported that non-wearers of hearing aids had lower HHIE-S scores than wearers of hearing aids, irrespective of degree of hearing loss. As the pure tone average in the better ear increased, the HHIE-S score also increased. For all pure tone average levels, however, the subjects who did not wear hearing aids consistently had lower HHIE-S scores than subjects who chose to pursue amplification. Bess attributed this finding to the fact that hearing-impaired persons who chose not to pursue amplification typically had milder degrees of hearing impairment.

Newman, Jacobson, Hug, Weinstein, and Malinoff (1991) showed that an HHIE-S score of 18 or more was notably related to successful hearing aid use. More specifically, they found significant improvement in the perceived emotional and social-situational effects of hearing impairment, based on change in HHIE-S scores, following short- and long-term hearing aid use in clinical patients having pre-aided HHIE-S scores of 18 or more. In the same study, Newman et al. also established a 95 percent confidence interval of 9.3 for use in assessing a true change in perceived handicap between two administrations of the HHIE-S. They recommended that the 9.3 value be rounded up to 10 for clinical purposes. A score obtained on the screening inventory after a hearing aid fitting, therefore, would have to be lower by 10 or more than the pre-fitting score for the fitting to be considered beneficial.

The HHIE and the HHIE-S have the potential for use as screening tools for hearing loss in the elderly population (Lichtenstein, Bess and Logan, 1988b; Bess, 1995). Mulrow, Tuley, and Aguiar (1990) evaluated the use of both the long and short versions of two different self-assessment scales in hearing screening. One set of scales compared was the Hearing Handicap Inventory for the Elderly (HHIE) and its companion short version, the HHIE-S. The other was the Revised Quantified Denver Scale of Communication Function (RQDS) and its short version, the RQDS -S. The authors found the discriminative ability, or sensitivity, for correctly identifying hearing loss for the scales to be as follows: HHIE - 78%, HHIE-S - 79%, RQDS - 73%, and RQDS-S - 74%. Using the HHIE-S cutoff points for identifying people with hearing handicap and those without hearing handicap, as defined by Ventry and Weinstein (1983), and comparing to corresponding cutoff points on the RQDS-S, the HHIE-S identified significantly more true positives than the RQDS-S. At lower cutoff points, the difference between the two scales in identifying true positives was not statistically significant. The authors concluded that: (1) the short versions of both scales were as clinically effective as the long-version counterparts, and (2) the HHIE-S was a superior and versatile tool for use both in hearing screening and as an outcome measure.

Lichtenstein, Bess, and Logan (1988a) also studied the performance of the HHIE-S against differing definitions of hearing loss. Patients over the age of 65 years from offices of four primary-care internists' practices in the Nashville, Tennessee, area participated in the study. The differing definitions of hearing loss included: Pure tone Audiometry (1982 and 1983, criteria), Speech Frequency Pure Tone Average (SFPTA), High Frequency Pure Tone Average (HFPTA), Speech Reception Threshold (SRT), and Speech Recognition (Word Recognition Score). Different cutoff points were initially chosen (2, 8, 16, and 24) to generate receiver-operating curves. The investigators found that those subjects with HHIE-S scores of 0-8 had likelihood ratios between 0.36 and 0.55. Likelihood ratios less than 1.0 are associated with a reduced probability that hearing loss is present. For the HHIE-S scores of 10-24 and 26-40, their data resulted in likelihood ratios ranging from 1.46 - 2.71 and 4.16 - 23.19, respectively. Raising the cutoff point increased the probability that individuals were categorized as hearing impaired, regardless of the definition of hearing loss. The sensitivity and specificity were specified for the various definitions of hearing loss. With the cutoff point set to 8, the *sensitivities* for the HHIE-S for the differing definitions of hearing impairment were as follows: Ventry and Weinstein pure tone criteria = 72%, SFPTA = 66%, HFPTA = 53%, SRT = 62%, and Speech Recognition (Word Recognition Score) = 63%. The *specificities* for the HHIE-S for the differing definitions of hearing impairment were as follows: Ventry and Weinstein pure tone criteria = 77%, SFPTA = 79%, HFPTA = 84%, SRT = 72%, and Speech Recognition = 72%. The authors concluded that the HHIE-S was a robust tool for screening hearing loss in the elderly population.

In another study by Lichtenstein, Bess, and Logan (1988b), sensitivity and specificity of the HHIE-S were analyzed for patients at two differing test locations: the hearing center and the physician's office. With a cutoff of 8 on the HHIE-S, the sensitivities were 72% and 76%, and the specificities were 77% and 71%, for the hearing center and the doctor's office, respectively. When the cutoff was raised to 24 on the HHIE-S, the sensitivities were 24% and 30% and the specificities were 98% and 96%, for the respective locations. The best results with respect to identifying hearing loss were found with the use of a Welch-Allyn Audioscope® in combination with the HHIE-S.[1] Test accuracy increased to 83% with the use of both instruments, but each tool separately (HHIE-S and the Audioscope) was shown to provide a valid, reliable, and inexpensive means for screening hearing loss in the elderly population.

Hearing Handicap Inventory for Adults

The Hearing Handicap Inventory for Adults (HHIA; Appendix C) was developed in 1990 by Newman, Weinstein, Jacobson, and Hug for use with adults under the age of 65 years. This Hearing Handicap Inventory is similar to the HHIE. Three questions were changed from the HHIE to account for the differing, primarily occupational, situations that younger adults experience as compared to elderly adults (who are typically retired). Like

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[1] This instrument is a portable otoscope capable of generating tones at 25 dB HL or 40 dB HL at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz.

the HHIE, the HHIA has two subscales: social-situational reactions to a hearing loss and emotional reactions to a hearing loss. As with the HHIE, 13 questions address the social-situational reactions to a hearing loss and 12 questions address the emotional reactions to a hearing loss, for a total of 25 questions. The HHIA is scored the same way as the HHIE. The maximum possible score is 100, which represents the strongest perception of hearing handicap. The points are totaled to produce an overall score, and subtotals can be calculated for each of the two subscales.

The screening version of the HHIA, the HHIA-S (Appendix D), was developed by Newman, Weinstein, Jacobson, and Hug (1991). It consists of 10 questions taken from the original 25 questions of the HHIA. The HHIA-S contains 8 of the 10 HHIE-S questions; thus only two questions differ between the HHIE-S and the HHIA-S. The maximum score for the HHIA-S, as with the HHIE-S, is 40 points.

Newman et al. (1990) studied the psychometric adequacy and the audiometric correlates of the HHIA. They found high internal consistency reliability (0.93 for the total HHIA score) and a low standard error of measurement. The coefficient alpha for the social-situational subscale was 0.85, and for the emotional subscale, 0.88. There was a weak, but statistically significant, relationship between the HHIA scores and pure tone sensitivity (based on SFPTA and HFPTA). Newman et al. found reliability coefficients to range from 0.29 - 0.35. There was also a weak negative, yet statistically significant, relationship between HHIA scores and Word Recognition Scores (-0.26 to -0.28). Newman et al. concluded that because the pure tone sensitivity and the Word Recognition

Scores did not account for the large variation in the HHIA scores, it is important to evaluate the patient's own reaction to his or her hearing loss. The range of scores obtained was 0-90 points, indicating a broad range of self-perceived hearing handicap. These findings substantiated earlier findings, based on work with the HHIE (and reported above), that audiometric measures alone are insufficient to predict a patient's reaction to a hearing loss.

Newman et al. (1991) evaluated the test-retest reliability of the HHIA and the HHIA-S. Their purpose was to evaluate the efficacy of using the HHIA as a measure of aural rehabilitation outcomes, such as hearing aid benefit. The test-retest reliability of the HHIA was high, with *r*s ranging from 0.93 to 0.97. The correlation coefficients for the HHIA-S were also good, with a range from 0.82 to 0.93. The standard error of measurement was low for both the HHIA and the HHIA-S. Newman et al. concluded that the HHIA and the HHIA-S can be used as outcome measures due to the two self-assessment scales' high test-retest reliability.

O'Rouke, Britten, Hill, and Malson (1996) investigated the potential of the HHIA as a hearing screening tool, in effect as a replacement for audiometric screening. They found the internal consistency reliability (Chronbach's alpha) to be high (0.91). The two subscales' internal consistency reliability was also high, 0.82 and 0.84 for the emotional and social-situational subscales, respectively. Coefficient alphas for the HHIE-S and the social-situational subscale were 0.85 and 0.84, respectively. Coefficient alpha, however, for the emotional subscale was substantially lower—0.35. This latter finding contrasts with that of earlier studies and no explanation for the low number was offered. The authors found that subjects who failed the audiological screening scored significantly higher on the HHIA and the HHIA-S than subjects who passed the audiological screening. They expressed their belief that the HHIA and HHIA-S have the potential to be useful additions to a hearing screening protocol for adults, and that the scales may be particularly useful when ambient noise levels are too high for traditional pure tone audiometric screening.

Multimedia Hearing Handicap Inventory

The Multimedia Hearing Handicap Inventory (MHHI), developed by Punch and Weinstein (1996), incorporates the HHIA-S and the HHIE-S into an interactive program for use in a multimedia environment. Currently, a PC with a Windows 95/98 operating system is required to run the program, which is commercially available. The Inventory is stored on a CD-ROM, and runs from the disk. For each social-situational question, there is an option to view a video illustration of the type of situation to which the question refers, and for each emotional question, the respondent has the option to have the question rephrased. The MHHI can be taken with reference to either an unaided or aided listening condition. At the time of program installation, selected information is stored on the system hard drive, and key data produced by the program during its administration are stored on a database that resides on the hard drive.

The MHHI is compartmentalized into a long program (LP) and a short program (SP). The long program provides an educational context in which either the HHIA-S or HHIE-S, depending on the respondent's age range, is embedded. Basic information about hearing loss and, for those who need it, a brief introduction to the computer, occur early in the long program. Following the questionnaire, respondents can view a section on *Treatments for Hearing Impairment*. Finally, an individualized *Hearing Profile* can be printed out, which the respondent can take home.

By incorporating counseling information in the context of an educational framework, and providing written recommendations for follow-up, the MHHI is consistent with the Health Belief Model (Janz & Becker, 1984; Rosenstock, 1990). This model suggests that patients are likely to comply with medical recommendations when they consider themselves vulnerable to a particular condition, when the condition is perceived as having serious medical or social consequences, when they perceive benefits from seeking assistance, and when they perceive that few barriers to compliance exist. To maximize the applicability of the Health Belief Model, the developers suggest that respondents be encouraged to view the Multimedia HHI in its entirety (i.e., the long program).

In the long program, the respondent can select a male or female talker as the narrator. The text that the male or female talker narrates is also visible for the subject to read at the same time through open captioning at the bottom of the computer monitor. The long program takes about 15-20 minutes to complete. Patients answer each of the 10 questions in the questionnaire portion by clicking (with the mouse) on either *Yes*, *Sometimes*, or *No*, which have respective weights of 4, 2, and 0. The computer automatically calculates and stores the S, E, and total (T) scores. A *Hearing Profile* containing the respondent's total hearing handicap score and individualized follow-up recommendations is printed out at the end of the questionnaire. The specific components of the long program are described in Appendix E.

The short program of the MHHI consists of only the *MHHI Questionnaire* and the *Hearing Profile*. It bypasses the introductory information and goes directly to the HHIA-S or the HHIE-S, depending on the age selected. It utilizes the male voice as the default and, like the long version, all text narrated by the male talker is available for the subject to read at the bottom of the computer monitor. The short program takes approximately two minutes to complete.

As shown in Table 2.1, the *Hearing Profile* consists of one of eight possible semi-customized sets of recommendations, based on whether or not the given respondent has previously completed the questionnaire, whether the hearing handicap score is 0-8 or 10-40, and whether the condition referred to is unaided or aided. Components of the *Hearing Profile* are detailed in Appendix F. Respondents who have taken the *MHHI Questionnaire*

Table 2.1: Hearing Profile contingencies.

Profile	Score*	Database	Aided
1	0-8	No	Unaided
2	0-8	No	Aided
3	0-8	Yes	Unaided
4	0-8	Yes	Aided
5	10-40	No	Unaided
6	10-40	No	Aided
7	10-40	Yes	Unaided
8	10-40	Yes	Aided

*There are no odd-numbered scores, such as 9, because response values are based on even numbers (i.e., Yes = 4, Sometimes = 2, No = 0), and the total score is derived by summing these values.

previously (with results stored on the database) are informed of their hearing handicap score on the most recent test date, as well as their current score. Profiles 1 and 3 (Table 2.1) are ones in which unaided respondents who have low hearing handicap scores are recommended to retake the questionnaire in one year, and to contact their audiologist or physician if they feel they have a problem that affects their hearing. Profiles 2 and 4 are ones in which aided respondents are told that their scores indicate that they are performing well with their hearing aid(s). Respondents who receive Profiles 5 and 7 are considered candidates for hearing or hearing aid evaluations, and are referred to an audiologist. Respondents who receive Profiles 6 and 8 are informed that they are experiencing hearing problems even with their hearing aids, and that they should consider repair or replacement of their current aid(s), or additional interventions to supplement their hearing aids. For individuals who have previously viewed either the short or long program, their Profiles note their most recent score, and provide critical-difference information (in lay terms, based on data from paper-and-pencil versions of the HHI) that will assist them in determining whether the previous score is substantially different from the current score. The design and substantive content of the eight possible *Hearing Profiles* are given in Appendix G.

For each respondent, the MHHI stores 23 data items to the system's hard drive on a given test date: (1)-(10) weights representing answers to the 10 respective questionnaire items, (*Yes*=4; *Sometimes*=2; *No*=0), (11) total E, the total emotional-item score, (12) total S, the total social-situational-item score, (13) total, the total E + S score, used in interpreting the printed *Hearing Profile*, (14) listening condition (Unaided; Aided), (15) age (Below 40; 40 to 60; 61 to 80; Above 80), (16) respondent's name, (17) respondent's ID number, (18) date, (19) time, (20) voice gender (Male; Female) preferred by the respondent, (21) number of times ILLUSTRATE button was accessed, (22) number of times REPHRASE button was accessed, and (23) whether the long program (LP) or short program (SP) was accessed. The examiner's name, title, address, and phone number are stored on the hard drive, apart from the database information, and printed out as part of the *Hearing Profile* for use as contact information for the respondent.

For retrieval purposes, the above data items are stored on the database as comma-delimited text. This allows a simple means of importing the data to a database, statistical package, spreadsheet, or word processing application of the user's choice. Such importation is essential to the reporting and analysis of aggregate or longitudinal data, but is not necessary for routine clinical use. The database information was used as a primary source of data for the analyses in this study.

This experiment sought to answer two primary questions concerning the use of the Multimedia Hearing Handicap Inventory: (1) Does the MHHI, when administered on a test-retest basis, provide a reliable measure of perceived hearing handicap in populations of young and elderly adults? (2) What is (are) the 95 percent critical-difference value(s) that may be used to evaluate the significance of differences in pre- and post-intervention MHHI scores?

Several additional questions were of secondary interest in the experiment: (1) How favorably do subjects react to the design and functional utility of the MHHI? (2) To what extent are the educational and socioeconomic levels of the subjects, and their general familiarity with computers and other technologies, associated with these reactions? (3) Given the limited subject sample in this study, what evidence is available to suggest that the MHHI provides a valid predictive measure for screening hearing loss in young and elderly adults?

Chapter 3

Method

Overview

In two separate test sessions, adults with a range of hearing sensitivity were administered a case history, one of three test-retest sequences of the Multimedia HHI (MHHI), and a battery of routine audiologic measures. Case history information and audiologic data were used to determine eligibility for participation in the study and for inclusion in specific components of the data analyses. Analyses related to the assessment of predictive validity were confined to 27 subjects, while the remaining analyses were conducted on all 36 subjects.

Subjects

Subjects were recruited from the greater Lansing, Michigan, community. They were recruited from the patient caseload of the Oyer Speech-Language-Hearing Clinic of Michigan State University, the membership of the East Lansing Senior Center, and from student and subject referrals.

The subjects were 18 men and 18 women, for a total of 36. Subjects were randomly assigned to one of three subject groups, based on test-retest sequence: Long Program/Short Program (LP/SP), Short Program/Short Program (SP/SP), or Short Program/Long Program (SP/LP). It was required, however, that six men and six women be assigned to each of the three groups, for a total of 12 per group, and that an equal number of adult and elderly adult subjects be administered the respective components of the *MHHI Questionnaire*. For purposes of the study, *adults* were considered those aged 60 or younger, while *elderly adults* were considered those aged 61 years or older.[2] Eighteen of the subjects qualified as elderly, with this subgroup consisting of 7 males and 11 females. Of the remaining 18 qualifying as non-elderly adults, 7 were females and 11 were males. A breakdown of subjects by gender and group is shown in Table 3.1.

Table 3.1: Distribution of male and female subjects in each test group, subdivided by adult subjects (MHHI-A) or elderly adult subjects (MHHI-E).

Group	Number of Males	Number of Females
LP/SP	6	6
SP/SP	6	6
SP/LP	6	6
MHHI-E	7	11
MHHI-A	11	7
Total	18	18

The 36 subjects ranged in age from 26-80 years. The mean ages for the three experimental groups were 61.2 for the LP/SP group, 63.6 for the SP/SP group, and 61.6 for the SP/LP group. The age distributions for the various subject groups and subgroups are given in Table 3.2. It is evident that the mean ages of adult (50.9 years) and elderly adult subjects (73.3 years) differed considerably and that the mean ages across the three experimental groups and subgroups were highly similar.

The subjects' hearing thresholds ranged from normal hearing to moderately severe hearing impairment. Of the 36 subjects, 24 had normal hearing (three-frequency PTA ≤25 dB HL),

[2] This dichotomy is consistent with the design and function of the MHHI.

nine exhibited mild hearing impairment (>25 dB HL and ≤40 dB HL), two had moderate losses (>40 dB HL and ≤55 dB HL), and one had a moderately severe hearing loss (>55 dB HL and ≤70 dB HL). All hearing losses were sensorineural, as determined by air- and bone-conduction thresholds that were within no more than 10 dB of one another at each audiometric frequency for a given ear. The mean hearing thresholds for the better ear [based on the three-frequency pure tones averages or Speech Reception Thresholds (SRT)] can be seen for the three experimental groups in Figure 3.1. The mean thresholds for elderly subjects versus adult subjects are given in Figure 3.2, while the mean thresholds for male subjects versus female subjects are shown in Figure 3.3.

Table 3.2: Means and standard deviations for subjects, subdivided by inventory, gender, experimental group, and age.

Group	Number of Subjects	Mean Age	Age Range	Standard Deviation
MHHI - E	18	73.3	17 (63 - 80)	3.5
MHHI - A	18	50.9	33 (26 - 59)	9.6
LP / SP	12	61.2	37 (43 - 80)	14.0
SP / SP	12	63.6	42 (34 - 76)	12.3
SP / LP	12	61.6	51 (26 - 77)	14.7
Males	18	57.3	54 (26 - 80)	15.8
Females	18	66.6	24 (51 - 75)	8.7
LP / SP - Elderly	6	72.5	10 (70 - 80)	4.8
SP/ SP - Elderly	6	74.3	13 (63 - 76)	3.3
SP / LP - Elderly	6	73.0	6 (71 - 77)	2.2
LP / SP - Adult	6	49.8	16 (43 - 59)	10.0
SP / SP - Adult	6	52.8	24 (34 - 58)	6.6
SP / LP - Adult	6	50.2	33 (26 - 59)	12.7

Subjects with hearing loss and who wore hearing aids were included in the test-retest reliability study. Nine of the thirty-six subjects wore at least one hearing aid. Subjects who wore hearing aids were included in each of the three test groups. Three subjects wore monaural hearing aids in the LP/SP test condition, four subjects wore binaural hearing aids in the SP/SP test condition, and two subjects wore binaural hearing aids in the SP/LP test condition.

Because the performance of the subjects on the MHHI may have been affected by educational and socioeconomic factors, subjects were queried about education and (as a proxy for socioeconomic status) annual income. The subjects' educational levels are shown in Table 3.3. The educational levels of the subjects varied from not completing high school to completing professional and doctoral degrees. While 2.8% had not completed high school, 30.6% of the subjects had at least one year of college, 41.7% had bachelor's degrees, 13.9% had master's degrees, and 11.1% had either professional or doctoral degrees. The relatively high levels of education in the overall sample reflect the fact that most of the subjects were recruited within the community that included or surrounded Michigan State University.

Subjects' mean annual income levels are given in Table 3.4. The modal income (30.6%) was \$30,000-\$50,000. For 13.9% of the subjects, annual incomes of \$30,000 or under were reported, while 22.2% and 25%, respectively, reported incomes of \$50,000-\$75,000 and \$75,000 or more. Incomes were not reported by 8.3% of the subjects.

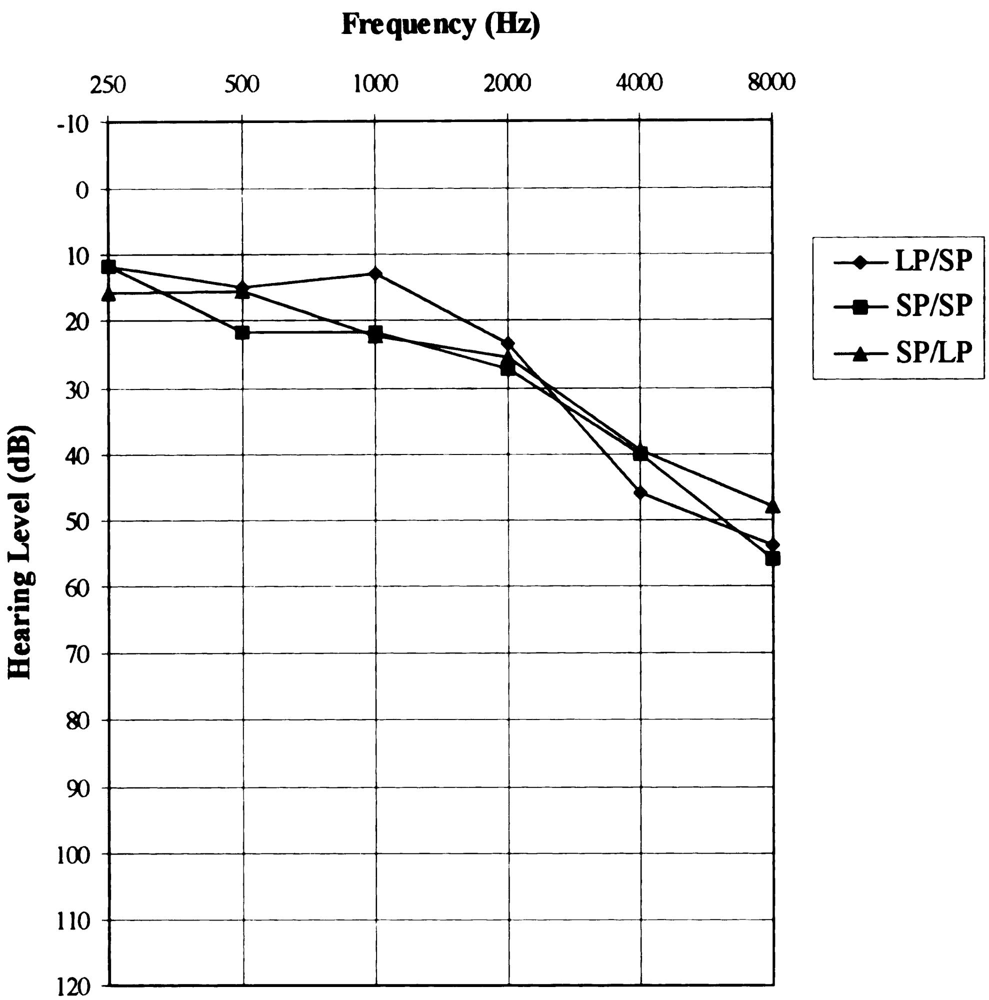

Figure 3.1: Mean air-conduction audiometric thresholds for the better ears of the experimental groups. Each group included 12 subjects, six of whom were adults and six of whom were elderly adults, classified as described in the text.

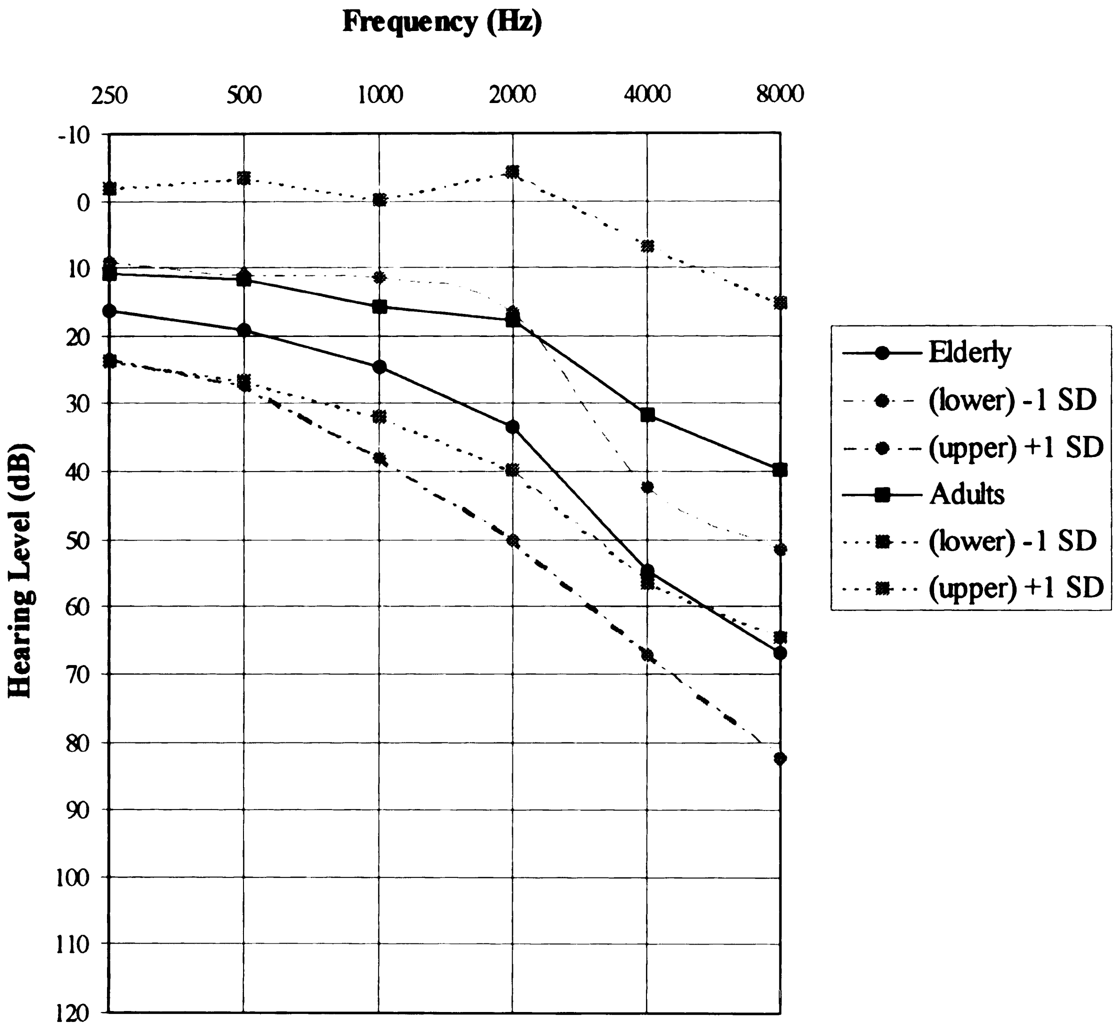

Figure 3.2: Mean air-conduction audiometric thresholds for the better ears of adult and elderly adult subjects. Each group included 18 subjects.

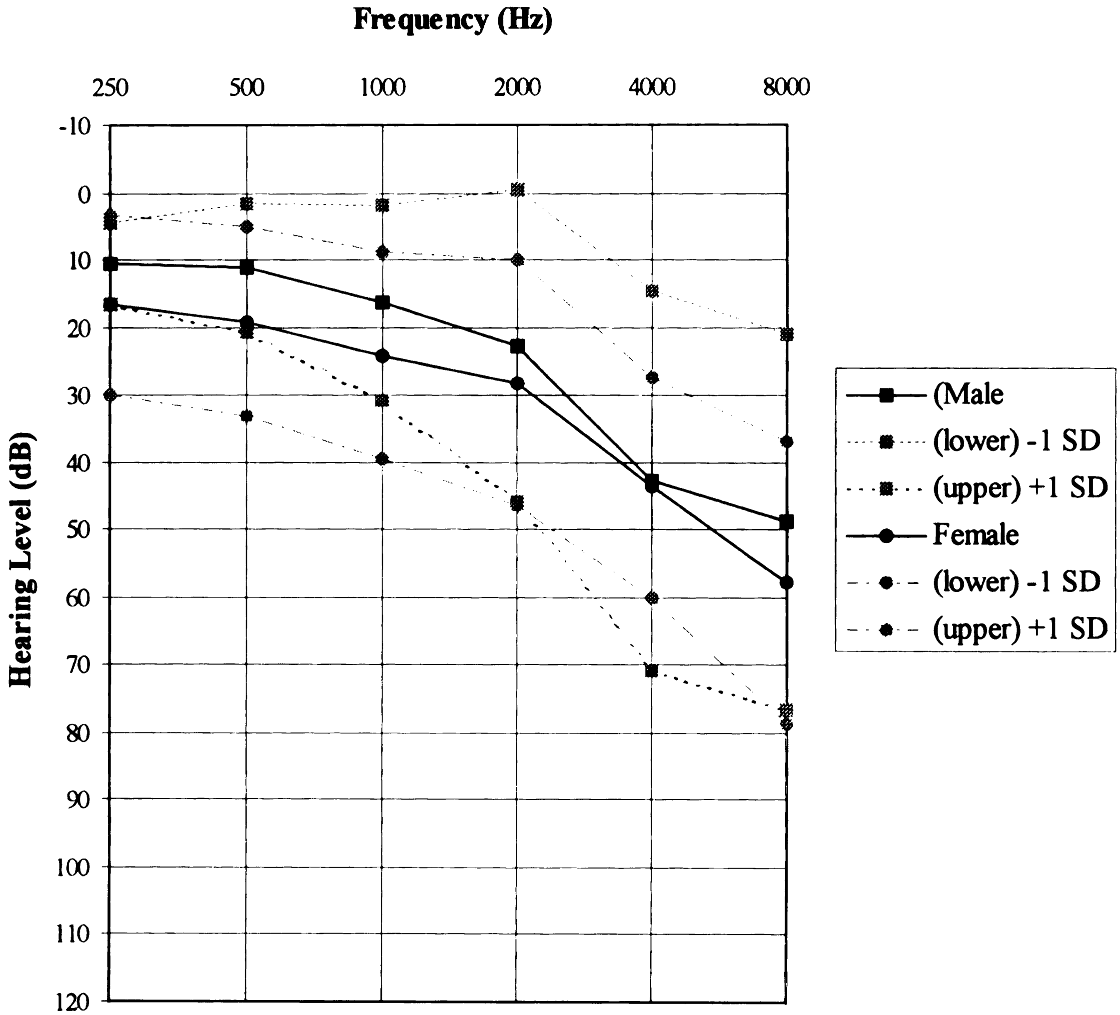

Figure 3.3: Mean air-conduction audiometric thresholds for the better ears of male and female subjects. Each group included 18 subjects.

Table 3.3: Subjects' educational levels.

Educational Level	Number	Percentage
Did not complete High School	1	2.8 %
One or more years of college	11	30.6 %
Bachelor's Degree	15	41.7 %
Master's Degree	5	13.9 %
Professional Degree or		11.1 %
Doctoral Degree	4	
Total	36	100.1 %

Table 3.4: Subjects' annual net incomes.

Income	Number	Percentage
$ 0 - $15,000	2	5.6 %
$15, 000 - $ 30,000	3	8.3 %
$ 30,000 - $ 50,000	11	30.6 %
$ 50,000 - $ 75,000	8	22.2 %
$ 75,000 or more	9	25.0 %
No Response	3	8.3 %
Total	36	100.0 %

Test-Retest Sequences

Recall that the three experimental groups were:

1. Test - Long Program / Retest - Short Program (LP/SP)
2. Test - Short Program / Retest - Short Program (SP/SP)
3. Test - Short Program / Retest - Long Program (SP/LP)

Any of these test sequences is likely to occur in a clinical setting. Although the developers of the MHHI (Punch and Weinstein, 1996) regard the LP/SP condition as the most preferred, the other two sequences are included because they are very likely possibilities in some clinical settings. For example, the SP condition may be administered as a screening measure of hearing handicap within or outside a hearing clinic, and the LP condition administered during an audiologic follow-up. To save time, some examiners might employ the SP/SP sequence. Because an LP/LP sequence is less likely to occur clinically, particularly within the three-week test-retest interval used in this investigation, it was not included as an experimental sequence.

Audiologic Evaluation

All audiometric testing was conducted bilaterally for each potential subject at the Oyer Speech-Language-Hearing Clinic, Michigan State University, in one of the Clinic's audiometric sound rooms. Otoscopy was first performed on each subject. Pure tone and speech audiometric testing was then performed using the GSI-16 audiometer equipped with Telephonics TDH-39 headphones and a Radioear B-71 bone-conduction receiver. SRTs were obtained utilizing CID W-1 spondee words (Hirsh, Davis, Silverman, Reynolds, Eldert, and Benson, 1952) and word recognition scores were obtained using List 1-A and 1-B of the NU-6 monosyllabic words (Tillman and Carhart, 1966). Audio CD recordings (Auditech of St. Louis) of these speech audiometric materials were used. Tympanograms were obtained with the GSI-33 immittance bridge, which was located in a quiet area outside the audiometric sound room. Electroacoustic analysis of any hearing aids worn by the subjects was performed using the Fonix 6500-C Hearing Aid Test System. Calibration of audiometric equipment was performed immediately prior to the experiment, and biological calibration was completed periodically throughout the experiment. In addition, a staff technologist maintained the calibration of all audiometric equipment used in the study as part of a regular maintenance schedule observed in the Oyer Clinic.

A multimedia-equipped PC, running at 200 MHz, with Sound Force 660 speakers and an associated inkjet printer, was used for all administrations of the MHHI. All MHHI administrations were completed in a sound-treated room designed to minimize external sound interference and internal sound reflections. The ambient noise in this room was typically around 43 dBA and 67 dBC, as measured by a Larson-Davis, Model 800B, sound level meter.

Interview Materials

A case history developed for the study was completed by all subjects prior to the first test session to assure their eligibility as participants. The case history questions were used to assess hearing health status, to determine possible causes of any existing hearing loss, and to establish a baseline against which to determine any change in hearing status between the first and second sessions. The case history consisted of the following questions (see Appendix H for case history form):

1. Do you think you have a hearing loss?
2. If so, was it gradual or sudden?
3. Do you notice any tinnitus (ringing or other sounds) in your ears?
4. Do you have a history of exposure to loud noises?
5. Do you have a history of ear infections?
6. Do you experience any dizziness or vertigo?

7. What medications are you currently taking?
8. What medications have you taken in the past for a prolonged period of time (one year or more)?
9. Have you noticed any fluctuation in your hearing in the past six months?
10. Do you currently wear hearing aids?
11. If so, how often and for how long do you wear the hearing aids?

A different set of case history questions was asked during the second session to assure consistency in hearing health during the test-retest interval. This was considered necessary to rule out extraneous factors (i.e., those outside the test measures themselves) that may have confounded results and interpretation of the test-retest reliability data. The following case history information was sought at the beginning of the second visit (see Appendix I for case history form):

1. Are you aware of a change in your hearing ability since the last test session?
2. Have you had a head injury since the last session?
3. Do you notice any tinnitus (ringing or other sounds) in your ears?
4. Has there been any change in any medications you are taking since the last session?
5. Do you experience any dizziness or vertigo?
6. Have you been exposed to loud noise since the last session?
7. If so, did you notice any tinnitus after the noise exposure?

8. Have you noticed any fluctuation in your hearing since the last session?
9. Have you acquired a new hearing aid, or aids, since the last session?
10. If so, how often and for how long do you wear it/them?
11. Has there been any change in the performance of your hearing aid(s) since the last session?

An exit questionnaire was administered at the end of the second session. Questions were answered on a 5-point Likert scale (1 - 5, where 1 = strongly disagree and 5 = strongly agree) and used to assess subject perceptions of the Multimedia HHI. The following is a list of questions used in the two exit questionnaires. (The actual questionnaires, as designed for two subgroups of subjects— those who performed either the LP/SP or SP/LP sequence or those who performed the SP/SP sequence, respectively—are shown in Appendices J and K.) Questions included in the Short Program Exit Questionnaire were:

1. The Multimedia Hearing Handicap Inventory program was easy to use.
2. The voice was easy to hear.
3. The voice was easy to understand.
4. The text was easy to read.
5. The *Hearing Profile* given to me at the end of the program was easy to understand.
6. I will follow the suggestions given to me in the *Hearing Profile*.

Questions included in the Long Program Exit Questionnaire were:

1. The Multimedia Hearing Handicap Inventory program was easy to use.
2. I found the section on use of the computer to be helpful.
3. I found the rephrasing of the questions helpful.
4. I found the illustrations of the questions helpful.
5. I learned some useful information about hearing loss from the program.
6. The voice was easy to hear.
7. The voice was easy to understand.
8. The text was easy to read.
9. I could easily follow the directions on how to use the program.
10. I learned some useful information about treatments for hearing loss.
11. The *Hearing Profile* given to me at the end of the program was easy to understand.
12. I will follow the suggestions given to me in the *Hearing Profile*.

Three additional questions were asked of each subject at the end of the exit interview. They were asked to indicate their salary range and educational level, and to rate the extent of their level of comfort with technologies including typewriters, calculators, adding machines, and computers.

Procedures

Approval for the use of human subjects in this study was sought and approved by Michigan State University's Institutional Review Board (IRB). Prior to the first test session, potential subjects were either mailed or given a case history form (paper-and-pencil format), which they completed at home and mailed back to the examiner. After receipt of the case history, the subjects were contacted by telephone. An effort was made to clarify all *Yes* responses on the case history form and to interpret the responses in light of their implications for participation in the study. The experimenter then made a decision regarding the eligibility of the individual to participate, and each participating subject was asked to sign an Informed Consent Form. Subjects were not paid for their participation, but were administered all audiologic tests free of charge and offered individual counseling following the completion of all experimental procedures.

Each subject was required to participate in two different test sessions (test and retest) separated by approximately a three-week interval. All subjects completed the retest exactly three weeks apart, with the exception of two subjects whose retest sessions were held three and one-half weeks after the first.

Both the first and the second sessions entailed the same test protocol: case history, MHHI, and audiological evaluation. This order was fixed for two, somewhat related, reasons: (1) to conform to what might be considered a typical clinical protocol, in which the MHHI is administered prior to the hearing evaluation to serve as the basis for audiologic referral, and (2) to preclude contamination of the MMHI hearing handicap score by perceptual biases that could potentially be introduced during the audiologic battery.

Table 3.5 indicates those conditions that signaled ineligibility of subjects to participate in either the reliability or the validity components of the study, based on the first case history. Students and professionals in audiology or speech-language pathology were excluded from all aspects of the study. Individuals who indicated the presence of a middle ear infection or sudden hearing loss within the past three months were excluded from both the validation and the reliability components, as were any persons for whom a fluctuating hearing loss was reported or documented. Subjects who currently wore hearing aids were administered all experimental measures, but only their data bearing on the test-retest reliability study were analyzed. Thirty-six subjects qualified for the reliability analysis, while 27 qualified for the validity analysis.

For subjects considered eligible for one or both analysis components, an appointment was made to complete the MHHI and an audiological evaluation. Each participating subject first completed the Multimedia HHI, with hearing aid users being instructed to answer as if they were wearing their hearing aids. A routine audiological evaluation followed, consisting of otoscopy, tympanometry, air- and bone-conduction audiometric thresholds, speech recognition thresholds (ASHA method, Asha, 1988) and word recognition testing. Test frequencies during pure tone audiometry included all audiometric frequencies between 250 Hz - 8000 Hz for air-conduction testing, and 250 Hz - 4000 Hz for bone-conduction testing. After audiologic testing, a listening check and electroacoustic analysis were performed on all hearing aids worn by subjects to determine whether the devices were working properly and appropriate for their current hearing losses. At the end of the first session, an appointment was made for the second session. The second visit started with a paper-and-pencil case history, completed by the subject. If the subject indicated any of the following conditions since the first evaluation, the subject was excluded from the test-retest reliability study: a significant hearing change, a head injury, tinnitus that was not present on the first case history, new hearing aids, a current hearing aid that was not functioning properly, or new medications that were potentially ototoxic. The case history was followed by the MHHI. An abbreviated audiometric evaluation, consisting of air-conduction thresholds and tympanometry, was then administered. For hearing aid users, the examiner performed a listening check and electroacoustic analysis of their hearing aids. The subjects completed a paper-and-pencil exit questionnaire. Lastly, the examiner answered any questions the subjects had about the purpose of the study, and counseled them with respect to their audiological findings and clinical follow-up recommendations.[4] The printed *Hearing Profiles* from the MHHI test and retest sessions were made available to the subjects at the end of the experiment.

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[4] All experimental procedures for patients of the Oyer Speech-Language-Hearing Clinic were administered in the context of any ongoing hearing and hearing aid evaluation appointments. Any new hearing aid fittings, however, were delayed until after the completion of all experimental procedures.

Table 3.5: Bases for eliminating subjects from test-retest reliability analysis and validity analyses, based on first case history.

Ineligibility for Test-Retest Reliability Analysis	**Ineligibility for Validity Analysis**
Current or recent middle ear infections (within last 3 months)	Current or recent middle ear infections (within last 3 months)
Sudden hearing loss (within last 3 months)	Sudden hearing loss (within last 3 months)
Reported or documented fluctuating hearing loss	Reported or documented fluctuating hearing loss
	Current hearing aid users[3]
Students or professionals in Audiology or Speech-Language Pathology	Students or professionals in Audiology or Speech-Language Pathology

Some subjects were excluded from the reliability analysis despite their completion of both test sessions. Such exclusion arose from factors related to information derived from their second case history or from results of the two hearing evaluations or two analyses of hearing aid performance. The bases for excluding subjects from the test-retest reliability study are shown in Table 3.6.

Significant health changes were characterized by any of the following conditions:

1. Subjects with a cold and exhibiting Type B or Type C tympanograms

[3] The experimental question with respect to validity was whether the MHHI, a measure of hearing handicap, is capable of identifying hearing impairment. Subjects who wear hearing aids may be presumed to have a hearing impairment and to admit it readily, particularly if asked to respond as if they were unaided. To obtain those data for the validity analysis, the examiner would have had to instruct them to refer to the unaided listening condition. That condition may be far removed from their immediate everyday (aided) experience and they may have had difficulty in reporting their perceptions based on unaided listening. In the reliability study, the examiner would have had to ask them to refer to the aided condition on the MHHI. It was decided, therefore, not to have hearing aid wearers participate in the validity study.

2. Subjects with a head injury since the first session and experiencing any of the following: tinnitus, dizziness, or vertigo
3. Subjects who were exposed to loud noise with post-exposure tinnitus
4. Subjects who noticed a fluctuating hearing loss
5. Subjects who had started taking potentially ototoxic medication(s) since first session
6. Subjects who perceived a change in their hearing status

Table 3.6: Bases for eliminating subjects from test-retest reliability analysis, based on second case history or audiometric data.

Ineligibility Based on Case History	Ineligibility Based on Audiometric Data
Documented or perceived fluctuating hearing loss	Non-functioning or malfunctioning hearing aids of current hearing aid users, or hearing aids whose functioning has changed since the first test session [defined by electroacoustic measurements: HFA-FOG, HFA SSPL90, or Equivalent Input Noise (EIN) > 5 dB between sessions]
Significant change, or potential change, in hearing health status since first session	Audiometric thresholds that differ between sessions by 10 dB HL or more at two frequencies, or 15 dB HL at one frequency
Malfunctioning hearing aid, or acquisition of new hearing aid(s) since first session	

The case history information, MHHI data, and audiometric findings from the first session were used for the validity analyses. For these analyses, an audiological pass was variously defined by the following criteria: Speech Frequency Pure Tone Average (SFPTA) < 25 dB HL, Speech Frequency Pure Tone Average (SFPTA) < 20 dB HL, Speech Reception Threshold (SRT) < 25 dB HL, Speech Reception Threshold (SRT) < 20 dB HL, High Frequency Pure Tone Average (HFPTA) < 25 dB HL, High Frequency Pure Tone Average (HFPTA) < 20 dB HL, the Word Recognition Score (WRS) $\geq$ 90 %, or the Ventry and Weinstein (1982, 1983) criteria. Ventry and Weinstein considered a subject as hearing impaired if a subject had audiometric thresholds at 1000 or 2000 Hz $\geq$ 40 dB HL in both ears and/or a subject had a hearing loss at 1000 and 2000 Hz $\geq$ 40 dB HL in one ear.

Chapter 4

Results and Discussion

Overview

In this chapter, results of the following analyses are reported and discussed: (1) a multivariate analysis of audiometric threshold data, (2) a descriptive analysis of MHHI scores, (3) analyses of MHHI's test-retest reliability and internal consistency reliability, (4) an analysis of critical-difference scores on the MHHI, (5) preliminary analyses of the MHHI's predictive validity, (6) analyses of the clinical utility and ease of use of the MHHI, (7) an analysis of the exit-interview questionnaire, and (8) an analysis of the relationship between ease of use of the MHHI and educational and income levels.

The analyses revealed the MHHI to have high test-retest reliability and internal consistency. A 95 percent critical-difference value of 10 was established as sufficient to reveal statistically significant differences in MHHI scores obtained across different administrations. The relatively low number of subjects, the low number of subjects with hearing loss, and the limited overall degree of hearing impairment exhibited, provided an insufficient basis for conclusions regarding the MHHI's predictive validity. Nonetheless, certain aspects of the analyses were encouraging. Subjects regarded themselves as generally familiar with selected technologies and responded favorably to the design and functional characteristics of the MHHI. No substantial relationship was revealed between subjects' perceptions of the MHHI and either their socioeconomic status or their level of comfort with technology. Finally, indications for future research are discussed.

Hearing Sensitivity Across Subject Groups

A General Linear Model (GLM) for repeated measures was used to determine significance of differences across subject groups. The subjects' thresholds in the three experimental groups (LP/SP, SP/SP, and SP/LP), shown in Figure 3.1, were analyzed to verify comparability of groups with respect to subjects' mean audiometric sensitivity. No significance differences were found in audiometric thresholds across the three experimental groups ($p < 0.05$). This outcome provides assurance that any differences that may occur among these groups in later analyses cannot be attributed to differences in hearing sensitivity among them.

When the GLM analysis was applied to a comparison of adult versus elderly adult subjects (Figure 3.2), a significant difference ($p > 0.05$) in audiometric thresholds was observed. Elderly adults exhibited poorer hearing thresholds at 2000, 4000, and 8000 Hz. Although this finding suggests the need for caution in interpreting the data, such differences between results for these two groups are not surprising, given the well-known higher prevalence of hearing loss in the elderly population.

Audiometric thresholds for male versus female subjects were subjected to a similar analysis. As demonstrated in Figure 3.3, females tended to have slightly poorer mean hearing thresholds than male subjects across a broad range of frequencies. This can probably be explained by the fact that female subjects had a higher mean age than the male subjects (Table 3.2). Results of the GLM analysis, however, revealed the differences not to be statistically significant except at 500 Hz. It is the author's view that such differences are not likely to account for any differences between the males' and females' responses to the MHHI.

Descriptive Analyses of MHHI

MHHI scores will first be reported by various subgroups. Descriptive analyses include the means, standard deviations, and 95% confidence intervals of the test and retest scores for the overall MHHI, MHHI-E, and MHHI-A (Table 4.1), as well as for the three experimental groups LP/SP, SP/SP, and SP/LP (Table 4.2). Scores reported in Table 4.1 and Table 4.2 cover the overall subject sample, and, therefore, include the scores of subjects without regard to their degree of hearing impairment. The mean MHHI scores ranged from 13.33 (MHHI-A retest) to 15.83 (LP/SP test). Mean results for the various subject subgroups were in excellent agreement from test to retest.

Test –Retest Reliability

Test-retest reliability refers to the extent to which a repeated test will yield the same score as the original test. The test-retest reliability of the MHHI was assessed using Pearson product-moment correlation coefficients (*r*s). Correlations were calculated for the overall MHHI, the MHHI-E, the MHHI-A (Table 4.3), the three experimental groups LP/SP, SP/SP, and SP/LP (Table 4.4), males and females (Table 4.5), and subgroups by age and gender (Table 4.6). In all cases, the reliability coefficients were calculated for the total scores and scores for each of the two subscales (emotional and social-situational).

Table 4.1: Means, standard deviations, and 95% confidence intervals for test and retest conditions for MHHI, MHHI-E, and MHHI-A. (standard deviations are in parenthesis; 95 % confidence intervals are in brackets).

Group	**Test**	**Retest**
MHHI	Total = 14.4	Total = 12.17
	(9.00)	(9.5)
	[11.4 - 17.4]	[10.9 - 17.4]
	Emotional = 6.0	Emotional = 5.4
	(4.7)	(4.9)
	[4.4 - 7.6]	[3.8 - 7.1]
	Social = 8.4	Social = 8.7
	(5.2)	(5.3)
	[6.6 - 10.1]	[6.9 - 10.5]
MHHI-E	Total = 15.0	Total = 15.0
	(8.1)	(8.0)
	[11.0 - 19.0]	[11.1 - 19.0)
	Emotional = 6.0	Emotional = 5.7
	(3.9)	(4.5)
	[4.1 - 7.9]	[3.5 - 7.9]
	Social = 9.0	Social = 9.3
	(4.8)	(4.4)
	[6.6 - 11.4]	[7.2 - 11.5]
MHHI-A	Total = 13.8	Total = 13.3
	(10.0)	(11.1)
	[8.8 - 18.8]	[7.8 - 18.8]
	Emotional = 6.0	Emotional = 5.2
	(5.4)	(5.4)
	[3.3 - 8.7]	[2.6 - 7.9]
	Social = 7.8	Social = 8.1
	(5.7)	(6.1)
	[5.0 - 10.6]	[5.1 - 11.2]

Table 4.2: Means, standard deviations, and 95% confidence intervals for the three experimental groups. (standard deviations are in parentheses; 95% confidence intervals are in brackets).

Group	Test	Retest
LP/SP	Total = 15.8 (9.8) [9.6 - 22.1] Emotional = 6.8 (4.4) [4.1 - 9.6] Social = 9.0 (6.4) [5.0 - 13.0]	Total = 14.8 (9.6) [8.7 - 21.0] Emotional = 5.5 (4.6) [2.6 - 8.4] Social = 9.3 (5.5) [5.9 - 12.8]
SP/SP	Total = 13.5 (9.0) [7.8 - 19.2] Emotional = 5.7 (5.2) [2.4 - 9.0] Social = 7.8 (4.8) [4.8 - 10.9]	Total = 13.7 (9.3) [7.7 - 19.6] Emotional = 5.3 (5.4) [1.9 - 8.7] Social = 8.3 (5.0) [5.2 - 11.5]
SP/LP	Total = 13.8 (8.8) [8.3 - 19.4] Emotional = 5.5 (4.7) [2.5 - 8.5] Social = 8.3 (4.7) [5.4 - 11.3]	Total = 14.0 (10.4) [7.4 - 20.6] Emotional = 5.5 (5.1) [2.3 - 8.7] Social = 8.5 (5.8) [4.8 - 12.2]

Pearson *r*s for the total scores and emotional and social-situational subscale scores of the MHHI showed test and retest scores to be highly correlated, being at least 0.86. Generally, high correlations were also observed for test-retest scores on the MHHI-E and MHHI-A, for emotional, social, and total scores. Each experimental group (LP/SP, SP/SP, and SP/LP) also showed high correlations for total and both subscales. Overall, all *r*s were high and statistically significant ($p < 0.01$), except for the scores of the elderly adult male group. All Pearson *r*s were greater than 0.7, thereby accounting for 50% or more of the variance, with the exception of elderly adult male subjects, whose respective Pearson *r*s for test-retest reliability for the emotional subscale and total score were 0.43 and .49. These relatively low correlations might be explained by a combination of relatively few subjects (7) and age, but appear not to be explained by either factor alone, as correlations were notably higher for the group of 7 adult females and 11 elderly females. Recall that the MHHI-E and MHHI-A questionnaires differ by only two questions. It seems reasonable to expect any differences in performance on these two versions of the questionnaire, therefore, to be attributed more to differences in age of the subjects than to differences in the inventories themselves. The overall conclusion from Tables 4.3-4.6 is that test-retest reliability was consistently high for all subject classifications except for the fairly small subgroup of elderly adult males.

Table 4.3: Pearson product-moment correlations for MHHI, MHHI-E, and MHHI-A, based on emotional score, social score, and total score.

Group	Emotional Score	Social Score	Total Score
MHHI (n = 36)	.86*	.86*	.91*
MHHI- E (n = 18)	.73*	.87*	.86*
MHHI - A (n = 18)	.93*	.86*	.94*

**Significant at 0.01 level, 2-tailed*

Table 4.4: Pearson product-moment correlations for three experimental groups, based on emotional score, social score, and total score.

Group	Emotional Score	Social Score	Total Score
LP-SP (n = 12)	.83*	.87*	.90*
SP-SP (n = 12)	.84*	.84*	.93*
SP-LP (n = 12)	.91*	.91*	.92*

**Significant at 0.01 level, 2-tailed*

Table 4.5: Pearson product-moment correlations for male and female subjects, based on emotional score, social score, and total score.

Group	Emotional Score	Social Score	Total Score
Males (n = 18)	.87*	.84*	.89*
Females (n= 18)	.86*	.88*	.93*

**Significant at 0.01 level, 2-tailed*

The MHHI Pearson *r*s are comparable to previous studies of other versions of the Hearing Handicap Inventories. Ventry and Weinstein (1982) found reliability coefficients ranging from 0.88 to 0.95 for the HHIE. Weinstein, Spitzer, and Ventry (1986) showed reliability coefficients for the HHIE to range from 0.92 to 0.96 and 0.79 to 0.84 for the emotional and social subscales, respectively. Newman, Weinstein, Jacobson, and Hug

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(1991) found Pearson *r*s ranging from 0.93 to 0.97 for the HHIA, and 0.82 to 0.93 for the HHIA-S. With a combined administration approach of verbally asking the HHIE questions and a pencil-and-paper completion, Newman and Weinstein (1989) again found the reliability to be high (total score = 0.94, emotional subscale = 0.91, and the social-situational subscale = 0.94).

Table 4.6. Pearson product-moment correlations for subjects subdivided by age group and gender, based on emotional score, social score, and total score.

Group	Emotional Score	Social Score	Total Score
Adult Males (n = 11)	.99*	.87*	.96*
Adult Females (n = 7)	.89*	.87*	.94*
Elderly Males (n = 7)	.43	.71	.49
Elderly Females (n=11)	.87*	.89*	.94*

**Significant at 0.01 level, 2-tailed*

The *MHHI Questionnaires* are highly reliable. Except for the limited case of elderly adult males, subjects tended to perform very similarly on test and retest administrations. Given no aural rehabilitation or intervention nor any change in their audiometric data between different administrations of the MHHI, subjects' scores can generally be assumed to reflect stabilized perceptions of their hearing handicap.

Internal Consistency Reliability

The internal consistency reliability of the MHHI was assessed using Cronbach's alpha (Cronbach, 1951; Carmines and Zeller, 1979). This measure provides a conservative estimate of the average value of the internal consistency of all possible combinations of items comprising half-tests (Iversen and Norpoth, 1976). Cronbach's alpha was calculated for the various subgroups of interest, covering test and retest scores and scores for the two subscales. The subgroups analyzed include adults and elderly adults, the experimental test groups (LP/SP, SP/SP, and SP/LP), adults and elderly adults within experimental groups, the MHHI-E, MHHI-A, and the overall MHHI.

Results are shown in Table 4.7 - Table 4.10. Total score alphas ranged from 0.79 (adults administered SP/SP test condition) to 0.96 (adults administered the SP/LP retest condition). Subscale alpha values ranged from 0.25 (emotional subscale for elderly adult subjects in the test SP/SP condition) to 0.95 (social subscale for adults in the retest SP/LP condition).

Results of the internal consistency reliability analysis for the MHHI are comparable to the results of O'Rouke, Britten, Hill, and Malson (1996) for the HHIA-S. O'Rouke et al. found the total score alpha to be high (0.91), with alpha for the emotional and social subscales being 0.82 and 0.84, respectively. The MHHI-A subscale values (see Table 4.7) were similarly high, ranging from 0.81 (social subscale) to 0.88 (emotional subscale). The lowest alpha occurred for the emotional subscale for the MHHI-E (0.61). Interestingly, in the study of Rouke et al., the emotional subscale also showed a substantially lower Cronbach alpha (0.35). Nonetheless, the relatively low number of subjects included in the present analyses may have been partially responsible for suppressing some of these internal cor

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consistency reliability values. O'Rouke et al. had 96 subjects in their study, whereas the number of subjects ranged from 6 to 36 for the various groups analyzed in this study.

Table 4.7: Cronbach's alpha for the MHHI by test and retest administrations and major subject subgroup.

Group	Cronbach Alpha - Test	Cronbach Alpha - Retest
MHHI (n = 36)	Total = .84 Emotional = .75 Social = .73	Total = .89 Emotional = .85 Social = .81
MHHI-E (n = 18)	Total = .82 Emotional = .61 Social = .75	Total = .85 Emotional = .77 Social = .77
MHHI-A (n =18)	Total = .87 Emotional = .82 Social = .81	Total = .93 Emotional = .88 Social = .86
LP/SP (n = 12)	Total = .84 Emotional = .64 Social = .84	Total = .89 Emotional = .77 Social = .82
SP/SP (n=12)	Total = .85 Emotional = .88 Social = .73	Total = .89 Emotional = .87 Social = .72
SP/LP (n = 12)	Total = .86 Emotional = .80 Social = .84	Total = .94 Emotional = .85 Social = .86

Table 4.8: Cronbach's alpha for the three experimental groups, subdivided by test and retest administrations, adult and elderly adult subjects, and inventory subscales.

Group	Cronbach Alpha - Test	Cronbach Alpha - Retest
LP/SP - MHHI-E	Total = .84	Total = .73
(n = 6)	Emotional = .62	Emotional = .65
	Social = .52	Social = .83
SP/SP - MHHI-E	Total = .89	Total = .86
(n = 6)	Emotional = .74	Emotional = .84
	Social = .81	Social = .60
SP/LP - MHHI-E	Total = .75	Total = .84
(n = 6)	Emotional = .25	Emotional = .71
	Social = .81	Social = .79
LP/SP - MHHI-A	Total = .81	Total = .92
(n = 6)	Emotional = .58	Emotional = .81
	Social = .93	Social = .85
SP/SP - MHHI-A	Total = .79	Total = .93
(n = 6)	Emotional = .95	Emotional = .95
	Social = .53	Social = .81
SP/LP - MHHI-A	Total = .93	Total = .96
(n = 6)	Emotional = .85	Emotional = .92
	Social = .85	Social = .95

Table 4.9: Cronbach's alpha for the two versions of the MHHI (short and long programs), for test and retest administrations in different experimental groups.

Program	**Cronbach Alpha - Test Data**	**Cronbach Alpha – Retest Data**
SP	SP-SP (n = 12) Total = .85 Emotional = .88 Social = .73	LP- SP (n = 12) Total = .89 Emotional = .77 Social = .82
	SP-LP (n = 12) Total = .86 Emotional = .84 Social = .80	SP-SP (n = 12) Total = .89 Emotional = .87 Social = .72
LP	LP-SP (n = 12) Total = .84 Emotional = .64 Social = .84	SP - LP (n = 12) Total = .94 Emotional = .85 Social = .86

Table 4.10: Cronbach's alpha for the MHHI-E and MHHI-A and the short and long programs of the MHHI.

Group	Cronbach Alpha - Test Data	Cronbach Alpha - Retest Data
MHHI-E - LP	LP/SP MHHI-E (n = 6) Total = .84 Emotional = .62 Social = .52	SP/LP MHHI- E (n = 6) Total = .84 Emotional = .71 Social = .79
MHHI-E - SP	SP/SP MHHI-E (n = 6) Total = .89 Emotional = .74 Social = .81	SP/SP MHHI-E (n = 6) Total = .86 Emotional = .84 Social = .60
	SP/LP MHHI-E (n = 6) Total = .75 Emotional = .25 Social = .81	LP/SP MHHI-E (n = 6) Total = .73 Emotional = .65 Social = .83
MHHI-A - LP	LP/SP MHHI- A (n = 6) Total = .81 Emotional = .58 Social = .93	SP/LP MHHI-A (n = 6) Total = .96 Emotional = .92 Social = .95
MHHI-A - SP	SP/SP MHHI-A (n = 6) Total = .79 Emotional = .95 Social = .53	SP/SP MHHI-A (n = 6) Total = .93 Emotional = .95 Social = .81
	SP/LP MHHI-A (n = 6) Total = .93 Emotional = .85 Social = .85	LP/SP MHHI-A (n = 6) Total = .92 Emotional = .81 Social = .85

Critical-Difference Scores

Ninety-five percent confidence intervals were calculated using the formula recommended by Demorest and Walden (1984):

$$(x_2 - x_1) \pm 2\sqrt{2}\,s_e,$$

where x_2 and x_1 are inventory scores on two respective occasions, $\sqrt{2}\,s_e$ is the standard error of the difference, and $2\sqrt{2}\,s_e$ is the critical-difference score (at the 95% confidence interval). Test-retest scores were used in all calculations. The critical-difference score is the change in score from one session to another that represents a statistically significant change. It is important in the context of this study because it provides examiners who administer the MHHI with a minimum value that signifies when a difference in two scores is large enough not to be attributable to chance. Such a value, particularly in view of the high overall test-retest reliability observed for the MHHI, is needed to be able to conclude that any aural rehabilitative intervention (e.g., hearing aids) is exerting a statistically significant effect.

Critical-difference scores for various experimental subgroups are presented in Table 4.11. Values ranged rather narrowly from 7.1 (SP/SP) to 8.7 (LP/SP). The critical-difference scores of the MHHI are similar to results from a previous study. Newman, Jacobson, Hug, Weinstein, and Malinoff (1991), who found a difference of 9.3 to indicate a true change in the HHIE-S score, suggested that a change of 10 or more would indicate a true change in scores for clinical purposes. Our overall findings suggest that a change in MHHI scores of at least 9 on different administrations would be adequate as an indicator of a true difference. Given that the test scores on the MHHI increment only by even-numbered values, the author recommends that a change in scores of at least 10 on different administrations should be regarded as a significant difference.

Table 4.11: Critical-difference scores (95% confidence interval).

Group	Number of Subjects	Critical-Difference Score
MHHI	36	7.9
MHHI-E	18	8.5
MHHI-A	18	7.3
LP/SP	12	8.7
SP/SP	12	7.1
SP/LP	12	8.0

Predictive Validity

As mentioned in the *Review of Literature*, one of the potential uses of the MHHI is as a screening measure of hearing impairment. As a research question, the goal of a predictive validity analysis was considered to be of secondary importance in the present study, mainly because of the limited number of subjects. This limitation restricted the distribution of subjects across a variety of degrees of audiometric hearing loss. Most of our hearing-impaired subjects demonstrated only mild or mild-to-moderate hearing loss. In addition, as explained earlier, hearing aid use served to disqualify some subjects from the validity analysis. As this criterion selectively precluded the participation of some hearing-impaired subjects, as opposed to normal-hearing subjects, it further reduced the number of hearing-impaired subjects whose data could be analyzed for predictive validity.

Despite these limitations, and despite the likelihood that they would produce unfavorable outcomes, several validity analyses were performed on the available data of the 27 eligible subjects. Sensitivity, specificity, and false-positive and false-negative rates were calculated for various MHHI cutoff scores, Pearson *r*'s for MHHI scores and selected audiometric indices were calculated, and the mean MHHI scores were calculated for different definitions of hearing loss.

First, the sensitivity and specificity for the MHHI were calculated using various MHHI cutoff points and various criteria for defining hearing impairment. MHHI cutoff scores included 2, 4, 8, 10, 16, and 24. These cutoffs were chosen based on the Lichtenstein, Bess, and Logan (1988a) study. The various definitions of hearing loss included: High Frequency Pure Tone Average (HFPTA) > 20 dB HL, High Frequency Pure Tone Average (HFPTA) > 25 dB HL, Speech Frequency Pure Tone Average (SFPTA) > 20 dB HL, Speech Frequency Pure Tone Average (SFPTA) > 25 dB HL, Speech Reception Thresholds (SRT) > 20 dB HL, Speech Reception Thresholds (SRT) > 25 dB HL, Word Recognition Scores < 90%, and the Ventry and Weinstein (1982 and 1983) criteria.

The data appear in Tables 4.12- 4.17. Sensitivity values ranged from 11.1 % to 55.6 % and specificity values ranged from 3.7 % to 81.8 %. These results show inadequately low sensitivity and specificity values. Outcomes were little affected by criteria used to define hearing loss. Only the use of an extremely high MHHI cutoff score, 24, resulted in reasonably high specificity values, but still at the cost of low sensitivity. Results differ from results of previous studies. Lichtenstein, Bess, and Logan (1988a), using an HHIE-S cutoff score of 8, obtained sensitivity values ranging from 53-72% and specificity values ranging from 70-84% against differing definitions of hearing loss.

Table 4.12: Sensitivity, specificity, false-positive, and false-negative rates using an MHHI cutoff score of 2, for various definitions of hearing impairment.

Criteria	Sensitivity	Specificity	False Positive	False Negative
HFPTA > 20	55.6%	7.4%	37.0%	0 %
HFPTA > 25	44.4%	3.7%	51.8%	0 %
SFPTA > 20	29.6%	7.4%	63.0%	0 %
SFPTA > 25	18.5%	7.4%	74.1%	0 %
SRT > 20	37.1%	7.4%	55.6%	0 %
SRT > 25	25.9%	7.4%	66.7%	0 %
WRS < 90%	18.5%	7.4%	74.1%	0 %
Ventry & Weinstein	11.1%	7.4%	81.5 %	0 %

Table 4.13: Sensitivity, specificity, false-positive, and false-negative rates using an MHHI cutoff score of 4, for various definitions of hearing impairment.

Criteria	Sensitivity	Specificity	False Positive	False Negative
HFPTA > 20	55.6%	11.1%	33.3%	0 %
HFPTA > 25	44.4%	7.4%	44.4%	0 %
SFPTA > 20	29.6%	11.1%	59.3%	0 %
SFPTA > 25	18.5%	11.1%	70.4%	0 %
SRT > 20	33.3%	11.1%	55.6%	0 %
SRT > 25	25.9%	11.1%	63.0%	0 %
WRS < 90%	14.8%	11.1%	74.1%	0 %
Ventry & Weinstein	18.5%	11.1%	70.4%	0 %

Table 4.14: Sensitivity, specificity, false-positive, and false-negative rates using an MHHI cutoff score of 8, for various definitions of hearing impairment.

Criteria	Sensitivity	Specificity	False Positive	False Negative
HFPTA > 20	51.8%	25.9%	18.5%	3.7 %
HFPTA > 25	44.4%	29.6%	25.9%	0 %
SFPTA > 20	33.3%	29.6%	37.0%	0 %
SFPTA > 25	18.5%	29.6%	51.8%	0 %
SRT > 20	33.3%	29.6%	37.0%	0 %
SRT > 25	25.9%	29.6%	44.4%	0 %
WRS < 90%	14.8%	29.6%	55.6%	0 %
Ventry & Weinstein	18.5%	29.6%	51.8%	0 %

Table 4.15: Sensitivity, specificity, false-positive, and false-negative rates using an MHHI cutoff score of 10, for various definitions of hearing impairment.

Criteria	Sensitivity	Specificity	False Positive	False Negative
HFPTA > 20	44.4%	33.3%	11.1%	11.1%
HFPTA > 25	37.0%	37.0%	18.5%	7.4%
SFPTA > 20	25.9%	37.0%	29.6%	7.4%
SFPTA > 25	18.5%	44.4%	37.0%	0 %
SRT > 20	25.9%	37.0%	29.6%	7.4%
SRT > 25	22.2%	40.7%	33.3%	3.7%
WRS < 90%	14.8%	44.4%	40.7%	0 %
Ventry & Weinstein	18.5%	44.4%	37.0%	0 %

Mulrow, Tuley, and Aguiar (1990) found the HHIE-S to have a sensitivity of 79%, although they reported a moderately high false-positive rate. With an MHHI cutoff of 4 and a hearing loss defined as the High Frequency Pure Tone Average (HFPTA) of 20 dB HL or greater in this study, the highest sensitivity was measured at 55.6%. The false-positive rate, however, was 33.3%, and the specificity was 11.1%

Table 4.16: Sensitivity, specificity, false-positive, and false-negative rates using a MHHI cutoff score of 16, for various definitions of hearing impairment.

Criteria	Sensitivity	Specificity	False Positive	False Negative
HFPTA > 20	33.3%	33.3%	11.1%	22.2%
HFPTA > 25	29.6%	40.7%	14.8%	14.8%
SFPTA > 20	22.2%	44.4%	22.2%	11.1%
SFPTA > 25	18.5%	55.6%	25.9%	0 %
SRT > 20	22.2%	44.4%	22.2%	11.1%
SRT > 25	18.5%	48.1%	25.9%	7.4%
WRS < 90%	14.8%	55.6%	29.6%	0 %
Ventry & Weinstein	18.5%	55.6%	25.9%	0 %

Table 4.17: Sensitivity, specificity, false-positive, and false-negative rates using an MHHI cutoff score of 24, for various definitions of hearing impairment.

Criteria	Sensitivity	Specificity	False Positive	False Negative
HFPTA > 20	11.1%	44.4%	0 %	44.4%
HFPTA > 25	11.1%	55.6%	0 %	33.3%
SFPTA > 20	11.1%	66.7%	0 %	22.2%
SFPTA > 25	7.4%	81.8%	3.7%	7.4%
SRT > 20	7.4%	63.0%	3.7%	25.9%
SRT > 25	7.4%	70.4%	3.7%	18.5%
WRS < 90%	7.4%	81.5%	3.7%	7.4%
Ventry & Weinstein	11.1%	81.5%	0 %	7.4%

As already mentioned, likely explanations for the differences in sensitivity and specificity outcomes for the MHHI and the other versions of the HHI relate to the number of subjects in our sample and the restricted degree of hearing loss exhibited by the sample. While this study had only 27 eligible subjects for the analysis, Lichtenstein, Bess, and Logan (1988a) studied 178 subjects and Mulrow, Tuley, and Aguilar (1990) studied 137 hearing-impaired subjects and 101 normal-hearing subjects.

The second method of assessing validity involved the calculation of Pearson product-moment correlations between the MHHI scores and differing audiometric data. Audiometric data used in the analysis included: Speech Frequency Pure Tone Average (SFPTA), Speech Reception Threshold (SRT), the High Frequency Pure Tone Average (HFPTA), Word Recognition Scores (WRSs), and the Speech Intelligibility Index (SII), or Articulation Index (AI) (Mueller and Killion, 1990).

Results are shown in Table 4.18 for the overall MHHI score, MHHI scores by the two age subgroups, and by the three experimental subgroups. As noted in the *Review of*

Table 4.18: Correlations between MHHI scores and selected audiometric indices.

Criteria	MHHI	MHHI-E	MHHI-A	LP (LP/SP)	SP (SP/SP)	SP (SP/LP)
SFPTA	0.67 **	0.55	0.74 **	0.80**	0.47	0.61*
SRT	0.57 **	0.42	0.66 **	0.75 **	0.54	0.44
HFPTA	0.62 **	0.68 *	0.58 *	0.66 *	0.54	0.55
WRS	- 0.50 **	-0.38	-0.66 **	-0.28	-0.27	-0.73 **
SII (AI)	- 0.61 **	-0.62 *	-0.61 *	-0.66 *	-0.40	0.24

**Significant at 0.05 level; **significant at 0.01 level*

Literature, correlations are not expected to be very high due to the fact that the Hearing Handicap Inventories are not a direct measure of hearing loss, but rather a measure of hearing handicap. It is expected that the MHHI score will generally rise with increasing degree of hearing loss, but that the degree of correlation between the MHHI and audiometric hearing loss will be only modest. Essentially all the correlations were in the direction expected. The only exception was the SII for the SP condition; the value of 0.24 was not statistically significant, however. Our data showed audiometric data to account for 25-45% of the overall MHHI score for the various audiometric criteria. These results are consistent with those of Ventry and Weinstein (1983), who found audiometric measures to account for 31-38% of the variance in HHI scores. For the MHHI-E and the MHHI-A scores, the audiometric data account for 14-55% of the variance. Interestingly, the audiometric data accounted for 8-64% of the variance when subjects' MHHI scores were based on the long program, whereas the audiometric data accounted for 6-37% of the variance for subjects administered the short program.

Lastly, all eligible subjects (n = 27) were divided into different classifications of hearing impairment based on audiometric data. Tables 4.19 - 4.25 show the mean MHHI scores and standard deviations for the normal-hearing and hearing-impaired subjects. Audiometric data included were: Speech Reception Thresholds (SRTs) with 20- and 25- dB HL cutoffs, Word Recognition Score (WRS), Speech Frequency Pure Tone Average (SFPTA) with 20- and 25- dB HL cutoffs, and High Frequency Pure Tone Average (HFPTA) with 20- and 25- dB HL cutoffs. The WRS cutoffs for excellent scores versus good and fair scores were chosen based on current clinical practice. Based on data from Thornton and Raffin (1978), a subject's score would need to change significantly to be considered different (e.g., a score would typically need to change from the *excellent* range to the *fair* range to be considered a significantly different score). Thus it is highly unlikely that individuals whose word recognition scores fall just on either side of a 90% cutoff score can be considered to have different scores, or that they should be expected to perform differently from one another on the MHHI.

For all audiometric data and cutoffs, as the hearing impairment increased, the mean MHHI score increased. For normal-hearing subjects, the mean MHHI score was 10-11, irrespective of audiometric criterion. Mild hearing loss was associated with mean scores ranging from 14-22, while moderate hearing loss (N=4) was associated with a mean score of 23. Ventry and Weinstein (1982) found the same trend for the HHIE. Despite the restricted range of hearing sensitivity shown by our subjects, these latter results show promise that the MHHI may ultimately be shown to have predictive validity equivalent or similar to that of its non-computerized predecessors.

Table 4.19: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects, as classified by the Speech Reception Threshold (SRT) with a 20-dB HL cutoff.

SRT (20-dB Cutoff)	Mean SRT	Mean MHHI	MHHI Standard Deviation
NORMAL HEARNG (0 - 20 dB HL)	9.4 dB HL (n = 20)	10.8	7.7
MILD HEARING LOSS (21 - 40 dB HL)	29.0 dB HL (n = 7)	18.3	6.6

Table 4.20: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects, as classified by the Speech Reception Threshold (SRT) with a 25-dB HL cutoff.

SRT (25-dB Cutoff)	Mean SRT	Mean MHHI	MHHI Standard Deviation
NORMAL HEARING (0 - 25 dB HL)	8.0 dB HL (n = 18)	10.6	7.9
MILD HEARING LOSS (26 - 40 dB HL)	28.89 dB HL (n = 9)	17.1	6.6

Table 4.21: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects, as classified by the Word Recognition Score (WRS).

WRS	Mean WRS	Mean MHHI	MHHI Standard Deviation
EXCELLENT (91 - 100%)	96.18 % (n = 22)	10.4	6.7
GOOD (81 - 90%)	86.5 % (n = 4)	24.0	3.3
FAIR (61 - 80%)	70 % (n = 1)	20.0	___

Table 4.22: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects, as classified by the Speech Frequency Pure Tone Average (SFPTA) with a 20-dB HL cutoff.

SFPTA (20-dB Cutoff)	Mean SFPTA	Mean MHHI	MHHI Standard Deviation
NORMAL HEARING (0 - 20 dB HL)	7.41 dB HL (n = 18)	10.0	6.9
MILD HEARING LOSS (21 - 40 dB HL)	28.7 dB HL (n = 9)	18.2	7.6

Table 4.23: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects, as classified by the Speech Frequency Pure Tone Average (SFPTA) with a 25-dB HL cutoff.

SFPTA (25-dB Cutoff)	Mean SFPTA	Mean MHHI	MHHI Standard Deviation
NORMAL HEARING (0 - 25 dB HL)	10.08 dB HL (n = 22)	10.6	7.3
MILD HEARING LOSS (26 - 40 dB HL)	32 dB HL (n = 5)	22.0	2.0

Table 4.24: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects as classified by High Frequency Pure Tone Average (HFPTA) with a 20-dB HL cutoff.

HFPTA (20-dB Cutoff)	Mean HFPTA	Mean MHHI	MHHI Standard Deviation
NORMAL HEARING (0 - 20 dB HL)	8.97 dB HL (n = 12)	7.8	6.7
MILD HEARING LOSS (21 - 40 dB HL)	30.76 dB HL (n = 11)	14.4	6.3
MODERATE HEARING LOSS (41 - 50 dB HL)	46.68 dB HL (n = 4)	23.0	3.8

Table 4.25: Mean MHHI scores and standard deviations for normal-hearing and hearing-impaired subjects as classified by High Frequency Pure Tone Average (HFPTA) with a 25-dB HL cutoff.

HFPTA 25-dB Cutoff	Mean HFPTA	Mean MHHI	MHHI Standard Deviation
NORMAL HEARING (0-25 dB HL)	11.15 dB HL (n = 15)	8.9	6.9
MILD HEARING LOSS (26 - 40 dB HL)	32.93 dB HL (n = 8)	14.7	6.5
MODERATE HEARING LOSS (41 - 50 dB HL)	46.68 dB HL (n = 4)	23.0	3.8

Subject Choices on the MHHI

Respondents who take the long program of the MHHI are offered several choices before beginning the questionnaire section. Among the choices chosen for analysis were the extent to which: (1) respondents chose whether to go through the *Computer Introduction*, (2) they preferred to listen to a male's voice or a female's voice, and (3) they chose to use the ILLUSTRATE or REPHRASE capabilities.

Subjects who use the LP version first have the option of receiving an introduction to the computer. Table 4.26 reports the percentages of subjects who used that option. Of the 12 subjects who had the option to go through the *Computer Introduction* during the first experimental session (LP/SP), 50% (6/12) chose to do so. Of those who had the option at the second session (SP/LP), 8.3% (1/12) chose it. Presumably, the experience of this group in operating the computer during the initial (SP) session was sufficient to make the majority feel comfortable with its operation. Overall, five of the 12 elderly subjects (41.7%) who had the option chose to do so, with the majority (58.3%) choosing not to view the introduction. Two of the 12 adults given the option (16.7%) chose to take it, while 83.3% chose not to take it. Thus while most subjects in either age group chose to circumvent the *Computer Introduction*, elderly adults were more prone to view the introduction than younger adults.

Table 4.26: Subjects' use of the Computer Introduction section of the MHHI.

Option Category (n = 12 per Category)	**Computer Introduction**	**No Computer Introduction**
First-Session Option	50.0%	50.0%
Second-Session Option	8.3%	91.7%
Elderly adult subjects	41.7%	58.3%
Adult subjects	16.7%	83.3%

For subjects in the two groups who were administered the LP version, exactly 1/3 (33.3%) chose the male voice and 2/3 (66.7%) chose the female voice. Slightly more than half the subjects (58.3%) chose the gender of the speaker that was opposite their own. Of those who either chose the male voice during the long program or were administered the male voice by default during the short program (SP/SP or SP/LP), 58.3% chose the female voice in the second session.

Each subject, in either the LP or SP versions of the program, had the option of having questions illustrated or rephrased. This option is explained only within the long program. Of those who did not have this option explained (SP/SP), none (0%) used the

ILLUSTRATE or REPHRASE features. Of those who had the option explained in the first LP session (LP/SP), one of the 12 (8.3%) used the REPHRASE option two times. Of those who took the long program during the second session (SP/LP), two subjects (16.7%) used the ILLUSTRATE and REPHRASE options. ILLUSTRATE was chosen three times and REPHRASE was chosen twice by the two subjects. Results of this analysis suggest that while these options may be useful to some subjects, they are not a critical feature of the questionnaire.

Exit-Questionnaire Analysis

Subjects completed an exit questionnaire regarding the MHHI at the end of the second session. Depending on whether a given subject had completed only a short program version of the MHHI (SP/SP) or had completed the long program version in either the LP/SP or SP/LP groups, a corresponding exit-interview questionnaire was administered. Results from the short program's exit questionnaire are presented in Tables 4.27 and 4.28, while results from the long program's exit questionnaire are shown in Tables 4.29 and 4.30.

Table 4.27: Exit-questionnaire results for subjects performing only the short program (SP/SP).

Question	Mean	Standard Deviation	Mode
#1 The Multimedia Hearing Handicap Inventory program was easy to use.	4.7	1.1	5
#2 The voice was easy to hear.	4.9	0.3	5
#3 The voice was easy to understand.	4.8	0.4	5
#4 The text was easy to read.	4.7	0.6	5
#5 I found the rephrasing of the questions helpful.	3.7	1.5	5
#6 I found the illustrations of the questions helpful.	3.9	1.2	5
#7 The *Hearing Profile* given to me at the end of the program was easy to understand.	4.4	1.2	5
#8 I will follow the suggestions given to me in the *Hearing Profile*.	4.7	0.7	5

(1 = Strongly Disagree, 3 = Neutral, 5 = Strongly Agree)

Table 4.28: Exit-questionnaire results for subjects performing the long program in either session (LP/SP or SP/LP).

Question	Mean	Standard Deviation	Mode
#1 The Multimedia Hearing Handicap Inventory program was easy to use.	4.9	0.4	5
#2 I found the section on the use of the computer to be helpful.	4.3	0.8	5
#3 I found the rephrasing of the questions helpful.	3.7	0.8	3
#4 I found the illustrations of the questions helpful.	4.5	0.7	5
#5 I learned some useful information about hearing loss from the program.	4.2	0.9	4
#6 The voice was easy to hear.	5.0	0	5
#7 The voice was easy to understand.	5.0	0.2	5
#8 The text was easy to read.	5.0	0.2	5
#9 The directions on how to use the program were easy to understand.	4.8	0.4	5
#10 I learned some useful information about the treatments for hearing loss.	4.0	1.0	4
#11 The *Hearing Profile* given to me at the end of the program was easy to understand.	4.8	0.4	5
#12 I will follow the suggestions given to me in the *Hearing Profile*.	4.7	0.4	5

(1 = Strongly Disagree, 3 = Neutral, 5 = Strongly Agree)

Table 4.29: Comfort level reported with selected technologies by subjects performing the short program only (SP/SP).

Device	Mean	Standard Deviation	Mode(s)
Manual Typewriter	3.5	1.5	5
Calculator	4.2	0.7	4 and 5
Adding Machine	4.2	1.4	5
Electric Typewriter	3.7	1.4	5
Computer without a mouse	3.3	1.4	2 and 5
Computer with a mouse	4.1	0.9	5

(1 = very uncomfortable, 3 = neutral, 5 = very comfortable)

Table 4.30: Comfort level reported with selected technologies by subjects performing the long program in either session (LP/SP or SP/LP).

Device	Mean	Standard Deviation	Mode(s)
Manual Typewriter	3.8	1.3	5
Calculator	4.1	1.2	5
Adding Machine	3.9	1.2	5
Electric Typewriter	3.7	1.4	4 and 5
Computer without a mouse	3.1	1.6	1 and 5
Computer with a mouse	3.6	1.5	5

(1 = very uncomfortable, 3 = neutral, 5 = very comfortable)

Subjects generally responded positively to the design and the functional characteristics of the MHHI. Further, they indicated that they learned from the program and that they intended to follow the suggestions given in the *Hearing Profile*. Although subjects in the SP/SP group (Table 4.27) rated the REPHRASE and ILLUSTRATE options moderately helpful (neutral to agree), our previously described analysis indicated that none of them actually used either feature. Subjects' ratings of comfort with the various technologies were generally in the neutral to comfortable range of the rating scale (Tables 4.29 and 4.30).

Three subjects did use the ILLUSTRATE or REPHRASE option. All three subjects had taken the long program in one of the two sessions and used both options during the long program administration only. Two subjects used the REPHRASE option only and one subject used both the ILLUSTRATE and REPHRASE options. These subjects gave the option of REPHRASE an average rating of 3.0. The responses ranged from 0 (subject left blank with a note they had not used the option) to 5 (rated very helpful), with the third subject rating the option a 4. The subject who used the ILLUSTRATE option rated it a 3. Caution should be taken in interpreting these results, given the small number of subjects covered in this analysis.

Seven subjects used the *Computer Introduction* option of the long program. Six of the seven were administered the long program at the first session, with the seventh subject completing the long program at the second session. These subjects rated their comfort with computers (either with or without a mouse) a mean of 2.4 and a mode of 1 (1 = *very uncomfortable* and 5 = *very comfortable*). Subjects who choose not to use the *Computer Introduction* option rated their comfort with computers (either with or without a mouse) a mean of 3.7. Again, caution should be taken in interpreting these results, given the few number of subjects who chose to use the *Computer Introduction* option.

Data from the exit questionnaires should generally be interpreted with caution. Mean responses on the Likert scale were rarely anything other than the extreme number 5. While it might be that the design of the MHHI was in fact very satisfactory, it is also possible that subjects were reserved in their criticism of the program. It is important to note that subjects were asked to rate their level of comfort, and not their level of experience or expertise, with the various technologies.

The comfort ratings were elicited to determine the extent to which subjects' responses might be related to their responses to the design and function (i.e., the utility) of the MHHI. This relationship, as well as the relationships between educational and income levels and responses on the design and functional utility questions of the exit interview, are addressed in Table 4.31 and Table 4.32. For the Spearman rank-order correlations (*rho* analyses) in these tables, the categorical educational and income variables (Table 3.3 and Table 3.4, respectively) were converted to ranked values. The educational response of "Did not complete High School" was assigned the value of 1 and a response of "Professional or Doctoral Degree" was assigned the value of 5. An income range response of $0 - $15,000 was assigned the value of 1 and the income range of $75,000 or more was assigned the value of 5. Intermittent values were ranked accordingly. Utility values for this analysis were taken from the ranks (1-5) referred to in the data from Tables 4.27 and 4.28, as appropriate.

Table 4.31: Spearman rho's for utility, income, education, and technology comfort for the SP/SP test group.

	Utility	Comfort	Education	Income
Utility	--	-0.22	0.20	0.02
Comfort	--	--	0.22	-0.01
Education	--	--	--	0.35
Income	--	--	--	--

Table 4.32: Spearman rho's for utility, income, education, and technology comfort for the LP/SP and SP/LP test groups.

	Utility	Comfort	Education	Income
Utility	--	-0.22	-0.11	-0.06
Comfort	--	--	0.37	0.30
Education	--	--	--	0.48 *
Income	--	--	--	--

* Correlation is significant at the 0.05 level (2-tailed).

Spearman *rho* results indicate that there was little correlation between the subjects' perceptions of the usefulness of the program and their education, income, or comfort level with the selected technologies. For the subjects who were assigned to either the LP/SP test condition or the SP/LP test condition, the Spearman *rho* was significant for the education versus income conditions. Thus for these subjects, the higher their education, the higher was their income. Overall, these results indicate that the subjects' perceptions of the program were not closely associated with their socioeconomic status or the level of comfort they felt with the various technologies.

Chapter 5

Conclusion

The major purposes of previous versions of the Hearing Handicap Inventories, as described by a number of recent investigators, include their use as a tool for: (1) screening for hearing loss, (2) measurement of hearing handicap, (3) measurement of outcomes-assessment of hearing aid benefit and other forms of aural rehabilitation, and (4) establishing hearing aid candidacy and use. In this study, it was firmly established that the MHHI is a reliable tool that can be used on a test-retest basis to measure hearing handicap and to assess outcomes of audiologic rehabilitation. An individual who is administered the MHHI in one session can be expected to exhibit approximately the same score during a subsequent session if his or her hearing status remains stable and there has been no rehabilitative intervention. The MHHI can be administered prior to a hearing aid fitting and, after a designated period of hearing aid use, the MHHI can be re-administered. If the score has improved by 10 or more, it can be concluded that the intervention of hearing aids has produced a perceived benefit, or reduction in hearing handicap. This suggested critical-difference value of 10 is highly consistent with earlier research on paper-and-pencil versions of the HHIE-S and HHIA-S.

The MHHI also has high internal consistency reliability. Its test-retest and internal consistency reliability generally apply to the test overall, as well as to its subscales.

While this study did not specifically address the MHHI as a tool for establishing hearing aid candidacy and prediction of successful hearing aid use, there is no reason to believe that the multimedia version of the HHI questionnaires would be any less capable than the pencil-and-paper or face-to-face interview versions in these regards. Newman et al. (1991) observed that if the HHIE-S score is greater than about 10, but less than 18, an individual is highly likely to have a hearing impairment, but is less likely to seek out or successfully use hearing aids than someone whose score is 18 or greater. In this study, MHHI scores of subjects who wore hearing aids reflected aided benefit, but our ability to perform this type of analysis was limited because many of the subjects' MHHI scores were less than 18—reflecting their relatively mild hearing impairments.

Predictive validity of the MHHI was not amply demonstrated in this study, based on the limited number of subjects. The study did reveal, however, that subjects who scored relatively high on the MHHI tended to have greater hearing impairment. Although this finding provides only preliminary evidence of the relationship between the MHHI score and hearing impairment, that evidence, along with previous research on the screening versions of the HHI, suggests that a reasonable approach is to use a minimum MHHI score of 10 for the identification of hearing loss. This approach seems reasonable at least until further research reveals a more-optimum value. As the mean score of our normal-hearing subjects was around 10, and the range of scores of mildly hearing-impaired subjects was 14-22, examiners should be aware of the probable overlap of MHHI scores within these groups of listeners. Examiners should be especially mindful of the high false-positive rate observed with most audiometric cutoff values utilized in the limited sample of this study.

This investigation raises several questions regarding the MHHI that are worthy of further study. Because a major potential use of the MHHI may be in hearing screenings, further study of its predictive validity is essential. A relatively small number of subjects was available for the predictive validity analysis in this experiment, which was aimed primarily at a determination of test-retest reliability. A serious study of sensitivity, specificity, and false-positive and false-negative rates requires a larger number of subjects than used here. In addition, subjects should exhibit a broader range of hearing impairment than was true in our sample.

The possibility exists that in the clinical setting, a subject may have already completed the paper-and-pencil HHI or may have been asked the HHI questions verbally before being administered the MHHI. The test-retest reliability across the different forms of administration should be specifically explored.

Subjects in this study responded favorably to the MHHI's features, rating it high on features that reflect its clinical utility. Given the relative non-use of the REPHRASE and ILLUSTRATE features, the usefulness of this particular feature in open to question. In future studies, respondents should be actively encouraged to use these features routinely, and their effect on reliability evaluated.

Lastly, the MHHI *Hearing Profile* includes specific, individualized recommendations for follow-up. Most participants in this study indicated that they would follow these recommendations. There was no attempt, however, to determine whether they actually did comply with the recommendations, which, in the case of hearing-impaired individuals, included the recommendation to schedule appointments for hearing and hearing aid evaluations. The degree to which those recommendations are associated with compliance behavior should be studied, particularly in relation to tenets of the Health Belief Model. In the end, the potential to improve audiologic compliance behavior could be the MHHI's greatest virtue.

APPENDICES

Appendix A

Hearing Handicap Inventory for the Elderly (HHIE)

The purpose of this scale is to identify the problems your hearing loss may cause you. Circle Yes, Sometimes, or No for each question. Do not skip a question if you avoid a situation because of your hearing problem. If you use a hearing aid, please answer the way you hear with the aid.

S-1 Does a hearing problem cause you to use the phone less often than you would like?
Yes Sometimes No

E-2 Does a hearing problem cause you to feel embarrassed when meeting new people?
Yes Sometimes No

S-3 Does a hearing problem cause you to avoid groups of people?
Yes Sometimes No

E-4 Does a hearing problem make you irritable?
Yes Sometimes No

E-5 Does a hearing problem cause you to feel frustrated when talking to members of your family?
Yes Sometimes No

S-6 Does a hearing problem cause you difficulty when attending a party?
Yes Sometimes No

E-7 Does a hearing problem cause you to feel "stupid" or "dumb"?
Yes Sometimes No

S-8 Do you have difficulty hearing when someone speaks in a whisper?
Yes Sometimes No

E-9 Do you feel handicapped by a hearing problem?
Yes Sometimes No

S-10 Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?
Yes Sometimes No

S-11 Does a hearing problem cause you to attend religious services less often than you would like?
Yes Sometimes No

E-12 Does a hearing problem cause you to be nervous?
Yes Sometimes No

S-13 Does a hearing problem cause you to visit friends, relatives, or neighbors less often than you would like?
Yes Sometimes No

E-14 Does a hearing problem cause you to have arguments with family members?
Yes Sometimes No

S-15 Does a hearing problem cause you difficulty when listening to the TV or radio?
Yes Sometimes No

S-16 Does a hearing problem cause you to go shopping less often than you would like?
Yes Sometimes No

E-17 Does a hearing problem or difficulty with your hearing upset you at all?
Yes Sometimes No

E-18 Does a hearing problem cause you to want to be by yourself?
Yes Sometimes No

S-19 Does a hearing problem cause you to talk to family members less often than you would like?
Yes Sometimes No

E-20 Do you feel that any difficulty with your hearing limits or hampers your personal or social life?
Yes Sometimes No

S-21 Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?
Yes Sometimes No

E-22 Does a hearing problem cause you to feel depressed?
Yes Sometimes No

S-23 Does a hearing problem cause you to listen to TV or radio less often than you would like?
Yes Sometimes No

E-24 Does a hearing problem cause you to feel uncomfortable when talking to friends?
Yes Sometimes No

E-25 Does a hearing problem cause you to feel left out when you are with a group of people?
Yes Sometimes No

For Clinician's Use Only: Total Score: __________
Subtotal E: __________
Subtotal S: __________

Appendix B

Hearing Handicap Inventory for the Elderly—Screening Version (HHIE-S)

The purpose of this scale is to identify the problems your hearing loss may cause you. Circle Yes, Sometimes, or No for each question. Do not skip a question if you avoid a situation because of your hearing problem. If you use a hearing aid, please answer the way you hear with the aid.

1. Does a hearing problem cause you to feel embarrassed when you meet new people?
   Yes Sometimes No

2. Does a hearing problem cause you to feel frustrated when talking to members of your family?
   Yes Sometimes No

3. Do you have difficulty hearing when someone speaks in a whisper?
   Yes Sometimes No

4. Do you feel handicapped by a hearing problem?
   Yes Sometimes No

5. Does a hearing problem cause you difficulty when visiting friends, relatives or neighbors?
   Yes Sometimes No

6. Does a hearing problem cause you to attend religious services less often than you would like?
   Yes Sometimes No

7. Does a hearing problem cause you to have arguments with family members?
   Yes Sometimes No

8. Does a hearing problem cause you difficulty when listening to TV or radio?
   Yes Sometimes No

9. Do you feel that any difficulty with your hearing limits or hampers your personal or social life?
   Yes Sometimes No

10. Does a hearing problem cause you difficulty when in a restaurant with relatives or friends? Yes Sometimes No

Appendix C

Hearing Handicap Inventory for Adults (HHIA)

The purpose of this scale is to identify the problems your hearing loss may cause you. Circle Yes, Sometimes, or No for each question. Do not skip a question if you avoid a situation because of your hearing problem. If you use a hearing aid, please answer the way you hear with the aid.

S-1 Does a hearing problem cause you to use the phone less often than you would like?
Yes Sometimes No

E-2 Does a hearing problem cause you to feel embarrassed when meeting new people?
Yes Sometimes No

S-3 Does a hearing problem cause you to avoid groups of people?
Yes Sometimes No

E-4 Does a hearing problem make you irritable?
Yes Sometimes No

E-5 Does a hearing problem cause you to feel frustrated when talking to members of your family?
Yes Sometimes No

S-6 Does a hearing problem cause you difficulty when attending a party?
Yes Sometimes No

S-7 Does a hearing problem cause you difficulty hearing/understanding coworkers, clients, or customers?
Yes Sometimes No

E-8 Do you feel handicapped by a hearing problem?
Yes Sometimes No

S-9 Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?
Yes Sometimes No

E-10 Does a hearing problem cause you to feel frustrated when talking to coworkers, clients, or customers?
Yes Sometimes No

S-11 Does a hearing problem cause you difficulty in the movies or theater?
Yes Sometimes No

E-12 Does a hearing problem cause you to be nervous?
Yes Sometimes No

S-13 Does a hearing problem cause you to visit friends, relatives, or neighbors less often than you would like?
Yes Sometimes No

E-14 Does a hearing problem cause you to have arguments with family members?
Yes Sometimes No

S-15 Does a hearing problem cause you difficulty when listening to the TV or radio?
Yes Sometimes No

S-16 Does a hearing problem cause you to go shopping less often than you would like?
Yes Sometimes No

E-17 Does a hearing problem or difficulty with your hearing upset you at all?
Yes Sometimes No

E-18 Does a hearing problem cause you to want to be by yourself?
Yes Sometimes No

S-19 Does a hearing problem cause you to talk to family members less often than you would like?
Yes Sometimes No

E-20 Do you feel that any difficulty with your hearing limits or hampers your personal or social life?
Yes Sometimes No

S-21 Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?
Yes Sometimes No

E-22 Does a hearing problem cause you to feel depressed?
Yes Sometimes No

S-23 Does a hearing problem cause you to listen to TV or radio less often than you would like?

Yes Sometimes No

E-24 Does a hearing problem cause you to feel uncomfortable when talking to friends?

Yes Sometimes No

E-25 Does a hearing problem cause you to feel left out when you are with a group of people?

Yes Sometimes No

For Clinician's Use Only: Total Score: __________

Subtotal E: __________

Subtotal S: __________

Appendix D

Hearing Handicap Inventory for Adults—Screening Version (HHIA-S)

The purpose of this scale is to identify the problems your hearing loss may cause you. Circle Yes, Sometimes, or No for each question. Do not skip a question if you avoid a situation because of your hearing problem. If you use a hearing aid, please answer the way you hear with the aid.

1. Does a hearing problem cause you to feel embarrassed when you meet new people?
   Yes Sometimes No

2. Does a hearing problem cause you to feel frustrated when talking to members of your family?
   Yes Sometimes No

3. Do you have difficulty hearing or understanding co-workers, clients, or customers?
   Yes Sometimes No

4. Do you feel handicapped by a hearing problem?
   Yes Sometimes No

5. Does a hearing problem cause you difficulty when visiting friends, relatives or neighbors?
   Yes Sometimes No

6. Does a hearing problem cause you difficulty in the movies or in the theater?
   Yes Sometimes No

7. Does a hearing problem cause you to have arguments with family members?
   Yes Sometimes No

8. Does a hearing problem cause you difficulty when listening to TV or radio?
   Yes Sometimes No

9. Do you feel that any difficulty with your hearing limits or hampers your personal or social life?
   Yes Sometimes No

10. Does a hearing problem cause you difficulty when in a restaurant with relatives or friends?
Yes Sometimes No

Appendix E

Components of the Long Program of the Multimedia Hearing Handicap Inventory (MHHI)

(1) *Program Overview*, which states the purpose of the program, distinguishes between hearing impairment and hearing handicap, and informs the respondent that an individualized *Hearing Profile* will be provided at the end of the program.

(2) *Computer Introduction*, in which respondents not familiar with computer operations are guided through the hardware and operational components essential to use the program. (This portion is optional.)

(3) *Hearing Loss*, which summarizes prevalence rates of hearing loss, common problems experienced by persons with hearing impairment, how we hear, and how hearing sensitivity is graphed on an audiogram. (This portion is optional.)

(4) *MHHI Questionnaire*, in which the age-appropriate screening version of the questionnaire is administered to younger and older adults. Adults aged 60 years and below are administered the HHIA-S, and those aged over 60 years are administered the HHIE-S. Respondents are asked whether their answers are based on their wearing of hearing aids or not (aided or unaided). The questionnaire consists of 10 items, including five social-situational and five emotional items. ILLUSTRATE and REPHRASE options are available to visualize or clarify the respective types of items. The respondent needs only to click on *Yes*, *Sometimes*, or *No* to answer each question.

(5) *Treatments for Hearing Loss*, a summary of major treatment options for hearing impairment. Treatments include medical, surgical, and audiological options. (This portion is optional.)

(6) *Hearing Profile*, a printed set of individualized results and recommendations for audiologic and medical follow-up, is given to each respondent at the end of the program. The following types of information are included in the *Hearing Profile*:

Respondent Name, Respondent ID, Listening Condition, Date, Time, Interpretation, *Hearing Profile*, Recommendations, Contact Information, Disclaimer (see Appendix F for details of disclaimer)

Appendix F

Components of the MHHI *Hearing Profile*

(1) *Respondent information*, in which identifying information, including the respondent's name and identification number, listening condition, and date and time are printed.

(2) *Interpretation*, in which the range of possible scores and a basic interpretation of scores are given.

(3) *Hearing Profile*, in which the respondent's score, including the score obtained on a previous administration (if applicable), is given. As appropriate, a summary of clinical research on the relationships between hearing handicap scores and hearing loss, and between hearing handicap scores and hearing aid use, is also given.

(4) *Recommendations*, based on the respondent's score, which may include, as applicable, referral to an audiologist or primary-care physician. This section includes options that are recommended for the respondent to follow. Specific options depend on the hearing handicap score and whether the listening condition is unaided or aided.

(5) *Examiner information*, consisting of the name, title, address and phone number of the examiner.

(6) *Disclaimer*, indicating that the Hearing Handicap Inventory is not a direct test of the respondent's hearing, and that recommendations and referral information are based on a comparison of the questionnaire score with scores obtained from samples of people who have known hearing characteristics.

Appendix G

Protocol Design for Eight *Hearing Profiles*

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 1)

(IF the current score is 0-9, AND a previous test result IS NOT found in the database for this individual, AND the listening condition is Unaided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: Your hearing handicap score today was (insert score here). A score in this range suggests either that there is no hearing loss, or if present, hearing loss is not interfering substantially with communication or other activities in your daily life.

Recommendations: It is recommended that you return to complete this Hearing Handicap Inventory in one year, or sooner if you should notice a change in your hearing. If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 2)

(IF the current score is 0-9, AND a previous test result IS NOT found in the database for this individual, AND the listening condition is Aided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: Your hearing handicap score today was (insert score here). A score in this range suggests that your hearing loss is not interfering substantially with communication or other activities in your daily life, and that you are receiving ample benefit from your hearing aid(s).

Recommendations: It is recommended that you return to complete this Hearing Handicap Inventory in one year, or sooner if you should notice either a change in your hearing or in the performance of your hearing aid(s). If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 3)

(IF the current score is 0-9, AND a previous test result for this individual IS found in the database, AND the listening condition is Unaided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: Your hearing handicap score today was (insert score here). A score in this range suggests either that there is no hearing loss, or if present, hearing loss is not interfering substantially with communication or other activities in your daily life. Your previous score on (insert date of last test here) was (insert last test score here). A difference in that score and today's score of less than 10 suggests no real change in perceived handicap, while a difference of 10 or more suggests a possible change in perceived hearing handicap.

Recommendations: It is recommended that you return to complete this Hearing Handicap Inventory in one year, or sooner if you should notice a change in your hearing. If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 4)

(IF the current score is 0-9, AND a previous test result for this individual IS found in the database, AND the listening condition is Aided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: Your hearing handicap score today was (insert score here). A score in this range suggests that your hearing loss is not interfering substantially with communication or other activities in your daily life, and that you are receiving ample benefit from your hearing aid(s). Your previous score on (insert date of last test here) was (insert last test score here). A difference in that score and today's score of less than 10 suggests no real change in perceived handicap, while a difference of 10 or more suggests a possible change in perceived hearing handicap.

Recommendations: It is recommended that you return to complete this Hearing Handicap Inventory in one year, or sooner if you should notice either a change in your hearing or in the performance of your hearing aid(s). If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 5)

(IF the current score is 10 or more, AND a previous test result for this individual IS NOT found in the database, AND the listening condition is Unaided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: According to your responses to the questionnaire, your hearing handicap score today was (insert score here). Research has shown that individuals with scores of 10 or greater are likely to have measurable hearing impairment. Many people who are considering using hearing aids for the first time have scores of 18 or greater, irrespective of severity of hearing loss. In addition, 3-4 weeks after these people have purchased hearing aids, their perception of hearing difficulties is dramatically reduced. This outcome suggests that hearing aids have helped them in problematic situations.

Recommendations: It is recommended that you contact a local audiologist to arrange for a hearing evaluation and possibly a trial period with hearing aids. If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 6)

(IF the current score is 10 or more, AND a previous test result for this individual IS NOT found in the database, AND the listening condition is Aided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: According to your responses to the questionnaire, your hearing handicap score today was (insert score here). This score suggests that you may have some residual disability associated with your hearing loss, even though you wear hearing aids. Recent research has shown that many people who are considering using hearing aids for the first time have scores of 18 or greater, irrespective of severity of hearing loss.

Recommendations: If you are experiencing difficulty with your hearing aid(s), such as whistling, need for frequent repair, or poorer-than-expected performance, it is recommended that you contact the professional who fitted your hearing aid(s). If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 7)

(IF the current score is 10 or more, AND a previous test result for this individual IS found in the database, AND the listening condition is Unaided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: According to your responses to the questionnaire, your hearing handicap score today was (insert score here). Research has shown that individuals with scores of 10 or greater are likely to have measurable hearing impairment. Many people who are considering using hearing aids for the first time have scores of 18 or greater, irrespective of severity of hearing loss. In addition, 3-4 weeks after these people have purchased hearing aids, their perception of hearing difficulties is dramatically reduced. This outcome suggests that hearing aids have helped them in problematic situations. Your previous score on (insert date of last test here) was (insert last test score here). A difference in that score and today's score of less than 10 suggests no real change in perceived handicap, while a difference of 10 or more suggests a possible change in perceived hearing handicap.

Recommendations: It is recommended that you contact a local audiologist to arrange for a trial period with hearing aids. If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

HEARING PROFILE:
HEARING HANDICAP INVENTORY
(Profile 8)

(IF the current score is 10 or more, AND a previous test result for this individual IS found in the database, AND the listening condition is Aided, print the following:)

Examinee Name: Insert here
Examinee ID: Insert here
Listening Condition: Insert Unaided or Aided here
Date: Insert here
Time: Insert here

Interpretation: Scores indicate degree of hearing handicap; the higher the number, the greater the perceived handicap associated with hearing impairment. The highest possible handicap score for a given administration of the questionnaire is 40. Scores between 0-9 should be interpreted as no perceived handicap, and scores between 10-40 represent varying degrees of perceived handicap.

Hearing Profile: According to your responses to the questionnaire, your hearing handicap score today was (insert score here). This score suggests that you may have some residual disability associated with your hearing loss, even though you wear hearing aids. Recent research has shown that many people who are considering using hearing aids for the first time have scores of 18 or greater, irrespective of severity of hearing loss. Your previous score on (insert date of last test here) was (insert last test score here). A difference in that score and today's score of less than 10 suggests no real change in perceived handicap, while a difference of 10 or more suggests a possible change in perceived hearing handicap.

Recommendations: If you are experiencing difficulty with your hearing aid(s), such as whistling, need for frequent repair, or poorer-than-expected performance, it is recommended that you contact the professional who fitted your hearing aid(s). If you have any medical problems such as pain or discharge from your ears, ringing or other sounds in your ears, or dizziness, you should schedule an appointment with your primary-care physician.

If you have any questions about this Hearing Handicap Inventory or its interpretation, please contact:

(Insert name, title here)
(Insert address here)
(Insert phone number here)

Disclaimer: This has not been a direct test of your hearing. Recommendations and referral information are based, in part, on a comparison of your questionnaire score with average scores obtained from a sample of people having known hearing characteristics, and do not directly identify hearing impairment or ear pathology.

Appendix H

First-Session Case History Form

First-Session Case History Form

Name:______________________________ Date of Birth: _______________

Please answer the following questions and send to the address at the bottom. You will receive a phone call as soon as we receive this form to clarify answers and/or to schedule a date for you to come in to participate in the study.

1. Do you think you have a hearing loss? **Yes** **No** (circle one)

2. Is so, was it gradual or sudden? **Sudden** **Gradual**

3. Do you notice any tinnitus (ringing or other sounds) in your ears? **Yes** **No**

4. Do you have a history of exposure to loud noises? **Yes** **No**

5. Do you have a history of ear infections? **Yes** **No**

6. Do you experience any dizziness or vertigo? **Yes** **No**

7. What medications are you currently taking?

   ____

8. What medications have you taken in the past for a prolonged period of time (one year or more)?

   ____

9. Have you noticed any fluctuation in your hearing in the past six months? **Yes** **No**

10. Do you currently wear hearing aids? **Yes** **No**

11. If so, how often and for how long do you wear the hearing aids?

____

Thank you for your time. Please send this form to the following address:

Sara Shogren
Oyer Speech-Language-Hearing Clinic
Audiology and Speech Sciences
Michigan State University
East Lansing, Michigan 48824-1212

Appendix I

Second-Session Case History Form

Second-Session Case History Form

Name:____________________________ Date of Birth: __________________

Please answer the following questions.

1. Are you aware of a change in your hearing ability since the last test session?
   Yes **No** (circle one)

2. Have you had a head injury since the last session? **Yes** **No**

3. Do you notice any tinnitus (ringing or other sounds) in your ears? **Yes** **No**

4. Have there been any changes in your medications you are taking since the last session?
   Yes **No** If yes, what? ____

5. Do you experience any dizziness or vertigo? **Yes** **No**

6. Have you been exposed to loud noise since the last session? **Yes** **No**

7. If so, did you notice any tinnitus (ringing in your ears) after the noise exposure?
   Yes **No**

8. Have you noticed any fluctuation in your hearing since the last session? **Yes** **No**

9. Have you acquired a new hearing aid, or aids, since the last session? **Yes** **No**

10. If so, how often and for how long do you wear it/them?
    ____

11. Has there been any change in the performance of your hearing aid(s) since the last session? **Yes** **No**

Thank you.

Appendix J

Exit Questionnaire—Long Program (LP/SP and SP/LP Sequences)

Exit Questionnaire—Long Program (LP/SP and SP/LP Sequences)

Name: ______________________________ Date of Birth: __________________

Please answer the following questions by circling a number 1 - 5.
Number 1 = Strongly Disagree, Number 3 = Neutral, and Number 5 = Strongly Agree.

1. The Multimedia Hearing Handicap Inventory program was easy to use.
   1 2 3 4 5

2. I found the section on use of the computer to be helpful.
   1 2 3 4 5

3. I found the rephrasing of the questions helpful.
   1 2 3 4 5

4. I found the illustrations of the questions helpful.
   1 2 3 4 5

5. I learned some useful information about hearing loss from the program.
   1 2 3 4 5

6. The voice was easy to hear.
   1 2 3 4 5

7. The voice was easy to understand.
   1 2 3 4 5

8. The text was easy to read.
   1 2 3 4 5

9. The directions on how to use the program were easy to understand.
   1 2 3 4 5

10. I learned some useful information about treatments for hearing loss.
    1 2 3 4 5

11. The *Hearing Profile* given to me at the end of the program was easy to understand.
    1 2 3 4 5

12. I will follow the suggestions given to me in the *Hearing Profile*.
    1 2 3 4 5

13. What is the range of annual gross income in your household?

___ $0-$5,000
___ $5,000 - $15,000
___ $15,000 - $30,000
___ $30,000 - $50,000
___ $50,000 - $75,000
___ over $75,000

14. What is the highest educational level completed?

___ Did not complete high school
___ Completed high school (high school diploma)
___ Completed 1 or more years of college
___ Completed college (bachelor's degree)
___ Master's degree
___ Doctoral degree (Ph.D., Ed.D., etc.)
___ Professional degree (M.D., J.D., etc.)

Please rate how comfortable you are with the following equipment by circling a number. Number 1 - Very Uncomfortable. Number 3 = Neutral, Number 5 = Very Comfortable. Assume you are being asked to demonstrate your use of each.

1. Manual typewriter

   1 2 3 4 5

2. Calculator

   1 2 3 4 5

3. Adding Machine

   1 2 3 4 5

4. Electric Typewriter

   1 2 3 4 5

5. Computer (without a mouse)

   1 2 3 4 5

6. Computer (with a mouse)

   1 2 3 4 5

Thank you for your time!

Appendix K

Exit Questionnaire—Short Program (SP/SP Sequence)

Exit Questionnaire—Short Program (SP/SP Sequence)

Name: ____________________________ Date of Birth: ________________

Please answer the following questions by circling a number 1 - 5.
Number 1 = Strongly Disagree, Number 3 = Neutral, and Number 5 = Strongly Agree.

1. The Multimedia Hearing Handicap Inventory program was easy to use.
   1 2 3 4 5

2. The voice was easy to hear.
   1 2 3 4 5

3. The voice was easy to understand.
   1 2 3 4 5

4. The text was easy to read.
   1 2 3 4 5

5. I found the rephrasing of the questions helpful.
   1 2 3 4 5

6. I found the illustrations of the questions helpful.
   1 2 3 4 5

7. The *Hearing Profile* given to me at the end of the program was easy to understand.
   1 2 3 4 5

8. I will follow the suggestions given to me in the *Hearing Profile*.
   1 2 3 4 5

9. What is the range of annual gross income in your household?
   ___ $0 - $5,000
   ___ $5,000 - $15,000
   ___ $15,000 -$30,000
   ___ $30,000 - $50,000
   ___ $50,000 - $75,000
   ___ over $75,000

10. What is the highest educational level completed?

___ Did not complete high school
___ Completed high school (high school diploma)
___ Completed 1 or more years of college
___ Completed college (bachelor's degree)
___ Master's degree
___ Doctoral degree (Ph.D., Ed.D., etc.)
___ Professional degree (M.D., J.D., etc.)

Please rate how comfortable you are with the following equipment by circling a number. Number 1 = Very comfortable, Number 3 = Neutral, Number 5 = Very Comfortable. Assume you are being asked to demonstrate your use of each.

1. Manual typewriter

   1 2 3 4 5

2. Calculator

   1 2 3 4 5

3. Adding Machine

   1 2 3 4 5

4. Electric Typewriter

   1 2 3 4 5

5. Computer (without a mouse)

   1 2 3 4 5

6. Computer (with a mouse)

   1 2 3 4 5

Thank you for your time!

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