COMPARISON OF SELECTED PURE-TONE AND SPEECH TESTS IN PREDICTING HEARING HANDICAP

THESIS

Presented to the Graduate Council of the

University of North Texas in Partial

Fulfillment of the Requirements

For the Degree of

MASTER OF ARTS

By

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August, 1991

Dye, Amy, Comparison of Selected Pure-Tone and Speech Tests in Predicting Hearing Handicap. Master of Arts (Communication Disorders), August, 1991, 61 pp., 3 tables, 5 illustrations, references, 40 titles.

This study assessed the effective use of pure-tone testing versus speech testing as used to predict the degree of hearing handicap experienced by an individual. Twenty-one subjects over the age of 65 were tested. Each subject was administered the following test battery: spondee threshold; a pure-tone evaluation, including air and bone conduction; Speech Perception in Noise (SPIN) test; Synthetic Sentence Identification (SSI) test; NU-6 for speech discrimination; establishment of most comfortable listening level (MCL) and loudness discomfort listening level (LDL); immittance testing including tympanograms, acoustic reflex thresholds, and reflex decay.

Prior to testing, each subject was asked to respond to the Hearing Handicap Inventory for the Elderly, by Ventry and Weinstein. This subjective analysis of handicap was compared to the measures of pure-tone and speech scores to determine the relative accuracy of each of these tests as predictors of hearing handicap.

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CHAPTER ONE

INTRODUCTION

As the number of people over the age of 65 years has increased, there has been an increase in the demand for providing assessment of the hearing impairment and the handicapping effects of hearing loss for the elderly. As of 1986, 29.6% of people over 65 years of age were estimated to have hearing impairment (Hotchkiss, 1989). This percentage of affected individuals increases dramatically for elderly adults in long-term care facilities (Garstecki, 1981). It is expected that the percentage of elderly individuals with hearing impairment will increase in the future. Hotchkiss (1989) reported projections for increases in the hearing impaired population of an additional 3.5 million between 1990 and 2015. Advances in medical technology and health care are allowing people to stay healthier and grow older. The services and care for this population must increase and improve accordingly to assist the elderly in dealing with hearing loss (Bess, Lichtenstein, & Logan, 1991).

Hearing loss affects individuals differently. The handicapping effects of hearing loss may be very minimal or devastating. The degree of handicap that a person experiences may also vary from situation to situation. The amount of hearing impairment is only one factor in the amount of handicap that a person experiences in everyday circumstances. Audiometric testing can reveal the degree and type of loss and the amount of difficulty a person is having understanding some speech. These tests are not well suited to quantifying the amount of handicap that the hearing loss is producing in an individual's day-to-day life.

The difference among audiometric tests and how they relate to hearing handicap is an important factor in the accurate assessment of hearing of the elderly (Weinstein & Ventry, 1983a). Different pure-tone audiometric configurations may result in similar hearing losses but produce widely varying handicaps for different people. More information may be needed to accurately assess the difficulty a person has coping with the environment and daily living with a hearing impairment.

A method for describing hearing handicap should be based on a comprehensive evaluation of the relationship of such factors as: the age of the individual, age of onset when the impairment was first noticed, age of onset when the impairment first occurred, degree and nature of the impairment, communication needs and settings for that individual, rehabilitation intervention already received, effect of the impairment on expressive communication, and the individual's reaction to the impairment (ASHA, 1981). An important tool for the comprehensive understanding of the subjective difficulty people experience when they are hearing impaired is a self-reporting hearing handicap scale.

The scale developed by Ventry and Weinstein (1982b) determines the effects of hearing loss on the emotional and social adjustment of older individuals. The responses to items on this questionnaire may be affected by such factors as a person's personality, age, health, lifestyle, and state of mind (Ventry & Weinstein, 1982b).

Professionals in the hearing health field need to be aware of the importance of correctly identifying the hearing needs of the elderly client. Without proper assessment and intervention older adults may become frustrated with their failure to cope with difficult listening situations and begin to withdraw from those situations. The combined use of audiometric tests and a self-reporting hearing handicap scale provides a comprehensive approach to determining degree and impact of hearing impairment on elderly individuals.

Statement of Purpose

The purpose of this study was to compare the effectiveness of a variety of audiometric measures in predicting the degree of hearing handicap reported by elderly hearing-impaired individuals using a self-administered hearing handicap scale.

Hypothesis

The hypothesis of this study is that the results of certain speech tests provide more effective information than pure tone test results in predicting the degree of hearing handicap reported by individuals using the self-administered Hearing Handicap Inventory for the Elderly.

Literature Review

Speech Perception in Noise

A common complaint of elderly hearing-impaired listeners is that they fail to understand speech which they hear. They often describe this difficulty as being worse in the presence of noise. In order to provide a clinical measure of the presence and extent of such a speech identification problem, Kalikow, Stevens, and Elliot (1977) described the development of the Speech Perception In Noise (SPIN) Test.

The test was designed to determine to what extent a listener used the available contextual and situational cues of speech as compared to the acoustic and phonemic information. The test is comprised of a series of sentences constructed to contain five to eight words and six to eight syllables. The sentence context was controlled so that the predictability of the last word in the sentence was either high or low depending on the semantic, syntactic, and prosodic cues. For high predictable (PH) sentences, the listener could use all of the lexical and acoustic aspects of the sentence to determine the last word. In the low predictable (PL) sentences, the only available cues were those of the key words themselves. The PL sentences provide no contextual information that might clue the listener about the key word. The authors stated that the intelligibility of a word is directly related to the predictability of that word as cued by the contextual linguistic and acoustic information.

The use of noise to compete with the stimuli in a controlled way simulates the daily listening situations to which most people are exposed. The speech babble used in this test has been shown to interfere more with speech understanding than a non-speech noise (Carhart, Johnson, and Goodman, 1975). The amount of interference depends on the number of different voices that are combined to produce the babble. Increasing the number of voices increases the degree of interference.

Kalikow, Stevens, and Elliot (1977) formulated 250 PH sentences and 250 PL sentences were for the SPIN test. These sentences were separated into 10 sets of 50 sentences, each containing 25 PH and 25 PL sentences. The PH and PL items were randomly ordered in each set, but there were no more than three consecutive items of any given predictability. Each even numbered test set was given an odd numbered counterpart with identical key words, but the key words were in sentences of the opposite type of context. See Table 1 for example of high and low predictable sentences and the counterbalancing of the key words.

Table 1

Examples of SPIN Sentences

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1. We should have considered the juice.
2. At breakfast he drank some juice.
3. The bomb exploded with a blast.
4. The class would consider the blast.

These sentence sets were recorded by a male speaker on one track of a two track tape. The second track contained a 12-speaker babble. The babble was a combination of three male and three female voices reading a story. The recorded voices of the readers was then recombined to produce the 12-speaker babble. Just prior to the presentation of the stimulus sentences, the speech babble was reduced by 10 dB to alert the listener to the next item.

The ten sentence sets were then tested for equivalence. Eighty listeners with normal hearing were presented with the sentences. Both the stimulus sentences and the competing babble were presented at 80 dB SPL. The author's results using normal listeners indicated that all test sets were adequately homogeneous and equivalent.

Kalikow, Stevens, and Elliot (1977) also tested the SPIN to assess performance at various signal to noise (S/N) ratios. A young group, ages 18 to 25 years, and an older group, ages 60 to 75 years, were tested at S/N levels of -5 dB to +10 dB. Results show that performance scores increased more rapidly for PH sentences than for PL sentences as the S/N levels increased. The scores for the older group were only slightly lower for both types of sentences than the scores for the younger group. The authors stated that the data reveal that older subjects were as capable as younger subjects in using sentence context to predict the key words.

Hutcherson, Dirks, and Morgan (1979) evaluated the SPIN test in terms of the effect of intensity levels of presentation and the signal to babble ratio on scores for speech discrimination in noise. All testing used individuals with normal hearing sensitivity. The authors reported that scores for the high predictability sentences were better than the scores for the low predictability sentences in all test conditions. The first experiment used presentation levels of 30, 50, and 80 dB SPL and signal to babble ratios of -4 to +8 in 2 dB steps. The results demonstrated that the presentation intensity level of the signal sentences does have a significant effect on the obtained scores. The reported scores for the high predictability stimuli at the 80 dB and 50 dB presentation levels increased at the rate of 15% per dB of the signal to babble ratio. The scores for the low predictability sentences rose at a slower rate, 7%/dB for 50 dB presentation level and 9%/dB for 80 dB presentation level. At the 30 dB presentation level performance scores were significantly reduced. The obtained speech threshold levels for the normal-hearing subjects ranged from 15 dB SPL to 22 dB SPL. Consequently, among subjects with speech thresholds as high as 22 dB SPL, the presentation at 30 dB SPL was only 8 dB above threshold for speech. High predictability scores rose at the rate of 7%/dB and the low predictability increased only 3%/dB. The results demonstrated that the presentation level of the stimulus had a significant effect on discrimination scores especially when the presentation level approached the level of threshold for spondaic words. The interaction of the signal to babble ratio to the obtained scores showed that there was a 40% difference between the scores for high predictability and low predictability sentences at signal-to-babble (S/B) ratios from -2 to +2. The differences between the high and low predictability sentences at S/B ratios above +2 and below -2 were less than 40%.

The second experiment presented the SPIN at levels from 25 dB to 40 dB SPL at a constant S/B ratio of +10 dB. It was found that the percentage of correct responses for both types of sentences increased as a function of increasing the levels of presentation.

The data collected on the normal subjects in the second experiment provided the reference for data collected for SPIN scores on individuals with sensorineural hearing loss. The case studies of the subjects with sensorineural hearing loss that were included in this study suggested that the SPIN "may provide a more insightful estimate of discrimination ability in everyday listening situations" for an individual than the monosyllabic word tests that are conventionally administered.

Bilger, Nuetzel, Rabinowitz, and Rzeczkowski (1984) tested the SPIN to assess what variances occurred under differing test conditions, administration, and methods. The SPIN was given to 128 listeners with some degree of sensorineural hearing loss. The speech stimuli were presented at 50 dB above the estimated threshold of the subject for the babble track for each listener and a S/N ratio of 8 dB. The threshold was estimated by using the subject's audiogram and the spectrum of the babble track. Half of the subjects listened through headphones and half through speakers. Half of the subjects were tested in a single session and half were tested in two sessions. The results indicated that the method of transmission, number of visits, and order of test forms did not significantly affect the performance scores. However, Bilger, et al (1984) did not find the test forms to be equivalent. The authors reported that total SPIN scores for forms 5, 4, 10, 1, and 2 represent a heterogeneous set of test forms. Total scores for forms 6, 3, 9, 7, and 8 were either very high or very low indicating a lack of objectivity and reliability for these forms. Based on this information, the authors stated that the forms of the SPIN were not equivalent and may not be equally reliable as testing tools.

Keith and Talis (1970) assessed the use of speech in noise as it might be used in diagnostic audiometry. They asserted that a better differential diagnosis of hearing impairment by adding the presence of noise to the speech discrimination testing.

Thirty subjects were used for this study. Their ages ranged from 15 to 55 years old. The subjects were divided into three groups: normal subjects with hearing no worse than 10 dB from 250 through 4000 Hz; subjects with sensorineural hearing losses with thresholds better than 20 dB from 250 through 1000 Hz and high frequency thresholds poorer than 30 dB at 2000 Hz and 40 dB at 4000 Hz; subjects with flat sensorineural losses with thresholds poorer than 25 dB at all frequencies. The subjects were familiarized with the CID W-22 word lists prior to test administration. The lists were presented in quiet at 30, 40, and 50 db sensation level (SL). If no maximum score was obtained at any of these three levels, 40 dB SL was used for this experiment. The W-22 lists were presented a second time using a white noise background at -8, 0, and +8 signal-to-noise ratios.

The data collected indicated that the presentation of the CID lists with various signal-to-noise ratios indicated that the addition of white noise did not significantly increase the diagnostic information because of the wide variability of the scores obtained in noise.

Dubno, Dirks, and Morgan (1984) studied the effects of age and mild hearing loss on speech recognition in noise. They used four subject groups which included younger and older normal-hearing individuals and younger and older individuals with mild hearing loss. The younger groups were comprised of individuals less than 44 years old and those of the older group were over 65 years of age. The SPIN test and selected spondee words were used as the speech stimuli. Speech recognition scores were obtained in quiet and in noise. Determinations were made of signal-to-babble ratio for each subject to achieve a 50% performance in quiet for spondees, PH, and PL stimuli presented at 56, 72, and 88 dB SPL using an up-down adaptive psychophysical method (Levitt, 1971).

The results of this study indicated that differences in the performance of the subjects in noise was a function of age. The difference in performance was observed in both the normal-hearing and hearing impaired subjects despite similar performance in quiet.

Synthetic Sentence Identification (SSI)

Speaks and Jerger (1965) developed a new method for assessing speech identification. They created a test that required subjects to make accurate identification from among proffered alternatives rather than a correct repetition as is required by other audiometric speech tests.

The authors used sentences for the stimuli; however, the use of real, everyday sentences involved the problems of contextual cues, word familiarity, word and sentence length, and sentence structure. The new test used artificial synthetic sentences instead of real sentences described by the authors as third approximations of real sentences.

Construction of artificial sentences was achieved through assessing the conditional probabilities of word sequences. Various levels of approximation of synthetic sentences as compared to real sentences were developed by using word pairs, word triplets, or longer sequences. First, second, and third order approximation sentences were constructed.

After testing each level of approximation, the authors determined that the third order approximation sentences yielded the best performance scores. They noted that as constraint on word order increased, scores increased as well. The sentence sets were also tested to determine if a practice effect occurred over successive trials. The results indicated that a learning effect was present for the initial three trials but the magnitude of the effect was significantly lowered after the first three sentence sets.

Table 2

Examples of Synthetic Sentences

1. Small boat with a picture has become
2. Women view men with green paper should

The authors described several advantages to this type of speech identification. First, the stimulus set is always closed. Secondly, the method of testing can be easily automated. Finally, the practice effect for a stimulus set is easily determined.

Speaks, Karmen, and Benitez (1967) studied the effect of the use of a competing message on the performance-intensity function for the synthetic sentences published by Speaks and Jerger (1965). Two experiments were undertaken utilizing trained and untrained listeners. In the first experiment, the trained listeners were presented with the SSI and instructed to identify the sentence that was heard. The stimulus sentences were presented at 30, 40, and 50 dB SPL. The competing message was varied systematically for each sentence intensity level. The results indicated that scores improved as the message to competition ratio (MCR) was made more favorable. However, at any given MCR the performance scores did not significantly improve with increased message intensity. The slope of the performance-intensity function became steeper as the intensity of the stimulus was increased systematically.

In the second experiment, the untrained listeners were presented the sentences at 30 dB SPL. Message to competition ratios ranging from -20 to +6 were used. The results indicated that the non-trained listeners did not preform as well as the trained listeners at any MCR level. The performance-intensity function was somewhat flatter for the non-trained subjects than for the trained subjects.

The authors concluded that these data indicate that the addition of a competing message for the SSI flattens the performance-intensity function. This allows a clinician to vary the presentation level of the stimulus sentences over a much wider range without compromising performance.

Orchik and Burgess (1977) studied the SSI in relation to the age of the listener and various message to competition ratios. The subject group consisted of 40 normal hearing individuals, divided into age categories: 10 to 12 years, 20 to 29 years, 40 to 49 years, and 60 years and older. The SSI was presented at 40 dB SL (re SRT) at MCRs of 20, 0, -10, -20, and -30 dB. The results indicated that as the level of competing message was increased the performance scores decreased. As a function of age, scores improved between the 10 to 12 year old group and the 20 to 29 year old group. Performance decreased as a function of age for both the 40 to 49 year old group and the 60 and older group. These functions were not consistent at all MCRs. There was no discernable age effect at the 20 db MCR or the 0 dB MCR. The age effect described above was most prevalent at the -20 dB MCR.

Northwestern University Auditory Test No. 6 (NU-6)

Tillman, Carhart, and Weber (1963) developed a new word identification test based upon earlier work of Peterson and Lehiste (1962). The new test of Tillman, Carhart, and Weber, called the Northwestern University Auditory Test No. 4 (NU-4) consisted of two lists of 50 single-syllable words each of which was comprised of a consonant-vowel-consonant combination. Subsequently, Tillman and Carhart (1963) expanded the NU-4 test with additional lists of words and the new test became known as Northwestern University Auditory Test No. 6 (NU-6).

The new word lists Tillman and Carhart (1963) constructed were intended to be a more effective assessment of listener's word identification ability than such existing word list tests as the Central Institute for the Deaf (CID) W-22 lists and the earlier PAL-50 Auditory Speech Tests constructed at the Harvard Psychoacoustic Laboratory which had been widely used by audiologists.

In order to evaluate their new test, Tillman and Carhart (1963) presented the lists to two groups of subjects. One group had twenty-four normal-hearing individuals and the other group had twelve people with sensorineural hearing losses. Each list was given twice to each subject at six ascending presentation levels ranging from -4 dB to 40 dB SL. Performance scores increased as sensation level increased, eventually reaching an asymptote at 32 dB for 100% correct discrimination scores. At a sensation level of 9 dB the performance scores reached 80% correct. All four of the NU-6 lists were reported to be equivalent and have high test-retest reliability.

MCL/LDL

Most comfortable listening level (MCL) is an acoustic intensity, most often for speech, which a specific listener chooses as the most comfortable for listening to sustained auditory input. This determination is commonly made in audiologic assessments and hearing aid evaluations. There is no uniform acceptance of the type of material that should be used or the procedure by which this measure is obtained. MCL is used to estimate the appropriate acoustic gain for hearing aids and in the comparison of hearing aids (Ventry and Johnson, 1978). This measure, when used with loudness discomfort level (LDL), is helpful in determining the presence of recruitment.

The hearing level at which speech becomes uncomfortably loud is the Loudness Discomfort Level (LDL). The purpose of this measure was to find the upper intensity limit of the subject's range of hearing for speech.

Woods, Ventry, and Gatling (1973) assessed the effects of ascending and descending measurement methods for Most Comfortable Listening (MCL) level. Twenty normal-hearing subjects were tested using pure-tone stimuli delivered through a Bekesy audiometer. All testing was performed at 1000 Hz. MCL was assessed for continuous and interrupted tones. For the ascending method, the tone was begun at threshold and increased by 2.5 dB/sec for one minute. The descending method began at 100 dB hearing level (HL) and was attenuated at 2.5 dB/sec for one minute. The results indicated that MCLs for the ascending method were approximately 18 dB lower than for the descending method. Continuous tone presentation also yielded lower MCL scores.

Morgan, Wilson, and Dirks (1974) investigated the methods and stimuli used for obtaining loudness discomfort levels (LDL). Six adults with normal hearing were used as subjects. They were presented with a 1000 Hz tone through a Bekesy audiometer for three different presentation methods: continuous, adjustment, and tracking. The stimuli was presented without interruption varying the intensity over a 10 dB range in 2 dB steps. This proved to be the most reliable method.

The subject's loudness discomfort levels (LDL) were then measured by the constant method varying the frequency range. Pure tones were presented at octave frequencies from 125 Hz to 4000 Hz and for a wide and narrow band of noise. The results indicated that the LDLs were highest at the low frequencies and did not vary significantly for 1000, 2000, 4000 Hz and for the wide-band noise. The authors reported that these frequency results correspond closely with the data from the loudness contour studies.

Wall and Gans (1984) assessed the test-retest reliability of a forced-choice method for obtaining MCL for speech. Thirty subjects with normal hearing were used for this study. Each subject had two test sessions. MCLs were established for each subject in one session by both ascending and descending methods. The subjects were presented with three spondees and only given two intensity levels at each trial sequence from which to choose the most comfortable level of each intensity pair presented. This procedure was continued, varying the two presentation intensities, until three selections at the same intensity were chosen. The same procedures were performed for the second test session, counterbalancing the order of presentation. The results of these authors indicated that there was no significant difference in results between the ascending and descending methods and that the test-retest reliability of the forced choice response method was high. The same test protocol was used in a second experiment using fourteen subjects with sensorineural hearing loss. All subjects had pure-tone averages of 20 dB HL or greater. The results of this experiment indicated that the forced-choice method yielded more stable MCLs than did the ascending and descending method of limits procedure.

Ventry and Johnson (1978) evaluated the method for measuring most comfortable loudness for speech. Additionally, the reliability of the measurement method was assessed as a function of approach mode (ascending versus descending), the severity of the hearing loss, and the pure-tone configuration. One hundred male subjects were used, ranging in age from 25 to 95 years. The subjects were categorized into groups according to the severity of hearing loss and the configuration of the loss. All subjects had at least 30 dB HL thresholds at 500, 1000, or 2000 Hz.

The results indicated that both ascending and descending approach methods were statistically and clinically reliable. The authors stressed that the descending approach method had smaller standard deviations and smaller range indicating that the difference between subjects was smaller using the descending method. The test-retest reliability for descending resulted in differences no greater than $\pm$ 5 dB for both approach methods. The results also indicated that the descending approach was less influenced by the degree of loss or the configuration of the loss than the ascending method.

Kopra and Blossner (1968) tested 26 individuals on the effects of three variables on the most comfortable listening level: measurement method, sex of listener, and repeated testing. The speech stimulus used was a recording of a Fulton Lewis, Jr. news commentary used in the Threshold of Intelligibility for Connected Discourse (TICD). The subjects were familiarized with the TICD passage before testing began. Measurements for MCL were obtained by three methods: a modified method of limits in which the experimenter controlled the intensity of the speech signal and adjusted them in response to hand signals from the subject; a method of adjustments in which the subject controlled the intensity of the stimuli but cannot see the intensity level of the attenuator; and the Bekesy method in which the subject tried to keep the speech signal at the MCL level by means of a Bekesy handswitch. The order in which these three methods were presented to subjects was randomized. Three to ten days after the initial session, subjects were asked to come back and MCL levels were reestablished with the same three methods.

Results from this experiment revealed that similar mean MCL levels were obtained for all three methods in both initial and retest conditions. Also, mean

MCL levels were consistent for any single method from test to retest. The sex of the individual did not significantly affect the MCL levels.

Hearing Handicap Inventory for the Elderly (HHIE)

Hearing handicap scales have been designed to try to quantify the amount and types of difficulty a person experiences as a result of a hearing impairment. Several different self-reporting hearing handicap scales have been developed to assess the effect of hearing loss and the handicap from that loss on an individual (Weinstein and Ventry, 1982b). The scales fall into three basic categories: situational, psychosocial, and scales that combine situational and psychosocial. Situational handicap scales would include the Hearing Handicap Scale (HHS) by High, Fairbanks, and Glorig (1964) and the Social Hearing Handicap Index (SHI) by Ewertson and Birk-Nielson (1973). The Denver Scale of Communication Function (Alpiner, Chevrette, Glascoe, Metz, and Olsen, 1971) is an example of a psychosocial scale. Combination inventories like the Hearing Measurement Scale (HMS) by Noble and Atherley (1970) and the Hearing Performance Inventory (Giolas, Owen, Lamb and, Schubert 1979) explore both aspects of the effects of hearing impairment. The Hearing Handicap Inventory for the Elderly (HHIE) by Weinstein and Ventry also falls into the category of a combination self-assessment scale.

Ventry and Weinstein (1982b) described the development and standardization of the Hearing Handicap Inventory for the Elderly (HHIE). The items for this scale were developed to address the concerns of elderly individuals and how they deal with or are affected by a hearing loss. This inventory uses twenty-five items in two sections: 13 questions focusing on the emotional consequences of hearing impairment and 12 focusing on social and situational effects of hearing impairment.

After extensive item development and evaluation, the final test version of HHIE was administered to 100 subjects 65 years or older. The subjects were representative of the clients seen at urban speech and hearing centers. Each subject was given a complete audiological evaluation. Most demonstrated sensorineural hearing loss. The HHIE was administered in a face-to-face interview style.

Weinstein and Ventry (1982b) stated that the mean HHIE score was about 30% with a range of 0 to 90%. This wide variability suggested that individuals respond very differently to hearing loss. It was also suggested that the consequences of hearing loss may have to be directly measured rather than predicted. The results indicated that the HHIE is highly reliable. There was also a high correlation between the sections and a high internal consistency of each section. All this data suggested to the authors that the test would maintain its reliability in shortened forms (i.e. a screening scale).

The validity of this scale was not tested directly in this standardization study by Weinstein and Ventry (1982b). However, the authors stated that they consider this a valid test measure based on the following rationale: the test measures what it purports to measure; concurrent validity with some other independent, valid measures; and construct validity based on previous testing of similar scales and populations.

Lichtenstein, Bess, and Logan (1988) assessed the screening version of the Hearing Handicap Inventory for the Elderly-Screening Version (HHIE-S) for validity and reliability. The screening version of this scale contains ten questions, five emotional and five social/situational. A Welch-Allyn audioscope was used in this study. This is an otoscope capable of presenting pure tones of 500, 1000, 2000 and 4000 Hz at a given intensity. This device may be used as a pure-tone screening tool. Measures from the screening Welch-Allyn audioscope and the HHIE-S were compared to pure-tone audiometric results. The 178 subjects were seen at physicians' offices and at a hearing clinic. The measures were taken at both locations. The combined use of the screening audioscope and the screening version of the HHIE yielded 83% accuracy. Both the audioscope and the HHIE-S were considered valid and reliable instruments for detecting hearing impairment in an elderly population.

Comparing Handicap Scales to Audiometric Tests

McCartney, Maurer, and Sorenson (1976) compared two hearing handicap scales with audiometric tests to determine which of the two scales was more highly correlated to the audiometric test results. The Hearing Handicap Scale (HHS) (High, Fairbanks, Glorig, 1964) and the Hearing Measurement Scale (HMS) (Noble & Atherley, 1970) were used for this comparison. High and Fairbanks stated that the HHS was standardized on subjects with predominantly conductive type hearing impairments. The HMS was described by its authors to have been created to address the hearing concerns of individuals with sensorineural hearing defects, especially those people with losses associated with their occupation.

McCartney, Maurer, and Sorenson (1976) used 36 subjects who were over the age of 60 years. Thresholds of each subject were obtained for pure tones and spondees. Speech discrimination scores were obtained using the Campbell 25-word discrimination list. Each subject's most comfortable listening level (MCL) was also determined. In addition, each subject responded to the questions of the two hearing handicap scales. The results indicate that both scales had a higher correlation with audiometric thresholds (pure-tone and SRT) than with measures of discrimination. Pure-tone averages had a higher correlation than did the speech reception thresholds. Three of the 7 HMS sections had the highest correlations to the total scale score: emotional response, speech hearing, and personal opinion. While these two scales were similar according to the correlation data, they cannot be used interchangeably. The significant differences include: administration time, administration style (self-assessed or interview), and difference in question content.

An additional aspect of the study of McCartney, Maurer, and Sorenson (1976) was to assess the effectiveness of the HMS on a different group of subjects from that on which it was initially standardized. The initial focus of Noble and Atherley (1970) for this scale was on individuals whose sensorineural hearing loss was related to occupational exposure. The test group used for this study also exhibited sensorineural losses but was comprised of elderly individuals and was not controlled according to noise exposure or occupation. The results of this study suggest that the HMS may be just as appropriate for use with an elderly population of individuals suffering sensorineural hearing impairment as with those exposed to occupational noise.

Berkowitz and Hochberg (1971) performed an investigation of the relationship between the HHS (High et al, 1964) and a selection of audiometric tests using an elderly population. One hundred subjects were tested ranging from 60 to 87 years. Each subject was administered the following battery: HHS, pure-tone air and bone conduction tests, speech reception thresholds using the CID Auditory Test W-1 word lists, speech discrimination test using the CID Auditory Test W-22 word list, and a speech reception threshold using CID Everyday Speech sentences.

The results of the study by Berkowitz and Hochberg (1971) indicated a significant relationship between the battery of audiometric tests and the self-reported hearing handicap. The results revealed significant findings according to specific age and sex of the subject. Among the 60 to 69 age group, the handicap scale scores of female subjects were significantly related to all of the audiometric tests. In the group of subjects 70 to 79 years, the handicap scale scores for male subjects were significantly related to pure-tone and speech reception thresholds. There was no significant correlation of the handicap scale scores to the audiometric scores for any individuals in the 80 to 87 age group. However, there were some substantial relationships found between the HHS and PTA and SRT. The authors stated that these results may have reached statistical significance if the size of the test group in this age range had been larger.

Berkowitz and Hochberg (1971) suggested that the HHS may not be sensitive enough to differentiate among people with conductive or sensorineural hearing losses but who have fairly good discrimination ability. The authors stated that questions on the scale may be more geared for the individual who has problems with hearing sensitivity instead of those with discrimination difficulties.

Ventry and Weinstein (1983a) compared the use of audiometric testing and a self-reporting hearing handicap scale to identify hearing handicap in the elderly. The subjects tested were all over 65 years old and demonstrated no neurological or psychological problems and none demonstrated a fluctuating hearing loss. All levels of hearing sensitivity were represented in this group, but the majority of the subjects had mild to moderate sensory neural losses. The Hearing Handicap Inventory for the Elderly (HHIE) (Ventry & Weinstein, 1982b) was administered prior to audiometric testing. The audiologic evaluation included measurement of pure-tone thresholds, spondee thresholds and speech discrimination using the CID Auditory Test W-22 word lists. This study showed a significant correlation between pure-tone results and reported hearing handicap. The subjects were divided into three categories of handicap according to their self-reported scores: no handicap, mild to moderate handicap, and significant handicap. The authors state that there is a relationship between actual hearing loss, as determined by pure-tone average (PTA), and the score of an individual determining the self-reported hearing handicap scale, but this relationship is not perfect. However, according to this data, the trend is that the degree of self-perceived handicap increases as hearing loss increases. The area of greatest variability is for the group with hearing losses between 26 dB and 40 dB. There is an almost equal distribution between individuals who perceived themselves as hearing impaired and those who denied such a condition. Almost all subjects with hearing losses greater than 40 dB reported having self-perceived handicap. There was a statistically significant correlation between speech discrimination and HHIE, but this correlation is weaker than it was for the pure-tone results.

Ventry and Weinstein (1983a) stressed that even though a statistically significant relationship exists between the audiometric measures and the HHIE, one should not be substituted for the other. They stated that the HHIE is not a measure of hearing sensitivity and audiometric testing results may not reveal the non-audiometric variables that contribute to hearing handicap.

Effects of Aging/Presbycusis

Presbycusis refers to hearing disorders that are a results of senescent changes in the hearing mechanism (Jerger and Jerger, 1981). There are many theories about the cause for loss of hearing as a person ages. The theories that involve environmental factors suggest that deterioration of the auditory system is a result of the daily exposure to the noises of our world. Additionally, it is suggested that factors such as infections, toxins, and trauma have a cumulative effect on the hearing system. Theories that are oriented to the genetic process of hearing loss stress that heredity is the primary factor to hearing loss with age.

The onset of presbycusis is gradual and progressive. The loss is characteristically bilateral and may be accompanied by a high pitched, ringing tinnitus. Age of onset varies but some degree of presbycusic hearing loss may be seen in individuals after the age of 37 (Jerger and Jerger, 1981).

Punch and McConnell (1969) investigated the effects of aging on the performance on word identification at various intensity levels. All subjects in this study were age 65 and over. The subjects were divided into two categories: those in group 1 demonstrated minimal hearing loss; subjects in group 2 had mild to moderate presbycusis hearing impairment.

Word identification scores were obtained using the Central Institute for the Deaf (CID) W-22 word lists presented at 10, 20, 30, and 40 dB sensation level (SL) re the spondee threshold (ST) of each subject. Results indicated that for both groups the mean word identification scores improved with increased intensity. When the two groups were compared, group one had significantly better mean word identification scores than did group two at all SL test levels. The standard deviations for group two at 30 and 40 dB SL were considerably higher than for that of group one. Punch and McConnell (1969) stated that the results indicated considerable deviation from normal in the ability of the group of subjects with minimal hearing loss to discriminate among speech sounds. This suggests a need to evaluate the speech discrimination ability of the person with presbycusis with reference to norms accounting for the diminished performance in older people. For the older individual with additional hearing impairment not associated with the aging process there is an even further reduction in discrimination performance. This suggests that older individuals have a narrower range of intensity than normal from which to use cues to facilitate discrimination.

Pestalozza and Shore (1955) conducted a study to review various tests of auditory function to determine the best way to improve the differential diagnosis procedure for individuals with hearing losses attributed to presbycusis. Pestalozza and Shore (1955) stated that the term presbycusis refers to the loss of hearing associated with the aging process and does not specify the site of lesion or reason for the hearing loss. Twenty-four subjects 60 years or older were selected from existing client files from the Hearing Clinic at Central Institute for the Deaf. All subjects selected had the following information in their files: complete case histories with special interest on medical history; pure tones for air and bone conduction; monaural speech reception threshold using spondees; monaural speech discrimination using Harvard PAL Test 12 word lists; sound field testing for speech threshold for sentences; and an otolaryngological examination. Subjects were brought in for retesting after their files had been reviewed and selected. All of the above testing was duplicated as well as the addition of recruitment testing by monaural loudness balancing.

Results from this study indicate a significant relationship between hearing loss and reduced discrimination ability. It was found that for this group of subjects, discrimination scores were poor for individuals with mild losses as well as those with more severe hearing impairment. The authors compared these findings to data collected on 25 younger subjects who had hearing losses similar to the older group. Subjects in this younger group were less than 40 years old and had acquired hearing losses after age twenty. These subjects had the same discrimination testing as the previous group. The findings indicated that younger individuals had less discrimination difficulty than did the older individuals even with equal amounts of hearing loss.

Another aspect of this study compared the results of speech thresholds for spondees and pure-tone tests. Results for the elderly subjects indicated that speech thresholds closely approximate the pure-tone average for 500, 1000, and 2000 Hz. The exception to this finding was for the subjects whose audiograms were sharply sloping. In this case the speech thresholds were more closely associated to 500 and 1000 Hz. When these findings were compared to similar tests of younger subjects, the authors found that there was a higher correlation between pure tone and speech thresholds for the younger group than for the older individuals.

Pestlozza and Shore (1955) stated that from the above findings it appears that age is a significant factor in the ability to understand speech. In all instances, the older group had more difficulty with the speech stimuli than did the younger group even when the degree of hearing loss was the same for both groups.

Another area that Pestalozza and Shore (1955) investigated was how recruitment related to discrimination. The results for the recruitment testing and for the discrimination testing were compared. Fifty percent of the subjects showed no recruitment, 30% showed only partial recruitment, and 20% had almost complete recruitment. There was no clear correlation between recruitment and loss of discrimination. The authors stated that while the presence of recruitment will predict a poor discrimination score, the absence of recruitment will not predict good or fair discrimination ability.

The authors conclude that relationships ordinarily found between auditory tests are not maintained in cases of presbycusis loss. Additionally, they state that discrimination testing alone is not of great diagnostic value for individuals who have losses associated with presbycusis.

CHAPTER TWO

PROCEDURES

Subjects

Twenty-one people over the age of 65 served as subjects. Of the 21 subjects, 13 were female and 8 were male. Ages ranged from 65 to 82 years old, with an mean age of 73.54 and a standard deviation of 5.89.

Subjects volunteered to participate in this study in response to a search for subjects made in local community organizations and retirement centers.

Every subject reported having an acquired hearing loss. One third of the subjects demonstrated mild to moderate sensorineural hearing losses of relatively flat contour with pure-tone averages (PTA) for 500, 1000, and 2000 Hz not exceeding 60 dB. Two thirds of the subjects demonstrated thresholds no greater than 25 dB through 1000 Hz with PTA for 500, 1000, and 2000 Hz not exceeding 25 dB and thresholds no worse than 80 dB in the high frequencies through 4000 Hz. Ten younger subjects with normal hearing sensitivity were used as controls for this study. Their ages ranged from 20 to 27. None had hearing thresholds greater than 20 dB at any frequency from 250 through 8000 Hz.

Instrumentation

The subjects were tested in one of two sound treated rooms meeting ANSI S3.1 (1977) standards for audiometric testing. In one test room, testing was performed using a Grason Stadler GSI-10, 2 channel audiometer calibrated to ANSI (1969) standards. Subjects listened to the audiometric signals through TDH-49 earphones fitted into MX 41/AR cushions. All speech tests were taped and routed through the above audiometer and presented with a Realistic SCT-82 tape deck.

In the other test room, testing was performed using a Grason Stadler GSI-16, 2 channel audiometer calibrated to ANSI (1969) standards. Subjects listened to audiometric signals through TDH-50 earphones fitted into P/N 510C017-1 cushions. All speech tests were recorded on tape and played on a Onkyo TA-RW11 tape deck. The taped signals and associated competing babble or messages were routed through the audiometer.

The output of each speech tape used for testing was calibrated with a 1000 Hz tone prior to each testing session. The sound pressure output of each audiometer and tape deck was calibrated prior to any testing.

Immittance testing was performed in a quiet room using a Grason Stadler GSI-33 Middle Ear Analyzer clinical bridge. Daily calibration checks were made prior to any testing.

Test materials

Speech Perception in Noise

The SPIN test is comprised of eight lists of fifty sentences each. In administering the test, the subject is requested to repeat the final word of each sentence. The authors of the test indicate that in half of the sentences of each list the sentence content makes the final word highly predictable. In the remaining twenty-five sentences, the authors report that the final word cannot be predicted from the sentence content but must be heard and interpreted by the subject.

The SPIN is presented using a two channel tape. On one channel is recorded the stimulus sentences and on the other channel is a recorded competing babble of human voices. The competing babble is a combining of the recorded voices of 4 individuals reading different passages simultaneously and subsequently recorded to produce the effect of twelve speakers. Both channels have a 1000 Hz calibration tone that precedes the test material. The subject is presented with both the stimulus sentences and the competing babble in the same ear. The intensity level of each channel is determined by the clinician. For this study the signal to babble ratio for the two channels ranged from +4 dB to +8 dB and was varied in 2 dB steps.

The subjects were told that they would hear a group of 50 sentences and that they were to repeat the last word of each sentence. Each item is scored as either correct if the subject correctly identified the last word or incorrect if they missed the word. The SPIN sentence lists used for the study were numbers 2, 4, and 5.

Synthetic Sentence Identification

This test consists of ten sentences that in the authors' words represent third order approximations of "real sentences" (Speaks & Jerger, 1965). The construction of these artificial sentences is primarily determined by the conditional probabilities of possible word sequences. Third order approximation sentences require that each word be conditional on the two preceding words. The conditional probability of word triplets determines which word sequences will be chosen to construct the synthetic sentences. The result is a nonsense sentence that gives no contextual cues. The test is presented on a two channel tape. One channel contains the stimulus sentences and the other channel contains a competing background message. The stimulus sentences were presented at 40 dB SL with a signal to competition ratio of 10 dB. The competing message is an unrelated story read by a single speaker. For this study, the two channels were presented to the same ear simultaneously. The subject was asked to ignore the story being read and to identify which of the ten synthetic sentences had been heard. A list of ten stimuli synthetic sentences, one of the several lists published by the authors, was placed before the subject during the test. The subject's task was simply to identify the number of the one synthetic sentence which was heard.

Northwestern University Auditory Test No. 6 (NU-6)

NU-6 lists are phonemically balanced lists of 50 words. Each word in the list is a single syllable, familiar word. Peterson and Lehiste (1962) compiled lists of consonant-vowel-consonant words, referred to as CNC words, since the vowel is the nucleus of the word. The phonemic-balancing of the lists was based on the composition of each list, not on English as a whole (Peterson & Lehiste, 1962). Tillman and Carhart expanded the original lists and recorded the resulting lists known as the NU-6 lists as described above (Tillman & Carhart, 1966).

In this study the first twenty-five words of the original 50 words in each of the NU-6 lists used were presented to the subject. The words were read by a male speaker and each stimulus word was preceded by the carrier phrase "Say the word". The test was presented in quiet at an intensity of 40 dB sensation level (SL). The subject was asked to listen to the tape and repeat the final word of each stimulus phrase.

No data collected from this test was analyzed for the purposes of this study. This test was included as a part of the standard audiometric test battery.

Spondee lists

To obtain a speech threshold (ST) for each subject, a recorded list of spondee words from a commercially available tape produced by Auditec of St. Louis was used. Each spondee recorded on the tape is a two-syllable word and is presented without a carrier phrase by a male speaker. Prior to establishing the threshold for speech, each subject was familiarized with the words to be used in the test. The examiner read each word to the subject at a comfortable listening level and the subject repeated the words back to insure that they were understood. In establishing the ST, the word list was presented initially at an estimated comfortable listening level. After each correct repetition of a stimulus word, the examiner decreased the intensity in 10 dB steps until the subject could no longer repeat the words correctly. The intensity was then increased in 5 dB steps and decreased in 10 dB steps until a level was reached at which the subject could correctly repeat the words at least 50% of the time. That level was chosen as the subject's ST.

Most Comfortable Listening level (MCL)

Assessment of the most comfortable listening level (MCL) was obtained by presenting the competing message tract for the Synthetic Sentence Identification test. The message is a story that is read by a single male speaker. The intensity level of taped running speech selected by the subject was regarded as most comfortable in two of three trials. The first ascending trial was begun at 20 dB above each subject's obtained speech threshold. A second descending trial was begun 20 dB above the MCL. A third ascending trial was used to confirm the MCL. The ascending trials were increased in 5 dB steps and the descending trials were decreased in 10 dB steps. The subjects were instructed to listen to the speech and identify which of the presented levels was most comfortable. MCL were used when giving instructions to the subject during the testing.

Loudness Discomfort Listening level (LDL)

The hearing level at which speech becomes uncomfortably loud is the Loudness Discomfort Level (LDL). The purpose of this measure was to find the upper intensity limit of the subject's range of hearing for speech. Assessment of loudness discomfort listening level was obtained using the same running speech used for MCL. The ascending levels were begun at 20 dB above the obtained MCL intensities unless the 20 dB increase was too loud for the subject's comfort and was increased in 5 dB steps. No subject indicated that words presented 20 dB above the MCL were uncomfortably loud. The subjects were instructed to signal when the speech became too loud to listen to for any length of time and that a further increase in loudness would be unbearable.

Test Protocol

Each subject was administered the following battery of audiometric tests: Pure-tone evaluation for all test frequencies at octave levels from 250 Hz to 8000 Hz for air conduction and at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz for bone conduction; spondee threshold; the Speech Perception in Noise (SPIN) test; the Synthetic Sentence Identification (SSI) test; NU-6 list for speech discrimination; establishment of most comfortable listening level (MCL) and loudness discomfort listening level (LDL); immittance testing including tympanograms, acoustic reflex thresholds, and reflex decay.

Prior to testing, each subject was asked to respond to the Hearing Handicap Inventory for the Elderly (HHIE) by Ventry and Weinstein.

CHAPTER THREE

RESULTS, DISCUSSION, CONCLUSIONS, AND AREAS FOR FURTHER RESEARCH

Results

A Pearson product-moment correlation analysis was used to determine the level of relationship among some of the variables in this study. All of the correlations were significant at the .05 level of significance. The mean scores and standard deviations for the test variables are presented below in Table 3.

Table 3

Means and Standard Deviations for Age and Pure-tone Average (PTA)

	Age	PTA (dB)
Mean	73.54	25
SD	6	16

A correlation coefficient of .58 was obtained when the analysis was run between the Hearing Handicap Inventory for the Elderly (HHIE) scale score and the pure-tone averages for 500, 1000, and 2000 Hz. This data indicate that a significant relationship is evident between these two variables. As an individual's hearing sensitivity for pure tones is elevated, the self-perceived degree of hearing handicap increased (See Figure 1).

Age and the pure-tone average for 500, 1000, and 2000 Hz are highly related as seen in Figure 2. The coefficient for these items was .67. As a person's age increased the pure-tone average thresholds correspondingly became higher.

Figure 3 shows the relationship between the individual's age and the HHIE scale score. The low correlation of only .13 indicates that there is not a significant relationship between age and self-reported degree of hearing handicap.

The correlation of the HHIE scores and the Speech Perception in Noise (SPIN) performance scores for the various signal-to-babble (S/B) ratios is shown in Figure 4. For the S/B 4 dB condition, a coefficient of .64 was obtained. At S/B 6 dB, .42 was the obtained coefficient. The S/B 8 dB condition yielded a .42 correlation coefficient. The data indicate that there is a significant relationship between the performance scores for the SPIN and the self-reported score for the HHIE. As shown, the more favorable the signal-to-babble ratio the better the performance score on the SPIN. The function of all of the ratios is essentially linear among the three levels.

When the performance scores for the SPIN at all three signal-to-babble ratios used were related to the pure-tone averages (PTA), the data indicates a coefficient of .77 for S/B 4 dB, .78 for S/B 6 dB, and .93 for S/B dB (See Figure

5). This data reveals a significant relationship between the SPIN scores and the obtained PTA. As pure-tone thresholds were elevated, the performance scores for the SPIN for all three S/B ratios were elevated to a significant degree indicating greater problems in word identification.

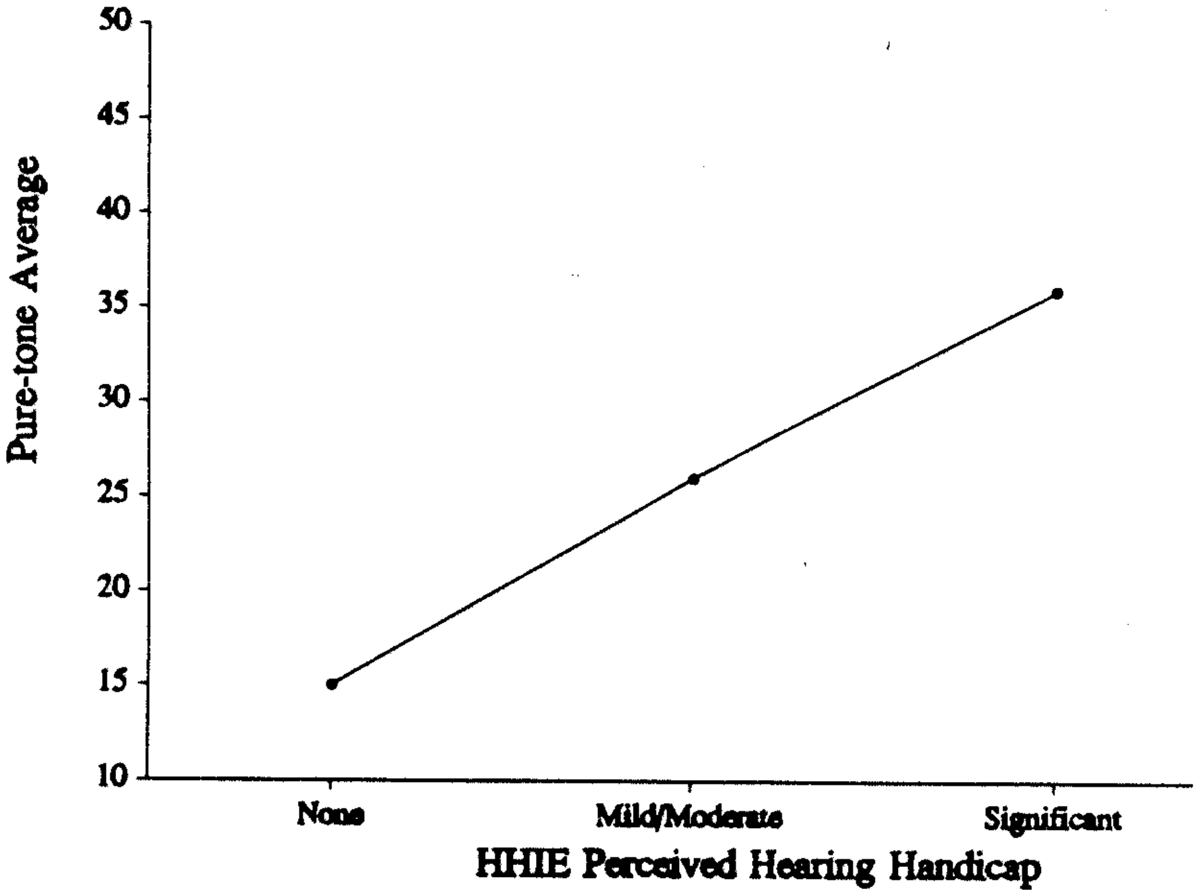

Figure 1: Mean Pure-tone Averages as Compared to Perceived Hearing Handicap

Figure 2: Mean Pure-tone Average as Compared to Age

Figure 3: Mean Scale Scores for the HHIE as Compared to Age

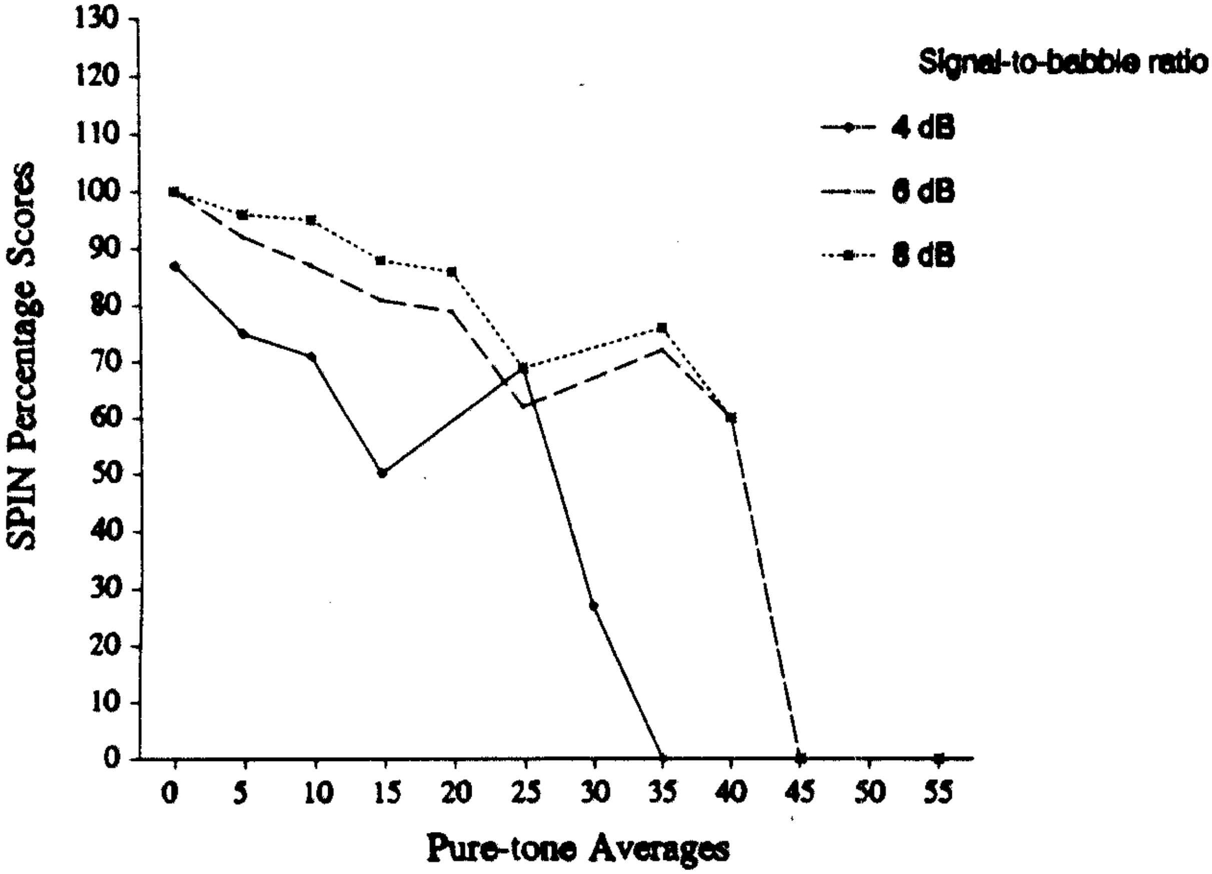

Figure 4: Mean Performance Scores on the SPIN as Compared to HHIE

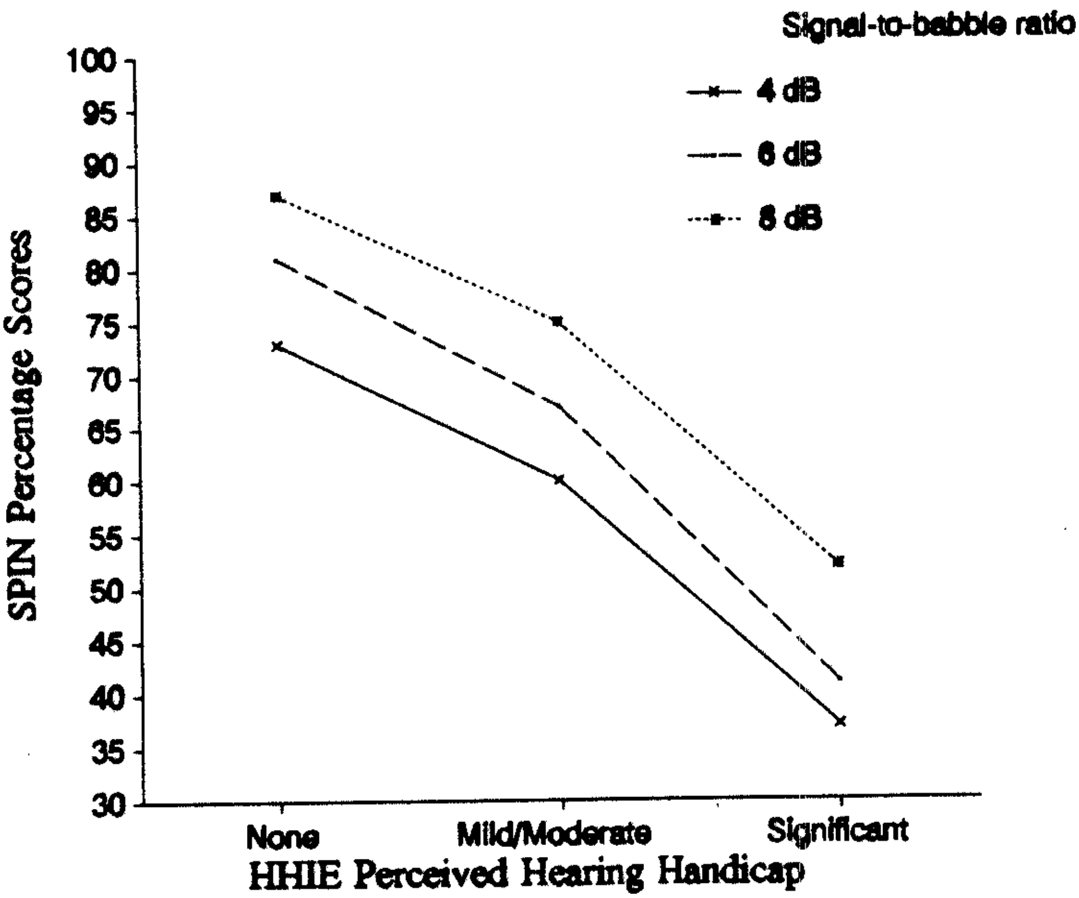

Figure 5: Mean Performance Scores for the SPIN as Compared to Mean Pure-tone Averages

Discussion

This study compared the results of a group of elderly hearing-impaired subjects on two audiometric measures, a pure-tone threshold determination of auditory sensitivity and a standardized sentential word identification task, the Speech Perception in Noise (SPIN) test.

The subjects suffered various degrees of mild to moderate sensorineural hearing impairment commonly associated with aging. The three frequency pure-tone average used in the study is widely used as a single statistic for characterizing the degree of hearing impairment suffered by a subject. It has been shown to relate closely with subject's threshold for spondees known as the speech threshold, described above. The impairment average is a reflection of thresholds and is, therefore, an indication of sensitivity, not directly of the handicap an individual might suffer in a failure to understand speech even when it is heard.

The SPIN test was designed to illicit information about the difficulty an individual experiences in listening to speech in the presence of ambient sound and the degree to which a listener utilizes linguistic cues to determine a speaker's message, even in the presence of competing babble sound. The SPIN was presented at three different signal-to-babble ratios with the signal presented at the subject's Most Comfortable Listening Level (MCL).

The subjects also responded to a standardized hearing handicap scale, the Hearing Handicap Inventory for the Elderly (HHIE) devised to illicit information about the degree of hearing handicap elderly individuals describe as resulting from their hearing impairment.

The data lent itself to analysis of relationships among age, various combinations of pure-tone test results, the results of the three different signal-to-babble presentation ratios for the SPIN test, and the subjects' responses to the HHIE.

Age

The results of the study indicate that a direct relationship existed between the subject's ages and the degree of hearing impairment which they exhibited in response to pure-tone signals. The results do not, however, reflect a significant correlation between the age of the subjects and the degree of hearing handicap they revealed in responding to the HHIE.

Hearing Sensitivity for Pure-tone Signals

A significant relationship was demonstrated between the hearing sensitivity for the average of the pure-tone signals of 500, 1000, and 2000 Hz of the subjects and their self-reported hearing handicap as revealed by their responses to the HHIE. As the subjects' thresholds for the three-frequency average of those pure tones were elevated, the degree of hearing handicap they reported also was increased.

Speech Perception in Noise

An analysis of the results of this study indicated that as the subjects' thresholds for the average of 500, 1000, and 2000 Hz pure-tone signals were elevated, the poorer was their success in identifying the target word of SPIN sentences. In brief, the greater their degree of hearing impairment as determined with pure-tone stimuli, the poorer was their ability to identify the target words in speech sentences in the presence of competing speech babble at every signal-to-babble ratio used.

The subjects' responses to the SPIN, while positively related to their responses in the HHIE, failed to reach the level of significance which existed between their sensitivity for the pure-tone signals and their responses to the HHIE.

Conclusions

The results of this study indicate that

1. The subjects in this study responded to the Hearing Handicap Inventory for the Elderly (HHIE) in much the same manner as did the subjects in a study of the HHIE's authors. That is, those with moderate to profound hearing losses, as reflected by pure-tone thresholds, indicated that they had experienced noticeable hearing handicap. Those individuals whose pure-tone thresholds reflected impairment of less than a moderate degree tended not to report a hearing handicap. The hearing impairment suffered by older individuals tends to have a gradual onset and effects sounds in the upper range of the human auditory spectrum earlier and to a greater degree than it does sounds in lower frequencies. The insidious advance of the impairment causes a loss of the ability to perceive a limited number of

speech sounds, leaving others relatively unaffected. Perhaps because the impairment is insidious, those affected often seem to be unaware of, or deny, its existence. Unless the affliction reaches a level described as moderate or severe, those afflicted seem to tend not to consider the loss a handicap when responding to a handicap scale.

2. The SPIN test previously has been demonstrated to be a valid and reliable clinical measure of the difficulties listeners experience in the presence of a background of competing speech babble. Subjects involved in this study demonstrated that the test is an effective indicator of the type and amount of difficulty elderly subjects experience in listening to speech in the presence of various levels of speech babble. As expected, they demonstrated increasing difficulty in word identification as the ratio of speech intensity to babble intensity was made less favorable. One might expect that the greater difficulty demonstrated by the results of the subjects on the SPIN would be reflected in a higher indication of self-awareness of hearing handicap as reflected by the results of the HHIE. While a positive correlation between the results of the subjects on the SPIN and the HHIE was demonstrated, the correlation was not as high as might be expected. The subjects' responses to the pure tone test signals were better predictors of hearing handicap than were their results on the SPIN.

3. The results of this study suggest that the subjects used in the inquiry seemed to evaluate their handicap primarily in terms of auditory sensitivity

rather than in terms of their most common presenting problem, word identification or speech perception.

Areas for Further Research

The results of this study comparing the relationship between hearing handicap and different audiometric tests were revealing and significant. However, given the relatively small number of subjects used in this study more research on this question might be undertaken using a large population of individuals. The subjects used in this study were representative of the local area and were diverse in their background, degree of education, age, and amount of hearing loss. The use of a larger subject group would determine if these results are substantiated for a wider population of hearing impaired elderly. Another area that future researchers might consider is testing time. It might prove beneficial to divide the testing into two sessions. The possibility of fatigue for the elderly individuals is greater than it might be for another population. The use of two test sessions would provide some information about the fatigue factor.

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