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COMPARING NORMALLY-HEARING AND HEARING-IMPAIRED CHILDREN'S PERFORMANCE ON WORD INTELLIGIBILITY BY PICTURE IDENTIFICATION (WIPI), PEDIATRIC SPEECH INTELLIGIBILITY (PSI), AND NORTHWESTERN UNIVERSITY-CHILDREN'S PERCEPTION OF SPEECH (NU-CHIPS) TESTS

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ABSTRACT

The Word Intelligibility by Picture Identification test (WIPI), the Pediatric Speech Intelligibility test (PSI), and the Northwestern University-Children's Perception of Speech test (NU-Chips) were analyzed to determine the sensitivity and specificity of each test. The three tests were administered to two groups of children. One group consisted of six subjects with normal hearing. The second group contained six subjects with a moderate to severe sensorineural hearing loss in the better ear. There were significant differences between the two groups of children in overall discrimination scores, among the three intensity levels (20, 30, and 40 dB SL) and the three speech discrimination tests. Correlations between the tests for the hearing-impaired group were highest at a level of 30 dB SL. Sensitivity (correct identification of abnormal) of the tests diminished when the level was increased from 30 to 40 dB SL.

The analysis of the data from the normally-hearing group suggested that all three tests exhibit good specificity (correct identification of normal). The WIPI test appears to be the most sensitive of the three tests for the hearing-impaired subjects included in this study, followed by NU-Chips. The word material on the PSI test was not judged to have good sensitivity in demonstrating the hearing-impaired group's discrimination difficulties.

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CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

Speech audiometry is recognized as an essential part of a comprehensive audiological evaluation of the young child (Olsen and Matkin, 1979 and Diefendorf, 1983). Pure tone or noise-band thresholds convey much information about the characteristics of the auditory system, but do not provide the audiologist with any precise measure of a person's ability to receive and respond to the speech message (Diefendorf, 1983). The audiometric threshold configuration is not always a good indication of an individual's ability to understand speech. Thus, determination of the degree of impairment may also be assisted by speech audiometry. Speech testing can give information concerning the type of loss, including the possible differentiation of peripheral and central hearing disorders.

When using speech audiometry with young children, numerous variables that can influence the outcome of test results must be taken into consideration: (1) selection of test material within the child's receptive vocabulary; (2) the use of a nonverbal response task; (3) the use of a test that is rapid and has sufficient appeal to keep the child's attention; and (4) the use of reinforcement. These same factors must also be carefully considered when testing hearing-impaired children, since receptive vocabulary may be depressed in these children (Diefendorf, 1983). If stimuli are selected which are unfamiliar to the child, the results of the test will not only reflect auditory discrimination abilities, but also the language delay imposed by the hearing loss. Furthermore, the response must be nonverbal due to the expressive language problems frequently exhibited by the hearing-impaired. Therefore, considering the factors of age and hearing-impairment, test instruments appropriate for children must be used to accurately measure speech discrimination.

Several tests have been developed in an attempt to assess the speech discrimination ability of children. One of these is the Word Intelligibility by Picture Identification (WIPI) test developed by Ross and Lerman (1970). This test was developed as a means of measuring speech discrimination ability in hearing-impaired children. According to the work by Schwartz (1971) and a follow-up study by Sanderson-Leepa and Rintelmann (1976), the utilization of the WIPI is appropriate for children with receptive language ages of four years and greater. The Pediatric Speech Intelligibility (PSI) test by Jerger (1980) was developed for children as young as three years of age. This test attempts to control for the contaminating influence of variable receptive language skills in children (Jerger, 1980). Both monosyllabic word and sentence materials can be used because of their unique value in detecting central auditory disorder, even in the presence of peripheral hearing loss (Jerger, 1980). The Northwestern University-Children's Perception of Speech (NU-Chips) test by Elliott and Katz (1980) was developed as a speech discrimination test appropriate for children and other patients having a language age as young as three years. It was designed to be similar to other speech discrimination test procedures used by audiologists and to utilize a closed-set, picture-pointing response task (Elliott and Katz, 1980). These three tests are some of the most frequently used clinical tests of speech discrimination for children.

In order to determine the validity of a test, or the extent to which the test actually measures what it says it measures (Battin, 1981), its sensitivity and specificity must be known. The sensitivity of a test is defined as its accuracy in correctly identifying the disordered subjects. Specificity is the test's accuracy in correctly identifying the nondisordered subjects. The goal for a valid test is to maintain a balance between these factors. There has been some research concerning the validity of the WIPI, the PSI, and NU-Chips. Although the authors of WIPI do not report such data, they suggest that a direct evaluation comparing their test with others would be a useful project for future investigation. They also state that articulation-gain functions would permit a more complete description of the test (Ross and Lerman, 1970). The authors of PSI reported the slope characteristics of performance-intensity (PI) functions of their test and NU-Chips. The slope of PI functions for NU-Chips was more gradual than that of PSI. The authors stated that differences may be due to: (1) the homogeneity of test items; (2) scoring techniques; (3) the influence of cognitive skills on the task; (4) the perceptual salience of the verbal materials; and (5) the number of test items per trial (Jerger, 1982). The authors of NU-Chips report correlations between performance on their test and the WIPI. Correlations for normally-hearing children were 0.62 for five-year-olds and 0.80 for ten-year-olds. Correlations for hearing-impaired children were 0.81 for the severely to profoundly hearing-impaired group and 0.88 for the moderately impaired group. PI functions revealed an age effect at sensation levels below 30 decibels (dB). Receptive vocabulary age was noted as a significant predictor of hearing-impaired children's performance on NU-Chips, but chronological age was not (Elliott and Katz, 1980).

While these tests have been developed for a particular purpose, and some data has been gathered to measure their validity, further research is necessary to make valid comparisons between these three measures. The research involving PSI used data reported by the authors of NU-Chips to quantify the slope of PI functions and compared this to their results. While NU-Chips and WIPI were compared using the same group of subjects, the correlation was low for normally-hearing five-year-olds. Moreover, none of this research compares the three tests with each other using the same subjects. In order to accurately compare them, a study must be constructed which administers these tests to the same group of subjects, under the same conditions, and using the same methods and procedures. It is also necessary to include hearing-impaired subjects to determine the validity of the tests for that population.

The purpose of this study was to compare three tests of children's speech discrimination - the WIPI, the PSI, and NU-Chips - with respect to their sensitivity and specificity. In order to determine sensitivity and specificity, normally-hearing subjects and subjects with bilateral sensorineural hearing loss comprised the subject population.

The experimental questions posed in this study were designed to investigate:

1. differences between the speech discrimination scores between groups (normally-hearing vs. hearing-impaired);

2. differences between the speech discrimination scores for three presentation levels (20, 30, and 40 dB SL);

3. differences between the scores on the WIPI, the PSI, and NU-Chips;

4. differences between the scores for the three presentation levels on the three different tests for the two groups.

CHAPTER II

METHODOLOGY

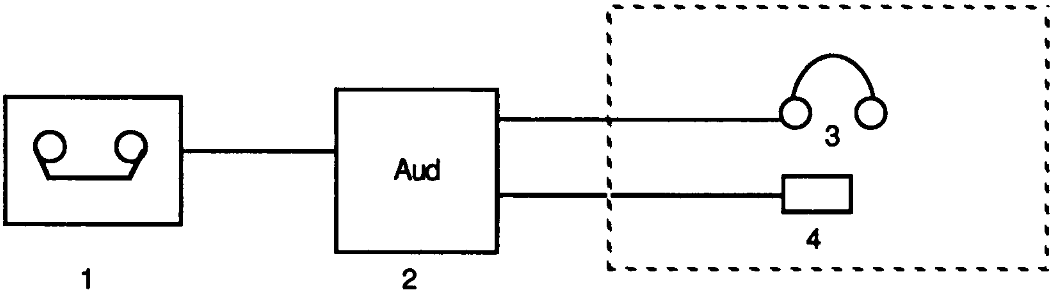
Instrumentation

The subjects were evaluated audiometrically by one examiner in a sound-treated audiometric suite (IAC sound booth). A two channel Madsen OB 802 Audiometer calibrated to the ANSI-1969 standard was utilized with TDH 39 earphones and a Radioear bone vibrator (model B-71). Otoscopy was performed with a Welch Allyn otoscope (model 25020). Immittance testing was performed on each subject with an Amplaid Model 702 impedance bridge. Screening tympanograms were performed using a Grason-Stadler tympanometer (model GSI-28). The speech stimuli were presented by the use of a Technics cassette tape recorder (model M205). Figure 1 illustrates the block diagram for testing.

The audiometer was calibrated before data collection with a Quest model AA-175 Audiometer Analyzer coupled with a model 155 sound level meter and a model OB-145 octave band filter. A comprehensive calibration check was performed according to procedures established by ANSI S3.6-1969.

Development of Test Material

Test stimuli for each test were three lists of fifty words each compiled from the original lists of the three discrimination tests.



1. Technics cassette tape recorder
2. Madsen OB 802 two channel audiometer
3. TDH 39 earphones
4. Radioear bone vibrator model B-71

Figure 1. Block diagram for pure-tone and speech testing

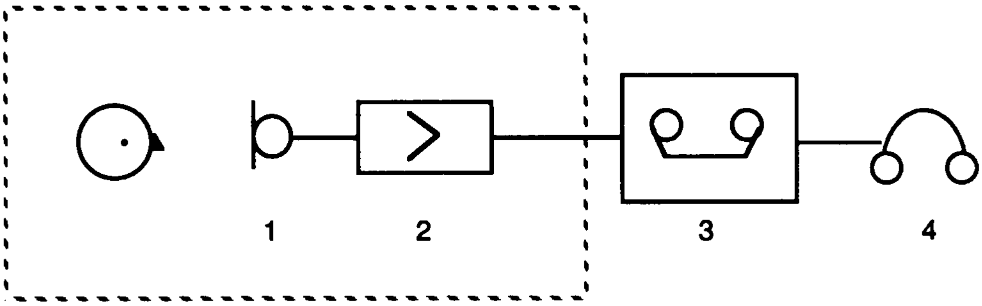
The four lists of twenty-five words on the WIPI were arranged into three lists of fifty words each (lists 1 and 2, lists 3 and 4, and lists 2 and 3). The twenty words included in the PSI test were randomized into three lists of fifty words each. The first three lists of the NU-Chips test were used for this study. There were six second intervals between the presentation of each word. A set of instructions (Appendix A) and a practice list were also recorded.

All test lists were recorded by one experienced male speaker with General American dialect. Figure 2 shows the block diagram for recording the lists. Audio cassette tapes for each test were recorded using a Studer Master Recorder Model A80 VU MKIV connected by a preamplifier to a Bruel and Kjaer measuring amplifier Type 2607 with a Bruel and Kjaer microphone Type 4145. A calibration tone was used at the beginning of each tape to control the input signal. These recordings were then dubbed onto cassette with a Technics cassette recorder Type M205.

Each tape was analyzed for variation in intensity. Figure 3 shows the block diagram for the analysis of the recordings. Graphic level recordings were made using a Bruel and Kjaer Type 2307 graphic level recorder. The range of peak intensity variation was found to be within ±4 dB.

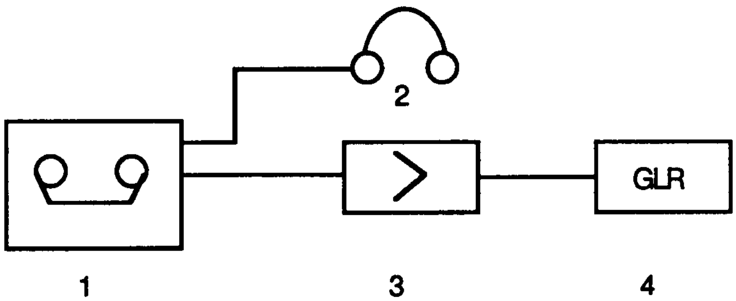
Subjects and Subjects-Selection Criteria

All subjects used were from four to seven years of age. In addition to being in this age range, each subject was able to demonstrate a receptive language age of at least four years (the



1. B & K Microphone, model 4145
2. B & K Measuring Amplifier, Type 2607
3. Studer Master Recorder Model A80 VU MKIV
4. Earphones

Figure 2. Block diagram for the recording of speech stimuli



1. Studer Master Recorder
2. Earphones
3. B & K Measuring Amplifier Type 2607
4. B & K Graphic Level Recorder Type 2307

Figure 3. Block diagram for analysis of test stimuli

minimum level acceptable for performance on the tests used) using the receptive portion of the Northwestern Syntax Screening Test (NSST) by Lee (1969). On this test, all the subject's scores were between the twenty-fifth and ninetieth percentiles for their age group. Otoscopy was performed at the beginning of the session. Each subject had a normal tympanogram (±50mm H_2O) in the probe ear and no reported ear infections in the last three months. The contralateral acoustic reflex was present at 500 Hertz (Hz) with the probe in the tested ear, at a level between 80 and 110 dB. The subjects had no apparent developmental delays as reported by the parent.

A group of six normally-hearing subjects (three males, three females) comprised the control group. These subjects met the criterion of bilateral hearing sensitivity of ≤15 dB (ANSI-1969) for the octave frequencies 250 through 8000 Hz and 6000 Hz for air conduction. The same criterion was met for bone conduction for the octave frequencies 250 through 4000 Hz. Six hearing-impaired subjects (three males, three females) were used as the comparison group. Hearing sensitivity thresholds (Figure 4) ranged from moderate to severe for the octave frequencies 250 through 8000 Hz and 6000 Hz for the better ear (test ear). Sensorineural hearing loss was confirmed through the use of bone conduction testing at the octave frequencies 250 through 4000 Hz. Each subject in the hearing-impaired group had received intensive training in an aural/oral program through early identification and amplification.

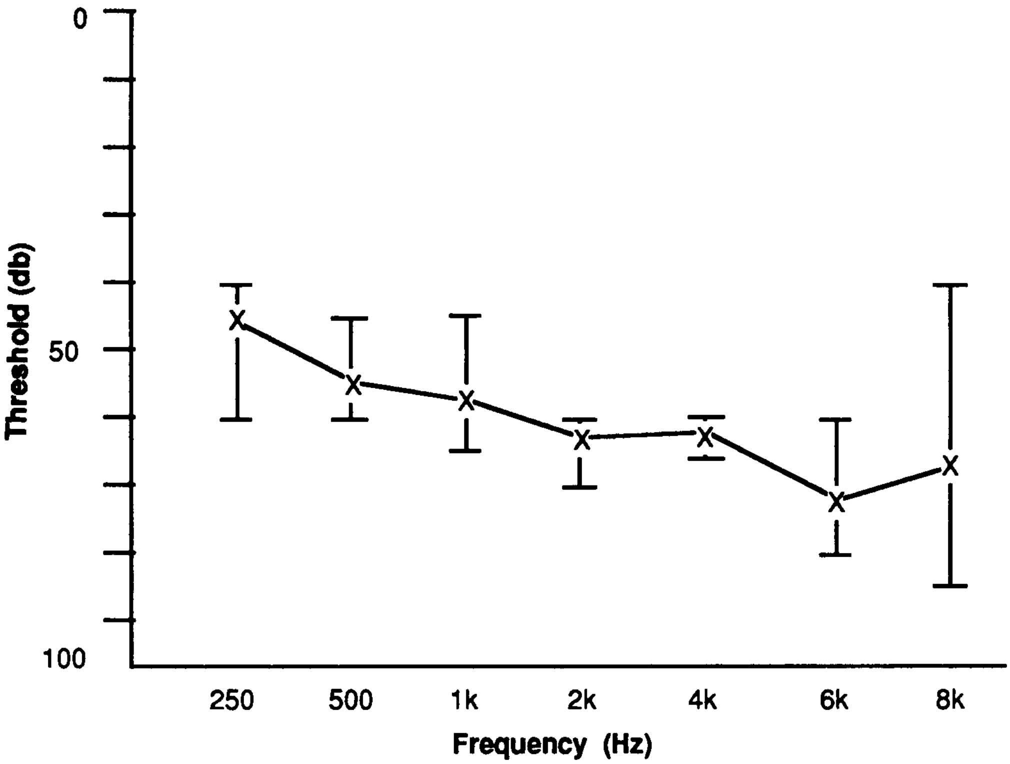


Figure 4. Mean thresholds and range of the six hearing-impaired subjects.

Each hearing-impaired subject was matched in chronological age (within six months) with a subject in the normally-hearing group.

Procedures

Testing was accomplished in two sessions. Each child was seen for audiometric, immittance, and receptive language age testing at the first visit. Discrimination testing was administered on a subsequent day to minimize fatigue. This also assured that the children were familiar with the test environment and examiner. Some precautions were taken to assure that there had been no change in the status of the child's hearing between visits. The parent was asked if they had noticed any change in hearing. A screening tympanogram, using the Grason-Stadler GSI-28 tympanometer, and a recheck of thresholds at two frequencies (500 and 2000 Hz) was performed. No subjects were disqualified by this recheck on the second day.

The response task utilized for all three discrimination tests was that of pointing to pictures. The children were seated and wearing earphones. Prior to testing, a speech reception threshold (SRT) test using a modified Chaiklin and Ventry method was given to each subject. The stimuli for the discrimination tests were presented at three intensity levels: 20, 30, and 40 dB sensation level (SL) reference to the speech reception threshold. The three lists of fifty randomized words developed from each test were used as the stimuli. The order in which the tests were given was counterbalanced between children to minimize the order effect. A score for each child was determined by the number correct on each test list multiplied by two. One child from each of the two groups returned for retesting to insure test-retest reliability.

Data Analysis

The data analyzed in this study were obtained from two groups of six subjects each, using three tests under three different conditions. A three-factor analysis of variance was used with an alpha level of 0.05 as the criterion. The Newman-Keul's multiple range test (Winer, 1977) was used for the post hoc analysis. Correlations between the three tests and the three presentation levels were also determined.

CHAPTER III

RESULTS

The data analyzed in this study were obtained from two groups of six subjects each. Results obtained from a computation of the data is presented in the following order:

1. differences between the speech discrimination scores between groups (normally-hearing vs. hearing-impaired);

2. differences between the speech discrimination scores for three presentation levels (20, 30, and 40 dB SL);

3. differences between the scores on the WIPI, the PSI, and NU-Chips;

4. differences between the scores for the three presentation levels on the three different tests for the two groups.

Test-Retest Reliability

Test-retest reliability was measured by retesting one child from each group. Scores obtained from the second testing agreed with those from the original testing within a 2% range. This suggested good test-retest reliability.

Comparison of Normally-Hearing vs. Hearing-Impaired Subjects.

An analysis of variance (Table 1) revealed that there was a significant difference between groups in their ability to

Table 1. Analysis of variance: subjects' performance on the three tests and three intensity levels

Source	SS	df	F	P
Group (G)	2,045.4	1	16.5	$p \leq 0.0023$
Error	1,241.3	10		
Test (T)	1,497.2	2	47.3	$p \leq 0.0001$
Intensity (I)	767.2	2	42	$p \leq 0.0001$
G X T	471.4	2	14.9	$p \leq 0.0001$
G X I	181.0	2	9.9	$p \leq 0.0010$
T X I	167.3	4	8.1	$p \leq 0.0001$
G X T X I	16.6	4	0.8	$p \leq 0.5278$

discriminate monosyllables. A comparison between the two groups, with the three tests analyzed as one, at 20 dB, 30 dB, and 40 dB SL (Figure 5) revealed the following results: overall mean scores were 96, 99, and 100% for the normally hearing group and 85, 90, and 94% for the hearing-impaired group, respectively. The differences between groups were found to be statistically significant at all sensation levels.

When the intensity levels were analyzed as one, the results of a comparison between the two groups on the WIPI, NU-Chips, and PSI (Figure 6) revealed overall mean scores of 96, 99, and 100%, respectively, for the normally-hearing group and 82, 90, and 96%, respectively for the hearing-impaired group. These scores were statistically significant between the groups for all tests.

Comparison of Intensity Levels

For both groups, there was an increase in the mean test score with each increase in intensity (Table 2). This increase is represented in Figure 7, which shows the mean speech discrimination scores for the two groups on the three different tests at the three levels. The value of improvement in scores was calculated by taking the two groups as one and subtracting the mean scores of the lowest intensity level (20 dB SL) from the highest level (40 dB SL) for each test. Mean improvement of 10, 4, and 6% was found between the two levels for the WIPI, PSI, and NU-Chips, respectively (Table 3). The improvement in the children's

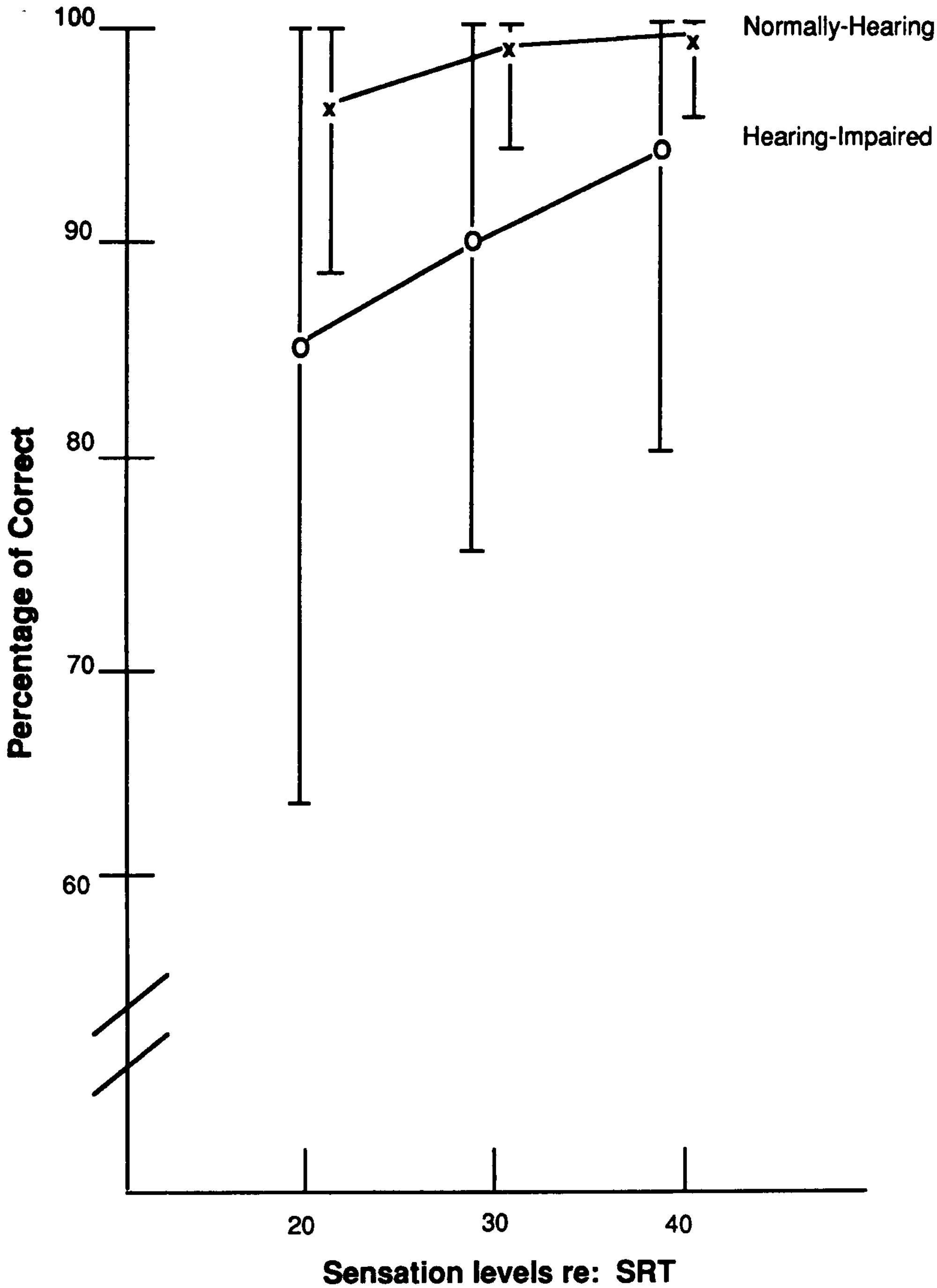


Figure 5. Overall performance-intensity functions for the normally-hearing and hearing-impaired subjects (means and ranges).

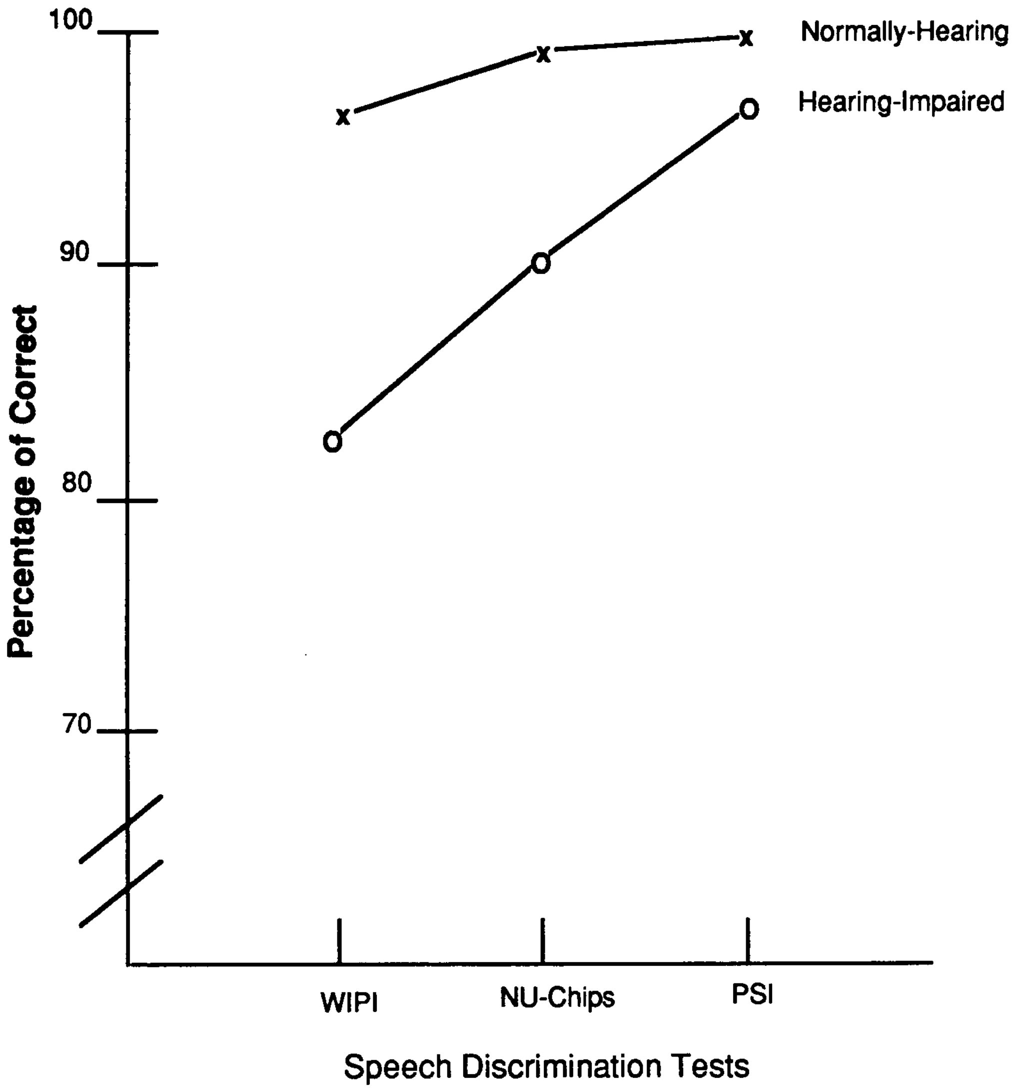


Figure 6. Overall mean scores for the speech.discrimination tests for the normally-hearing and hearing-impaired subjects.

Table 2. Mean discrimination scores (%) from hearing-impaired and normally-hearing subjects (standard deviation shown in parentheses)

	Intensity (dBSL)		
	20	**30**	**40**
WIPI			
Hearing-Impaired	76 (10)	82 (6)	89 (7)
Normally-Hearing	92 (4)	97 (2)	99 (2)
PSI			
Hearing-Impaired	93 (7)	97 (4)	99 (2)
Normally-Hearing	99 (2)	100 (0)	100 (0)
NU-Chips			
Hearing-Impaired	85 (7)	90 (7)	95 (4)
Normally-Hearing	98 (2)	100 (1)	100 (0)

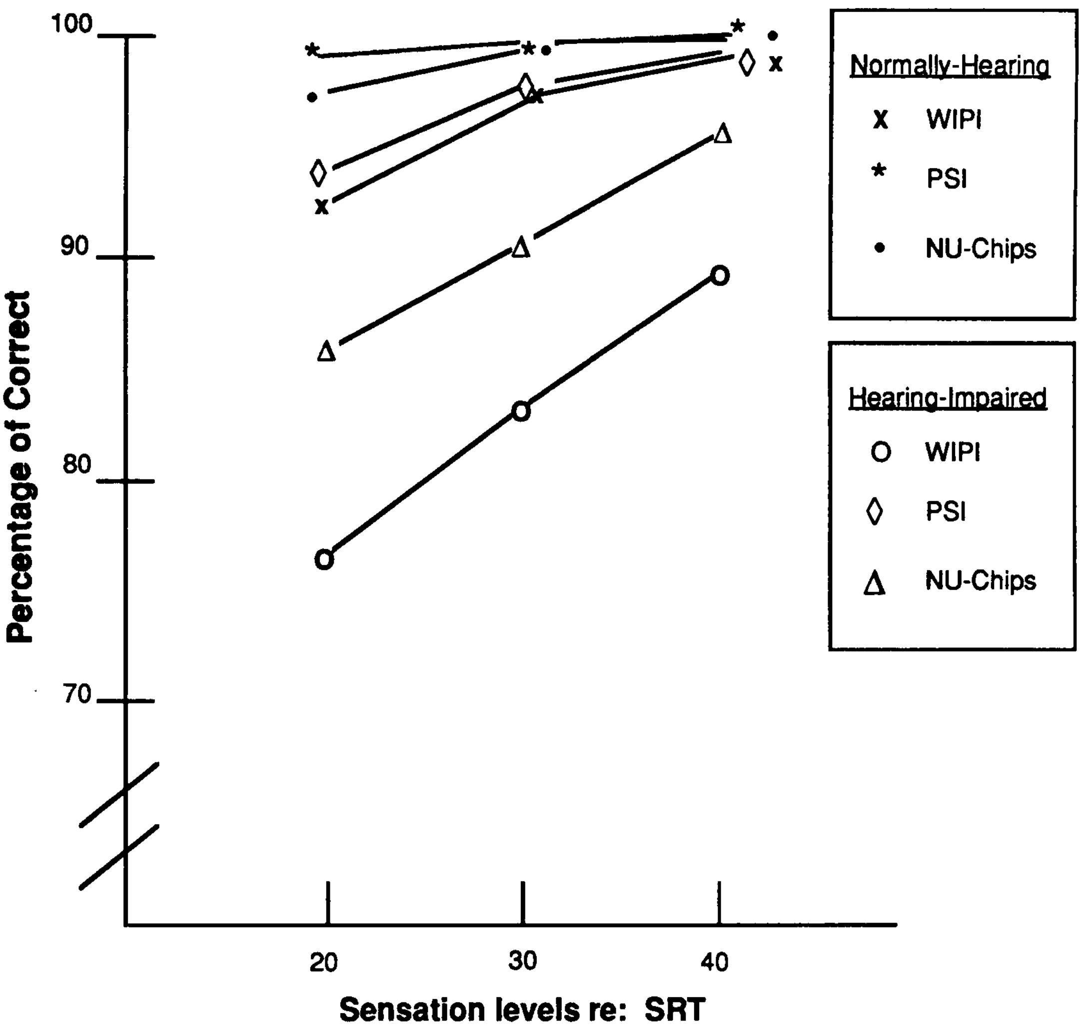


Figure 7. Performance-intensity functions for the three speech discrimination tests.

Table 3. Combined mean discrimination scores (%) obtained from the two groups of subjects on the three tests

	Intensity (dBSL)			
	20	**30**	**40**	**Improvement**
WIPI	84	90	94	10
PSI	96	99	100	4
NU-Chips	92	95	98	6

performance as a function of intensity level was found to be statistically significant.

The Newmann-Keuls' multiple range test (Winer, 1977) was utilized to determine which intensity levels produced a significant difference in scores. Results of this analysis revealed significant differences in scores for all intensities. When the discrimination scores of the three tests were collapsed and analyzed together (Table 4), there were significant differences between all intensity levels with one exception. An increase in intensity from 30 to 40 dB SL showed no significant difference in scores for the normally-hearing group. When both groups were analyzed as one (see Table 3), a comparison between intensity levels within each test revealed significant differences between levels with one exception. For the PSI test, an increase in intensity from 30 to 40 dB SL did not reveal a significant difference in discrimination scores.

Comparison of Test Stimuli

In evaluating the performance of the subjects on the three different speech discrimination tests, the analysis of variance indicated a significant difference between the tests (see Figure 6). The post hoc analysis revealed significant differences between the WIPI, PSI, and NU-Chips tests. However, when the results of the tests were analyzed between the two groups, with intensity levels analyzed as one (Table 5), the hearing-impaired group's performance on the PSI did not differ significantly with the normally-hearing group's performance on the WIPI. The performance of the normally-

Table 4. Overall mean discrimination scores (%) for the three intensity levels from the two groups.

	Intensity (dBSL)		
	20	**30**	**40**
Hearing-impaired	85	90	94
Normally-hearing	96	99	100

Table 5. Overall mean discrimination scores (%) for the three tests from the two groups.

	Test		
	WIPI	**NU-Chips**	**PSI**
Hearing-impaired	82	90	96
Normally-hearing	96	99	100

hearing group on the PSI was not significantly different from their performance on the NU-Chips test. When both groups were analyzed as one (see Table 3), a comparison of the tests at the same intensity levels showed significant differences between all tests at the three levels with one exception. At a sensation level of 40 dB, the PSI and NU-Chips tests did not differ significantly.

The scores of the hearing-impaired subjects were compared in order to investigate the sensitivity (correct identification of abnormal) of each test. Figure 8 represents a percentage distribution of scores for the hearing-impaired subjects at 30 dB SL. For the WIPI, 17% of the subjects obtained scores of 90 to 100%, 50% of the group achieved scores of 80 to 89%, and 33% of the subjects scored below 80%. For the PSI test, 100% of the subjects scored above 90%. For the NU-Chips test, 50% scored above 90% and 50% scored between 80 and 89%. Figure 9 shows a percentage distribution of scores for the hearing-impaired group at 40 dB SL. For the WIPI, 33% scored above 90% and 67% scored between 80 and 89%. For both the PSI and NU-Chips tests, 100% of the subjects scored above 90% at this sensation level. All of the normally-hearing subjects scored above 90% on all tests at a level of 30 dB SL, as illustrated by Figure 10.

Correlations between the tests for the hearing-impaired subjects are displayed in Table 6. Between the three tests, correlations ranged from moderate to good, with the lowest correlation (0.478) being between the WIPI and the PSI at 20 dB SL. Correlations between the tests were highest at a level of 30 dB SL,

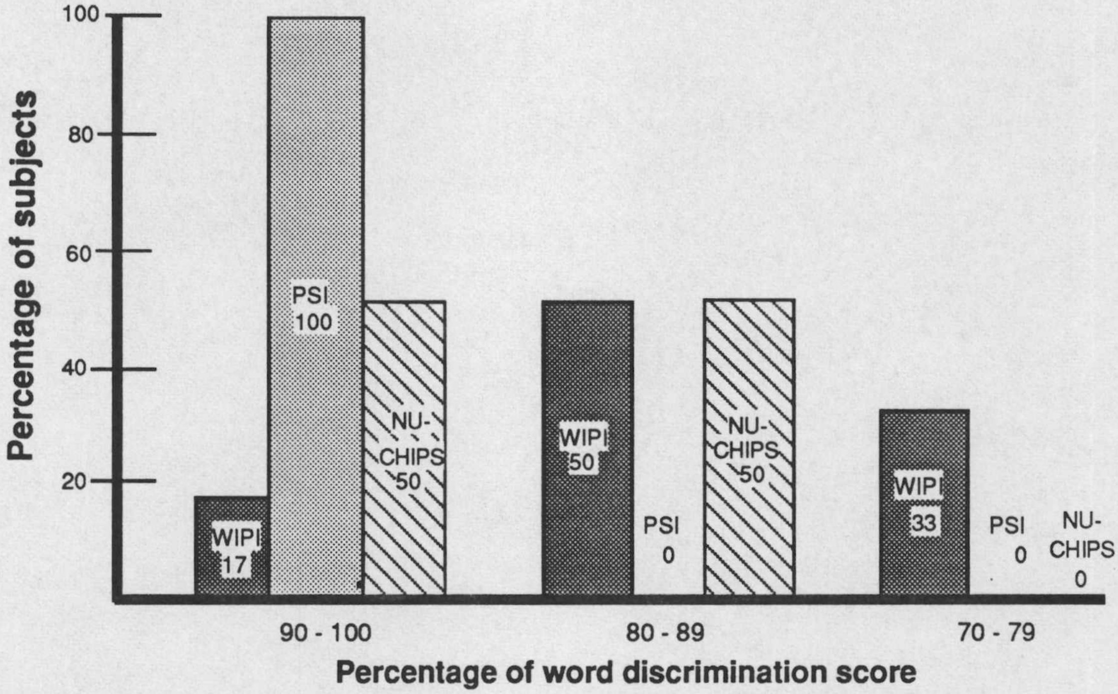


Figure 8. Percentage distribution of scores obtained on the WIPI, PSI, and NU-Chips tests for the hearing-impaired subjects at 30 dB SL.

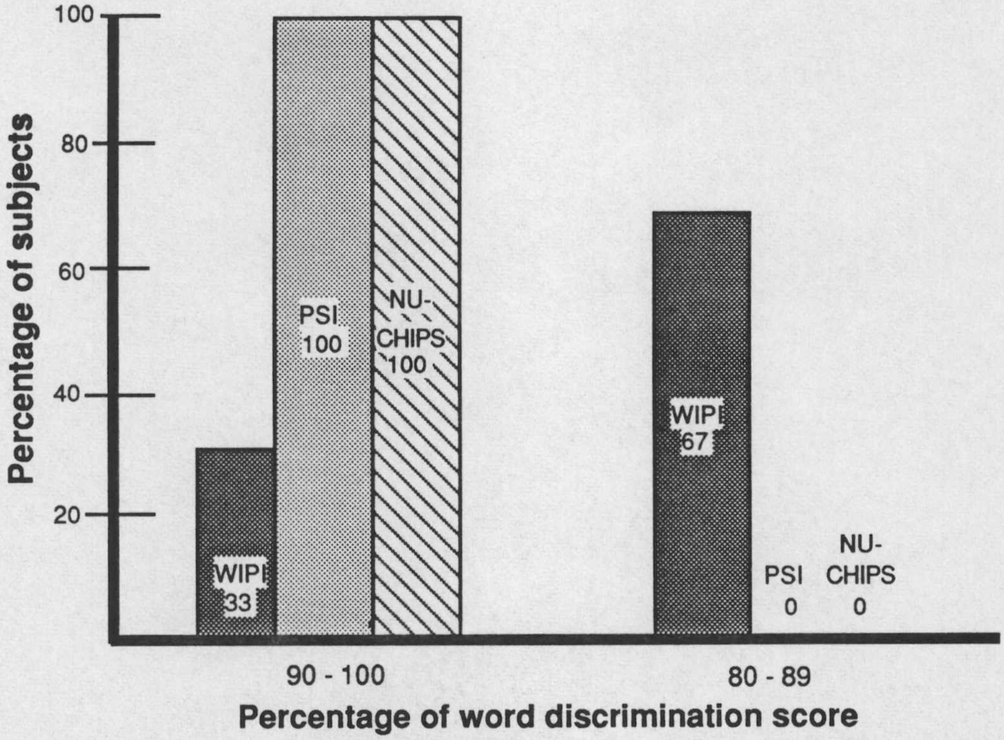


Figure 9. Percentage distribution of scores obtained on the WIPI, PSI, and NU-Chips tests for the hearing-impaired subjects at 40 dB SL.

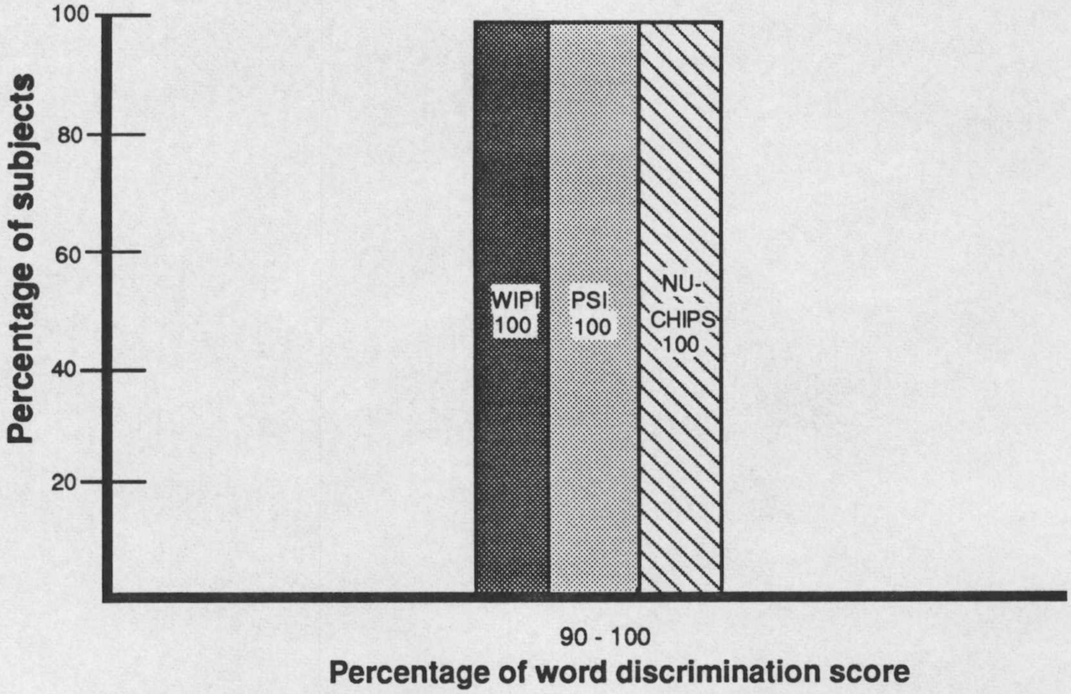


Figure 10. Percentage of distribution of scores obtained on the WIPI, PSI, and NU-Chips tests for the normally-hearing subjects at 30 dBSL.

Table 6. Correlation coefficient of the WIPI, PSI, and NU-Chips tests at the three intensity levels for the hearing-impaired subjects.

		NU-Chips			PSI		
		20	30	40	20	30	40
WIPI	20	0.845			0.478		
	30		0.854			0.786	
	40			0.714			0.556
PSI	20	0.643					
	30		0.708				
	40			0.56			

suggesting this to be the most desirable level for predicting the speech discrimination score of one test from another test. At 30 dB SL, correlations between the tests were 0.854 between WIPI and NU-Chips, 0.786 between WIPI and PSI, and 0.708 between PSI and NU-Chips. The correlations of these three tests were somewhat weaker at higher and lower intensity levels. The PSI always had weaker correlations with the other two tests.

CHAPTER IV

DISCUSSION

The results of this study indicate that the optimal intensity for administration of the WIPI, PSI, and NU-Chips, for the subjects included, is 30 dB SL, since the correlations between the tests were highest at this level (see Table 6, page 30). A comparison of the percentage distribution of scores obtained at 30 dB SL (see Figure 8, page 27) with the distribution at 40 dB SL (see Figure 9, page 28) also supports the use of a 30 dB sensation level. When the intensity is increased from 30 to 40 dB SL, the sensitivity (correct identification of abnormal) is diminished since all the hearing-impaired children obtained scores above 90% on the PSI and NU-Chips, and the portion of children scoring above 90% on the WIPI is almost doubled. However, for the normally-hearing group, there was no significant difference between the scores obtained at 30 dB SL and at 40 dB SL. This suggests that for a normally-hearing population, these tests may be given at either 30 or 40 dB SL. For the PSI test, there was no difference between the scores obtained at 30 dB SL and at 40 dB SL for either group. This indicates that the words on the PSI may be given at either 30 or 40 dB SL without a significant difference between scores.

Due to the discrimination difficulties imposed by a moderate to severe hearing impairment, scores on the speech discrimination tests used in this study would be expected to be lower for the hearing-impaired group than for the normally-hearing group. However, in this study, the mean score of the hearing-impaired group on the PSI did not differ significantly from the mean score of the normally-hearing group on the WIPI. This suggests that the PSI is less difficult than the WIPI, thus, yielding fewer correct identifications of abnormal. Furthermore, at a sensation level of 40 dB, scores on the PSI and NU-Chips did not differ significantly. This indicates that both tests are less difficult (less sensitive) than the WIPI.

When considering a percentage distribution of scores obtained on the tests in this study (see Figure 8, page 27), the WIPI appears to best demonstrate the discrimination difficulty imposed by the hearing impairment of the children. A small percentage (17%) of subjects scored above 90% on the WIPI,with 50% scoring between 80 and 89%, and 33% scoring between 70 and 79% indicating better sensitivity than for the PSI or NU-Chips for the subjects in this study. NU-Chips followed in sensitivity, with 50% of the subjects scoring above 90% and 50% scoring below 90%. The sensitivity of the PSI was not judged to be effective in demonstrating the hearing-impaired group's discrimination difficulties, since all subjects performed at a level above 90%.

Figure 10, page 29, illustrates the percentage distribution of scores for the normally-hearing group at 30 dB SL. All subjects scored at a level of 94% or above for all tests at this intensity level.

This indicates that all three tests had excellent specificity (correct identification of normal) for the subjects in this study.

Jerger (1982) states that the slope of performance-intensity (PI) functions for NU-Chips was more gradual than that of the PSI, thus indicating that the test material of NU-Chips is more difficult than the material of the PSI. The results of this study support this conclusion, since the PSI was found to be the least sensitive and least difficult of the tests included. In addition, the results of this study suggest that the WIPI test is more sensitive and more difficult than either the PSI or NU-Chips.

Test stimuli used in this study may be either restricted (PSI) or unrestricted (WIPI and NU-Chips). The stimuli are considered restricted when each target item is specified, but foil items are not included. The words in a restricted set are not phonemically similar. Unrestricted refers to target items which are embedded among foil items which may represent selected phonemic confusions (Jerger, 1984). In attempting to minimize the influence of receptive language skills on test performance, the authors of PSI used test materials representing the actual responses of children, with a restricted set of stimuli. Jerger (1984) states that there is some criticism of the restricted set, since it may not require phonemic discrimination. The child may more easily select the correct response in a restricted set since he may choose on the basis of an isolated consonant or vowel segment. Further, PSI has a smaller pool of words than WIPI or NU-Chips. The unrestricted set may be more difficult since the child must discriminate between slight phonemic differences (for example, mouse vs. mouth). The results of this study support this observation. The WIPI and NU-Chips, both using unrestricted test stimuli, were found to be more difficult than the PSI, which uses a restricted set of stimuli.

The results of this study are limited to the population of hearing-impaired subjects defined by the subjects selection criteria. Different degrees and configurations of hearing impairment, as well as different receptive language ages may alter the results found in this study.

CHAPTER V

SUMMARY AND CONCLUSIONS

Three speech discrimination tests (WIPI, PSI, and NU-Chips) were administered in this study at three different intensity levels (20, 30, and 40 dB SL) to two groups of children, ranging from four years to seven years of age. One group consisted of six normally-hearing children. The second group consisted of six hearing-impaired children with a sensorineural loss ranging from moderate to severe. Testing was accomplished in two sessions. At the first session, subjects were tested to determine whether they met the subjects selection criteria. The speech discrimination tests were administered at the subsequent session.

The data obtained in this study was analyzed using a three-factor analysis of variance with an alpha level of 0.05 as the criterion. A post hoc analysis was performed to determine where differences occurred. Correlations were also determined between the tests and the intensity levels.

The results of this study suggest that the overall optimum level for administration of these tests is at 30 dB SL. The results also indicate that while the PSI test has excellent specificity for the normally-hearing group, it exhibits poor specificity in identifying the hearing-impaired group's discrimination difficulty.

Both the WIPI and NU-Chips tests appear to have excellent specificity, with greater sensitivity than the PSI.

This study indicated that the WIPI and NU-Chips tests are appropriate for administration to both normally-hearing and hearing-impaired children at a level of 30 dB SL, with the WIPI test having greater sensitivity for the hearing-impaired. It is concluded from this study that the word material on the PSI test is not recommended for administration to hearing-impaired children with the configuration of hearing loss specified, since the scores of this group on the PSI were consistently above 90% at a level of 30 dB SL. Administration of the PSI words on the population specified may lead to exaggerated estimations of discrimination abilities.

LIST OF REFERENCES

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Battin, R.R. (1981). Psycho-educational assessment of children with auditory language learning problems. In R.J. Roeser and M.P. Downs (Eds.), Auditory Disorders in School Children. New York: Thieme-Stratton, Inc.

Diefendorf, A.O. (1983). Speech audiometry with infants and children. Seminars in Hearing, 4, 241-253.

Elliott, L.L., and Katz, D.R. (1980). Northwestern University Children's Perception of Speech. St. Louis: Auditec of St. Louis.

Jerger, S., Lewis, S., Hawkins, J., and Jerger, J. (1980). Pediatric Speech Intelligibility Test. I. Generation of test materials. International Journal of Pediatric Otorhinolaryngology, 2, 217-230.

Jerger, S., and Jerger, J. (1982). Pediatric Speech Intelligibility Test: Performance-intensity characteristics. Ear and Hearing, 3, 325-334.

Jerger, S. (1984). Speech audiometry. In J. Jerger (Ed.), Pediatric Audiology. San Diego: College-Hill Press.

Lee, L.L. (1969). Northwestern Syntax Screening Test. Northwestern University Press.

Olsen, W.O., and Matkin, N.D. (1979). Speech audiometry. In W.F. Rintelmann (Ed.), Hearing Assessment. Baltimore: University Park Press.

Ross, M., and Lerman, J. (1970). A picture identification test for hearing-impaired children. Journal of Speech and Hearing Research, 13, 44-53.

Sanderson-Leepa, M.E., and Rintelmann, W.F. (1976). Articulation function and test-retest performance of normal-learning children on three speech discrimination test: WIPI, PBK-50, and NU Auditory Test No. 6. Journal of Speech and Hearing Disorders, 41, 503-519.

Schwartz, D. (1971). The usefulness of the WIPI- A speech discrimination test for pre-school children. Master's thesis. Central Michigan University, Mount Pleasant, Michigan.

Winer, B.J. (1977). Statistical Principles in Experimental Design. New York: McGraw-Hill.

APPENDIXES

APPENDIX A

Instructions for the speech discrimination tests:

"You are going to hear a man talking to you on a tape recorder. He will say a word and I will show you some pictures. When you hear the word, point to the correct picture. Understand? Let's practice."

APPENDIX B

Table A-1. Each subject's performance on the three tests at the three intensity levels.

Speech Discrimination Test

Subject		WIPI			PSI			NU-Chips		
		20 dBSL	30 dBSL	40 dBSL	20 dBSL	30 dBSL	40 dBSL	20 dBSL	30 dBSL	40 dBSL
	1	64	76	80	88	94	98	78	84	92
	2	76	76	84	82	90	94	80	84	92
	3	64	80	88	94	100	100	80	86	92
HI	4	84	86	88	96	100	100	96	100	100
	5	82	84	100	100	100	100	86	94	100
	6	84	90	94	98	100	100	92	94	96
	7	88	94	96	96	100	100	100	100	100
	8	90	96	100	100	100	100	96	100	100
	9	96	96	100	100	100	100	98	100	100
Normal	10	88	96	100	100	100	100	96	98	100
	11	98	100	100	100	100	100	100	100	100
	12	90	98	100	100	100	100	100	100	100

VITA

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