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Auditory/visual word recognition test materials : computer application and standardization of the picture identification task with normal hearing children

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Cunningham, Leslie Allison, M.A.

San Jose State University, 1991

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AUDITORY/VISUAL WORD RECOGNITION TEST MATERIALS:
COMPUTER APPLICATION AND STANDARDIZATION
OF THE PICTURE IDENTIFICATION TASK
WITH NORMAL HEARING CHILDREN

A Thesis
Presented to
The Faculty of the Division of
Special Education and Rehabilitative Services
Program in Communication Disorders and Sciences
San Jose State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

By
Leslie A. Cunningham
May, 1991

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ABSTRACT

Auditory/Visual Word Recognition Test Materials: Computer Application and Standardization of the Picture Identification Task with Normal Hearing Children

By Leslie A. Cunningham

The purpose of this investigation was to standardize existing auditory/visual test materials known as the Picture Identification Task (Wilson and Antablin, 1980) with normal hearing children and to demonstrate the utility of using a computer monitor for administering the visual stimulus. Subjects were 24 fourth grade students with normal hearing who could read at a fourth grade level. The subjects listened to auditory stimulus words presented through earphones. They responded to the auditory stimulus by repeating what was heard orally and by pointing to the written word representing the auditory stimulus on the computer monitor. The results indicated that the subjects could easily perform the pointing task using the computer monitor. These results will provide normative performance levels for using the Picture Identification Task with hearing-impaired children under similar test conditions.

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CHAPTER I

INTRODUCTION

In the standard audiological evaluation, audiologists routinely assess word-recognition ability. Word-recognition, in this setting, refers to recognizing or identifying words or sentences that are presented to a listener through earphones or loudspeakers at various intensity levels. Conventional measurements require that the individual respond orally by repeating what was heard. In this way, information regarding an individual's receptive auditory communicative ability is obtained.

In some clinical situations, the conventional word-recognition task that requires an oral response to auditory stimulus words may not be appropriate. This is because an oral response may not reflect accurately the true status of the individual's receptive auditory communicative abilities. For example, some individuals may be non-verbal owing to expressive aphasia, some may have articulation or speech problems owing to a hearing impairment, or some may have other communicative difficulties. In order to assess word-recognition ability in these types of situations, audiologists often employ an alternative response method utilizing auditory/visual test materials. Here, the individual points to the written word, sentence, or picture that represents the auditory stimulus.

Although auditory/visual test materials can be used with many populations, they are most commonly used with children. This is because these materials are normalized to assess a child's receptive auditory ability without the constraints of expressive speech or language levels. Several of the

auditory/visual tests materials available for clinical use with children include: (a) The Word Intelligibility by Picture Identification Test (WIPI, Ross & Lerman, 1970); (b) Northwestern University Children's Perception of Speech Test (NU-CHIPS, Katz & Elliot, 1978); and (c) Pediatric Speech Intelligibility Test (PSI, Jerger, Lewis, Hawkins, & Jerger, 1980; Jerger, Jerger, & Lewis, 1981; Jerger & Jerger, 1982).

Typically, these test materials are comprised of pictures representing the auditory stimulus (monosyllabic words or sentences). The pictures are presented in a closed-response set either on cards (PSI) or in booklets (WIPI and NU-CHIPS). The PSI materials are laid out in a truncated horseshoe format with one of five cards representing the auditory stimulus, whereas the WIPI and NU-CHIPS materials use picture templates containing the target word as well as three or five response foils. Each of these auditory/visual test materials requires a psychomotor response in which the child must point to the word or sentence heard. The auditory portion of the PSI and NU-CHIPS auditory/visual materials has been professionally recorded on analog tape. The test materials of the PSI and NU-CHIPS have been standardized for children as young as 3 years of age (Katz & Elliot, 1978; Jerger et al., 1980), while the WIPI is appropriate for children as young as 4 years of age (Ross & Lerman, 1970).

Although the use of language-appropriate materials is a primary concern when assessing the word-recognition ability of children, other variables such as cooperation or attentiveness also influence the test results. Therefore, it is imperative that the word-recognition evaluation be performed in a timely as well as accurate manner. Predictably, the use of a computer in the audiological setting may provide several benefits in this diagnostic situation. Such benefits

include the synchronization of auditory/visual test stimuli and responses, and automatization of scoring procedures.

Statement of the Problem

There is no research on the use of a computer for administering the visual portion of auditory/visual test materials with children to estimate word-recognition performance. Therefore, the effectiveness, appropriateness, and benefits of utilizing auditory/visual test materials in a computerized format with children is presently unknown.

Purpose of the Study

The purpose of this study was twofold. The first goal was to standardize existing auditory/visual test materials, the Picture Identification Task (PIT) written word portion (Wilson & Antablin, 1980) with normal hearing children. The PIT was originally standardized with non-verbal adults but because of the nature of the auditory/visual stimuli, the test should be easily applied to children. Several studies have shown that adult materials have been used successfully to evaluate a child's word-recognition performance (Brooks & Geotzinger, 1966; Larson, Peterson & Jacquot, 1974; Sanderson-Leepa & Rintelmann, 1976).

The second goal was to computerize the response portion of the PIT such that the visual response, target words and alternative foils (written words), would appear on a computer monitor. The task of the children was to point to the written word on the computer monitor in response to an auditory stimulus, thus demonstrating the utility of using auditory/visual test materials in a computer format.

Hypotheses:

It was hypothesized that:

1. The auditory/visual test materials of the Picture Identification Task (written word portion) are appropriate for children with a fourth grade reading level or better.
2. Children can perform the word pointing task utilizing the computer monitor.
3. The data will provide normative performance levels for future use with hearing impaired children.

CHAPTER II

REVIEW OF THE LITERATURE

Currently, there is no available research on the administration of auditory/visual test materials to establish word-recognition performance in children utilizing a computer application. Due to the absence of such research, this literature review will focus on the development and standardization of current audiological tests used for assessing word-recognition performance in children. The word-recognition tests materials discussed are the (a) Word Intelligibility by Picture Identification Test (Ross & Lerman, 1970), (b) Northwestern University Children's Perception of Speech Test (Katz & Elliot, 1978), and (c) Pediatric Speech Intelligibility Test (Jerger et al., 1980; Jerger et al., 1981; Jerger & Jerger, 1982). In addition to these three children's tests, the Picture Identification Task (Wilson & Antablin, 1980), a word-recognition test using similar auditory/visual test materials standardized on non-verbal adults, will be discussed.

Word Intelligibility by Picture Identification Test

Ross and Lerman (1970) developed one of the most popular word-recognition tests for children, the Word Intelligibility by Picture Identification Test (WIPI). The WIPI evaluates the word-recognition performance of hearing-impaired children. The auditory test materials consist of four word lists composed of 25 words each. Simple monosyllabic words, derived from children's books and word-count lists, (a) were selected because the words were thought to be within the recognition vocabulary of the hearing-impaired child and (b) were easily pictorialized. The visual test materials consist of 25

hand-drawn color picture templates containing six pictures each. The six pictures were arranged in a matrix with words representing both fine and gross discrimination tasks.

Subjects for the final evaluation phase of the WIPI were 61 hearing-impaired children ranging in age from 4 years 7 months (4:7 years) to 13 years 9 months (13:9 years). The word lists were presented at a sensation level (SL) of 40 dB re: Speech Recognition Threshold (SRT) or 5 dB below the subject's Loudness Discomfort Level (LDL), with the carrier phrase "show me" or "point to," and delivered via monitored live voice. All lists were counterbalanced for order of presentation. Utilizing a closed-set response, the subject pointed to one of the six pictures on the template which represented the stimulus word. Re-administration of the test occurred one to three weeks later.

Ross and Lerman concluded from the results that all four word lists were comparable and highly reliable. Additionally, the results suggested that a learning effect occurred on repeated administrations of the test.

Sanderson-Leepa and Rintelmann (1976) investigated the appropriateness of the WIPI for use with normal hearing children. In this study, they examined the word-recognition performance of normal hearing children on the WIPI, the Phonetically Balanced Kindergarten Word Lists (PBK-50, Haskins, 1949), and the Northwestern University Auditory Test No. 6 (N.U. No. 6, Tillman & Carhart, 1966). The subjects were grouped according to age (3 years 5 months [3:5], 5 years 5 months [5:5], 7 years 5 months [7:5], 9 years 5 months [9:5], and 11 years 5 months [11:5]) with 12 subjects in each groups.

The study established performance-intensity (PI) functions on the WIPI, PBK-50, and N.U. No. 6. To establish the PI functions, the WIPI used a closed-

set picture pointing response task, whereas the PBK-50 and the N.U. No. 6 used an open-set oral response task. The word lists from each set of speech materials were recorded and presented at successively higher intensity levels with a different list of the test given at each sensation level re: SRT (8, 16, 24, and 32 dB).

The results indicated that the WIPI yielded the highest word-recognition performance scores followed by the PBK-50, with the N.U. No. 6 having the lowest scores. Based on the comparative results from these test materials, Sanderson-Leepa and Rintelmann (1976) suggested that the administration of the WIPI would be most appropriate for normal hearing children 3:5 years of age and older. Additionally, they concluded that the WIPI or the PBK-50 be used with normal hearing children 5:5 years of age or older, and that the N.U. No. 6 be used with normal hearing children 7:5 years of age and older. The results from this investigation using normal hearing children supported Ross and Lerman's (1970) original findings that the mean list differences of the WIPI were less than one word (4%) among hearing-impaired children reinforcing the assumption that the four WIPI word lists are equivalent in quiet.

Northwestern University Children's Perception of Speech Test

Katz and Elliot (1978) developed a similar word-recognition test for use with young children, the Northwestern University Children's Perception of Speech Test (NU-CHIPS). Similar to the WIPI, NU-CHIPS also uses auditory/visual test materials comprised of monosyllabic words in a closed-set picture identification response paradigm. The test is appropriate for children and other individuals having a language age as young as 3 years. Additionally,

the NU-CHIPS materials provide the clinical audiologist with equivalent multiple test forms that have been professionally recorded.

Katz and Elliot (1978) developed the test material for the NU-CHIPS based on the receptive language abilities of 25 inner-city 3-year-old children with English as their primary language. The authors selected commonly used monosyllabic nouns found in children's books. Of the original 67 words, 50 were selected as final test items based on ease of picture identification (items identified correctly by 88% of the children tested), and by eliminating the extremely high and low percentages correct based on an articulation function of normal adult listeners. The final test version consisted of four word lists containing the 50 selected words with each word list randomized for order of presentation. Two line-drawn black and white picture booklets accompanied the four test forms. Each test booklet consisted of 50 test templates containing four pictures in a quadrant format with one of the four words representing the stimulus word.

Katz and Elliot (1978) performed a series of tests on the new auditory/visual test materials to determine:

whether several different forms can be administered in the closed-set format without respondents demonstrating a learning effect; whether performance is equivalent on the different Test Forms; the extent to which performance improves as the intensity of the test presentation increases; the relation of performance of NU-CHIPS to performance on other tests of speech discrimination; whether performance on the first half of a list is equivalent to performance on the last half; whether the test is appropriate for children with a language age as low as three years; and whether the test is appropriate for hearing-impaired children. (p. 5)

Normal hearing and hearing-impaired children served as subjects for the evaluation of the NU-CHIPS test materials. Hearing-impaired subjects were

selected based on the degree of hearing loss whereas the normal hearing subjects met the following criteria:

1. air conduction thresholds no poorer than 15 dB HL at any octave interval between 250 - 4000 Hz in the test ear,
2. normal tympanograms (maximum peak pressure within -150 to +50 mm H₂O),
3. measurable acoustic reflexes at 1000 Hz, and
4. Picture Peabody Vocabulary Test (PPVT, Dunn, 1965) scores falling within one standard deviation of the expected score based on chronological age.

From their investigations, Katz and Elliot (1978) concluded that "This new test of speech discrimination is appropriate for testing children having minimum receptive vocabulary levels (PPVT) of about 3 years and is likely to be most useful in testing patients for whom other tests are too difficult" (p. 19). Additionally, they found that the test forms (the male-talker version) had equivalent means and variances for both normal and hearing impaired individuals. Their research also suggested that the half-list scores were equivalent and differences in the performance-intensity functions occurred at low sensation levels among 3-, 5-, and 10-year-old normal hearing subjects. However, all of these same subjects approached the test ceiling at an increased sensation level of 30 dB or lower. Katz and Elliot (1978) also found that the test demonstrated good reliability and construct validity (i.e., profoundly hearing-impaired children performed more poorly than moderately hearing-impaired children who performed more poorly than normal hearing children). Finally, data revealed a higher correlation between performance on the NU-CHIPS and

the WIPI for both normal and hearing-impaired children than between the NU-CHIPS material and other more sophisticated tests (e.g., PBK-50 and W-22).

Pictures must be recognized as an important variable when using auditory/visual test materials to assess word-recognition performance. That is, the visual test materials, or pictures, must be within the child's recognition vocabulary and be easily identifiable. Dengerink and Bean (1988) found that 5% or more of forty 5-year-old children could not correctly identify five picture test items on the NU-CHIPS and seven items on the WIPI. Visual recognition of the target picture is therefore important because an incorrect response may reflect the child's difficulty in recognizing the stimulus picture rather than reflecting the child's true receptive auditory capabilities (Olsen & Matkin, 1990).

Pediatric Speech Intelligibility Test

The Pediatric Speech Intelligibility Test (PSI, Jerger et al., 1980; Jerger et al., 1981; Jerger & Jerger, 1982) is another word-recognition test standardized and developed for use with young children. The authors of this test addressed the importance of selecting appropriate word-recognition materials based on the child's receptive language abilities and cognitive skills rather than on chronological age.

Jerger et al. (1980) discussed the generation and standardization of the PSI test materials. In this study, the subjects were 87 normal hearing children from Houston, Texas, ranging in age from 3 years 3 months (3:3 years) to 6 years 8 months (6:8 years). The testing for each subject included the administration of the Peabody Picture Vocabulary Test (PPVT, Dunn, 1965), the Northwestern Syntax Screening Test (NSST, Lee, 1971), and 60 PSI stimulus picture cards developed from the first vocabularies of children (30 cards

represented monosyllabic words whereas 30 cards represented sentences). The word cards consisted of nouns representing objects, animals, and toys, whereas the illustrated sentence cards represented verbs such as brushing, eating, and drinking. Following visual stimulation of the picture cards, each subject was prompted by the carrier phrase "What is this?" for the word materials or "What is happening in this picture?" for the sentence materials. The examiner recorded all responses for transcription.

The responses elicited by the subjects produced four different sentence patterns:

1. article noun/auxiliary verb-ing/article noun (e.g., A rabbit/is reading/a book),
2. pronoun/auxiliary verb-ing/article noun (e.g., He/is reading/a book),
3. (article noun) (pronoun)/auxiliary verb-ing/article noun (e.g., A rabbit/is reading/a book or He/is reading/ a book), and
4. article noun/verb-ing/article noun (e.g., A rabbit/reading/a book).

Jerger et al. (1980) found consistent differences in vocabulary (PPTV) and receptive language skills (NSST) between children who produced more adult type utterances as in Pattern 1 (A rabbit/is reading/a book) and the children with less sophisticated utterances as produced in Pattern 4 (A rabbit/reading/a book).

From this research, Jerger et al. (1980) designed two sets of sentence materials based on the subject's receptive language abilities. They developed one set of sentence materials for children with lower receptive language levels (Format I) and a second set of materials for children with higher receptive language levels (Format II). Format I stimulus materials contained the carrier

phrase "Show me," preceding the stimulus card (e.g., "Show me a bear brushing his teeth."). In contrast, the more sophisticated Format II materials did not contain a carrier phrase (e.g., "A bear is brushing his teeth.").

The final stimulus materials for Format I and Format II consisted of 10 sentence cards. From the original 30 sentence picture cards, the utterances from all the subjects were categorized according to syntactic and semantic structure. Sentences for each format were selected if 80% of the children from Pattern 1 produced, either syntactically or semantically, the target sentence (e.g., "A bear is combing his hair" or "A bear is combing his fur").

The results from the word stimulus cards suggested that the responses from the subjects did not differ as a function of chronological age, vocabulary skill, or receptive language ability. Twenty word picture cards (those words correctly identified by 95% of the children tested), were selected as the PSI word stimulus material. Hence, the PSI auditory/visual test material is composed of 20 monosyllabic words and 10 sentences for each of the two syntactic constructs (Format I and II) accompanied by corresponding picture cards.

Jerger et al. (1981) performed three additional investigations on the PSI word and sentence material. The first two studies (Study 1 and Study 2), "assessed the validity of the different PSI sentence forms...as a means of equating performance among young children who differ in receptive language ability" (p. 102), whereas the third study (Study 3) investigated the effects of receptive language age on word-recognition performance as assessed by the PSI monosyllabic word materials.

The testing for all children included a pure-tone audiogram (with hearing levels not exceeding 20 dB HL at any octave interval between 500 and 4000 Hz), the Northwestern Syntax Screening Test (NSST), and PSI word and sentence materials (Format I and/or Format II). The test materials were recorded and presented at 50 dB HL with message-to-competition ratios (MCRs) of 10 dB to -20 dB for Studies 1 and 2 and at MCRs of 10 dB to -4 dB for Study 3. The sentence materials for Format I and Format II consisted of two lists (List A and List B) containing five sentences each. The word material (20 monosyllabic words) consisted of four lists of five words each. Each of the word and sentence lists corresponded to a picture identification card (i.e., each card had five pictures). All subjects completed an MCR function for List A and List B for both sentence formats and word materials.

Study 1 assessed the validity of the PSI sentence formats (Format I and Format II) as a means of controlling the influence of receptive language ability on word-recognition performance. Subjects were 24 normal hearing children between the ages of 3 years 4 months (3:4 years) and 9 years (9:0 years).

The results from the data generated three different performance-MCRs patterns suggesting: (a) that the PSI materials (Formats I and II) were too easy and not appropriate for children with NSST scores (receptive language scores) of 37-40 (scores were generally produced by older children), (b) Format I was most appropriate for children with receptive language scores of 15-31 and that Format II was most appropriate for children with receptive language scores of 32-36 regardless of chronological age (CA), and (c) that "if the sentence format is varied as a function of the child's receptive language score, performance for Format I and Format II materials is equivalent" (p. 107). Based on these results,

Jerger et al. (1981) concluded that "the different PSI sentence formats are an effective means of controlling the influence of receptive language ability on speech intelligibility performance for sentences" (p. 107).

Study 2 developed criteria for selecting the most appropriate PSI sentence material (Format I or II) for assessing word-recognition performance. Subjects were 50 normal hearing children between the ages 3 years 4 months and 9 years. All subjects met the same testing criteria as that in Study 1. Twenty-four of the 50 subjects in Study 2 also participated in Study 1.

The results from Study 2 indicated that the selection of the appropriate PSI format material for assessing word-recognition performance is based on the absolute NSST receptive language raw score. As identified in Study 1 and confirmed in this study, Format I is most appropriate for children with NSST scores between 15 and 31 and Format II is most appropriate for children with NSST scores between 32 and 36.

The third and final study assessed the effects of receptive language ability on monosyllabic word-recognition performance. The subjects were 40 normal hearing children ranging in age from 3 years 2 months to 6 year 9 months (eight of these subjects participated in Study 2). Of the 40 subjects selected, 20 qualified for Format I materials (NSST scores from 15 to 31) and 20 qualified for Format II materials (NSST scores from 32 to 39).

The results indicated that the PSI "word materials generated by normal children between 3 and 7 years of age did not differ as a function of CA and receptive language skills" (p. 113). However, there was a correlation between CA and word-recognition performance in that word-recognition scores increased as chronological age increased. For example, the average word-

recognition performance score was 75% for 3-year-olds and 87% for 6-year-olds. The overall change in word-recognition performance with increasing age from 3 to 6 years was approximately 10%.

Jerger and Jerger (1982) continued to evaluate the PSI word and sentence materials by establishing performance-intensity (PI) functions in quiet and in the presence of background noise. Subjects were 40 children between 3 years 1 month and 6 years 10 months of age. As in previous studies, all testing included a pure-tone audiogram (hearing levels [HL] not exceeding 20 dB HL at any octave interval between 500 and 4000 Hz on both ears), the NSST, and the PSI word and sentence (either Format I or Format II) materials. The subjects were grouped according to their NSST raw scores with 20 children qualifying for Format I materials (NSST scores of 15 to 31), and 20 children qualifying for Format II materials (NSST scores of 32 to 37). Criteria for selecting the appropriate PSI sentence materials (Format I or II) was defined in the previously discussed study (Jerger et al., 1981).

Performance-intensity (PI) functions were established beginning at 50 to 60 dB sound pressure level (SPL). The level was then decreased in 10 dB steps until a "knee"¹ was reached, at which time the level was reduced in 5 dB steps. A high-intensity performance point also was established at 100 dB SPL (sound field condition) or at 110 dB SPL (earphone condition). The PI functions were established in quiet and in the presence of background noise with a MCR of 0 dB for the PSI sentence material and 4 dB for the PSI word material. Subjects qualifying for Format I sentence materials were tested in the sound

¹Knee is defined as "the inflection below which performance decreased rapidly with further decrease in intensity" (Jerger & Jerger, 1982, p. 326).

field whereas subjects qualifying for Format II sentence materials were tested via earphones.

The results from this study provided (a) data on the steepness of the PI function for words and sentences in quiet and in competition, (b) data on the speech thresholds for words and sentences in quiet and in competition, and (c) the framework for detecting a significant rollover effect in children with suspected retrocochlear disorders. Specifically, no significant differences were found between the Format I and Format II groups with regard to the steepness of the PI functions for the PSI word materials in quiet and in competition, and the PSI sentence materials in quiet. However, the steepness of the PI function for sentence materials in competition was significantly different between the two Format groups. Additionally, Jerger and Jerger (1982) found that within the same Format group, words and sentences in quiet provided a steeper slope than words and sentences in competition. Also, in comparative studies with other pediatric word and adult sentence materials, the PSI materials provided a steeper PI function. Although the PSI materials provided a steeper PI function, it should be noted that the PSI uses a closed-set picture pointing response task whereas the other materials use an open-set oral response task.

Wilson and Antablin (1980) also demonstrated that a closed-set response paradigm produced a steeper PI function than an open-set response paradigm. They attributed the difference in the steepness of the curves to the minimum number of response cues available to the more difficult open-set response task. Therefore, comparing the steepness of PI functions of adult materials (open-set oral response) to the PSI materials (closed-set pointing

response) may not be appropriate unless the materials in question have been previously assessed utilizing the same response paradigms.

Picture Identification Task

Although auditory/visual test materials primarily have been developed for use with children, there have been investigations into the use of this type of test material with adults. Wilson and Antablin (1980) developed the Picture Identification Task (PIT) to estimate the word-recognition performance of nonverbal adults. The Picture Identification Task has a similar response paradigm to the WIPI and the NU-CHIPS in that the auditory/visual test material requires a closed-set psychomotor or picture pointing response to the auditory stimuli.

The auditory/visual test material of the Picture Identification Task consisted of common monosyllabic consonant-nucleus-consonant (CNC) words chosen from the Teacher's Word Book of 30,000 Words (Thorndike & Lorge, 1944). The final test version of the PIT consisted of four word lists, each composed of 50 phonemically balanced monosyllabic words. Two-hundred hand-drawn color picture templates served as the visual response material that corresponded to the auditory stimulus. Each template contained four pictures in a quadrant format, with one of the four pictures representing the target word with the remaining three words representing rhyming alternatives or foils. All stimulus materials were recorded by a male speaker with each stimulus word preceded by the carrier phrase, "Show me."

Study 1. In the first of two experiments, Wilson and Antablin (1980) examined the relationship between the performance-intensity functions obtained in quiet and in noise using the Picture Identification Task and the

Northwestern University Auditory Test No. 6 (N.U. No. 6). Subjects were 16 normal hearing adults (<15 dB Hearing Level [HL] at any octave interval between 250 and 8000 Hz) with a mean age of 21 years. The subjects responded to the Picture Identification Task and N.U. No. 6 test materials in the open-set response paradigm by writing down their responses to the auditory stimulus. Performance-intensity functions were established in quiet by presenting both sets of test materials in increments of 4 dB from -2 to 26 dB re: the Speech Recognition Threshold (SRT). Noise conditions were established by presenting eight signal-to-noise (S/N) ratios from -12 dB to 16 dB with the level of broadband noise being held constant at 70 dB SPL.

From the results obtained in experiment 1, Wilson and Antablin (1980) concluded that "the performance-intensity function obtained in an open-set paradigm with the Picture Identification Task materials are equivalent to the functions generated with the N.U. No. 6 materials" (p. 231). Therefore, they found no significant differences existed between the Picture Identification Task and the Northwestern University Auditory Test No. 6 materials in an open-set response paradigm in quiet or in noise.

Study 2. The second experiment compared the Picture Identification Task in a closed-set response paradigm with the N.U. No. 6 both in an open-set and a closed-set response paradigm. Subjects were 24 normal hearing adults with a mean age of 24 years. The subjects responded to the Picture Identification Task by pointing to one of the four pictures on the test template that represented the stimulus word. The subjects responded to the N.U. No. 6 closed-set material by marking the correct written target word from a multiple choice answer sheet. Three-rhyming alternative words that served as foils, also

accompanied the written target word in the closed-set N.U. No. 6 task. For the N.U. No. 6 open-set response paradigm, the subjects wrote their responses. The test materials were presented in 4 dB increments from -2 to 26 dB re: SRT.

The results from this study indicated that significant differences existed between the response paradigms (closed-set pointing [PIT], closed-set multiple choice [N.U. No. 6], and open-set writing [N.U. No. 6]) at lower intensity levels re: SRT. The subjects performed best on the closed-set multiple choice task, followed by the closed-set pictured-pointing and open-set oral response task. Wilson and Antablin (1980) attributed the differences between closed-set and open-set responses paradigms at the lower intensity levels to the "minimum number of response cues available" (p. 231) in the open-set response task as compared to the closed-set task. Additionally, Wilson and Antablin (1980) found that the three response tasks produced similar results when the test materials were presented at a high stimulus-presentation level (26 dB re: SRT). Finally, the results indicated that the four Picture Identification Task word lists were interchangeable and half-list scores equivalent.

Clinical Evaluation of the Picture Identification Task. Following these initial experiments, Wilson and Antablin evaluated the Picture Identification Task in the clinical setting for use with nonverbal adults to estimate word-recognition performance. The 28 subjects used for clinical evaluation were divided into two groups according to the severity of their communication disorder (mild aphasic, moderate aphasic, glossectomy, or laryngectomy). Group 1 subjects could comprehend and respond verbally to an open-set response task and performed both the Picture Identification Task (closed-set response) and the N.U. No. 6 (open-set response). Group 2 subjects, who were

unable to respond with verbal accuracy, utilized only the Picture Identification Task in a closed-set picture-pointing response task. All subjects had similar hearing loss configurations (a mild to moderate high-frequency sensorineural hearing loss from 2000-8000 Hz).

Two presentation levels of 50 dB HL and 70 dB HL were used in this evaluation process. The 50 dB HL was selected to determine how well an individual understands speech at a normal conversational speech level and 70 dB HL was selected because it represents a point on the performance-intensity function that estimates maximum word-recognition performance.

The results indicated that Group I performed significantly better on the Picture Identification Task than on the N.U. No. 6 open-set response material. However, the N.U. No. 6 material generated results that were consistent with results found in other studies using subjects with similar hearing loss. Group II achieved similar performance results on the Picture Identification Task as compared to Group I. Based on these results, the authors concluded that the "Picture Identification Task provides a good estimation of word-recognition performance" (p. 236).

Summary

In summary, to assess word-recognition performance in an individual, the test materials need to be within the subject's speech and language competences, the response task needs to be a skill easily performed by the individual, and administration of the test material needs to be performed in a timely and accurate manner. As discussed in this literature review, the current auditory/visual test materials (WIPI, NU-CHIPS, PSI, and PIT) all provide a good estimation of word-recognition performance for the populations on which the

tests were normed. However, none of these word-recognition tests currently use a computer to administer the test materials. Therefore, the goals of this study are (a) to standardize the Picture Identification Task (Wilson & Antablin, 1980) on normal hearing children, and (b) to demonstrate the utility of administering the visual portion of existing auditory/visual test materials (the Picture Identification Task) in a computer format.

CHAPTER III

METHODOLOGY

Traditional word-recognition tests that require an oral response are routinely used in the clinical audiological setting to assess an individual's receptive auditory communicative abilities. For individuals who are unable to respond orally or who have speech or language difficulties, an alternative response method, such as a word- or picture-pointing task is often used. The response portion of these types of auditory/visual test materials commonly appear in test booklets or on picture cards. However, with the advent of the personal computer into the clinical setting, it is possible to adapt these existing visual response materials (words or pictures) into a computer format for more timely and accurate test administration.

Research Design

Because of the lack of research currently available in using a computer to administer auditory/visual test materials to assess word-recognition performance, this investigation examined the feasibility of using the computer in the clinical audiological setting to estimate word-recognition performance in children. A parametric, within-subject experimental research design (Plutchik, 1974) was conducted (a) to determine if children can perform a word-pointing task using a computer monitor, (b) to determine if the auditory/visual test materials of the Picture Identification task are appropriate for children with a fourth grade reading level, and (c) to establish normative performance levels for future use with hearing-impaired children.

The Instrument

The Picture Identification Task (PIT, Wilson & Antablin, 1980), originally developed to estimate word-recognition performance of nonverbal adults, served as the test materials. The auditory-stimulus portion (target words) of the PIT consisted of two lists of 50 monosyllabic phonetically balanced words. The target words were digitally recorded (male speaker) for compact disc² presentation. The visual response stimuli consisted of written words corresponding to the target words along with three rhyming alternative response foils (Appendix A).

Each of the target and alternative words was evaluated in order to assess the appropriateness of the vocabulary items for children. An alphabetical list of the 216 target and alternative words can be found in Appendix B. Beside each word is a number, from 1 to 6+, that represents the grade level at which children normally incorporate the vocabulary item into their reading vocabulary. These grade levels come from a standard reference text on the reading ability of elementary school children (Johnson, Moe, & Baumann, 1983). Of the 216 target and alternative words, 192 (89%) were determined to be at or below a fourth grade reading level. Of the remaining 24 more difficult words, 10 were target words, representing 10% of the total 100 target words.

The target and alternative words were programmed into the computer memory (ELTECH, Model 9870). The words appeared in a quadrant format on a color display computer monitor (Positive Corp, Model MM-1468J) with the target word randomly appearing in one of the quadrants (a total of four words

²Speech Recognition and Identification Materials Disc I, VA Medical Center, Long Beach, California.

appeared on the screen at one time). Dark, oversized, lower case letters on a white background were used to maximize visual contrasts in order to facilitate the visual recognition of the test material.

Subjects

Subjects for this study were recruited from local elementary schools in San Jose, California. The subjects represented a culturally diverse population typically seen in metropolitan elementary schools. The first 24 fourth grade students who volunteered for participation and met the normative criterion were selected as subjects. The experimental group consisted of 24 fourth grade students (9 boys, 15 girls), ranging in age from 9 years 1 month to 11 years four months with a mean age of 10 years 1 month.

Procedure

Each subject was given an audiological evaluation and a reading level screening test prior to inclusion in this study. The audiological evaluation protocol and normative criterion were as follows:

1. otoscopy,
2. screening immittance audiometry (single-peaked tympanogram [$\pm$ 100 daPa] with present ipsilateral acoustic reflex at 1000 Hz [105 dB HL]),
3. pure tone audiometrics (air-conduction thresholds not exceeding 15 dB at any octave interval from 250 - 8000 Hz in the test ear), and
4. Speech Recognition Thresholds (within -8 to +6 of the pure-tone average).

Additionally, a raw score of 56 on the Reading Level I portion of the Wide Range Achievement Test (WRAT, Jastak & Jastak, 1978) was required for participation

in this study. The Reading Level I portion of the WRAT consisted of 75 lower cased printed words that varied in reading difficulty. The reading difficulty successively increased from simple monosyllabic words to more complex multisyllables (i.e., from "cat" to "aborigines"). The subjects were asked to read orally the first 31 consecutive words, from "cat" to "struck," producing a raw score of 56 representing a fourth grade reading level. Although the subjects were either completing or just entering fourth grade, the first 24 students evaluated for participation in this study successfully met the reading criterion.

Each subject listened to 8 half-lists (25 words each) in the four experimental test conditions (each condition was repeated twice). Two of the test conditions required a psychomotor or pointing response and two conditions required an oral response. In each condition, the auditory-stimulus words were presented via a Sony compact disc player (Model D-25) through an audiometer (GSI 16) and delivered to the test ear via earphones (TDH-50) encased in cushions (MX-41/AR). Broadband noise was delivered ipsilaterally to the test ear through the audiometer at a fixed level of 60 dB HL. Presentation of the target words occurred at levels corresponding to either -4 or 8 signal-to-noise ratio (pointing condition) or 2 or 8 signal-to-noise ratio (oral conditions). The signal-to-noise ratio's (S/N) selected represented two points on the psychometric function (above chance and below 100% performance). The half-list and response conditions were counterbalanced to lessen possible order and learning effects. See Table 1 for a summary of the four experimental conditions.

Table 1

The Four Experimental Test Conditions

Condition	Response Task	Signal-to-noise ratio (dB)
Condition 1	Pointing	-4
Condition 2	Pointing	8
Condition 3	Oral	2
Condition 4	Oral	8

For the pointing response paradigm, the subjects, stationed in front of the computer monitor, listened to the auditory stimulus. Written words representing the auditory stimulus (the target word) and the three alternative foils appeared in each quadrant of the computer monitor. The subjects responded by pointing to the written word that represented the auditory stimulus; pointing to the target word constituted a correct response. After responding, the subject pressed the "enter" command on the computer keyboard prompting the next set of stimuli to appear on the computer monitor. The examiner, seated behind the subject's right shoulder, observed and recorded the pointing responses. For the oral response task, the subjects responded by repeating the target word orally. The examiner transcribed the verbal responses. At the conclusion of the test session, each subject answered two questions: "Which task was easier, pointing to the words on the computer monitor or saying the words aloud, and why?"

Data Analysis

Percent correct recognition/identification for the Picture Identification Task was obtained for each subject in each of the four experimental conditions. The percent correct recognition/identification responses then were calculated and averaged to establish mean percent correct and standard deviation data for each experimental condition. The purpose here was to establish the relationship between the two response paradigms (oral and pointing), and to provide normative data for the word-pointing task in the computer format. Additionally, a preferred response task (oral verses pointing) percentage was tabulated based on the subjective opinions of each subject.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was two-fold. The first goal was to standardize existing auditory/visual test materials (PIT written word portion) with children. The second was to demonstrate the utility of using auditory/visual test materials in a computer format. Statistical analysis included establishing mean and standard deviation data for the auditory/visual test materials in each of the four experimental test conditions (oral 2-dB S/N, oral 8-dB S/N, pointing -4-dB S/N, and pointing 8-dB S/N). Additionally, an item analysis of the target words correctly identified in each of the four experimental conditions is reported.

Table 2 displays the percentage of correct recognition/identification responses along with the mean percent correct and standard deviation data for each subject in each of the four experimental conditions. The mean percent correct for the oral conditions (2-dB S/N and 8-dB S/N) was 34.4% and 60.1% respectively, whereas the pointing condition elicited a mean percent correct of 50.1% (-4-dB S/N) and 86.4% (8-dB S/N). Standard deviations for both of the oral conditions (2-dB S/N and 8-dB S/N) and the pointing condition (-4-dB S/N) ranged from 10.5 to 12.7. In the pointing condition at 8-dB S/N however, the variability was reduced to 4.1, which was probably due to a ceiling effect. The mean percent correct and standard deviation results indicated that significant differences exist between the two oral conditions (2-dB S/N and 8-dB S/N) and between the two pointing conditions (-4-dB S/N and 8-dB S/N).

The mean percent correct recognition/identification data for each of the four experimental conditions were calculated as a function of S/N (see Figure 1).

Table 2
Individual Subject Data from the
Four Experimental Conditions

Subject Number	Ear	Age (Yr.Mo.)	Sex	Oral 2-dB S/N	Oral 8-dB S/N	Pointing -4-dB S/N	Pointing 8-dB S/N
1	L	9.6	F	40%	70%	58%	90%
2	L	10.4	F	36%	58%	26%	88%
3	L	10.4	F	38%	66%	58%	88%
4	R	11.2	F	38%	50%	48%	90%
5	L	11.4	F	16%	40%	32%	76%
6	L	10.11	F	42%	60%	66%	86%
7	L	10.6	F	22%	66%	60%	88%
8	L	10.7	F	36%	52%	36%	86%
9	R	10.8	F	32%	50%	50%	88%
10	R	10.2	M	46%	78%	42%	86%
11	R	10.4	F	48%	68%	70%	86%
12	R	10.8	F	32%	62%	62%	88%
13	R	10.6	M	26%	64%	48%	82%
14	R	9.7	M	42%	68%	36%	84%
15	R	9.1	F	38%	44%	52%	92%
16	R	10.7	M	16%	58%	44%	86%
17	L	9.9	M	38%	50%	66%	94%
18	L	9.3	M	24%	56%	52%	86%
19	L	9.6	F	20%	30%	52%	84%
20	L	9.4	F	32%	56%	38%	82%
21	L	9.6	M	30%	68%	42%	78%
22	R	9.2	M	36%	76%	66%	90%
23	L	9.5	M	62%	88%	56%	90%
24	L	10.2	F	34%	64%	42%	86%
Mean (M)				34.4%	60.1%	50.1%	86.4%
SD				10.5	12.7	11.9	4.1

The results obtained for the oral conditions (open-set response) are represented as circles whereas the results for the pointing conditions (closed-set response) are represented as triangles. The data points are connected by a straight line.

FIGURE 1. The mean percent correct recognition/identification scores for the four experimental conditions as a function of signal-to-noise ratio (S/N).

NOTE: The circles represent the oral open-set response conditions, and the triangles represent the pointing closed-set response conditions.

The comparative results established between the closed-set and the open-set response tasks demonstrated that the subjects performed consistently better on the pointing (closed-set) task than on the oral (open-set) response task at the same S/N. Similar results have been reported by Wilson and

Antablin (1980) and Jerger and Jerger (1982) for percent correct performance in open- versus closed-set response paradigms.

An item analysis performed on each of the four half-lists (list 1A, 1B, 2A, and 2B) at each experimental condition (oral 2-dB S/N and 8-dB S/N, pointing -4-dB S/N and 8-dB S/N) determined the number of correct responses for each target word (see Table 3 and Table 4). The percent of correct responses for each target word and a mean percent correct for each word list was calculated for each condition.

The mean percent correct recognition/identification for the pointing condition at -4-dB S/N ranged from 54.0% to 54.5% for lists 1B, 2A, and 2B. However, List 1A produced a mean correct percentage of 40.5%. The reason for a lower mean correct percentage on list 1A as compared to the other three word lists is unclear. One possible premise suggests that the target words on list 1A have a higher reading difficulty than those on the other three word lists. However, this premise was rejected, as List 1B contains more stimulus words exceeding a fourth grade reading level than lists 1A, 2A, or 2B. Additionally, the results indicated that at an increased S/N of 8-dB, the performance improved with the mean correct percentage ranging from 86.5% to 88.8% correct for all word lists. Further analysis indicated that "match, road, catch, mail, tool, robe, and page" accounted for the majority of the errors in the 8-dB S/N condition with these words being distributed among all four word lists.

In reviewing the data, the query as to why "match, road, catch, mail, tool, robe, and page" were consistently missed was investigated. The first assumption postulated that the missed words exceeded the subject's fourth grade reading ability. However, these commonly missed words were well

Table 3

Mean Percent Correct Performance Scores for the
Target Words in the Pointing Response Conditions

List 1A	-4-dB S/N	8-dB S/N	List 1B	-4-dB S/N	8-dB S/N	List 2A	-4-dB S/N	8-dB S/N	List 2B	-4-dB S/N	8-dB S/N
wing	29%	100%	head	72%	100%	gun	35%	100%	tool	20%	47%
yarn	22%	100%	bed	43%	100%	dam	35%	80%	path	50%	67%
pearl	07%	55%	sun	86%	100%	chalk	71%	100%	sing	60%	100%
juice	29%	100%	run	72%	100%	chief	88%	100%	cheese	60%	100%
ship	29%	100%	noose	29%	65%	load	47%	100%	dice	50%	100%
wave	57%	91%	hut	43%	100%	jail	82%	100%	hill	90%	94%
chain	57%	100%	rug	43%	94%	catch	12%	0%	rain	80%	100%
nose	50%	100%	chair	100%	100%	pass	24%	80%	bug	60%	87%
goose	22%	91%	bath	43%	53%	door	77%	80%	hose	50%	94%
match	29%	09%	town	29%	94%	nail	88%	100%	gown	20%	87%
tire	43%	91%	kite	72%	100%	wig	71%	100%	net	50%	94%
lake	43%	100%	cash	14%	71%	sail	94%	100%	shed	40%	100%
rose	50%	100%	boat	43%	82%	shop	35%	100%	robe	0%	13%
shawl	36%	100%	laugh	43%	59%	wet	53%	100%	rock	80%	100%
sub	43%	100%	dog	43%	76%	lamb	41%	100%	bone	30%	87%
pill	43%	91%	mop	100%	100%	jar	71%	100%	face	60%	80%
sock	57%	100%	leak	72%	100%	vine	65%	100%	thief	40%	94%
cage	64%	55%	thumb	72%	94%	sick	47%	100%	lick	90%	100%
dive	29%	55%	book	29%	82%	mail	30%	40%	toad	40%	94%
wheat	64%	91%	girl	86%	100%	back	53%	60%	page	60%	47%
pan	72%	91%	road	57%	24%	map	35%	80%	night	70%	100%
coat	43%	55%	light	57%	94%	man	65%	100%	hair	80%	100%
dig	22%	91%	jet	43%	100%	feet	41%	100%	wheel	50%	94%
fire	36%	100%	veil	29%	88%	cave	47%	100%	rat	30%	100%
top	36%	73%	mill	43%	88%	cut	53%	100%	log	90%	87%
Mean % correct	40.5	85.6		54.5	86.6		54.4	88.8		54.0	86.6

Table 4

Mean Percent Correct Performance Scores for the
Target Words in the Oral Response Conditions

List 1A	2-dB S/N	8-dB S/N	List 1B	2-dB S/N	8-dB S/N	List 2A	2-dB S/N	8-dB S/N	List 2B	2-dB S/N	8-dB S/N
wing	12%	47%	head	43%	91%	gun	55%	94%	tool	27%	43%
yam	25%	47%	bed	57%	100%	dam	09%	53%	path	20%	43%
pearl	25%	53%	sun	79%	100%	chalk	45%	60%	sing	33%	86%
juice	63%	80%	run	43%	82%	chief	27%	40%	cheese	33%	100%
ship	37%	94%	noose	0%	36%	load	64%	60%	dice	47%	86%
wave	25%	73%	hut	22%	55%	jail	0%	53%	hill	67%	72%
chain	37%	47%	rug	64%	91%	catch	0%	47%	rain	40%	57%
nose	37%	87%	chair	86%	100%	pass	19%	60%	bug	47%	57%
goose	25%	73%	bath	29%	91%	door	19%	94%	hose	47%	100%
match	0%	33%	town	22%	45%	nail	0%	53%	gown	40%	72%
tire	25%	67%	kite	29%	36%	wig	55%	87%	net	60%	29%
lake	50%	53%	cash	0%	45%	sail	09%	47%	shed	53%	43%
rose	12%	67%	boat	38%	91%	shop	0%	40%	robe	13%	14%
shawl	0%	60%	laugh	29%	55%	wet	19%	67%	rock	80%	86%
sub	25%	80%	dog	38%	82%	lamb	36%	67%	bone	13%	57%
pill	37%	67%	mop	38%	55%	jar	0%	60%	face	80%	86%
sock	25%	80%	leak	0%	09%	vine	45%	80%	thief	0%	29%
cage	25%	20%	thumb	38%	73%	sick	73%	80%	lick	20%	43%
dive	12%	33%	book	22%	73%	mail	36%	47%	toad	20%	14%
wheat	12%	40%	girl	57%	100%	back	27%	40%	page	13%	14%
pan	37%	60%	road	50%	91%	map	27%	53%	night	40%	43%
coat	15%	73%	light	29%	91%	man	55%	73%	hair	67%	86%
dig	25%	60%	jet	64%	91%	feet	36%	67%	wheel	33%	57%
fire	12%	80%	veil	29%	45%	cave	09%	27%	rat	27%	29%
top	0%	20%	mill	43%	91%	cut	27%	53%	log	47%	29%
Mean % Correct	23.92	59.76		37.96	72.76		27.68	60.08		38.68	55.0

within a fourth grade reading level (Johnson et al., 1983). In fact, the subjects usually identified correctly more difficult words from a reading perspective (e.g., gown, mop, sub). This analysis suggests that these errors probably can not be attributed to reading difficulty.

The second assumption hypothesized that the commonly missed words were less audible than the other target words. However, when these same target words, with the exception of "robe" and "page," were presented at 8-dB S/N in the oral condition, the target words were correctly identified. This result suggested that all the target words were equivalently audible.

The third and most viable assumption as to why these seven words were consistently missed was attributed to a rhyming scheme, which is supported by the Cohort model of word-recognition (Marslen-Wilson & Welsh, 1978). The Cohort word-recognition model proposes that a listener can identify auditory stimuli (i.e., a word) by listening primarily to the initial part of the word. As the listener hears the initial stimulus, he/she begins to create cognitively a set of possible responses. From this cognitive set of possible words or cohorts, the listener selects the response. Often the listener correctly identifies the target word by hearing only the initial portion of the word while virtually ignoring the final portion of the auditory stimulus.

In a majority of the stimulus items from the Picture Identification Task, the rhyming scheme for the target word and alternative foils occurred in the final consonant position (i.e., the final portion of the word remained the same for the target word and foils as in "wing, sing, ring, king"). However, in most of the commonly missed words, the rhyming scheme remained constant at the beginning of the word (the initial consonant position) with the change occurring

at the end of the word or in the final consonant position (e.g., "match, map, man, mask"). If the Cohort word-recognition model is correct, then it is reasonable to assume that the subjects in this study created a rhyming set of cohorts with the final consonant position remaining the same (e.g., wing, sing, ring, king).

Therefore, when a target word and rhyming alternatives differed by the final consonant, with the initial consonant remaining unchanged (e.g., match, map, man, mask), the word was missed. Since these words were distributed among all the word lists, it is unlikely that these stimuli would significantly affect the overall performance of an individual subject.

Table 4 displays the mean percent correct recognition/identification for target words in the oral response paradigms. The mean percent of correctly identified target words for each word list at the 2-dB S/N ratio was 23.9% (List 1A), 38% (List 1B), 27.7% (List 2A), and 38.7% (List 2B). At an increased S/N ratio of 8-dB, the mean percent of correctly identified target words improved with a range of 55.0% to 60% for lists 1A, 2A, and 2B. List 1B, however, produced a mean percent correct of 72.8%. Again, a select group of words accounted for a majority of the errors (cage, top, leak, robe, toad, and page). Of these six commonly missed words (those words missed more than 75% of the time at the 8-dB S/N ratio), "robe" and "page" were the only two words consistently missed in all four experimental conditions. The reason for these two words continually being missed is unclear. Because these six words were distributed among three of the four word lists it is doubtful that these words would significantly effect the overall performance of the individual.

Finally, when the subjects were asked which task was easier, pointing to the word or saying the word aloud, 75% of the subjects reported that they

preferred responding to the target word by pointing rather than repeating it orally. The children felt it was easier to point to the words because, in general, they could hear and see the words, as well as have a choice of responses.

These results challenged the hypotheses generated earlier in this paper. Hypothesis 1 was tested by performing an item analysis on the Picture Identification Task auditory/visual test material. Eighty-nine percent of the 216 words used by the Picture Identification Task (the target words and alternative foils) were within the reading vocabulary of fourth grade students. Of the remaining 24 words, 10 were target words (gown, leak, mop, noose, shawl, sub, thief, veil, wig, and yam), representing 10% of the total 100 target stimuli. Of these more difficult words, all were correctly identified at least 87% of the time in the closed-set response mode at the +8 S/N; the exception was "noose" which was correctly identified 65% of the time. This analysis supports Hypothesis 1 illustrating that the auditory/visual test materials of the Picture Identification Task (written word portion) are appropriate for children with a fourth grade reading level or better.

Hypothesis 2 stated that the children could easily perform the word pointing task utilizing the computer monitor. The application of establishing mean percent performance scores showed that the subjects correctly identified 86.6% of the target words by pointing to them on the computer monitor at a S/N of 8-dB. In addition, 75% of the subjects subjectively felt that it was easier to point to the words on the computer monitor than to say the words orally. Hypothesis 2 was supported by these results.

Hypothesis 3 stated that the data would provide normative performance levels for future use with hearing-impaired children. This was accomplished by

calculating mean and standard deviations from the test results generated by 24 normal hearing fourth grade students. Table 2 provides normative performance levels, supporting Hypothesis 3.

CHAPTER V

SUMMARY

With the increased use of computers in the home, educational, and professional environments, audiologists have begun to investigate the benefits and limitations of the computer in the audiological setting. Tests that use auditory/visual test materials to assess word-recognition performance lend themselves nicely to computer administration. That is, the visual stimulus, words and pictures, can easily be displayed on the computer monitor. In this study, existing auditory/visual word-recognition test materials, the Picture Identification Task, was standardized on normal hearing children using a computer to administer the visual stimulus (written words). The subjects were 24 fourth grade students with normal hearing and could read at a fourth grade level.

The results established normative performance levels for using the Picture Identification Task with normal hearing and hearing-impaired children to establish word-recognition performance. Further, the results showed that children could easily perform the word pointing task using the computer monitor.

Clinical Implications

As demonstrated by this study, auditory/visual test materials can be utilized successfully in a computer format to assess word-recognition performance. Following publication of these results, the written word portion of the PIT now may be utilized with all children reading at a fourth grade level or above. Once reading ability is established via an appropriate screening test,

good word-recognition performance can be expected when stimuli are presented at a S/N of 10-dB or greater. Performance that is poorer than 80% should be considered indicative of hearing impairment.

In order for the audiologist to utilize the automated PIT program, a computer must be available in the clinical setting. Since computers are becoming more readily available to professionals and currently exist in many audiology clinics, the purchase of additional software (the PIT) could easily bring this "state-of-the-art" technology to the professional audiological setting. When assessing word-recognition performance in young children, the test must be administered in a timely and accurate manner. This is important because undesirable variables such as lack of cooperation or attentiveness may affect the child's word-recognition performance. Therefore, it would be beneficial to fully automate the PIT test protocol to meet the needs of very young children.

Automatization of the PIT (written word portion) would involve (a) developing software to assess the reading ability of the individual and incorporating this sub-test into the existing PIT software, (b) updating the computer hardware to include a touch or heat sensitive monitor to "call-up" automatically the next set of auditory/visual stimulus items, and (c) updating software to include automatic scoring and the ability to calculate the percentage of correct responses.

Future Research

Future investigations will explore the use of color pictures representing the auditory stimulus words accompanied by three alternative foils on a computer monitor. Inserting pictures instead of written words into the computer application will enable the PIT to be administered to very young children since

young children can identify words represented by pictures before they can identify words represented by written lexicon. In addition to using picture identification materials with very young children, these materials can also be used with children with limited language abilities or other communication difficulties (e.g., speech or articulation problems due to a hearing impairment). With current technology, the existing hand-drawn pictures materials of the PIT can be scanned electronically and programmed into the computer memory. With the implementation of graphics and more advanced three-dimensional computer programs, the visual test materials may be quite realistic, thus, eliminating the variable of an incorrect response due to the difficulty of recognizing a picture. Therefore, by automating the PIT, it is reasonable to assume that establishing word-recognition performance in children would be more accurate when using a computer to administer the picture identification materials.

Conclusion

What is suggested from this investigation is that computer hardware along with software applications can be developed and used to evaluate the auditory capabilities of an individual. It is time for the field of Audiology to incorporate the available "state-of-the-art" science technologies into the clinical setting. In doing so, many of the traditional diagnostic tests used today will need to be re-standardized using a computer format. Initially, this may be a timely and lengthy process, but ultimately, the use of the computer in the clinical setting will facilitate and expedite many audiological test protocols without sacrificing the needs of the individual.

REFERENCES

References

- Brooks, R., & Goetzinger, C. P. (1966). Vocabulary variables and language skills in the PB discrimination of children. Journal of Auditory Research, 6, 358-370.
- Dengerink, J. E., & Bean, R. E. (1988). Spontaneous labeling of pictures on the WIPI and NU-CHIPS by 5-year-olds. Language, Speech, and Hearing Services in Schools, 44, 144-152.
- Dunn, P., (1965). Expanded Manual for The Peabody Picture Vocabulary Test. Minneapolis, MN: American Guidance Service.
- Haskins, H. (1949). A phonetically balanced test of speech discrimination for children. Master's thesis, Northwestern University, Evanston, IL.
- Jastak, J.F., & Jastak, S. (1978). The Wide Range Achievement Test: Manual (2nd ed.). Wilmington, DE: Jastak Associates, Inc.
- Jerger, S., & Jerger, J. (1982). Pediatric speech intelligibility test: Performance-intensity characteristics. Ear and Hearing, 3, 325-334.
- Jerger, S., Jerger, J., & Lewis, S. (1981). Pediatric speech intelligibility test. II. Effect of receptive language age and chronological age. International Journal of Pediatric Otorhinolaryngology, 3, 101-118.
- Jerger, S., Lewis, S., Hawkins, J., & Jerger, J. (1980). Pediatric speech intelligibility test. I. Generation of test materials. International Journal of Pediatric Otorhinolaryngology, 2, 217-230.
- Johnson, D. D., Moe, A. J., & Baumann, J. F. (1983). The Ginn word book for teachers. Lexington, MA: Ginn.
- Katz, D., & Elliot, L. (1978). Development of a new children's test of speech discrimination. A paper presented at the American Speech and Hearing Association Convention, San Francisco, CA.
- Larson, G. W., Peterson, B., & Jacquot, W. S. (1974). Use of Northwestern University No. 6 for speech discrimination testing with children. Journal of Auditory Research, 14, 287-292.
- Lee, L. (1971). The Northwestern Syntax Screening Test. Evanston, IL: Northwestern University Press.
- Marslen-Wilson, W. & Welsh, A. (1978). Processing interactions and lexical access during word-recognition in continuous speech. Cognitive Psychology, 10, 29-63.

- Olsen, W. D., & Matkin, N. D. (1990). Speech audiometry. In W. F. Rintelmann (Ed.), Hearing Assessment (pp. 39-135). Austin, Texas: Pro-Ed.
- Plutchik, R. (1974). Foundations of experimental research (2nd ed.). New York: Harper & Row.
- Ross, M., & Lerman, J. (1970). A picture identification test for hearing-impaired children. Journal of Speech and Hearing Research, 13, 44-53.
- Sanderson-Leepa, M., & Rintelmann, W. (1976). Articulation functions and test-retest performance of normal-hearing children on three speech discrimination test: WIPI, PBK-50, and NU auditory test No. 6. Journal of Speech and Hearing Disorders, 41, 503-519.
- Thorndike, E., & Lorge, I. (1944). Teacher's word book of 30,000 words. New York: Bureau of Publications, Teachers College, Columbia University.
- Tillman, T., & Carhart, R. (1966). An expanded test for speech discrimination utilizing CNC monosyllabic words: Northwestern University Auditory Test No. 6. (Tech. Rep. No. SAM-TR-66-55). Brooks Air Force Base, Texas: USAF School of Aerospace Medicine.
- Wilson, R., & Antablin, J. (1980). A picture identification task as an estimate of the word-recognition performance of nonverbal adults. Journal of Speech and Hearing Disorders, 45, 223-238.

APPENDICES

Appendix A

PICTURE IDENTIFICATION TASK Word List 1A

<u>Target Word</u>	<u>Rhyming Alternative Foils</u>		
1. wing	sing	ring	king
2. yam	lamb	dam	ham
3. pearl	curl	twirl	girl
4. juice	goose	noose	moose
5. ship	whip	chip	lip
6. wave	shave	grave	cave
7. chain	plane	cane	rain
8. nose	bows	toes	hose
9. goose	noose	moose	juice
10. match	map	mask	man
11. tire	fire	wire	choir
12. lake	snake	cake	rake
13. rose	hose	bows	nose
14. shawl	ball	doll	wall
15. sub	tub	cub	club
16. pill	hill	mill	bill
17. sock	clock	knock	rock
18. cage	gauge	page	stage
19. dive	dial	dice	dime
20. wheat	meat	feet	seat
21. pan	man	can	fan
22. coat	cone	coke	comb
23. dig	twig	pig	wig
24. fire	choir	wire	tire
25. top	stop	shop	mop

Appendix A Cont.

PICTURE IDENTIFICATION TASK Word List 1A

<u>Target Word</u>	<u>Rhyming Alternative Foils</u>		
26. head	bed	sled	shed
27. bed	shed	sled	head
28. sun	gun	bun	run
29. run	bun	gun	sun
30. noose	juice	goose	moose
31. hut	cut	putt	nut
32. rug	jug	hug	bug
33. chair	pear	hair	bear
34. bath	back	bat	badge
35. town	gown	clown	frown
36. kite	bite	light	night
37. cash	catch	cap	calf
38. boat	note	goat	coat
39. laugh	lap	lamb	lamp
40. dog	log	hog	jog
41. mop	shop	stop	top
42. leak	cheek	peak	beak
43. thumb	gum	bum	drum
44. book	crook	cook	hook
45. girl	twirl	curl	pearl
46. road	rose	roast	robe
47. light	kite	night	bite
48. jet	pet	net	wet
49. veil	sail	jail	nail
50. mill	bill	hill	pill

Appendix A Cont.

PICTURE IDENTIFICATION TASK Word List 2A

<u>Target Word</u>	<u>Rhyming Alternative Foils</u>		
1. gun	run	bun	sun
2. dam	ham	lamb	yam
3. chalk	sock	hawk	rock
4. chief	beef	thief	leaf
5. load	toad	road	mowed
6. jail	veil	nail	sail
7. catch	cab	cat	cap
8. pass	path	pan	pack
9. door	pour	store	core
10. nail	veil	jail	sail
11. wig	dig	twig	pig
12. sail	veil	nail	jail
13. shop	mop	stop	top
14. wet	pet	net	jet
15. lamb	dam	yam	ham
16. jar	bar	star	car
17. vine	mine	sign	wine
18. sick	chick	lick	stick
19. mail	jail	veil	nail
20. back	shack	tack	sack
21. map	man	mask	match
22. man	fan	pan	can
23. feet	meat	seat	wheat
24. cave	wave	shave	grave
25. cut	putt	hut	nut

Appendix A Cont.

PICTURE IDENTIFICATION TASK Word List 2A

<u>Target Word</u>	<u>Rhyming Alternative Foils</u>		
26. tool	stool	pool	school
27. path	pan	pack	pass
28. sing	king	wing	ring
29. cheese	keys	bees	knees
30. dice	rice	slice	mice
31. hill	mill	bill	pill
32. rain	cane	plane	chain
33. bug	hug	jug	rug
34. hose	rose	bows	nose
35. gown	town	clown	frown
36. net	pet	jet	wet
37. shed	head	sled	bed
38. robe	road	rope	rose
39. rock	sock	clock	lock
40. bone	cone	phone	stone
41. face	race	vase	lace
42. thief	leaf	chief	beef
43. lick	chick	stick	sick
44. toad	load	road	mowed
45. page	gauge	cage	stage
46. night	kite	light	bite
47. hair	pear	chair	bear
48. wheel	peel	heel	kneel
49. rat	hat	cat	bat
50. log	dog	jog	hog

Appendix B

An Alphabetical Listing of the PIT Target and Alternative Words by Grade Level

Target Word	Grade	Target Word	Grade	Target Word	Grade	Target Word	Grade
back	1	chalk	4	frown	4	lamb	2
badge	5	cheek	3	gauge	5	lamp	3
ball	1	cheese	3	girl	1	lap	3
bar	2	chick	3	goat	2	laugh	1
bat	2	chief	2	goose	2	leaf	3
bath	3	chip	4	gown	5	leak	6
beak	4	choir	6	grave	3	lick	2
bear	1	clock	2	gum	3	light	1
bed	1	clown	3	gun	2	lip	3
beef	6+	club	2	hair	1	load	2
bees	2	coat	2	ham	4	lock	2
bill	2	coke	5	hat	1	log	2
bite	2	comb	3	hawk	3	mail	3
boat	1	cone	2	head	1	man	1
bone	2	cook	2	heel	3	map	2
book	1	core	4	hill	1	mask	3
bows	3	crook	6+	hog	4	match	2
bug	2	cub	6	hook	3	meat	2
bum	6+	curl	3	hose	4	mice	2
bun	5	cut	1	hug	3	mill	3
cab	5	dam	3	hut	3	mine	1
cage	2	dial	4	jail	2	moose	5
cake	2	dice	3	jar	3	mop	6
calf	4	dig	2	jet	3	mowed	6
can	1	dime	4	jog	6	nail	3
cane	3	dive	3	jug	4	net	3
cap	2	dog	1	juice	3	night	1
car	1	doll	2	keys	2	noose	6+
cash	4	door	1	king	1	nose	2
cat	1	drum	3	kite	4	note	2
catch	1	face	1	knees	2	nut	3
cave	2	fan	3	knock	1	pack	2
chain	3	feet	1	lace	5	page	1
chair	1	fire	1	lake	2	pan	2

Appendix B Cont.

An Alphabetical Listing of the PIT Target and Alternative Words by Grade Level

Target Word	Grade	Target Word	Grade	Target Word	Grade	Target Word	Grade
pass	1	road	1	sing	1	tool	3
path	2	roast	5	sled	4	top	1
peak	4	robe	4	slice	3	town	1
pear	3	rock	1	snake	2	tub	4
pearl	4	rope	2	sock	3	twig	5
peel	4	rose	2	stage	2	twirl	4
pet	2	rug	3	star	2	vase	5
phone	3	run	1	stick	1	veil	6
pig	1	sack	3	stone	2	vine	3
pill	4	sail	2	stool	4	wall	1
plane	1	school	1	stop	1	wave	1
pool	1	seat	2	store	1	wet	2
pour	2	shack	6	sub	6	wheat	3
putt	6+	shave	5	sun	1	wheel	2
race	1	shawl	5	tack	5	whip	3
rain	1	shed	3	thief	5	wig	5
rake	3	ship	1	thumb	4	wine	3
rat	3	shop	2	tire	3	wing	2
rice	3	sick	2	toad	2	wire	2
ring	2	sign	2	toes	2	yam	5