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PRE-SCHOOL CHILDREN'S PERFORMANCE ON A MULTIMEDIA PICTURE IDENTIFICATION TASK

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By

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ABSTRACT

Pre-school Children's Performance on a Multimedia Picture Identification Task

By Julie K. Cutting

The purpose of this study was to establish normative performance on a new multimedia word-identification task (Picture Identification Task) using pre-school children as subjects. In this study, 20 subjects listened to an auditory stimulus word (target word) through earphones, and pointed to the corresponding picture on a computer monitor (target word plus three rhyming alternatives). Target words were presented at four levels (O, 8, 16, and 24 dB HL) to establish the auditory psychometric function (percent correct as a function of level). The results indicated that the Picture Identification Task was appropriate for use with the subject population. Further studies will extend the use of these materials to non-verbal and hearing impaired pre-school children.

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CHAPTER I

INTRODUCTION

Word recognition testing has been an integral part of the diagnostic hearing evaluation for many years. Word recognition refers to an individual's ability to discriminate words presented aurally through earphones or speakers at a level considerably above his/her speech recognition threshold. While pure-tone testing provides the audiologist with an indication of a person's sensitivity to sounds throughout the frequency range, word-recognition assessment provides essential information on how well an individual can recognize or identify speech sounds (Olsen & Matkin, 1991).

Word-recognition tests have been developed for use with adults and with children. These tests usually involve listening to words and repeating them orally (open set), or listening to words and indicating the correct response by pointing to the corresponding pictorial representation from a choice of four alternatives on a response card (closed set) (Jacobson & Northern, 1991). With the closed-set methods, known as word-identification, word-recognition performance can be estimated for non-verbal individuals, persons with limited speech abilities, and those with articulation difficulties or language delay.

Word recognition performance of children is influenced by developmental differences in receptive language ability relative to chronological age, and limitations imposed by expressive vocabulary skills (Jerger, Jerger & Abrams, 1983). Therefore, testing of young children typically utilizes the closed-set paradigm to reduce the influence of expressive speech ability. A number of methods have been utilized in an attempt to produce age-appropriate auditory/visual materials for young children. A common characteristic of most word lists is the emphasis on word familiarity. Some of the materials commonly used with children are the Word Intelligibility by Picture Identification (WIPI, Ross & Lerman, 1970), The Northwestern University Children's Perception of Speech Test (NU-CHIPS, Elliot & Katz, 1978), and The Pediatric Speech Intelligibility Test (PSI, Jerger, Lewis, Hawkins, & Jerger, 1980; Jerger, Jerger, & Lewis, 1981; Jerger & Jerger, 1982; Jerger, Jerger & Abrams, 1983).

Computerized formats recently have been developed for administering word-recognition tests, thus providing a multimedia approach to testing (McCullough, Cunningham, & Wilson, 1992; McCullough, Wilson, Birck, & Anderson, 1994). The multimedia approach utilizes a computer software program and two color monitors (one for the patient and one for the audiologist). The audiologist controls the presentation level of the target word using a monitor in the control room, and observes the patient's pointing response on a monitor in the test room. Incorrect responses are recorded via the control room computer. The increased use of computers in the audiology clinic enables the audiologist to employ a more automated testing approach. Moreover, the use of a computer monitor for the response portion of the word-identification test probably is more appropriate for children than using the traditional paper cards, since children are familiar with a TV-screen format.

The purpose of the present project was to obtain normative performance data for pre-school children (aged four and five years) on the Picture-Identification Task (Wilson & Antablin, 1980; 1982) administered in the multimedia format. Once normative performance has been established for normal-hearing children, the materials may be used for evaluating the word-identification performance of hearing-impaired children in a clinical audiology setting.

Statement of the Problem

Presently, performance on the computerized Picture-Identification Task has been measured only for fourth grade children utilizing a word-pointing paradigm. The appropriateness of this computerized test for establishing accurate word-identification scores with pre-school children has not yet been determined.

Purpose of the Study

The purpose of this study was to establish normative performance data, using an auditory psychometric function, for four and five year old normal-hearing children on the Picture-Identification Task in the computerized multimedia format.

Hypothesis:

It was hypothesized that:

1. Normal hearing pre-school children can perform a computerized picture pointing task in order to assess their word-recognition ability.
2. The data will provide normative performance levels for future use with four and five year old normal hearing children.

CHAPTER II

REVIEW OF THE LITERATURE

Presently, there is only limited research available on the use of multimedia word-recognition testing for children and adults. Current word-recognition tests utilize auditory/visual materials in a non-computerized response format to assess word-recognition performance in children. The use of a computer in word-recognition testing with children, however, is more appropriate than the traditional paper cards since children are used to looking at a television screen and playing computer games.

This literature review describes the development of major auditory/visual word-recognition tests for children during the past 25 years. These tests include: Word Intelligibility by Picture Identification Test (Ross & Lerman, 1970), Northwestern University Children's Perception of Speech Test (Elliot & Katz, 1978), and Pediatric Speech Intelligibility Test (Jerger et al., 1980; Jerger et al., 1981; Jerger & Jerger, 1982). The review also focuses on the Picture Identification Task (Wilson & Antablin, 1980; 1982), an audio/visual word-recognition test established for non-verbal adults which was subsequently computerized and normalized for use with elementary school children. This review describes the development of the Computerized Picture Identification Task (McCullough et al., 1992), and, in addition, describes a Danish computerized word-recognition test, the Four Alternative Forced Choice Test (Keidser, 1990)

Pediatric Word-Recognition Materials

Word Intelligibility by Picture Identification

One of the early picture identification tests was developed by Ross and Lerman (1970). The Word Intelligibility by Picture Identification Test (WIPI) was designed for testing the word recognition ability of young hearing impaired children. The authors felt that existing tests were unsuitable for the hard-of-hearing pediatric population because of potential expressive language delays that would make verbal test responses impossible.

The test consists of four word lists of 25 words each and is developed from the original six word lists of 26 words each. The lists consist of simple monosyllabic words carefully chosen from children's books and word-count lists, with each list representing the same degree of ease and difficulty of word discrimination. The pictorial illustrations are arranged in twenty-five matrices with four pictures in each matrix consisting of the target word plus three foils thus providing a closed-set response. The child identifies the target word by pointing to the appropriate picture on the matrix.

The final version of the WIPI (Ross & Lerman, 1970) was evaluated by administering the test to 61 hearing impaired children ranging in age from 4 years 7 months (4:7) to 13 years 9 months, (13:9) with a mean age of

10 years 2 months. The word lists were presented to the subjects at a 40 dB sensation level re: Speech Recognition Threshold (SRT), (i.e., 40 dB above their lowest listening level) or at a level 5 dB below the subject's uncomfortable loudness level (UCL) (i.e., the level at which speech and noise becomes painful to listen to) where necessary. The word lists were delivered by monitored live voice (i.e., a VU meter is used by the examiner to monitor his/her presentation level) using the carrier phrase "show me" and were re-administered by the same examiner one to three weeks later for test-retest reliability.

Final evaluation of the WIPI by Ross and Lerman showed that all four word lists produced reliable results with consistent inter-list reliability. Results also suggested the occurrence of a learning effect when multiple lists were administered. The authors suggested that the test be used with children aged five or six when a moderate hearing loss exists, and children aged seven or eight when a severe hearing loss exists. The test was not recommended for children younger than five years of age since normative data were not collected for this population. In addition, the authors found that the pointing task was too easy for children with only minimal hearing loss who consistently obtained scores of 100%. It was recommended that conventional speech discrimination tests, i.e., open-set format should be utilized with this population in order to assess differences in ability.

Sanderson-Leepa and Rintlemann (1976) utilized the WIPI along with two additional word-recognition tests, the Phonemically Balanced Kindergarten Word Lists (PBK-50), and Northwestern University Auditory Test No. 6 (NU 6) to study children's word discrimination performance. These three word recognition tasks all utilized different test formats. The WIPI, as previously mentioned, was a non-verbal closed-set task designed for children. The PBK-50 also was designed for children but utilized an open-set paradigm. The NU 6 was developed for adults and utilized an open-set task.

Subjects who participated in the study were 60 normal hearing male and female children, with ages evenly distributed between three and one half years and 11 and one half years. Each test was administered at a variety of sensation levels with each successive presentation given at a higher level than the previous one. The number of tests and sensation levels administered differed depending on the appropriateness for the age group in question.

Results showed, not surprisingly, that the WIPI was the easiest task for all age groups and produced the highest scores. Since the WIPI has the closed-set format and utilizes a picture pointing task it eliminates confounding factors such as the child's expressive language ability. The PBK produced the second highest scores with results improving for children aged seven years and older. The NU 6 was found to be the most difficult task for the children to perform due to the complexity of the vocabulary utilized in the test.

The authors concluded that the WIPI and the PBK offer reliable measurements of normal hearing children's speech recognition ability. They recommended the use of the NU 6, however, in hearing aid evaluations since it more accurately determines speech discrimination differences between the ears and because the complexity of the task produces a wider range of scores.

Papso and Blood (1989) also utilized the WIPI to compare the word recognition skills of young normal hearing children, between the ages of 4 and 6, with those of adults in quiet and in background noise. Unlike most word recognition studies where testing is administered under earphones, this test looked at word scores obtained in the sound field. The WIPI was utilized because of its ability to test young children with competing background noise.

Sixty subjects participated in the study, 30 children both male and female, (4 years to 5 years 10 months), and 30 adults (19 years to 28 years). All subjects had air conduction thresholds of 15dB HL re: ANSI (1989) or better. The subjects were presented with the WIPI word lists utilizing a 6 dB signal-to-noise ratio (S/N), and were required to identify the stimulus word by pointing to the corresponding picture.

Results showed normal speech recognition scores (88-100%) in quiet for all sixty subjects. However, the children performed significantly more poorly than adults in the presence of competing background noise. The poorest scores were recorded when multitalker background noise was utilized. These results indicated that caution should be taken when considering the suitability of word recognition tests with background noise if the test is normed on adults only.

North Western University Children's Perception of Speech

The NU-CHIPS is another word-recognition task for children utilizing a picture pointing technique with a closed-set paradigm. The test was designed by Elliott and Katz (1978) primarily for use with preschool children with three year old receptive language skills. The test was normed on three-to-five year olds, ten year olds, and adults, none of whom had previously participated in word recognition testing. Subjects were required to have normal hearing (15dB HL or better from 250 Hz - 8000 Hz). Children who participated in the study were required to have a receptive vocabulary level commensurate with their chronological age (within one standard deviation) with regard to the Peabody Picture Vocabulary Test. Hearing impaired subjects were representative of children from both aural/oral and "total communication" school programs.

The test materials for the NU-CHIPS consisted of 50 monosyllabic words selected from 67 words which the authors established as appropriate for children with three year old vocabularies. Four test forms were utilized, each using the same words in an altered sequence. The test words were administered (by earphones or in the sound field) and the child was required to select the correct response from a choice of four (the target word plus three phonemically similar foils). The administrator used a pre-designed answer sheet to record the responses.

Elliot and Katz (1978) investigated the reliability and test equivalency of the four test forms (whole and half list) used in their study both for normal hearing and hearing-impaired children. Results indicated good reliability and intertest equivalency with half word lists providing approximately equivalent performance scores. No learning effect was observed after administration of four word lists. Performance intensity functions showed that normal hearing children peaked in performance at 30 dB SL or lower. At levels lower than 30 dB SL performance improved as a function of age. For hearing impaired children performance varied as a function of receptive language ability. It was concluded, therefore, that the NU-CHIPS should be administered at 30 dB SL level or higher for best performance. When performance on the NU-CHIPS was compared to performance on the WIPI (Ross & Lerman, 1970) the authors found good correlation between the two tests. The authors concluded that the NU-CHIPS should be utilized for word-recognition testing when receptive language ability is limited and that other recognized tests with more difficult vocabulary be administered when the child has the appropriate language maturity.

In 1984, Chermak, Pederson, and Bendel looked at the reliability of the NU-CHIPS when administered in a background of white noise. The authors rationale for the study was their contention that speech recognition testing in noise, when utilized with other test data, gives important information for assessment of site of lesion and hearing aid candidacy.

Thirty six subjects participated in the study, 22 girls and 14 boys, aged between nine and one half years and ten and one half years. The four lists of the NU-CHIPS were administered in a randomized order at one of three S/N (-4, 0, +2). Presentation level was set at 30 dB SL (re: SRT) as previously determined by Elliott and Katz.

Results of the study showed the NU-CHIPS to be less reliable when administered with background noise. Analyses of the data showed differences in performance on the four word lists and a lack of correlation with results for half word lists. The authors do not, therefore, recommend the administration of the NU-CHIPS for word recognition testing in noise and state that if the test is utilized the clinician should avoid the use of half word lists.

Pediatric Speech Intelligibility Test

Another picture pointing word-recognition test, the Pediatric Speech Intelligibility Test (PSI), was developed by Jerger, Lewis, Hawkins & Jerger (1980), Jerger, Jerger & Lewis (1981), and Jerger & Jerger (1982). This test utilizes both monosyllabic words and words in simple sentences in an attempt to improve the audiologist's ability to detect word recognition deficiencies in young children. Jerger et al.(1980) emphasize the importance of selecting test materials based on the child's cognitive level and receptive language abilities in preference to consideration of the child's chronological age.

The test materials for the PSI were developed from thirty picture cards representing monosyllabic words and thirty pictures representing actions described in sentences. The target words were chosen from nouns and verbs common to children's early vocabulary. Before administration of the PSI the children's vocabulary and receptive language level were established using the Peabody Picture Vocabulary Test (PPVT, Dunn, 1965) and the Northwestern Syntax Screening Test (NNST, Lee, 1971). The sixty pictures then were shown to 87 normal hearing children with ages ranging from 3 years 3 months (3:3) to 6 years 8 months (6:8). The subjects were asked to respond to the question "What is this?" (for the monosyllabic words) or "What is happening in this picture?" (for the sentences).

Responses to the pictures representing sentences were categorized by the authors into three broad sentence patterns:

1. article noun/verb-ing/article noun (e.g., "A bear brushing his teeth")
2. article noun/auxillary verb-ing/article noun (e.g., "A bear is brushing his teeth"), and
3. pronoun/auxillary verb-ing/article noun (e.g., "He is brushing his teeth").

Jerger et al. (1980) established a correlation between vocabulary (PPVT) and receptive language level (NSST) with the type of response recorded for the sentence description. Children in pattern group 2 (article noun/auxillary verb-ing/article noun) were about 2 1/2 years advanced in vocabulary and receptive language skills than children in pattern group I (article noun/verb-ing/ article noun).

Jerger et al. (1980) applied their findings to the development of two sets of sentence materials for further clinical testing. One set of materials was designed for lower level vocabulary and receptive language abilities (format 1) using a carrier phrase "show me," while the other set was designed for higher vocabulary and receptive language abilities (format 2) without the use of a carrier phrase.

To select the final test sentences for the PSI the authors categorized the children's utterances for all 30 cards in terms of syntax and semantic usage. Sentences for both formats were selected when 80% or more of the subjects produced the target sentence. This procedure resulted in 10 sentences being included in the PSI test in both formats 1 and 2.

Results when testing the 30 monosyllabic words for inclusion in the PSI did not demonstrate a significant difference with regard to chronological age, vocabulary level or receptive language ability. From the original 30 words a list of 20 words were selected for inclusion in the PSI based on a 95% correct response rate to the target word.

Jerger et al. (1981) completed three additional investigations on the PSI looking at the effects of receptive language and chronological age. The first two studies looked at the validity of using the two PSI sentence types, formats 1 and 2, when assessing a child's receptive language ability. The third study was designed to assess how the child's receptive language age influences his or her word recognition performance on the monosyllabic word portion of the PSI.

Testing for the three studies included a pure tone audiogram, the Northwestern Syntax Screening Test (NSST) and either the monosyllabic word materials or sentences from formats 1 or 2, whichever was appropriate. Test materials consisted of 20 monosyllabic words administered as 4 lists of 5 words, or 10 sentences in either format 1 or format 2 configuration, administered as 2 lists of 5 sentences. The test materials were presented in sound field at a constant intensity level of 50 dB SPL. Competing messages were presented through a range of intensity levels giving message-to-competition ratios (MCRs) from +10dB to -20dB for the sentences presentations (studies 1 and 2) and +10dB to -4dB for the monosyllabic word testing (study 3). Each list was represented by picture cards and the subject was asked to select the appropriate response. Subjects completed a MCR function for list A and B for formats 1 and 2 and for the word items.

Study 1 looked at the use of the PSI sentence material as an appropriate means of testing speech audiometry without undue influence from the subjects receptive language ability. Subjects for this study were 24 children, 10 girls and 14 boys, between the ages of 3 years 4 months (3:4) and 9 years (9:0).

Performance patterns from Study 1 testing were interpreted by the authors as follows: (i) when NSST receptive language scores were 37-40 the PSI was too easy and therefore inappropriate for word-recognition testing, (ii) when NSST scores were 15-31 format 1 sentence materials produced the best results and were therefore deemed the most appropriate, while format 2 sentences were found to be more appropriate for subjects scoring 32-36 on the NSST. Jerger et al. (1981) concluded that both sentence formats are an appropriate and effective means of controlling the influence of receptive language ability on speech recognition testing.

Study 2 was designed to specify appropriate criteria for selection of PSI format 1 or format 2 sentence material in speech recognition testing. Subjects for this study were 50 children, 34 boys and 16 girls, between the ages of 3 years 4 months (3:4) and 9 years (9:0). Twenty four of the fifty subjects had previously participated in Study 1.

The authors of this study concluded the following: (i) when NSST scores are 15-36 the appropriate criteria for format selection should be based on the NSST absolute raw score, and (ii) when NSST scores are between 37 and 40 both the raw score and the corresponding percentile score should be taken into consideration. These results concurred with the findings of Study 1 and reinforced the authors desire to reduce the influence of receptive language ability on speech recognition results.

Study 3 considered the effects of receptive language ability on speech recognition testing using monosyllabic words rather than sentences. Subjects for this study were 40 children, 24 boys and 16 girls, between the ages of 3 years 2 months (3:2) and 6 years 9 months (6:9). Eight of the 40 children had previously participated in Study 2. All 40 subjects were tested with the same word items but results were recorded in terms of the subjects NSST scores. Twenty of the subjects qualified for format 1 materials (i.e., NSST scores of 15-31) and 20 of the subjects qualified for format 2 (i.e., NSST scores of 32 and above).

Results of this study verified the authors' earlier conclusions that chronological age and receptive language level did not significantly influence the scores obtained on the word portion of the PSI. Chronological age alone showed a 10% improvement in performance with increasing age from 3 to 6 years.

Jerger & Jerger (1982) conducted a further study which looked at the performance-intensity characteristics of the PSI. The purpose of the study was to establish normal performance-intensity (PI) functions for the test materials both in quiet and in the presence of competing background noise.

Subjects for this study were 40 children, 21 girls and 19 boys, between the ages of 3 years 1 month (3:1) and 6 years 10 months (6:10). Pure tones and receptive language levels (NSST) were established before administration of the PSI. Using the criteria previously described the appropriate materials were selected for the subjects (i.e., based on their NSST raw score) with 20 children qualifying for format 1 (tested in sound field) and 20 children qualifying for format 2 (tested under earphones).

Performance-intensity functions were initially recorded at an intensity level of 50-60 dB SPL. The intensity level was gradually decreased in 10 dB steps until a "knee" (i.e., "the point of inflection below which performance decreased rapidly with further decrease in intensity" p. 326) was reached. Once the knee-point was reached the intensity level was then reduced in 5 dB increments. The high-intensity point of the PI function was established by raising the sound pressure level to 100 dB SPL (in soundfield) and 110 dB SPL (under earphones). PI functions were established in quiet and in the presence of competing background noise. The MCR for this study was 0 dB for format 1 and format 2 sentences and 4 dB for monosyllabic words.

The results of this study recorded the steepness of the PI function for words and sentences in quiet and in background noise. In addition, the study recorded data on the speech thresholds for words and sentences in both conditions. Finally, the authors discussed a framework for identifying roll-over in young children where a possible retrocochlear disorder exists.

With regard to the steepness of the PI function in this study Jerger et al. (1982) showed that no significant difference existed between the two groups tested with word materials in quiet and in noise. When the sentence materials were presented there was no significant difference in quiet between the two groups but the steepness of the PI function in noise was found to be significantly different. Other results included the finding that within each group there was a significant difference between the steepness of the function between words and sentences presented in quiet versus words and sentences presented in noise.

The PSI was found to produce a steeper PI function than other pediatric and adult word-recognition materials. The authors noted however, that this difference might reflect the use of a closed-set format versus an open-set format. The authors refer to a study by Wilson & Antablin (1980) which concurred with their theory that a closed-set paradigm produces a steeper PI function than an open-set paradigm. Wilson & Antablin (1980) postulated that response curve differences exist as a result of a minimum number of response choices (i.e., closed-set) versus the open-set format. It can be argued, therefore, that these test differences make comparison of PI functions inappropriate between open and closed-set testing.

Picture Identification Task

In 1980 Wilson & Antablin developed the Picture Identification Task (PIT) for word recognition testing of non-verbal adults. The development of this test was prompted by the lack of suitable material available for testing non-verbal patients i.e., test material requiring only a gestural response, and the need for audiological information beyond pure-tone audiometry (air and bone conduction testing), and acoustic immittance (impedance and acoustic reflex results) for this population.

In this study the authors described the normative data and performance-intensity functions for the Picture Identification Task. The effectiveness of the test materials was examined by comparing the results obtained from the PIT with results obtained from an established word-recognition test utilizing the same subjects.

The materials used to compile the test were chosen from the Teachers Word Book of 30,000 Words (Thorndike and Lorge, 1944) and consisted of consonant-vowel nucleus-consonant (CNC) words. Four lists of 50 phonemically balanced words were prepared, with the target word in each case illustrated with three rhyming alternatives on a response plate. Two experiments were completed using these words lists with performance-intensity functions obtained at eight separate presentation levels.

In the first study, Wilson & Antablin (1980) looked at the relationship between results obtained from the PIT and Northwestern University auditory Test (N.U. No.6) when presented in quiet and in noise, by comparing the performance-intensity function of each test result when an open-set response paradigm was used. Subjects for the study were 16 normal hearing adults with an average age of 21. Monosyllabic words were first presented in quiet using a test range of -2 dB to 26 dB, with regard to speech-reception thresholds, with each presentation changing in 4 dB increments. The word lists for presentation in noise were administered at eight S/N from -12 dB to 16 dB. The test words were presented under earphones (TDH-39's) with the subject placed in an anechoic chamber. Results from the experiment showed no significant difference between the PIT and the N.U. No. 6 word lists in terms of performance intensity functions both in quiet and in noise when an open-set paradigm was utilized.

The second study compared the PIT in a closed-set response paradigm with the N.U. No.6 in a closed-set response paradigm and an open-set response paradigm. Subjects for this experiment were 24 normal hearing adults with an average age of 24. Subjects presented with the PIT word lists were asked to respond by pointing to the appropriate picture on the response card. However, these same subjects were asked to respond to the N.U. No. 6 (open-set) by writing down the appropriate answer and by selecting the appropriate word from a multi-choice answer sheet for the closed-set response condition. As with study one the test materials were administered in 4 dB increments using a range of -2 dB to 26 dB with regard to their speech-reception threshold.

Results from this study clearly showed that significant differences existed at low presentation levels using the three response paradigms, i.e., closed-set pointing (pictures), closed-set multi-choice (written words), and open-set writing (written words). Responses to the N.U. No.6 closed-set multi-choice unexpectedly yielded better results than the PIT (picture identification) task. The authors postulated that these results might be due to the more advanced processing skills that are required to transform a picture into a word. The N.U. No. 6 open-set response paradigm proved, as expected, to be the most difficult task since it provided the least available response cues. Results for all three response modes at high presentation levels did not show significant differences. Results from this experiment also showed that the four word lists can be used interchangeably and that half-list scores yield equivalent results.

On completion of the two studies Wilson & Antablin (1980) went on to clinically evaluate the effectiveness of the PIT in assessing the word recognition ability of non-verbal adults. Twenty eight subjects were used in the evaluation and were divided into two groups according to their verbal ability. Group one consisted of 12 subjects with an average age of 61.7 years and "with histories of cortical insult and mild aphasia" (stroke with loss of receptive or expressive language). These 12 subjects were able to make verbal responses to test material. The second group consisted of 16 subjects with an average age of 58.3 years and included patients "with moderate aphasia or dysarthria, one glossectomy, and one laryngectomee." These 16 subjects were unable to make verbal responses to the test materials. The presentation levels used for the clinical evaluation were selected at 50 dB and 70 dB HL. The 50 dB HL presentation level was chosen as being representative of normal conversational speech while the 70 dB HL presentation level was representative of the level of maximum performance on the performance intensity function. The subjects in group one were able to respond to both the open-set response task on the N.U. No. 6. and the closed-set response task on the PIT. Results showed a significant difference in performance at both levels of presentation between the PIT and the N.U. No. 6. with the PIT (closed-set) results showing higher word recognition scores. The results for the N.U. No. 6 were, however, found to be consistent with previous results recorded for this test using subjects with a similar degree of hearing loss.

The subjects in group two were only able to respond to the PIT picture pointing task. Results for this testing showed a significant increase in performance when the presentation level was increased. Performance results for the PIT for both groups were found to be similar.

The authors concluded from their findings that the PIT is an effective tool in accurately assessing word recognition performance in non-verbal adults and could be used effectively as part of the audiological evaluation of these patients.

Computerized Audiology

Yanz and Siegel (1989) discuss the importance of utilizing multi-media systems in the audiology clinic. Incorporating computer technology into the audiological evaluation reflects the increased use of multi-media systems everywhere. Computers offer the audiologist a sophisticated, quick, efficient and effective way of testing patients in the clinic without compromising accuracy and consistency. Automated routine tests and scoring techniques and the ability to incorporate more sophisticated tests in the audiological examination give the clinician increased freedom and flexibility. In addition, computerized systems offer a more efficient and space saving method of data storage in the office, dispensing with the need for bulky patient files.

Computerized word recognition testing is now being incorporated into the audiological test battery offering several major advantages. Magnetic storage of speech materials provides a permanent method of keeping word lists without fear of deterioration of the recordings. In addition, digital recordings offer the clinician greater flexibility with the speech materials. Finally, each test item need only be recorded once and can be recalled instantly for multiple presentations during a test session.

Since the development of the Picture Identification Task for non-verbal adults the test has subsequently been computerized and developed for use with school age children. McCullough, Cunningham, & Wilson, (1992) studied the appropriateness of using the PIT materials with fourth-grade children in the computerized format. The subjects who participated in the study were 24 fourth grade students aged between nine years one month (9:1) and eleven years four months (11:4). Pure tone audiometry and speech reception thresholds were obtained to determine all subjects had hearing within normal limits. The Wide Range Achievement Test (WRAT), reading level portion, was also administered to establish that each student met the fourth grade reading level criterion of the Reading Level I portion of this test. The PIT was administered in quiet and in noise under earphones in both open-and closed-set formats using two word lists (IA and IB). With the use of the closed-set format the subjects were required to identify a word on the computer monitor from one of four choices by pointing to the target word heard through the earphones. In the open-set format the subjects were required to repeat the stimulus word verbally. Broadband white noise was presented to the test ear of the subject at 85 dB SPL. Presentation of the word lists was administered at either -4 dB or 8 dB S/N for the pointing condition and 2 dB or 8 dB S/N for the oral condition. Each subject listened to 8 half-word lists in total (25 words per list), two in each of the four conditions so that a percentage correct score could be recorded for the equivalent of a

50 word list. In addition, an average performance was calculated for the 24 subjects.

Results of the testing showed a mean percent correct of 50.1% for word identification (pointing condition) at -4 dB S/N and 86.4% correct at 8 dB S/N. Results for the verbal condition were a mean percent correct of 34.4% at 2 dB S/N and 60.1% at 8 dB S/N. Seventy five percent of the children stated that the picture pointing task with the computer monitor was the easier of the two tasks.

The authors concluded that the Picture Identification Task is an appropriate task for establishing word-recognition scores of elementary school children with a fourth grade reading level. They suggest, however, that presentation of the stimulus words at a 10dB S/N or greater should be utilized for the most accurate results.

Another computerized system has been developed in Denmark by Gitte Keidser (1990). The system utilized digital speech recordings in noise and was administered to normal hearing and hearing impaired adults. The test was designed to more accurately measure and analyze speech recognition results while controlling the presentation of the test materials in a random order. The author suggests that this type of computerized presentation may "enhance the flexibility of the experimental design and to some extent reduce the training effect and thereby improve the reliability of the results obtained by statistical analysis of the data" (pp. 147-148).

Keidser (1990) conducted a study to ascertain if an existing Danish multiple choice test could be utilized with the computerized system thereby negating the necessity of making a new recording. The speech material used in the study was presented as a four alternative forced choice (4AFC) (closed-set) response. The test consisted of 100 monosyllabic words based on consonant confusions, comprising 25 sets of four words each. Since the test was not designed specifically for word recognition testing consideration was not given to phonemic balance and other linguistic properties.

The subjects in the study were 9 normal hearing listeners aged between 19 and 36 years of age and 14 hearing impaired listeners aged between 54 and 69 years of age. The hearing impaired subjects had a maximum hearing loss of 55 dB HL at 4000 Hz. The speech material was presented to the subjects at 6 different signal-to-noise ratios in 3 dB steps using the carrier phrase "Sunrise is duly chimed every day" and speech intelligibility curves were obtained at each level. The signal was presented to the normal hearing listeners at 70 dB SPL and to the hearing impaired listeners (better ear) at 85 dB SPL. In this way the authors looked at the S/N required to achieve a percent correct word recognition score. The written word lists were presented to the subject on a computer monitor in groups of four words (numbered one-four) and the subject was required to indicate the stimulus word by selecting the corresponding number on a keypad in front of him.

Results of this study for the normal hearing subjects showed a score of 62.5% at -8 dB S/N whereas results for the hearing impaired listeners showed that the S/N must be improved by 4 dB to obtain the same percentage score. The authors stated that a learning effect was demonstrated during a test session when multiple presentations of the words were administered. A further innovation of the multimedia word-recognition test is discussed by McCullough, Wilson, Birck & Anderson (1994). In this report the authors explain the utilization of computerized word recognition testing with multi-lingual patients. Accurate assessment of non-native English speakers is compounded by the clinicians inability to distinguish between errors due to language ability and those due to hearing loss. Multimedia audio/visual materials offer a viable solution to this dilemma. Target words can be administered to the patient aurally from digital recordings of their native language and identified by the patient by pointing to the appropriate picture or word on the computer screen. Utilization of this method of word-recognition testing negates the necessity of the clinician speaking the language of the patient in order to accurately assess word-recognition ability.

Summary and Conclusions

Until recently auditory/visual word-recognition testing was the usual method of choice for establishing young childrens' speech discrimination ability. The use of a multimedia system reflects changing technology, the increased use of computers in the audiology clinic, and the exigency of utilizing "state of the art" equipment and testing methods. In addition, the use of computerized administration and scoring techniques will allow the clinician to more accurately and reliably assess word-recognition performance. Moreover, the use of a computer in word-recognition testing with children is more appropriate than the traditional paper cards since children are used to looking at a television screen and playing computer games.

The purpose of this study, was to extend the use of computerized word-recognition testing in the audiology clinic to English speaking pre-school children with normal hearing. The appropriateness of the Picture-Identification Task for establishing accurate word-recognition scores with pre-school children was studied using twenty four-year-old and five-year-old children as subjects.

CHAPTER III

METHODS

Word-recognition tests for children utilize either a verbal (open set) response format, or a picture pointing (closed set) response format, to assess word recognition (open set) or word identification (closed set). The type of format that is administered is contingent upon a child's expressive language ability. Traditional picture-pointing word-identification tasks commonly used with pre-school children consist of auditory-stimulus words (target words) and visual-response materials (pictures corresponding to the target word, as well as rhyming alternative words). The multimedia approach to word-recognition testing utilizes a computer monitor for indicating responses to auditory stimuli. Incorporating computers into the clinical test battery may provide the audiologist with a faster, more accurate, and reliable way of administering and scoring word-recognition performance.

The Instrument

This study utilized The Picture-Identification Task (Wilson & Antablin, 1980), an auditory/visual word-identification task developed originally for non-verbal adults. From the original 217 phonemically-balanced words utilized in the test, 100 items were selected for use with pre-school children. A pilot study (Bearce, 1991) established that these 100 items were recognized by four-year-old children with approximately 90-100% accuracy. The vocabulary items comprising the Picture-Identification Task for pre-school children are given in Appendix A. Of the 100 items, 50 items were chosen as "target" words, based on word familiarity (as established in the pilot study), and an inclusive representation of English phonemes.

In order to construct the auditory-stimulus portion of the test, 50 target words were recorded by a female speaker in the following manner. The recordings were made in a sound booth using a microphone (AKG Acoustics, Model C 460 B), a preamplifier (Symetrix, Model SX202), and a 16-bit analog-to digital converter (Antex, Model SX10) that sampled 20,000 points/s. A carrier phrase, `show me ----,' followed by a 200-ms silent time interval then was added to the beginning of each target word. The digitized words were transferred from a PC-based file format into a Macintosh format, and the resulting files were stored in a software program for later administration and scoring.

In order to construct the visual-response portion of the test, the color pictures corresponding to the target word and the three corresponding alternative words were scanned (digitized) into computer files and arranged on a computer monitor in quadrants. Twenty-five four-word groupings were constructed from the l00 vocabulary items. The picture-response files also were entered into the administration and scoring software program.

Subjects

Subjects who participated in this study were recruited from local pre-schools in San Jose, California. Twenty English-speaking children, ranging in age from three years ten months to five years eight months participated in the experiment. Of the 20 subjects, 12 were females and 8 were males. (See table 1.) The experimental group was representative of a diverse socio-economic and cultural population.

Procedure

Before administration of the computerized word-recognition testing, each subject was given an otoscopic examination and evaluated for normal hearing sensitivity utilizing pure-tone audiometrics and tympanometry. The protocol and stipulated parameters for the audiological evaluation were as follows:

1. otoscopy,
2. screening immittance audiometry (single-peaked tympanogram [+/- 100 daPa] with present acoustic reflex at 1000 Hz [105 dB HL],
3. pure-tone audiometrics (air-conduction thresholds 15 dB HL or better at four frequencies: 500, 1000, 2000, and 4000 Hz (re: ANSI, 1989).

Subjects were tested individually under earphones (TDH 50p) in a sound-treated room. Each subject was seated in front of a computer monitor.

Color pictures representing the target word and three rhyming alternatives foils appeared on the screen in a quadrant format. The subject was instructed to respond to each auditory-stimulus word (heard through the test earphone) by pointing to the corresponding picture on the computer monitor. The examiner initiated the target word on the computer (Mac II VX), routed the signal through an audiometer (GSI, model 16), and observed the subject's pointing response to the stimulus word. Responses were scored by the examiner on a score sheet in the control room as correct or incorrect. A response was correct when the auditory stimulus word was identified with a pointing response to the corresponding color picture on the computer monitor. Subjects were instructed to take a guess at each target word. Each subject was presented with a total of 50 words during the 20-minute test session. Of the 50 target words, 25 were presented at one level (either 0, 8, 16, or 24 dB HL) and 25 at another. The target-word order (words 1-25, known as List IA or 26-50, known as List IB) and level were randomized across subjects. Since each of the 20 subjects listened at 2 levels, 10 data points were established for each of the presentation levels.

Data Analysis

The percent correct responses for all subjects at each presentation level were calculated and averaged to establish a mean percent correct performance. Standard deviations for each presentation level also were calculated. From the mean percent correct scores, a psychometric function was produced in which mean percent correct performance was shown as a function of the presentation level. A psychometric function is the preferred methodology for establishing the normative performance of speech audiometric materials.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to obtain normative performance data for pre-school children (aged four and five years) on the Picture-Identification Task in the multimedia format. In addition, the study demonstrated the utility of using a computerized format for establishing word-identification performance of pre-school children. A statistical analysis was performed to establish mean scores and standard deviations for the four experimental presentation levels (0 dB, 8 dB, 16 dB, and 24 dB HL). In addition, an error analysis was completed for the two highest presentation levels (16 dB and 24 dB HL) to determine if specific target words were missed more often than others.

Table 1 shows the individual and mean percent-correct scores and standard deviations for the 20 subjects who participated in the picture-pointing closed-set task. Mean performance for List IA (words 1-25) was 44.7%, 64%, 84%, and 87% from 0 dB to 24 dB HL respectively. Performance for List IB (words 26-50) was 40%, 48.8%, 80.8%, and 84.7% from 0 dB to 24 dB HL respectively. Standard deviations for List IA and List IB were approximately 4% at all levels except at the 8 dB HL condition (List IB) where a 16% standard deviation was noted. The performance on List IA and List IB were combined to establish a group mean percent correct score (and standard deviation) at each

Table 1
Individual Subject Data from List 1A (words 1-25) and List 1B (words 26-50).

Subject	Ear	Age Yr-Mo	Sex	0 dB		8 dB		16 dB		24 dB	
				(1A) %	(1B) %	(1A) %	(1B) %	(1A) %	(1B) %	(1A) %	(1B) %
1	R	3-10	M	36			36				
2	L	5-1	M					72			76
3	L	4-0	F				48	88			
4	L	4-5	F					88			84
5	L	4-10	F				68			92	
6	R	5-3	M			72			88		
7	R	3-11	F			48					76
8	R	4-7	F				52			68	
9	R	5-2	F			68			68		
10	L	5-8	M			60			80		
11	L	4-10	F			72					92
12	L	4-6	F		32			88			
13	R	4-5	F	44					84		
14	L	5-1	F	44							84
15	R	3-11	F		40			84			
16	R	4-7	M	36			40				
17	R	4-10	M	68							96
18	R	4-8	F		44					96	
19	L	4-2	M	40					84		
20	L	4-11	M		44					92	
Mean (M)				44.7	40	64	48.8	84	80.8	87	84.7
SD				11.9	5.7	10.2	12.5	6.9	7.7	12.8	8.2
Combined Mean (M) (1A and 1B)				42.8		56.4		82.4		85.6	
Combined SD (1A and 1B)				9.8		13.4		7.1		9.7	

of the four presentation levels. Group mean performance ranged from the lowest score of 42.8% (slightly above chance) at 0 dB HL to the highest score of 85.6% at 24 dB HL.

From the collective group data, a psychometric function for the closed-set picture-pointing task was generated and is shown in Figure 1. In this figure, mean performance is shown as a function of presentation level. The slope of the function was calculated from the best-fit third-degree polynomial. The slope of the function was determined to be 3%/dB. This slope is consistent with the slope of functions from other closed-set word-identification tasks (Wilson & Antablin, 1980; McCullough et al., 1984).

In order to determine if some test items were missed more frequently than others, an error analysis was performed at the 16 dB and 24 dB HL presentation level conditions. In this analysis, the number of times a given target word was missed was divided by the number of times it was presented, in order to determine the error percentage. The error analysis is presented in Table 2, where the percent of incorrect responses is given for each target word. The analysis revealed that, for List 1A at the 16 dB and 24 dB HL presentation levels, 8 out of 25 words never were missed, 8 words were missed 10% of the time, one word was missed 13% of the time, one word was missed 20% of the time, three words were missed 23% of the time, one word was missed 35% of the time, one word was missed 38% of the time, one word was missed 53% of

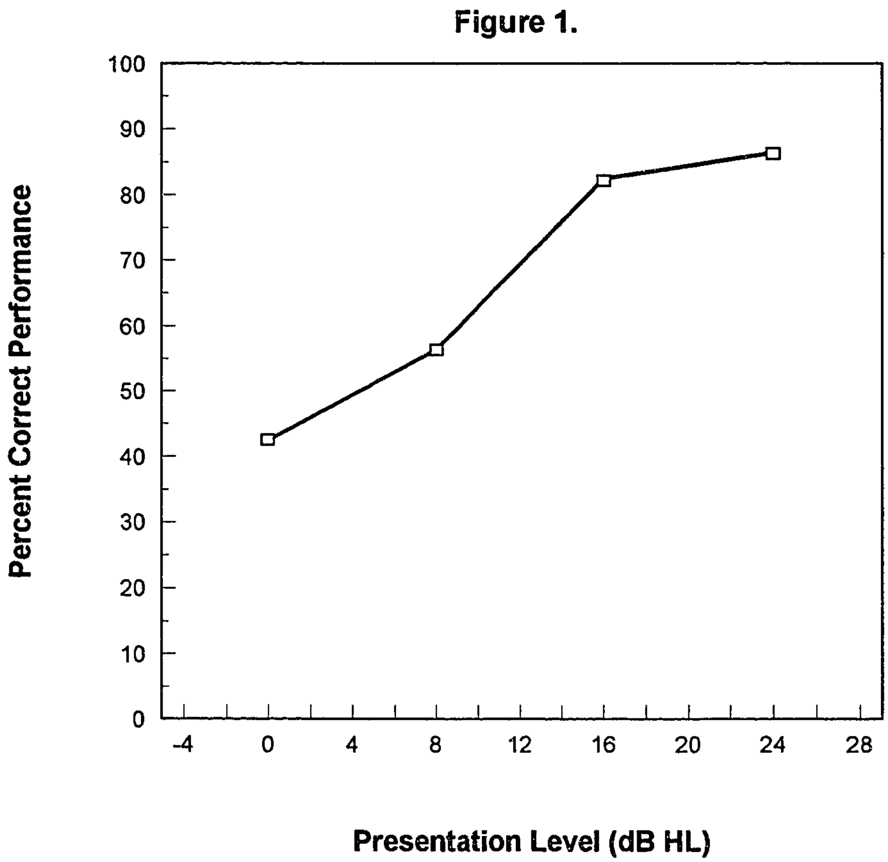

FIGURE 1. The mean percent correct recognition/identification scores for the picture-pointing task as a function of presentation level.

Table 2
Percentage of Errors of Target Words in the Picture-Pointing Task.

List 1A	16 dB	24 dB	List 1B	16 dB	24 dB
Nose	20%	0%	Toes	0%	33.3%
Cake	0%	0%	Snake	20%	16.7%
Rock	20%	0%	Sock	0%	16.7%
Can	20%	0%	Man	0%	0%
Light	0%	75%	Kite	0%	0%
Pet	20%	0%	Net	40%	33.3%
Hat	0%	25%	Cat	0%	0%
Chair	0%	0%	Hair	40%	16.7%
Stool	80%	25%	School	0%	16.7%
Rug	0%	0%	Hug	0%	16.7%
Star	0%	0%	Car	0%	0%%
Run	0%	0%	Gun	0%	0%
Feet	20%	0%	Seat	60%	66.7%
Bed	0%	0%	Head	0%	0%
Bees	20%	50%	Knees	80%	50%
Rice	40%	75%	Slice	80%	50%
Lamb	40%	0%	Laugh	60%	33.3%
Rain	0%	0%	Plane	0%	0%
Ring	0%	0%	King	0%	0%
Goat	20%	0%	Boat	0%	0%
Ship	20%	0%	Lip	0%	0%
Race	20%	0%	Face	0%	0%
Road	20%	25%	Robe	60%	33.3%
Sick	20%	25%	Lick	40%	0%
Tire	20%	25%	Fire	0%	0%

the time, and one word was missed 58% of the time. The four words most commonly missed were "bees," "light," "stool," and "rice." Similar results were obtained for List 1B, where 12 out of 25 words never were missed, three words were missed 8% of the time, one word was missed 17% of the time, one word was missed 18% of the time, one word was missed 20% of the time, one word was missed 28% of the time, one word was missed 37% of the time, two words were missed 47% of the time, one word was missed 63% of the time, and two words were missed 65% of the time. The three words most commonly missed were "seat," "knees," and "slice."

Of the 10 most commonly missed words, four were from List 1A and 6 were from List 1B. These words are "light," "stool," "bees," "rice," "seat," "knees," "slice," "laugh," "robe," and "net." The range in error scores for these 10 words is 35% to 65%. Four of the 10 most commonly missed target words appear as rhyming words on the same response foils and may have been confused for each other. However, for one of these pairs, "rice" and "slice" it seems more likely that the pictures themselves were not easily identifiable since the subjects showed some hesitation in choosing their response to these target words. The target word "light," depicted as a flashlight also appeared to confuse the subjects. Since there were a few words per list that were commonly missed, test scores above 80% should indicate good performance.

Observation of the subjects' performance revealed additional information concerning the clinical use of the multimedia word-identification task with the pre-school children. First, subjects' responses were seen to improve once the task had become familiar. A refinement of this test should include the use of practice items to familiarize the subjects with the task. Due to the young age of the subjects in this study, the length of concentration required for the task was another concern. While most of the subjects were able to maintain their focus for the fifty-word presentation, a few were more easily distracted and needed to be refocused. This lack of attention was a particular problem when presenting target words at very low levels (barely above threshold). Also, the need for careful instruction of the subject was apparent in this investigation. Since the target words for List IA and List IB appeared on the same response foil, some of the subjects were inclined to repeat their response from the first time the pictures appeared on the computer monitor. When the subject was specifically instructed that the target word would most likely be different for the second 25 word list, their response appeared to improve. Finally, it has been suggested that a touch-screen version of the Picture-Identification Task would enhance the speed and efficiency of the test (McCullough et al., 1994). A touch-screen probably would not, however, be appropriate for young pre-school children since the subjects in the investigation frequently touched the screen randomly before pointing to their final response to the target word.

The results of this study support the hypothesis that the multimedia picture-pointing response task is appropriate for four and five year old children for estimating word-recognition scores. Combined mean percent performance scores for the two half-word lists showed that the subjects correctly identified over 80% of the target words at levels at or exceeding l6 dB HL. The mean performance data should be considered as normative performance when hearing impaired pre-school children are evaluated with the multimedia picture-pointing task in the audiology clinic.

CHAPTER V

SUMMARY

The increased use of computers in the audiology clinic reflects changing technology and the exigency of utilizing "state of the art" equipment and testing methods. Moreover, the use of a computer in word- recognition testing with children probably is more appropriate than the traditional paper cards since children are used to looking at a television screen and playing computer games.

In order to more accurately and reliably assess word-recognition performance, computerized administration and scoring formats have recently been developed, thus providing a multimedia approach to testing. In this study, the Picture Identification Task, in the computerized format, was administered to 20 normal-hearing pre-school children to establish normative data for this population.

The results of this study established means and standard deviations from which a psychometric function was generated. The results clearly showed that the computerized picture-pointing task was an appropriate method of measuring word-identification ability in young pre-school children. The mean data indicated "good" performance (80% correct) at high presentation levels. The information obtained in this study will facilitate the use of multimedia systems in the audiology clinic for efficient test administration and scoring of word-recognition materials.

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APPENDIX

Appendix A

Target words for the pre-school version of the Picture-Identification Task, List 1A (words 1-25) and List 1B (words 26-50) plus rhyming alternatives.

nose (1A)	bows	hose	**toes** (1B)
lake	***snake*** (1B)	**cake** (1A)	rake
sock (1B)	clock	knock	**rock** (1A)
pan	***man*** (1B)	**can** (1A)	fan
light (1A)	night	**kite** (1B)	bite
net (1B)	***pet*** (1A)	jet	wet
rat	***cat*** (1B)	***hat*** (1A)	bat
chair (1A)	pear	***hair*** (1B)	bear
tool	***stool*** (1A)	pool	***school*** (1B)
bug	***hug*** (1B)	jug	***rug*** (1A)
jar	bar	***star*** (1A)	***car*** (1B)
gun (1B)	***run*** (1A)	bun	sun
feet (1A)	meat	***seat*** (1B)	wheat
shed	***head*** (1B)	sled	***bed*** (1A)
cheese	keys	***bees*** (1A)	***knees*** (1B)
dice	***rice*** (1A)	***slice*** (1B)	mice
laugh (1B)	lap	***lamb*** (1A)	lamp
rain (1A)	cane	***plane*** (1B)	chain
sing	***king*** (1B)	wing	***ring*** (1A)
boat (1B)	note	***goat*** (1A)	coat
ship (1A)	whip	chip	***lip*** (1B)
face (1B)	***race*** (1A)	vase	lace
road (1A)	rose	roast	***robe*** (1B)
lick (1B)	chick	stick	***sick*** (1A)
tire (1A)	***fire*** (1B)	wire	choir