AUDITORY SENSITIVITY OF NON-INSTITUTIONALIZED EDUCABLE MENTALLY IMPAIRED CHILDREN

MASTER OF ARTS

MICHIGAN STATE UNIVERSITY

DONALD G. SCHOEN

1975

AUDITORY SENSITIVITY OF NON-INSTITUTIONALIZED
EDUCABLE MENTALLY IMPAIRED CHILDREN

By
Donald G. Schoen

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Audiology and Speech Sciences

1975

DEDICATED

To the ones who have loved and

believed in me,

I owe all of this to you.

ACKNOWLEDGMENT

The writer wishes to express appreciation to Dr. Daniel S. Beasley, for his guidance as thesis advisor and also to Dr. Linda L. Smith and Mrs. Janis Forbord for serving as thesis committee members.

Grateful acknowledgment is also extended to Mr. Daniel Konkle and Mr. Barry Freeman for their assistance. Great appreciation is due to Mrs. Janis Forbord, audiologist, who aided in the development of this testing program; and to my classmates who assisted in the testing of these children.

Finally, to my special love, who without her love, understanding and assistance, this thesis could not have been completed.

TABLE OF CONTENTS

LIST OF TABLES

Page

Table

AUDITORY SENSITIVITY OF NON-INSTITUTIONALIZED EDUCABLE MENTALLY IMPAIRED CHILDREN

By

Donald G. Schoen

ABSTRACT

Pure-tone air and bone-conduction thresholds, at octave frequencies from 250 Hz through 4,000 Hz, were obtained for educable mentally impaired children. One hundred and sixty-seven educable mentally impaired children (having an IQ 50 to 80) consisting of 102 males and 65 females ages 3 to 13 years, from type A classrooms in the Lansing Public School system were examined. The thresholds for pure-tones were obtained under earphones and with a bone vibrator. Two procedures were used to obtain pure-tone thresholds; a modified Hughson-Westlake technique and a descending technique.

The incidence rate of 34% for hearing loss in the educable mentally impaired population was obtained by use of strict criteria. The criteria consisted of air-bone differences of 10 dB or greater at 2 or more frequencies or air conduction thresholds of 20 dB HL or greater at any one frequency. The results indicated that the older age groups had poorer thresholds than the younger age groups with the exclusion of the 3 to 5 year olds.

The normative data obtained by this study approximated similar data from earlier child studies. If children who ex-

hibited a hearing loss had been excluded from this study, the normative data may have been closer to laboratory threshold norms.

CHAPTER I

INTRODUCTION

Research, concerning hearing loss in the mentally impaired population, has been undertaken over the past twenty years. During those years, audiologists have studied various parameters associated with incidence, validity, reliability, and procedures for hearing testing in the mentally impaired population, but have failed to establish normative data on thresholds for the mentally impaired population.

Incidence rates of hearing loss among the mentally impaired ranged from 8% to 56%, depending upon variables such as equipment calibration, frequency range tested (Kodman, 1958; Schlanger and Gottsblen, 1956), time intervals used between test and retest (Fulton, 1967; Fulton and Graham, 1964; Lloyd et al., 1968; and Lloyd and Melrose, 1966a, b), differences in stimulus presentation levels (Darley, 1961; Lloyd, 1966b; Lloyd and Melrose, 1966a, b; Kodman, 1958), the type of hearing loss as a function of IQ and of age (Lloyd and Reid, 1967), and the attention, motivation and cooperation of the child being tested (Schlanger, 1958; Lloyd and Cox, 1972; Lloyd and Fulton, 1972; and Dahle and Daly, 1974). A study of non-institutionalized mentally impaired children carried out by the Michigan Health Department (1966) indicated the incidence of hearing loss was 11% in this population.

Investigators have found that the incidence of hearing loss declined as IQ increased (Fulton, 1967; Fulton and Graham, 1964; Lloyd and Reid, 1967; Hall and Tarkington, 1972). Investigators (Fulton, 1967; Fulton and Graham, 1964; Kopatic, 1963; LaCross and Bidlake, 1964; Schlanger, 1962) however have questioned the reliability of pure-tone hearing tests with the mentally impaired because the incidence of hearing loss is two to six times greater than in normals. Recent findings (Fulton, 1967; and Lloyd and Reid, 1967) have shown high reliability and validity across different IQ levels, different age groups (Lloyd, 1966a) and different degrees of hearing impairment (Lloyd et al., 1968).

Mentally impaired children who exhibited IQ levels lower than 50 have been discovered to have a higher incidence rate of hearing loss than children whose IQ is greater than 50 (Dassinger and Madow, 1966; Lloyd and Reid, 1967; Newby, 1958; Schlanger, 1958). This increase in hearing loss has been attributed to a higher occurrence of sensorineural hearing losses, congenital abnormalities that are etiologically related to mental impairments, and conductive hearing impairments resulting from inadequate self care skills.

The screening criterion for hearing loss is important because this criterion can influence the incidence rates of hearing loss found. As would be expected, a more stringent screening criterion resulted in a higher percentage of hearing losses than the use of the less stringent criterion (Lloyd and Reid, 1967). As a result, a less strict criterion level of 20 dB HL at 1,000 Hz and 2,000 Hz and 25 dB at 4,000 Hz has been advocated for identification audiometry (Darley, 1961; Lloyd, 1966a; Wilson, 1975).

Various techniques of responding to an auditory signal have been used with the mentally impaired, including the standard hand raising procedure, modified ear choice (Curry and Kurtzrock, 1951), and play audiometry (Barr, 1955; Lloyd and Frisina, 1965; Lloyd and Melrose, 1966a, b). Lloyd and Melrose (1966a) stated that the block dropping technique in response to pure-tones, using a descending approach, was the most accurate means of assessing a mentally impaired child's hearing threshold (Fulton and Graham, 1964; Lloyd, 1966b; Lloyd and Reid, 1967; Lloyd et al., 1968).

Several investigators have noted that hearing loss may have a detrimental effect on language acquisition and development (Schlanger, 1953; Schlanger and Galanowsky, 1966; Schlanger and Gottsblen, 1956), and this problem is compounded when intelligence is depressed (Darley and Winitz, 1961; Schlanger and Gottsblen, 1956; Siegal, 1972). Thus, it is imperative that auditory receptive abilities be evaluated early and continuously with the educable mentally impaired population (Lloyd and Cox, 1972; Lloyd and Reid, 1967; Schlanger, 1953; Schlanger and Galanowsky, 1966; Schlanger and Gottsblen, 1956).

The purpose of this study was: 1) to establish pure-tone threshold data for an educable mentally impaired population (ranging in age from 3-13 years), 2) to determine the incidence of possible hearing loss, and 3) to arrive at a possible hearing test criterion level for pure-tone screening to be used with an educable mentally impaired population.

CHAPTER II

REVIEW OF THE LITERATURE

Pure-Tone Audiometry for Children

Research and development trends have generally supported the contention that conventional pure-tone audiometry can be used when testing children from 6 to 7 years of age (Barr, 1955; Eagles and Wishik, 1961; Kennedy, 1957). Modification of conventional pure-tone audiometric techniques, as in play audiometry, have been shown to be reliable with the majority of children as young as 3 years of age (Lowell et al., 1956; Myklebust, 1954; O'Neill et al., 1961). Lefanov (1971) found that the successful use of pure-tone play audiometry dropped markedly in children below the age of 3 years. If a child was 2½ years old, Barr (1955) found that play audiometry can be used effectively with only 20% of the cases. Pure-tone play audiometry, in which the child was conditioned to beat a drum when he heard a tone, was later found to be an effective and reliable technique in assessing pure-tone thresholds for normal children as young as 2½ years old and with hearing impaired children as young as 3½ years old (Lowell et al., 1954). Investigators (Barr, 1955; Bloomer, 1942; Dix and Hallpike, 1947; Lowell et al., 1956; O'Neill et al., 1961) have found that with more concrete game-type of responses, as in play audiometry vs. conventional hand-raising responses, improvement in thresholds were obtained with the younger children, ages 3 to 6 years old. The improvement of hearing thresholds in children aged 3 to 6 years old has been related to the child's attention span (Fulton and Lloyd, 1969). It has been shown that beyond the age of 6 years, normal hearing children perform conventional pure-tone tasks with good reliability (Barr, 1955; Eagles et al., 1961, 1967; Kennedy, 1957; Lagenback, 1964).

There appeared to be a trend of improved threshold results for children of normal intelligence between the ages of 3 to 6 years. This improvement has been related to the child's increased attention span resulting in the ability to maintain interest in a particular task (Fulton and Lloyd, 1969; Lowell et al., 1956). Normal children, older than 6 years, have been shown to perform conventional audiometry adequately and may show improvement in thresholds with increased general growth and development.

Identification Programs

Detection of hearing loss in the younger school-age population was emphasized by the Committee on Identification Audiometry (Darley, 1961; Wilson, 1975). The Committee recommended that screening be carried out on a yearly basis from kindergarten through the third grade, particularly with high risk children. Examples of high risk children are those who repeat a grade, require special education programs, are new to the school system, absent during a previously scheduled screening exam, fail a threshold test the previous year, have speech and/or language problems, are suspected to have a hearing impairment, and have a medical problem associated with a hearing impairment. After grade 3, testing could be performed every 3 or 4 years (Darley, 1961), or not at all is the school system administration decides that the children do not benefit sufficiently to warrant a hearing identification program (Wilson, 1975). The Committee also suggested immediate testing be carried out on children who exhibited social or emotional problems, were specifically referred by the classroom teacher, or were mentally impaired.

Lescouflair (1973) stated that some of the screening objectives set down by Darley (1961) were not being met. These objectives were to identify even minimal hearing loss and identify the presence of an active ear pathology. Cohen and Sade (1973) and Melnick et al. (1964) found that conductive impairments could be missed up to 50% of the time if a conventional sweep frequency technique with a 25 dB HL (re: ANSI, 1969) criterion level was used. It was suggested that new methods be devised to help in the detection of minimal hearing problems. It is important to detect mild hearing losses as well as more severe losses because it has been shown that educational retardation may occur with a mild conductive or peripheral hearing loss (Fulton, 1967; Holm and Kunze, 1969; Luria, 1963). Another approach to detection of minimal hearing loss might be the establishment of new criterion levels for air conduction screening and air-bone differences at the different frequencies.

In recent years, there has been increasing interest in the education of the school age mentally impaired child. Related to this has been the awareness of the need for improved audiological testing programs for these children, to allow for maximum sensory stimulation.

Educable Mentally Impaired Children: Pure-Tone Threshold Reliability and Validity With The Mentally Impaired Child

Research has been performed in the areas of reliability and validity of threshold results for the educable mentally impaired population. More recent results have contradicted the earlier findings which suggested that hearing testing results with this population were unreliable and frequently invalid. Kopatic (1963) and Schlanger (1962) suggested that retesting or continuation was necessary to obtain accurate thresholds in order to detect the large number of hearing losses found in the mentally impaired population used in their study.

Fulton and Graham (1964) ascertained that with a group of educable mentally impaired children and young adults (Mean CA. = 19 years) pure-tone test-retest reliability was within $\pm$ 5 dB, and that reliability progressively decreased with decreasing mental function. Lloyd and Melrose (1966a, b) studied 40 normal-hearing mentally-impaired persons with a mean chronological age of 12 years 6 months (ranging in age from 8 years to 15 years) who had passed a sweep frequency screening test. Their studies of subjects who had an IQ of 40 and above revealed good (87.5%) reliability. Lloyd et al. (1967)

also studied the test-retest reliability of institutionalized normal and hearing-impaired individuals, who had hearing thresholds ranging from 0 to 60 dB HL and IQ levels from 40 to 70. Their results indicated good reliability across different intelligence levels, from an IQ of 70 to 80. Fulton (1967), Lloyd et al. (1968), and Spradlin et al. (1969) also showed that, with the intellectual level of the child (IQ 40 to 80), pure-tone test-retest reliabilities with the mentally impaired were good when either conventional or play audiometry were used.

The literature has revealed pure-tone threshold results to be reliable and valid with the mentally impaired population, regardless of their hearing and/or intellectual level (Fulton, 1967; Fulton and Graham, 1964; Kopatic, 1963; Lloyd and Melrose, 1966a, b; Lloyd et al., 1968; Schlanger, 1962; Spradlin et al., 1969). Research (Fulton, 1967; Lloyd et al., 1968; Rittmanic, 1971; Spradlin et al., 1969) has also shown that retesting of the mentally impaired child is not absolutely necessary to obtain reliable and valid results.

Identification Audiometry for Mentally Impaired Populations

Threshold levels and associated problems encountered in the detection programs must be known by the audiologist so proper audiological services can be provided to the mentally impaired child. The audiologist also should be aware of variables involving the test environment, subjects, and test procedures, in order to enable him to make proper recommendations.

Lloyd and Fulton (1972) suggested that variables associated with environmental factors, acoustic stimuli, audiometric calibration, instructions, response criteria, threshold criteria and the schedule of stimulus presentations, must either be defined or controlled in an identification audiometry program. In addition, the audiologist working with the mentally impaired population should be aware of special problems associated with language variables, motivation, cooperation and attention, response-mode variables, stimulus variables and threshold methodology variables.

Lloyd and Fulton (1972) have advised, that to develop a good audiological identification program, the audiologist must develop questions to be answered when evaluating a patient. For example, does the individual's hearing deviate significantly from normal? What is the pathology of the loss? What is the severity of the individual's hearing handicap, and what habilitative procedures should be initiated? Obviously, the more information one has about a mentally impaired child, the better the chances are that the child will receive proper habilitative care. Information pertaining to auditory sensitivity across frequencies, stability of hearing threshold levels, dynamic range and tolerance, habituation and fatigue and the condition of the middle ear mechanism is necessary. A total hearing evaluation program for the mentally impaired individual should include an otologic examination and follow-up procedures by the audiologist, e.g. diagnostic procedures, aural rehabilitation, hearing aid selection, and counseling of the patient and parents.

Lloyd and Frisina (1965) have cited several reasons why they felt it reasonable to assume that a larger percentage of hearing impairment would be found among the mentally impaired than would typically occur among non-impaired individuals. These reasons included a high number of sensorineural hearing losses, congenital anomalies, and frequently, poor self-care habits. Lloyd and Reid (1967) showed that conductive hearing losses were more prevalent than sensorineural losses in the mentally impaired population. Nudo (1965) showed that more conductive impairments occurred in younger mentally impaired children; however, more sensorineural cases were found in the older educable mentally impaired individuals. Dassinger and Madow (1966) found hearing loss among mentally impaired children was two to six times greater than among normal children, depending upon the criterion used for determining hearing loss.

Lloyd and Crosby (1972) in their report cited information about the standards adopted by the Accreditation Council for Facilities for the Mentally Retarded (1971). These standards emphasized that any child entering a program for the mentally impaired must have an audiometric test before an educational or habilitative program can be implemented. To insure they have obtained maximum sensory input to aid in their educational development, periodic rescreening and reassessment of the individual's hearing should take place annually through age 10. Lloyd and Cox (1972) suggested using 20 dB HL (re: ANSI, 1969) for the frequencies 500 through 4,000 Hz and expanding the testing to include 250 through 6,000 or 8,000 Hz when possible. The absence of a response to the 20 dB HL tone at any frequency presented to either ear constituted a failure. They also stated that exact levels for resereening of individuals varied between programs depending upon administrative considerations (such as age, social, emotional and educational functioning level, and personnel available to test).

After audiological assessment, a child who failed the criterion measure should be classified according to an active, inactive or difficult-to-test category. If the results indicated a hearing loss, the child should be classified active and be referred for an appropriate follow-up otolaryngologic examination, medical habilitation, audiologic reassessment, and/or aural rehabilitation. The child who is difficult to test requires more time to adequately evaluate his hearing mechanism, and appropriate steps should be taken upon completion of the assessment.

<u>Summary</u>

The above review of the literature described several of the variables the audiologist should be aware of when a mentally impaired population is tested. The audiologist should be able to formulate an appropriate screening level for the mentally impaired child, after considering both what an identification program should be composed of and what criterion levels should be implemented. Early identification and treatment of learning problems has been found to very important, especially for the mentally impaired child (Luria, 1963). Lloyd and Cox (1972) and Lloyd and Reid (1967) emphasized that proper audiological information is necessary to help provide services than can contribute to the child's full cognitive development and social and cultural adjustment. It was shown that different types of hearing losses and incidence rates might have occurred with different age populations.

The purpose of this study, then, was: 1) to establish pure-tone threshold data with an educable mentally impaired population (ranging in age from 3-13 years, 2) to determine the incidence of possible hearing loss, and 3) to arrive at a possible hearing test criterion level for pure-tone screening to be used with an educable mentally impaired population.

CHAPTER III

EXPERIMENTAL PROCEDURES

Information concerning subjects, instrumentation, calibration, stimuli, and experimental procedures used in this study will be presented in this Chapter.

Subjects

One hundred and sixty-seven educable mentally impaired children (102 males and 65 females) having a chronological age of 3 years to 13 years and an IQ range of 50 to 80 were tested. Children younger than 10 years old had lower IQ's ranging from 50 to 70. All the subjects were enrolled in the Lansing School District Special Education Program (Type A).

Instrumentation

All equipment employed during pure-tone testing, except the earphones, were located in the control room of the test suite.

Maico Ma-24 Audiometer: The Ma-24 is a dual channel instrument which allows for 11 different half-octave and octave frequency specifications from 125 to 8,000 Hz, and also a Hearing Threshold Level (HTL) Range from -5 to 80 dB (re: ANSI, 1969) at 125 Hz, -5 to 110 dB (re: ANSI, 1969) from 500 Hz to 4,000 Hz and -5 to 90 dB (re: ANSI, 1969) at 8,000 Hz. It was coupled to a TDH-39 headset using MX-41/AR cushions.

Grason-Stadler (GS) 1701 Audiometer: The GS 1701 is a dual channel instrument which allows for testing 11 different half-octave and octave frequencies, and also has a Hearing Threshold Level (HTL) Range for air conduction from -15 to 75 dB (re: ANSI, 1969) at 125 Hz, -15 to 112 db (re: ANSI, 1969) at 500 and 2,000 Hz, -15 to 118 dB (re: ANSI, 1969) at 1,000 Hz, -15 to 114 dB (re: ANSI, 1969) at 4,000 Hz and -15 to 98 dB (re: ANSI, 1969) at 8,000 Hz. It was coupled to a TDH-49 headset using MX-41/AR cushions.

Allison-22 Audiometer: The Allison-22 is a dual channel instrument which allows for testing 11 different half-octave and octave frequencies from -10 to 80 dB (re: ANSI, 1969) at 125 Hz, -10 to 110 dB (re: ANSI, 1969) from 500 to 2,000 Hz, -10 to 100 dB (re: ANSI, 1969) at 4,000 Hz and -10 to 90 dB (re: ANSI, 1969) at 8,000 Hz. It was coupled to a TDH-39 headset using MX-41/AR cushions.

Oscilloscope and Spectrum Analyzer: The type 564B Tektronix Storage oscilloscope is designed to store cathode ray tube displays for viewing or photographing input signals. The instrument was operated as a conventional oscilloscope and used to measure the stimulus rise and decay times.

Frequency Counter: The Beckman Eput and Timer (Model 6148) can measure frequencies up to 100 MHz in order to measure time intervals, periods, multiple periods, rates and multiple rates, and also can be used as a random event counter. It has a stability of ± 3 points in 10^9 points per day. Visual measurements are presented in an eight digit, in line, numerical display using glow tubes. This piece of equipment was used to determine the frequency of the modulation rates of the audiometers.

Bruel and Kjaer Band Sound Level Meter 2204: The B and K 2204 is an instrument that measures the sound pressure level emitted from various sources such as room noise, earphones, and sound generators. This instrument (A-scale) was used with a Bruel and Kjaer microphone (Model 4144 or Model 4145) to obtain calibration measurements of pure-tone and random noise measurements.

Test Environment

Testing for pure-tone thresholds was conducted with the subjects in three testing situations. In two situations, the subjects were in a prefabricated double walled IAC 1200 series chamber and the experimenter in a single walled IAC 400 series control room. In the third situation, the subject sat in an acoustically treated room. The dimensions of the test room were 4 yards 26 inches by 4 yards 15 inches by 2 yards 35 inches. In the test room, carpeting covered the floor and went up the four walls a distance of 1 yard 25 inches, while acoustical tile covered the ceiling and the remaining wall (1 yard 7½ inches). The examiner sat in a room adjacent to the test booth, with carpeting on the floor and acoustical tile on the ceiling.

Calibration

Calibration of pure-tone acoustical measurements was performed bimonthly according to ANSI-1969 specifications. Specifically, the audiometers were calibrated or checked at the frequencies employed in the study for frequency, harmonic distortion and sound pressure level output. In addition, the stimulus rise and decay times and attenuator linearity were checked.

Test Stimuli

Stimuli employed during the experiment consisted of pure-tones generated from one of the clinical audiometer's oscillators to either TDH-39 or TDH-49 earphones.

Experimental Procedures

Pure-tone thresholds were obtained for a group of non-institutionalized educable mentally impaired children using the Ma-24, GS 1701 or Allison-22 clinical audiometers. Thresholds for pure-tones were first obtained under TDH-39 or TDH-49 earphones, and then with a Radioear 70A white dot bone vibrator at 250 Hz, 500 Hz, 1,000 Hz, 2,000 Hz and 4,000 Hz. The thresholds were obtained using a modified Hughson-Westlake technique or a descending method. Repeated thresholds at 1,000 Hz were performed with all subjects to check the reliability of the subject's responses.

The one hundred and sixty-seven subjects were individually tested in class group time slots, with a different class coming on separate days for testing purposes.

Threshold Determination

Two procedures were used to obtain pure-tone thresholds. The first technique was the modified Hughson-Westlake technique (Carhart and Jerger, 1959). The second method was a descending technique described by Lloyd (1966a, b). Conventional hand-raising responses were required from children older than 6 years old, and play audiometry was used with the children younger than 6 years old.

The examiners in this study were advanced graduate students in the audiology program at Michigan State University. Supervision of these examiners was carried out by three clinically certified (CCC-A, ASHA) audiologists. The examiners were allotted approximately 45 minutes to test each child.

Analysis of Data

The data were analyzed in terms of mean pure-tone air and bone conduction thresholds at each frequency and for each age level. The rank orders across ages for each frequency were totaled for each age to obtain a total rank order. The rank orders across frequencies for each age were also totaled for each frequency to obtain a total rank order. These totals, in turn, were rank ordered by age and frequency.

The individual audiograms also were analyzed in terms of a stringent criteria, 20 dB HL at one frequency or 10 dB air-bone differences at 2 or more frequencies, in order to detect the incidence of hearing loss in this population.

CHAPTER IV

RESULTS

The average thresholds for both ears across age groups and frequencies were within a 7.5 dB range for air conduction and 2.2 dB range for bone conduction. The mean air conduction thresholds for both ears across ages and frequencies was 9.5 dB (HTL). The mean better bone conduction threshold across ages and frequencies was 3.8 dB (HTL). There was an overall air-bone mean difference of 5.7 dB.

With the exception of the youngest age group, the 3 to 5 year olds, it appeared that as the children increased in age, the mean air-conduction thresholds became poorer and air-bone mean differences increased. The poorer to better rank order for mean thresholds and the larger to smaller air-bone mean differences was 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz, and 2,000 Hz.

It also was found that the right ear had a greater number of poorer thresholds in age groups which had the poorer binaural thresholds. The air conduction thresholds between ears were less than 5 dB in all but 4 cases and indicated no ear difference.

The children's reliability was judged in this study to be good or fair, using a retest frequency of 1,000 Hz, in

95.2% of the population. The means in Tables 1 and 2 were rank ordered and summed for air and bone conduction across frequency for all ages and across each age for all frequencies. The totals of the rank orders and means were used to determine the poorest to the best hearing thresholds (re: ANSI, 1969) for each age group and each frequency.

Binaural air conduction results, shown in Table 1, indicated that the poorest to the best thresholds (re: 0 dB HTL) for the different age groups were the 3 to 5 year olds, 9 year olds, 11 year olds, 12 and 13 year olds, 7 year olds, 10 year olds, 8 year olds, and 6 year olds when using mean totals and total rank orders.

The bone conduction results found in Table 2 indicated the poorer to better thresholds (re: ANSI, 1969) were in the 3 to 5 year olds, 7 year olds, 9 year olds, 8 year olds, 11 year olds, 10 year olds, 12 to 13 year olds and 6 year olds when using total means. The ages between the poorest threshold (re: 0 dB HTL) for the 3 to 5 year olds, and the best threshold for the 6 year olds were found to be different when using the total mean threshold and the total rank order to determine the final rank orders for the age groups.

The mean differences between binaural air and better bone conduction thresholds for each frequency across all age levels are found in Table 3. These means were rank ordered at each frequency across ages and at each age for all frequencies. The rank order obtained from each frequency across all ages were then added up at each age group to obtain a total

Table 1.--The binaural means (left and right ears combined) are rank ordered across frequency which are found in / / and across ages which are found in ( ) for air conduction. The rank ordered numbers found in / / are totaled down each frequency and the rank ordered numbers found in ( ) are totaled across for each age group. The total rank orders and total means have a final rank order number assigned.

Age	Frequency 250 Hz dB	500 Hz dB	1,000 Hz dB	2,000 Hz dB	4,000 Hz dB	Total Rank Order	Final Rank Order	Total Means dB	Final Rank Order
3-5	18.0/1/(1)	12.7/2/(2)	11.4/5/(1)	11.8/3/(1)	11.7/4/(1)	(6)	1	13.1	1
6	11.9/1/(8)	11.3/2/(4)	2.1/4/(8)	4.4/3/(7)	-1.3/5/(8)	(35)	8	5.7	8
7	12.4/1/(7)	10.9/2/(5)	7.8/4/(4)	7.2/5/(3)	8.3/3/(6)	(25)	4.5	9.3	5
8	13.6/1/(5)	10.4/2/(6)	5.1/4/(7)	3.7/5/(8)	7.1/3/(7)	(33)	7	8.0	7
9	15.2/1/(3)	11.6/2/(3)	9.1/4/(3)	8.7/5/(2)	9.9/3/(3)	(14)	2	10.9	2
10	13.2/1/(4)	10.4/2/(7)	5.5/5/(6)	5.8/4/(6)	9.2/3/(4)	(27)	6	8.8	6
11	16.0/1/(2)	12.7/2/(1)	5.6/5/(5)	6.6/4/(5)	11.5/3/(2)	(15)	3	10.5	3
12-13	12.7/1/(6)	9.8/3/(8)	9.9/2/(2)	7.1/5/(4)	9.0/4/(5)	(25)	4.5	9.7	4
Total Rank Order	/8/	/17/	/33/	/34/	/28/				
Final Rank Order	1	2	4	5	3				
Total Means dB	14.1	11.2	7.0	6.9	8.2			9.5	
Final Rank Order	1	2	4	5	3				

Table 2.--The better bone means are rank ordered across frequency which are found in / / and across ages which are found in ( ). The rank ordered numbers which are in / / are totaled down each frequency. The rank ordered numbers found in ( ) are totaled across for each age group. The total rank orders and total means have a final rank order number assigned.

Age	250 Hz dB	500 Hz dB	1,000 Hz dB	2,000 Hz dB	4,000 Hz dB	Total Rank Order	Final Rank Order	Total Means dB	Final Rank Order
3-5	5.0/2/(5)	3.6/4/(6)	4.4/3/(2)	5.9/1/(2)	5.0/2/(2)	(17)	1.33	4.8	1
6	5.0/1/(5)	2.5/2/(8)	5.0/1/(1)	1.9/3/(4)	-1.3/4/(8)	(26)	8	2.6	8
7	3.9/3/(6)	4.3/2/(5)	3.2/4/(5)	3.2/4/(3)	6.8/1/(1)	(20)	4.5	4.3	2.5
8	5.3/1/(4)	3.4/3/(7)	4.2/2/(3)	3.2/4/(3)	4.2/2/(3)	(20)	4.5	4.1	4.5
9	3.8/3/(7)	4.8/2/(4)	3.0/5/(6)	6.6/1/(1)	3.4/4/(6)	(24)	6	4.3	2.5
10	5.8/1/(2)	5.5/2/(2)	1.3/5/(3)	1.5/4/(5)	3.5/3/(5)	(17)	1.33	3.5	6
11	5.4/2/(3)	6.5/1/(1)	3.5/4/(4)	1.5/5/(5)	3.7/3/(4)	(17)	1.33	4.1	4.5
12-13	6.3/1/(1)	4.9/2/(3)	2.7/3/(7)	0 /5/(6)	1.0/4/(7)	(24)	7	3.0	7
Total Rank Order	/14/	/18/	/27/	/27/	/23/				
Final Rank Order	1	2	4.5	4.5	3				
Total Means dB	5.1	4.4	3.4	3.0	3.3			3.8	
Final Rank Order	1	2	3	5	4				

Table 3.--The mean differences of binaural air-better bone measurements: rank ordered across frequency which are found in / / and across ages which are found in ( ). The rank order numbers which are in / / are totaled down each frequency. The rank ordered numbers found in ( ) are totaled across for each age group. The total rank orders and total means have a final rank order number assigned.

	Bone Better Than Air — Frequency								
Age	250 Hz dB	500 Hz dB	1,000 Hz dB	2,000 Hz dB	4,000 Hz dB	Total Rank Order	Final Rank Order	Total Means dB	Final Rank Order
3-5	13.0/1/(1)	9.1/2/(1)	7.1/3/(2)	5.9/5/(2)	6.7/4/(3)	(9)	1	8.4	1
6	6.9/2/(7)	8.8/1/(2)	2.9*/5/(8)	.6/3/(6)	0 /4/(8)	(31)	8	4.2	7
7	8.5/1/(4)	6.7/2/(5)	4.6/3/(4)	4.0/4/(5)	1.5/5/(7)	(25)	5	5.0	6
8	8.3/1/(5)	7.0/2/(3)	.9/4/(7)	.5/5/(8)	2.9/3/(6)	(29)	7	4.1	8
9	11.4/1/(2)	6.8/2/(4)	6.1/4/(3)	2.1/5/(7)	6.5/3/(4)	(20)	3.5	6.6	3
10	7.4/1/(6)	4.9/3/(7)	4.2/5/(5)	4.3/4/(4)	5.7/2/(5)	(27)	6	5.3	5
11	10.6/1/(3)	6.2/3/(6)	2.1/5/(6)	5.1/4/(3)	7.8/2/(2)	(20)	3.5	6.4	4
12-13	6.4/1/(8)	4.9/5/(7)	7.2/2/(1)	7.1/3/(1)	8.0/1/(1)	(18)	2	6.7	2
Total Rank Order	/9/	/20/	/31/	/33/	/24/				
Final Rank Order	1	2	4	5	3				
Total Means dB	9.1	6.8	4.4	3.7	4.9			5.8	
Final Rank Order	1	2	4	5	3				

* Bone was worse than air.

rank order. The total means and total rank orders were in terms of the poorest threshold to the better thresholds (re: ANSI, 1969) (Table 3). The overall mean difference between binaural air and better bone conduction results was 5.8 dB.

The 3 to 5 year olds, 12 to 13 year olds, 9 year olds and 11 year olds had the largest air-bone mean differences. The ordering of these age groups remained the same for total means and total rank orders. With the exception of the 3 to 5 year olds, it appeared that there was a trend for binaural air and better bone mean differences to become larger as age level increased. The older age groups, namely, the 9 year olds, 11 year olds and 12 to 13 year olds, were also the age groups with the poorest binaural and right ear air conduction thresholds (see Tables 1 and 5). There was no similarity in the age pattern between larger binaural air-bone mean differences (Table 3) and better bone conduction thresholds. The mean left and right ear air conduction thresholds found in Tables 4 and 5 revealed that the poorer to better thresholds (re: ANSI, 1969) at each age did not follow exactly the binaural air conduction threshold trends. The mean right ear air conduction thresholds found in Table 5 suggested that the age groups with poorer air conduction thresholds (re: ANSI, 1969) were similar to those found for binaural air conduction (Table 1) and air-bone mean differences (Table 3). This finding further supported the trend of the older age groups having the poorer thresholds and larger air-bone mean differences, with the exception of the 3 to 5 year olds.

Table 4.--The left ear means (LA) and total means (TLA) for air conduction at each age and frequency.

Age	250 Hz dB LA	500 Hz dB LA	1,000 Hz dB LA	2,000 Hz dB LA	4,000 Hz dB LA	TLA dB
3-5	18.3	11.4	9.3	9.1	11.7	12.8
6	13.8	13.8	0	6.3	-5	5.8
7	13.0	11.6	7.2	8.4	11.1	10.3
8	13.9	11.6	5.3	3.4	6.6	8.2
9	13.9	10.2	8.0	7.0	7.5	9.3
10	14.0	10.7	5.0	8.6	11.7	10.0
11	15.8	11.2	4.4	5.2	10.6	9.4
12-13	10.8	8.5	12.5	5.1	7.6	8.9
	TLA	TLA	TLA	TLA	TLA	
$\bar{x}$	14.2	11.1	6.5	6.6	7.7	9.3
Rank Order	1	2	5	4	3	

Table 5.--The right ear means (RA) and total meams (TRA) for air conduction at each age and frequency.

Age	250 Hz dB RA	500 Hz dB RA	1,000 Hz dB RA	2,000 Hz dB RA	4,000 Hz dB RA	TRA dB
3-5	17.0	14.1	13.6	14.5	11.7	14.2
6	10.0	8.8	3.8	2.5	2.5	5.5
7	11.9	10.3	8.4	5.9	5.7	8.4
8	13.3	9.2	5.0	3.9	8.1	7.9
9	16.6	13.0	10.2	10.9	12.6	12.7
10	12.4	10.0	6.0	3.1	6.7	7.6
11	18.3	14.4	6.7	8.0	12.7	12.0
12-13	14.6	11.1	7.4	9.0	10.5	10.5
	TRA	TRA	TRA	TRA	TRA	
$\bar{x}$	14.3	11.4	7.6	7.2	8.8	9.9
Rank Order	1	2	4	5	3	

Individual frequencies were rank ordered in Tables 1, 2 and 3 across ages, from the poorer to the better thresholds (re: ANSI, 1969) or larger to smaller air-bone means. Individual frequencies were then checked to see if any one group of ages were poorer than any of the other age groups. For binaural air conduction mean thresholds found in Table 1, it can be seen that the 9 year olds, 10 year olds and 11 year olds had poorer air conduction thresholds at 250 Hz and 4,000 Hz, than any of the other age groups in this study. The better bone conduction mean thresholds found in Table 2 showed the 10 year olds, 11 year olds and 12 to 13 year olds had poorer mean thresholds (re: ANSI, 1969) at 250 Hz and 500 Hz, and that the 3 to 5 year olds, 7 year olds, and 8 year olds had poorer mean thresholds (re: ANSI, 1969) at 2,000 Hz and 4,000 Hz. The binaural air and better bone mean differences found in Table 3 indicated that the 7 year olds, 8 year olds and 9 year olds had the largest mean differences at 250 Hz. The 11 year olds and 12 to 13 year olds had larger binaural air and better bone mean differences at 2,000 Hz and 4,000 Hz.

The preceding findings shown in Tables 2 and 3 revealed that larger binaural air and better bone mean differences occurred in the age groups which had the better bone mean thresholds (re: ANSI, 1969), suggesting the presence of an occlusion effect.

It was concluded that a trend appeared for better bone (Table 2) binaural air and better bone conduction mean differences (Table 3) which indicated that an occlusion effect was present. It has also been shown that the older ages, 9 year olds, 11 year olds, 12 to 13 year olds, had poorer air conduction thresholds (re: ANSI, 1969), better bone conduction thresholds except the 6 year old group (re: ANSI, 1969), and larger air-bone mean differences than the younger age groups, with the exception of the 3 to 5 year olds.

Frequency Trends for Air and Bone Conduction Mean Thresholds and Air-Bone Mean Differences

The data used to determine the frequencies at which the poorest to the best thresholds (re: ANSI, 1969) occurred was obtained from binaural air conduction thresholds (Table 1) and better bone conduction thresholds (Table 2). Binaural air and better bone mean differences (Table 3) were also used to obtain frequency data.

The frequency data for air and better bone conduction thresholds (Tables 1, 2, 4, and 5) and air-bone mean differences (Table 3) were obtained through the addition of the mean values across ages at each frequency and divided by the number of age groups (8) tested. At each age, five frequency mean threshold values or air-bone mean differences were rank ordered from the poorest to the best thresholds or the largest to the smallest air-bone mean differences, respectively. Using these rank ordered numbers, addition was performed for each frequency across ages to obtain a total rank order number. Total mean values and total rank orders were then assigned a final rank order value.

A general frequency pattern for binaural air conduction

(Table 1), right ear air conduction (Table 5), better bone conduction thresholds (Table 2) and air-bone mean differences (Table 3) was found. This frequency pattern indicated that 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz were the poorer to better thresholds and had the larger to smaller air-bone mean differences. The left ear air conduction means were similar to the previous data with the exception of 2,000 Hz having poorer air conduction means than 1,000 Hz.

The frequency trends found for binaural and right ear air conduction (Tables 1 and 5), better bone conduction (Table 2) and air-bone mean differences (Table 3) were then examined across age groups to see which ages followed these trends.

In Table 1 the rank orders and the total means followed the frequency trend of the poorer to better thresholds being 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz in only the 7 year olds, 8 year olds, and 9 year olds. However, all the ages from 3 through 11 years had their poorest air conduction thresholds (re: ANSI, 1969) at 250 Hz and 500 Hz.

The rank orders and mean values for better bone conduction shown in Table 2 only followed the overall frequency trend of 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz in the 10 year olds. The 6 year olds, 10 year olds, 11 year olds and 12 to 13 year olds followed the trend of having their poorest thresholds at 250 Hz and 500 Hz.

The total binaural air and better bone mean differences and rank orders for these differences are found in Table 3. The general frequency trend, that is, the largest to smallest air-bone mean differences occurring at 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz, only occurred with the 8 year olds and 9 year olds.

The left ear (Table 4) air conduction thresholds revealed that the general frequency trends for binaural air conduction (Table 2) and air-bone mean differences (Table 3) occurred only in the 3 to 5 year olds and 8 year olds. Three additional age groups, the 7 year olds, 10 year olds, and 11 year olds, were found to have followed the left ear air conduction mean threshold pattern of 250 Hz, 500 Hz, 4,000 Hz, 2,000 Hz and 1,000 Hz.

The right ear air conduction thresholds (Table 5) for the different age groups indicated that only the 8 year olds followed the general frequency pattern of binaural air conduction thresholds, better bone conduction thresholds (Tables 1 and 2) and air-bone mean differences (Table 3) of 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz. However, when using the left ear air conduction frequency pattern of 250 Hz, 500 Hz, 4,000 Hz, 2,000 Hz and 1,000 Hz the 9 year olds, 11 year olds and 12 to 13 year olds followed the frequency pattern.

The general frequency pattern of 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz air conduction thresholds, better bone conduction thresholds (re: ANSI, 1969) (Tables 1 and 2) and binaural air and better bone mean differences (Table 3) found when the data were collapsed did not occur at all the individual age levels. However, the general frequency pattern of 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz, and 2,000 Hz found when the ages were collapsed for the left ear (Table 4) and right ear (Table 5) air conduction thresholds were found to occur within the majority of the individual age levels. It was found that most of the age groups followed the general frequency trend of poorest to best frequencies being 250 Hz, 500 Hz, 4,000 Hz, 1,000 Hz and 2,000 Hz or 250 Hz, 500 Hz, 4,000 Hz, 2,000 Hz and 1,000 Hz. Furthermore, with the exception of the left ear results in the 10 year olds (Table 4), all the poorest air conduction thresholds for the left (Table 4) and right ear (Table 5) were at 250 Hz and 500 Hz.

Left Versus Right Ear Mean Differences

Table 6 presents the difference in means between the left and right ear and air conduction mean thresholds. The ages at which the left ear had a greater number of poorer thresholds than the right ear were 6 year olds, 7 year olds, 8 year olds, and 10 year olds. These same ages were found to have the better binaural air conduction thresholds presented in Table 1. The age groups which had poorer threshold results and a majority of poorer thresholds in their right ear as compared to the left ear were the 3 to 5 year olds, 9 year olds, 11 year olds and 12 to 13 year olds. These were also the ages at which the poorest thresholds for binaural air conduction mean thresholds occurred. Table 6 revealed the difference between the left and right ear thresholds at each age, in terms of which ear had the poorest mean air conduction thresholds. The results indicated that the left ear had a majority of poorer air conduction thresholds at 250 Hz and the right ears had a majority of poorer thresholds at 1,000 Hz, 2,000 Hz, and

Table 6.--The mean differences between the left and right ear air conduction scores for each frequency.

Age	Frequency				
	250 Hz dB	500 Hz dB	1,000 Hz dB	2,000 Hz dB	4,000 Hz dB
			Air Conduction		
3-5	1.3+	2.7	4.3	5.4	0.0
6	3.8+	5.0+	3.8	3.8+	7.5
7	1.1+	1.3+	1.3	2.5+	5.4+
8	.6+	2.4+	.3+	.5	1.5
9	2.7	2.8	2.2	3.9	5.1
10	1.6+	.7+	1.0	5.5+	5.0+
11	2.5	3.2	2.3	2.8	2.1
12 to 13	3.8	2.6	5.1+	3.9	2.9

+ indicates the left ear scores are poorer than the right ear scores, all other scores have the right ear poorer than the left ear.

4,000 Hz. There was a trend for poorer thresholds to be found in the right ear in those ages which exhibited poorer binaural air conduction thresholds (Table 1).

Table 6 showed the left and right ear air conduction thresholds to be within ± 5 dB of each other with the exception of five instances. The thresholds that were greater than 5 dB were at 1,000 Hz for 12 to 13 year olds, 2,000 Hz for 3 to 5 year olds and 10 year olds, and 4,000 Hz for 7 year olds and 9 year olds. The results indicated that there was no left ear or right ear advantage found for air conduction thresholds in this population.

Reliability of the Educable Mentally Impaired Population

The test/retest reliability for this educable mentally impaired population was determined by retesting at 1,000 Hz. The graduate students conducting the examinations made a reliability rating of the children which was influenced by the child's performance during the entire testing session.

As can be seen in Table 7, the 3 to 5 year olds had the poorest reliability. The overall good to fair reliability rating from 3 to 13 years old was 95.2%. These results indicated, that with the exception of 3 to 5 year olds, reliability with this population was excellent.

Table 7.--The reliability of Educable Mentally Impaired children (ranging in age from 3 to 13 years) judged to be good to fair or poor to no comment. Also the percentage of children falling into each category at each level, along with final percentages.

Age	Good-Fair	%	Poor-No Comment	%
3 to 5	9	69.2	4	30.8
6	5	100	0	0
7	15	100	0	0
8	16	95	1	5.0
9	22	100	0	0
10	19	100	0	0
11	24	96	1	4.0
12 to 13	49	96	2	4.0
Final Percentages		95.2		4.8

CHAPTER V

DISCUSSION

During the past 25 years, audiologists, through the use of identification audiometry, have worked to improve methods used to detect hearing losses in children. Their findings indicated that children younger than 13 year olds who have normal intelligence had a greater incidence of conductive hearing problems (Eagles et al., 1976) than older children. Many investigators have recommended that the children younger than 8 year olds be tested on a regular basis (Darley, 1961; Eagles, et al., 1961; Newby, 1964; Wilson, 1975). The incidence of hearing impairment in the mentally impaired population has been reported to vary from 8% to 56% (Dahle and Daley, 1974; Dassinger and Madow, 1966; Fulton, 1967; Fulton and Graham, 1964; Kodman, 1958; Kodman et al., 1958; Lloyd and Cox, 1972; Lloyd and Fulton, 1972; Lloyd and Melrose, 1966a; Lloyd and Reid, 1967; Lloyd et al., 1967; Schlanger, 1962; Schlanger and Gottsblen, 1956). However, in the past it had been thought that pure-tone audiometric test results with mentally impaired individuals generally were unreliable (Fulton and Graham, 1964; Kopatic, 1963; Schlanger, 1962). Recently several investigators (Fulton, 1967; Lloyd and Melrose, 1966a, b; Lloyd and Reid, 1967; Lloyd et al., 1967, 1968) have shown that pure-tone thresholds with this population were quite reliable and valid.

It was found by Lloyd and Reid (1967), Pantelakos (1963), and Nudo (1965) that there was a greater incidence of hearing loss in the mentally impaired population when compared to the normal population. It has been suggested by Fulton and Giffin (1967) and Fulton and Lloyd (1972) that the mentally impaired population have a greater precentage of congenital anomalies. These congenital anomalies may be a collapsable external auditory meatus, mycrosia or stenosis of the ear canal. It has also been suggested that the muceus membrane may be more susceptible to infection in the mentally impaired child (Jordan, 1972), which may lead to the greater number of conductive hearing losses found in this population. The pure-tone incidence results in the present study were obtained with very stringent criteria, which consisted of air-bone differences of 10 dB or greater at 2 or more frequencies or air conduction thresholds of 20 dB or greater at any one frequency being criteria for failure. Using this criteria, 58 of the 167 or 34% of the educable mentally impaired population failed the identification clearance task.

The 3 to 5 year olds, 9 year olds, 11 year olds, and 12 to 13 year olds all had poorer binaural and right ear (Table 5) air conduction thresholds and largest binaural air-bone mean differences, compared to the 6 to 9 year old groups. These results seemed to indicate that the older educable mentally impaired children, with the exception of the 3 to 5 year olds, had more middle ear problems than the younger age groups. This finding suggested that testing of the mentally impaired population should be performed on a regular yearly basis for both the younger and older age groups, rather than yearly for the younger children and at 3 or 4 year intervals for the older children, which Darley (1961) and Wilson (1975) had recommended for children of normal intelligence.

Melnick et al. (1964) showed that when either strict or lenient criteria levels were used as a screening procedure, over half of the child population who needed medical attention were not detected. It has been suggested by some investigators (Fulton and Giffin, 1967; Lloyd and Fulton, 1972; Jordan, 1972) that middle ear anomalies may be more predominant in the mentally impaired population. If this was the case, poorer normative thresholds along with a larger percentage of abnormal results would be found.

The air conduction threshold levels found for the educable mentally impaired population were quite similar to those thresholds obtained from a normal hearing population (Glorig et al., 1957 and Eagles and Wishik, 1961) shown in Table 8. The Glorig et al. (1957) study obtained normative data from a "mass" screening technique of subjects 18 to 24 years old with no history of significant noise exposure, factory work, military service or difficulty with their ears and with no physical evidence of perforations of the drum head or discharge from the ears. Testing was done in a sound treated booth. The Glorig et al. (1957) study was in agreement with other "mass" studies, such as the Public Health Study (Beasley, 1935, 1936), Steinberg et al. (1940) and Webster et al. (1950) health surveys and Sivian and White (1933) data.

Eagles and Wishik (1961) used children from 3 to 17 years

Table 8.--The hearing threshold levels obtained from the Glorig et al. 1957 study (WSF 1957), Glorig et al. 1956 study (WSF 1955), Lowell et al. 1956 study, Eagles and Wishik 1961 study, and the Educable Mentally Impaired Population (EMI 1975) from this study, in relationship to ANSI 1969 specifications.

Study	Frequency				
	250 Hz (HTL)	500 Hz (HTL)	1,000 Hz (HTL)	2,000 Hz (HTL)	4,000 Hz (HTL)
WSF (1957) a	-	14.1	9.6	10.4	8.8
WSF (1956) b	2.2	1.6	1.6	1.7	1.9
Lowell et al. (1956) c	-	12.6	6.1	5.5	-
Eagles & Wishik (1961) d	7.4	8.1	6.5	5.4	4.3
EMI (1975) e	14.0	11.2	7.0	6.9	8.9

a Testing carried out with PDR-10 earphones and values used were medians.

b Testing carried out with TDH-39 earphones and values were means.

c Assumed testing was carried out with Western Electric 705A earphones and values were means.

d Testing was carried out with Western Electric 705A earphones and values were means.

e Testing carried out with TDH-39 and TDH-49 earphones and values were means.

of age from the Pittsburgh Public School system who were untrained listeners. Their results were even closer to the educable mentally impaired population thresholds of the present study than the Glorig et al. (1957) results, suggesting that children do have more sensitive hearing thresholds than older individuals.

The preceding studies were used by the American Standard Association as the basis of the 1951 standards for pure-tone thresholds. Dadson and King (1952) and Wheeler and Dickenson (1952) did laboratory studies in Britain, which found markedly different findings than the findings of the American Standards Association (1951). "Experimental studies in 1955, Glorig et al., a Walter Reed Medical group, and a National Bureau of Standards group did further 'laboratory' research to develop pure-tone threshold standards" (Glorig et al., 1956, p. 1111). The Glorig et al. (1956) results, along with the results of other studies, found that "laboratory" thresholds using 18 to 24 year old listeners who were carefully screened as in the Glorig et al. (1957) study and were trained to become experienced listeners and had two test periods administered to them (Glorig et al., 1956), were found to produce better thresholds. Lowell et al. (1956) found children had better thresholds than the norms (ASA 1951) developed at that time. The norms Lowell et al. (1956) obtained at 500, 1,000 and 2,000 Hz for a group of children 2 years 6 months to 3 years 4 months, were within 1.4 dB (HTL) (re: ANSI, 1969) of the data found for the educable mentally impaired children, ages 3 to 13 years, used in this study (see Table 8). The binaural thresholds from the educable mentally impaired children were quite close to the thresholds from (Lowell et al., 1965) the "mass" thresholds obtained by other investigators (Glorig et al., 1957 and Eagles and Wishik, 1961). The educable mentally impaired population did have better thresholds than the 18 to 24 year olds used in the Glorig et al. (1957) study. This supported the Eagles and Wishik (1961) investigation with normal school-age children ranging in age from 3 to 17 years, which showed the children's hearing to be better than that of the average adult thresholds in a "mass" screening program. Eagles and Wishik (1961) used children with little or no previous listening experience. Further, Eagles and Wishik combined the otologically normal and abnormal results. The educable mentally impaired population used in this study were shown to have poorer thresholds than the normal children found in the Eagles and Wishik (1961) study.

This may be due to the fact that the educable mentally impaired group of the present investigation included 4.8% of the children who were judged to have poor reliability in the study whereas, in the Eagles and Wishik (1961) data the results of the 3.5% of the children judged to be unreliable were not included in the reported results. The poorer thresholds obtained from this study also may be partly due to the tendency for educable mentally impaired children to exhibit a greated percentage of conductive hearing losses.

The normative data found in this study indicated that the thresholds obtained were close to the previous normative data found for earlier "mass" screenings and childhood norms (Glorig et al., 1957; Eagles and Wishik, 1961). Melnick et al. (1964) suggested that when a strict pure-tone criteria was used audiologists would still not be able to detect all the children who needed medical attention (Melnick at al., 1964). Melnick et al. (1964) and Eagles et al. (1961, 1967) stated that other tests were necessary to detect hearing losses in children. However, in identification audiometry, air conduction hearing levels have been used. This was because of problems encountered with calibration of bone vibrators and the ambient noise levels found which would affect the hearing levels obtained. The screening criteria level used in this study, which was 10 dB air-bone differences at 2 or more frequencies or 20 dB HL at any one frequency, may prove to be a more sensitive and accurate indicator of hearing loss if environmental factors are controlled. Speech, impedance audiometry, and otoscopic observations should be used in conjunction with pure-tone audiometry in the future, to aid in the recognition of conductive and sensori-neural problems in the educable mentally impaired child.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was: 1) to establish pure-tone threshold data with an educable mentally impaired population (ranging in age from 3-13 years), 2) to determine the incidence of possible hearing loss, and 3) to arrive at a possible hearing test criterion level for pure-tone screening to be used with an educable mentally impaired population. One hundred and sixty-seven educable mentally impaired children (having an IQ of 50 to 80), consisting of 102 males and 65 females ages 3 to 13 years, from type A classrooms in the Lansing Public School system were tested at octave frequencies from 250 Hz through 4,000 Hz. The thresholds for pure-tones were obtained under TDH-39 and TDH-49 earphones, and with a Radioear 70A white dot bone vibrator. Repeated threshold measurements were performed at 1,000 Hz for reliability purposes. One of the two procedures were used to obtain pure-tone thresholds, a modified Hughson-Westlake technique and a descending technique. The method of presentation of the signal to the subject was randomly determined.

The overall binaural air conduction mean threshold was poorer than the overall better bone conduction average by 5 dB. The air conduction results were quite similar to those results obtained in previous studies on normal children. Using a criteria level of 20 dB (HTL) (re: ANSI, 1969) at one or more frequencies or 10 dB air-bone differences at two or more frequencies, the results indicated over one-third of the population had a possible hearing loss. The results also revealed that with the exception of the 3 to 5 year olds, the older children evidenced more hearing problems than the younger children. The reliability of the test results were judged to be good to fair in 95.2% of the cases tested. Finally it appeared that some frequencies showed poorer thresholds than other frequencies.

Conclusions

The following conclusions seem warranted:

1. The overall binaural air-conduction threshold was 9.5 dB and the better bone-conduction threshold was 3.8 dB. Thus, there is a greater than 5 dB air-bone mean difference, which is suggestive of possible organic problems.

2. The normative threshold data procured by this study approximated data found in the earlier "mass" and threshold screening programs for children.

3. There were 58 out of 167 educable mentally impaired children or 34% of this population which failed the stringent criterion. The stringent criterion consisted of 10 dB air-bone differences or greater at two or more frequencies or 20 dB (HL) at any one frequency.

4. It appeared that 250, 500, 4,000, 1,000 and 2,000 Hz were the worst to the best frequencies, respectively, in terms of thresholds (re: 0 dB HTL) for binaural air and better bone conduction mean thresholds, air-bone mean differences and right ear air conduction thresholds.

5. The percentage of hearing losses found for this population was much greater than what has been found in a normal pre-school and school age population. Other tests and investigations are needed to determine the validity and feasibility of using these criterion levels.

Suggestion for Further Research

Further studies need to be carried out with the educable mentally impaired population concerning the "laboratory" and "mass" screening threshold levels. The pure-tone data should be analyzed using only the individuals who passed the screening criteria levels, to see if the results are closer to earlier "laboratory" findings. Results should be obtained to see which of the two methods, a Modified Hughson-Westlake technique or a descending technique, produced the lowest thresholds. Pure-tone play audiometry vs. pure-tone conventional audiometry should also be studied to see if there are any threshold differences found between the two methods for these children.

Speech reception thresholds should be obtained using a large educable mentally impaired population to determine if it is a reliable and valid measure. Speech discrimination testing should be studied, in an educable mentally impaired population, to determine whether a picture pointing or repeat back procedure allows the child more opportunity to perform at his maximum ability level.

Impedance results should be studied to determine the incidence rate of hearing problems in this population. A longitudinal study should be done comparing pure-tone, speech, and impedance audiometry and otoscopic observations to see if the older aged children do, in fact, have more hearing problems, and further, to determine if this trend continues after medical referrals have been made. Other important aspects should also be studied. These include determining if there is hearing improvement or any behavioral or educational changes occurring after medical referrals are followed through. A comprehensive screening battery is needed for this population to aid in the detection of children with hearing problems.

LIST OF REFERENCES

Accreditation Council for Facilities for the Mentally Retarded: Standards for residential facilities for the mentally retarded. Chicago: Joint Commission on Accreditation of Hospitals (1971).

American National Standards Institute. American national standard specifications for audiometers, 53.6-1969. New York: ANSI (1969).

American Standard Specification for Audiometers for General Diagnostic Purposes (ANSI Z24.5-1951), New York: American National Standards Institute, Inc. (1951).

Barr, B., Pure-tome audiometry for preschool children: A study with particular reference to children with severely impaired hearing. Acta Otol. Suppl., 121, 1-34 (1955).

Beasley, W., The basis of the present American standard is the U.S.P.H.'s survey in "The Testing of Hearing in the Armed Services," (eds.) David, H., Eldredge, D., and Usher, J. (Technical Report No. 8 to the Office of Naval Research from the Central Institute for the Deaf).

Bloomer, H., A simple method for testing the hearing of small children. J. of Speech Dis., 7, 311-312 (1942).

Carhart, R. and Jerger, J., Preferred method for clinical determination of pure-tone thresholds. J. Speech Hearing Dis., 24, 330-345 (1959).

Cohen, D. and Sade, J., Hearing on Secretary Otitis Media, Canadian J. Otol., 1, 27 (1972).

Curry, E. and Kurtzrock, G., A preliminary investigation of the ear choice technique in threshold audiometry. J. Speech and Hearing Dis., 16, 340-345 (1951).

Dadson, R. and King, J., A determination of the normal thresholds of hearing and its relation to the standardization of audiometers. J. Laryn. Otol., 66, 366-378 (1952).

Dahle, A. and Daley, D., Tangible rewards in assessing auditory discrimination performance of mentally retarded children. Amer. J. Mental Deficiency, 78 (5) p. 625 (1974).

Darley, F. (ed.), Committee on Identification Audiometry, Identification for School Age Children: Implementing the Program, Amer. Speech and Hearing Association. J. Speech and Hearing Monograph Suppl., 9, 36-44 (1961).

Darley, F. and Winitz, H., Age of First Work: Review of Research, J. Speech and Hearing Dis., 26(3) (1961).

Dassinger, S. and Madow, A., Verbal audiometry screening with the mentally retarded. J. Speech and Hearing Res., 387-392 (1966).

Dix, M. R. and Hallpike, C. S., The peep show: a new technique for pure-tone audiometry in young children. British Med. J., 719-724 (1947).

Eagles, E. and Wishik, S., A study of hearing in children: objectives and preliminary findings. Transaction AAOO, May-June (1961).

Eagles, E., Wishik, S., Doerfler, L., Hearing sensitivity and ear disease in children: A prespective study. Laryngoscope, 71, 628-646 (1961).

Eagles, E., Wishik, S., Doerfler, L. Hearing sensitivity and ear disease in children: A prospective study. Laryngoscope Monograph (1967).

Fulton, R., Standard pure-tone and Bekeshy audiometric measures with the mentally retarded. Amer. J. Mental Deficiency, 72, 60-73 (1967).

Fulton R. and Giffin S., Audiological-otological considerations with the mentally retarded. Mental Retardation, 5(3) 28-31 (1967).

Fulton, R. and Graham, J., Pure-tone reliability with the mentally retarded. Amer. J. Mental Deficiency, 69, 265-268 (1964).

Fulton, R. and Lloyd, L., Audiometry for the retarded: With implications for the difficult-to-test, Baltimore: Williams and Wilkens (1969).

Glorig, A., Quiggle, R., Wheeler, D., and Grings, W., Determination of the normal hearing reference zero. J. Acous. Soc. Am., Vol. 28, No. 6, 1110-1112 (1956).

Glorig, A., Wheeler, D., Quiggle, R., Grings, W., and Summerfield, 1954 Wisconsin State Fair Hearing Survey, Monograph, Amer. Acad. Ophthal. and Otol. (1957).

Hall, S. and Talkington, L., Trends in programming for deaf mentally retarded in public residential facilities. Mental Retardation, 50-52 (1972).

Holm, V. A. and Kunze, L. H., Effect of chronic otitis media on language and speech development. Pediatrics, 43, 833-839 (1969).

Jordan, O., Mental Retardation and Hearing Defects. Scand. Aud., Vol. 1, No. 1, March (1972).

Kennedy, H., Maturation of hearing activity. Laryngoscope, Vol. 67, 756-762 (1957).

Kodman, F., The incidence of hearing loss in mentally retarded children. Amer. J. Mental Deficiency, 675-678 (1958).

Kodman, F., et al., An investigation of hearing loss in mentally retarded children and adults. Amer. J. Mental Deficiency, 460-463 (1959).

Kopatic, N., The reliability of pure-tone audiometry with the mentally retarded. Training School Bulletin, 130-137 (1963).

LaCrosse, L. L. and Bidlake, H., A method to test the hearing of mentally retarded children. Volta Review, 27-30 (1964).

Lagenbeck, B., Text book of practical audiometry. Baltimore: Williams and Wilkins Company, 23-25 (1964).

Lefanov, V., Hearing tests of three year and older children by pure-tone play audiometry method. Zh Ush Nos i Gorl Bol. 5, 114-115 (1971). (Cited in DSH Abstracts).

Lescouflair, G., French-Canadian J. Public Health. Nov.-Dec. Issue, 574-581 (1973).

Lloyd, L., Behavioral Audiometry viewed as an operant procedure. J. of Speech and Hearing Dis., Vol. 31, p. 126-136, (1966a).

Lloyd, L., Comments on Dilemmas in identification audiometry. J. of Speech and Hearing Dis., Vol. 31, 161-165, (1966b).

Lloyd, L. and Cox, P., Programming for the audiologic aspects of mental retardation. Mental Retardation, 22-26 (1972).

Lloyd, L. and Crosby, K., Establishment of standards for speech pathology and audiology services in facilities for the retarded. Mental Retardation, 30-31, (1972).

Lloyd, L., Frisina, D. (eds.), The audiologic assessment of the mentally retarded, Proceedings of a national conference, Parsons, Kansas: Speech and Hearing Department (PSH and TC) (1965).

Lloyd, L. and Fulton, J., Audiology's contribution to communications programming with the retarded. In McLean, Yoder and Schefelbusch (ed.), Language intervention with the retarded: Developing strategies. Baltimore, MD: Univ. Park Press, (1972).

Lloyd, L. and Melrose, J., Inter-method comparisons of selected audiometric measures used with normal hearing mentally retarded children. J. of Acous. Res., Vol. 6, 205-217, (1966b).

Lloyd, L. and Melrose, J., Reliability of selected auditory responses of normal hearing mentally retarded children. Amer. J. of Mental Deficiency, Vol. 71, 133-143, (1966a).

Lloyd, R. and Reid, M., The incidence of hearing impaired in an institutionalized mentally retarded population. Amer. J. Mental Deficiency, Vol. 7, No. 5, 746-764 (1967).

Lloyd, L., Reid, M., and McManis, D., The effects of response mode on the SRT's obtained from retarded children. J. Auditory Res., 7, 219-222 (1967).

Lloyd, L., Reid, M., and McManis, D., Pure-tone reliability of a clinical sample of institutionalized mentally retarded. Amer. J. Mental Deficiency, Vol. 73, No. 2, 279-282 (1968).

Lowell, E., Rushford, G., Hoverston, G., and Stoner, M., Evaluation of pure-tone audiometry with pre-school age children. J. of Speech and Hearing Dis., 21, 292-302 (1956).

Luria, A., Psychological studies of mental deficiency in the Soviet Union. In Ellis, N., (ed.), Handbook of mental deficiency, New York: McGraw-Hill, (1963).

Melnick, W., Eagles, E., and Levine, H., Evaluation of a recommended program of identification audiometry with school age children. J. Speech and Hearing Dis., 29:3-13, (1964).

Michigan Department of Health, Vision and Screening in selected classes for the mentally retarded-City of Detroit. United States Department of Health, Education and Welfare (Welfare Administration, Children's Bureau), (1966).

Mykelbust, E., Auditory Disorders in Children. New York, Grune and Stratton, Inc., (1954).

Newby, H., Audiology, Meridith Publishing Co. (1958, 1964).

Nudo, L. A., Comparison by age of audiological findings in a state residential institution for the mentally retarded: a preliminary report. In Lloyd, L. and Frisina, D. (eds.), The audiometric assessment of the mentally retarded: The proceedings of a National Conference, Parsons, Kansas: Speech and Hearing Dept. (PSH and TC) (1965).

O'Neill, J., Oyer, H., and Hillis, Audiometric procedure with children. J. Speech and Hearing Dis., Vol. 26, 61-66 (1961).

Pantelakos, C., Audiometric and otolaryngologic survey of retarded students. N.C. Med. J., 24, 238-242 (1963).

Rittmanic, P., The mentally retarded and mentally ill. Chapter in Rose, Audiological Assessment, Prentice Hall, (1971).

Schlanger, B., Speech measurements of institutionalized mentally handicapped children, Amer. J. of Mental Deficiency, Vol. 58, 114-122 (1953).

Schlanger, B., Results of varying presentations to brain damaged children of auditory word discrimination. Amer. J. of Mental Deficiency, Vol. 63, 646-648 (1958).

Schlanger, B., Effects of listening training on audiometric thresholds of mentally retarded children. Asha, 273-275 (1962).

Schlanger, B. and Galanowsky, G., Auditory discrimination by mentally retarded and normals, four different discrimination tests - IQ's 50-70. J. Speech and Hearing Res., Vol. 9, No. 3, 434-440 (1966).

Schlanger, B. and Gottsblen, R., Testing the hearing of the mentally retarded. J. Speech and Hearing Res., Vol. 21, 487-493 (1956).

Siegal, G., Three approaches to speech retardation. In Schiefelbush (ed.), Language of the mentally retarded. Baltimore: Univ. Park Press, (1972).

Sivian, L. and White, D., On minimum audible sound fields. J. Acous. Soc. Am., 4, 288-321 (1933).

Spradlin, J. E., Locke, B. J., and Fulton, R. T., Conditioning and audiological assessment. Chapter in Fulton, R. and Lloyd, L. L., Audiometry for the retarded: With implications for the difficult-to-test, Baltimore: Williams and Wilkens (1969).

Steinberg, J., Montgomery, N., and Gardner, M., Results of the world's fair hearing tests. J. Speech and Hearing Dis., 12, 291-301 (1940).

Webster, J., Himes, H., and Lichtenstein, M., San Diego County Fair hearing survey. J. Acous. Soc. Am., 32, 473-483 (1950).

Wheeler, L. and Dickson, D., The determination of the threshold of hearing. J. Laryngol. Otol., 66, 379-395 (1952).

Wilson, W., Chaiklen, J., Hopkinson, N., Graham, J., Shoeny, Z., Sonday, F., Byers, V., and McLauchlin, R., Guidelines for identification audiometry. ASHA, 2, (1975).