A COMPARATIVE ANALYSIS OF GROUP AND INDIVIDUAL HEARING TEST RESULTS

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ABSTRACT

An investigation was made of the value of the Purdue Modified Massachusetts Hearing Test and the Western Electric 4-C Test when compared with the individual pure tone screening test. The Purdue Modified Massachusetts Hearing Test equipment consisted of a set of 40 Maico receivers, manufactured for use with the Massachusetts Hearing Test, coupled to a Maico D-9 audiometer. The test was composed of the frequencies 256, 512, 1024, 2048, 2896, and 4096 at a testing level equivalent to 15 db, so judged by loudness balancing, plus an attenuator increase of 5 db. The Western Electric 4-C Test equipment consisted of a hand-wound, spring-driven turntable and a magnetic reproducer connected to 40 receivers. Columbia Record KS 10087, a two-sided recording of a woman's voice reciting columns of two digit numbers, was used with the 4-C equipment.

Three hundred and fifty-two students, enrolled in grades three through 12 in a school in Tippecanoe County, Indiana, were tested with the Purdue Modified Massachusetts Hearing Test, the individual pure tone test, the Western Electric 4-C Test, and a second administration of the Purdue Modified Massachusetts Hearing Test. Two methods of scoring were used with the Purdue Modified Massachusetts Hearing Test, and three methods were used to score the Western Electric 4-C Test. A chi-square test was used to

determine significant differences between the two group hearing tests, scored with the various methods.

The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified 93.5 per cent of the students and discovered 90.5 per cent of the students who had hearing impairments. No single method of scoring the Western Electric 4-C Test was able to match this performance at the five per cent level of significance.

A COMPARATIVE ANALYSIS OF GROUP AND INDIVIDUAL HEARING TEST RESULTS

INTRODUCTION

An estimated thirty-four million students were enrolled in all schools throughout the country in 1953. A considerable number of these students probably have hearing losses. A question exists about the best method of detecting these losses. The estimated incidence of hearing defects that would be found within this population varies from three to 20 per cent, depending upon the testing method and criterion used. For instance, Rodin (19), using the Western Electric 4-A phonograph audiometer in San Francisco, tested 36,191 school children between the ages of nine and 16. On the first test he found 17.7 per cent had significant hearing losses, at least nine sensation units, in one or both ears. Upon retest, this figure was reduced to 9.5 per cent. Peterson (17) tested 3,393 school children in Indiana with an individual pure tone screening technique. Seven octaves, beginning at 128 cps, were used at a signal level of 20 db. A failure on two or more frequencies in the same ear constituted a failure on the test. On the first screening, 21.75 per cent failed. Upon retest, 8.7 per cent failed. Sullivan (22) tested 25,708 elementary school children in the Minneapolis Public Schools with individual pure tone tests. With a threshold

of 15 db for one or more frequencies considered a hearing loss, the percentage of children with an impairment ranged from 17.5 to 20.5. However, the moat widely accepted figure for the percentage of children afflicted with deficient hearing is derived from a report of the Committee on Hard of Hearing Children of the American Hearing Society prepared by its Chairman, Dr. Warren H. Gardner (9). In this report the estimate was given as four per cent. Spilka and Steer (20), in their statistical survey on the incidence of speech and hearing deficiency in the general population and school population of the United States, estimated that in 1951, there was a total of 1,324,840 hearing defectives in all the schools in the United States.

Because of the large number of persons with hearing losses, increasing attention is being directed toward the development of group hearing tests by means of which it will be possible to screen effectively large groups. It is axiomatic that the most desirable procedure for testing the hearing of large groups is to use a method which requires a minimum expenditure of time and which results in separating those with an impairment of hearing at any frequency from those with essentially normal hearing. It seems, therefore, that the need specifies a reliable and valid pure tone hearing test applicable to group administration.

History of Group Hearing Testing Devices

The need for a quick and accurate measurement of hearing has been recognized for many years. In 1926 and in the years following, the Western Electric Corporation marketed the 4-A, 4-B, and the 4-C group phonograph speech audiometers. From 10 to 40 earphones in compartmented trays were carried from school to school. In the 4-A audiometer the earphones were connected to the phonographic reproducer, consisting of a hand-wound, spring-driven motor and turntable and a magnetic reproducing head. There was no power supply since the magnetic phonograph pick-up generated its own power from the revolving record. The later 4-B and 4-C models were available with either spring-driven or electrically-operated turntables.

The records used with these audiometers consisted of two-sided pressings of two or three digit numbers. These were pronounced as single digits: 4-2-5 (four-two-five). Each set of digits was attenuated by three db, so that the first and loudest began at 30 db above normal threshold and the last set ended three db below threshold. The subjects responded by writing the numbers on specially prepared test blanks as they were heard. Nine sensation units was generally used as a criterion for failing (8,19,23).

Newhart and Reger (16) have described a standard procedure for testing hearing in the public schools with

the Western Electric 4-C group phonograph speech audiometer. The procedure consists of four steps: (1) the group phonograph speech audiometric test is given to all children who are to be tested; (2) those who fail the initial test are retested with the group phonograph speech audiometer; (3) those who show defective hearing on the second group test are given an individual screening test with a pure tone audiometer; and (4) those who have significant hearing impairment (a loss in excess of 15 db for two or more frequencies in either ear) are given individual threshold acuity tests on a pure tone audiometer.

There are several objections to this type of group hearing testing: 1. it is time-consuming; 2. high frequency losses frequently are not detected; (15,16); 3. tonal gaps in the speech range are not always discovered (4); 4. sudden noises interfere (12); 5. the test is rigidly structured; and 6. it is unsuitable for children who are unable to write dictated numbers (15).

In an attempt to detect the presence of medically significant high frequency losses which are not revealed by the phonograph speech test method,the individual discrete frequency screening test was brought into use in 1938 (23). The testing is usually conducted at 15 or 20 db. Ten to 30 children can be tested per hour, depending upon the age of the children and the conditions of the test. However,

this test is also time-consuming, and errors are caused by operator fatigue 117).

The Bell Telephone Laboratories (21) in their exhibits at the New York and San Francisco World's Fairs in 1939 and 1940 tested the hearing of 550,000 people with a group pure tone test. The test was a progressively attenuated recording of series of one, two, or three short bursts of tone. The ranee covered 62 db for the frequencies 440, 880, l?60, and 3520, and 48 db for the frequency 7040. The testing was conducted in seven sound-treated booths with the signal coming through a telephone receiver held to the ear. A recorded group pure tone test, similar in nature, was used by West and his associates in conducting the Wisconsin Hearing Survey in 1939 through 1941 (5).

The objections to recorded pure tone hearing tests are the presence of surface noises, the difficulty of reproducing high frequencies satisfactorily, and lack of flexibility in the testing routine (13).

A group pure tone test using a pure tone audiometer as the sound source was developed in 1945 for use at the U. S. Naval Submarine Base, New London, Connecticut. This test is described by Harris (10). The equipment, a Western Electric 6B audiometer and 12 ANBH-1 phones, was calibrated in the following manner: (a) a normal-hearing subject was given several individual tests with a 705A calibrated phone

and the 6B audiometer; (b) mean thresholds were obtained from these audiograms for each frequency octave from 256 to #192 inclusive; (c) the same subject was given an audiometric test using each phone of the group audiometer; (d) the mean threshold of the 12 phones for each frequency was then corrected for any deviation from zero threshold on the 705A phone and used as the zero point for that frequency on the group audiometer.

A test-retest reliability check yielded less than a 1.5 db difference between individual examination and the groun test with equivalent phones. From this, Harris concluded that the group procedure was as reliable as the usual individual pure tone audiometric test. However, when the group retest phone was chosen at random, the significance of the difference between individual and group procedures was increased. Changing phones for a group retest lowered reliability by a small but significant amount.

The validity of a group audiogram was ascertained by comparing a subject's thresholds obtained by the group test with his thresholds obtained by a careful individual pure tone test. The small differences between mean loss as well as the correspondence of the standard deviations were indicative to Harris that there was no strong tendency for group averages to differ from individual averages.

In 1947 Newby (13) reported the results of hearing

testing in the Iowa City Public Schools with a group pure tone test devised by Reger and Newby (18). A motor-driven, mechanically-operated tone interrupter device, which made possible the presentation of the same sound stimulus patterns, one, two, three, or four spurts of tone, every time the test was administered, was coupled to a pure tone audiometer having 40 balanced earphones. The frequencies 256, 1024, 2048, and 4096 cps were presented to the subjects at the successively decreasing intensity levels of 40, 30, 20, 15, 10, and five db.

After administering this test to 188 ears in the third through eighth grades, Newby reported that the validity of the test, determined by comparing it with individual threshold tests obtained on the same subjects, was such that a difference of 15 db or less was found between the two tests for 94 per cent of the ears, a difference of 10 db or less for 89 per cent, and a difference of five db or less for 80 per cent of the total ears.

A test-retest measure of reliability resulted in 89 per cent of 840 ears showing differences between group test and group retest of five db or less and 96 per cent of the total ears showing discrepancies of 10 db or less. With a criterion for a significant hearing loss of 20 db for two or more frequencies or 30 db for one frequency, Newby missed 5.3 per cent of the pupils with true hearing losses

and needlessly retested 11.2 per cent. Newby concluded that this test was not only satisfactorily valid and reliable, but efficient as well.

In 1948 a group pure tone test using a different method of presenting the stimulus was reported by Johnston (12). Instead of counting spurts of tone, the subjects signaled presence or absence of tone by underlining "yes" or "no" on the answer sheet. A pure tone audiometer with Western Electric phones was used in this test, which is called the "Massachusetts Hearing Test." However, "the term 'Massachusetts Hearing Test' refers to a particular methodology which stresses prescribed forms of scoring, signal presentation, and calibration rather than unique combinations of equipment components (12)."

This test was designed to screen 40 children simultaneously, using the frequencies and intensities listed in Table 1. Later the frequency 1024 was discarded, and only the three frequencies 512, 2048, and 11,584 were used in testing. The system was calibrated with the loudness balance technique, by having five normal hearing adults match signals in one of the group receivers to signals in a calibrated receiver. The tone interrupter control was used manually by the tester. The signal or non-signal interval was not critical, but, according to Johnston, should have been a total minimum length of three seconds.

Table 1. Signal levels used in the Massachusetts Hearing Test of Johnston.

.Frequency	Single level (db) (ref. zero threshold)
512	20
1024	25
2043	25
11534	30

The test was flexible in that signals could be repeated an indefinite number or times, or the test could be delayed if sudden, extraneous noise should occur. In order to facilitate grading, the children were instructed to sum the number of negative responses in each column (Appendix A) and make the entry at the bottom of the column. All test papers which were in error by two negative responses or less per ear were considered satisfactory and, consequently, discarded. Children who failed were later retested with the group pure tone test. Children failing the group retest were given an individual pure tone test prior to referral to an otologist. Using these scoring methods, it was reported that a group of 40 children could be tested and all papers graded in approximately 17 minutes.

Johnston demonstrated, by sequential analysis, that the group pure tone test was superior to the phonograph speech test. He stated also that the Massachusetts Hearing Test had these advantages over the pulsetone technique: (a) lowered cost; (b) the minimizing of intelligence factors; (c) superiority in scoring speed; and (d) flexibility of operation.

Becker (2) in 1951 and DiCarlo and Gardner (6) in 1953 modified the Massachusetts Hearing Test and adapted it for a university testing program. In this modified test, the final attenuator settings were calculated by testing

Table 2. Signal levels used in the Modified Massachusetts Hearing Test of Dicarlo and Gardner.

frequency	Signal Level (db) (ref. zero threshold)
500	15
1000	15
2000	15
8000	15

eight normal hearing subjects with the group equipment to obtain threshold values for the frequencies 500, 1000, 2000, and 8000. These thresholds were noted, and the signal level was increased 15 db for screening purposes.

A comparison of results between group and individual tests on 630 ears revealed that 2.8 per cent had losses that were not detected by the group test and 6.0 per cent did not have losses but would have been needlessly retested. DiCarlo and Gardner were satisfied that the Massachusetts Hearing; Test, as modified, provided a very efficient tool for testing: the hearing of university students.

Statement of the Problem

This study was undertaken to investigate the value of two group hearing tests when used with elementary and secondary school children. The research was directed toward , answering the following questions:

1. What is the efficiency of the Purdue Modified Massachusetts Hearing Test when compared with the individual pure tone test?

2. What is an acceptable level for testing with the Purdue Modified Massachusetts Hearing Test?

3. What is an acceptable method of scoring the Purdue Modified Massachusetts Hearing Test?

4. What is the validity of the Purdue Modified Massachusetts Hearing Test when compared with the individual

pure tone test?

5. What is the test-retest reliability of the Purdue Modified Massachusetts Hearing Test?

6. What is the efficiency of the Western Electric 4-C Test when compared with the individual pure tone test?

7. What is an acceptable method of scoring the Western Electric 4-C Test?

8. What is the validity of the Western Electric 4-C when compared with the individual pure tone test?

9. Is the Purdue Modified Massachusetts Hearing Test a significantly better screening instrument than the Western Electric 4-C Test?

INSTRUMENTATION

This research was conducted to determine the value of two group hearing tests, the Western Electric 4-C Test and a modification of the Massachusetts Hearing Test. The Western Electric 4-C Test equipment was not measured and described in detail because phonograph speech audiometers have become less and less popular with workers in the field of hearing testing. Between the school years 1944-1945 and 1947-1943 there was reported a gain of 22 per cent for phonograph speech audiometers owned by school systems, public health centers, etc., which Gardner (9) states is not so much a gain in purchase as it is in recording the number of instruments in the field, since over 1500 have been reported sold. There was a gain of over 600 per cent in pure tone audiometer registration. The trend in testing the hearing of school children, as indicated above, is toward the use of pure tone audiometers.

Since the Massachusetts Hearing Test had already been modified by Becker (2) and DiCarlo and Gardner (6),the Massachusetts Hearing Test as modified by the experimenter was called the Purdue Modified Massachusetts Hearing Test. The Purdue Modified Massachusetts Hearing Test was designed to include the seven frequencies 256, 512, 1024, 2048, 2896, 4096, and 8192. Seven frequencies were used in this test instead of the three or four frequencies generally used in

a group pure tone test for the purpose of obtaining as close . correspondence to the individual pure tone screening test as possible. The frequency 2896 was used so that there would be no large gap between the frequencies usually thought to represent the speech range.

A set of 40 phones, with adaptor, manufactured by the Maico Corporation for use with the Massachusetts Hearing Test, was used in this study 1 . The group phones were coupled to a Maico D-9 audiometer that met the specifications of the American Medical Association.

Measurement of Receivers

The experimenter measured the receivers with respect to distortion, linearity, and intensity to determine the characteristics of the receivers. Such a description of equipment makes possible comparisons with equipment used in other research. The Hewlett-Packard Harmonic Wave Analyzer, Model 300A; the Audio Development Company Artificial Bar, Model D5153 with power supply; the Ballantine Laboratories Electronic Voltmeter, Model 300; and the Dumont Cathode-Ray Oscillograph, Type 208-B were used to obtain these measurements. The equipment, indicated schematically in the block diagram, Figure 1, was unmodified and conformed

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These phones were loaned by the Maico Corporation to the Purdue Speech and Hearing Clinic for use in this research investigation.

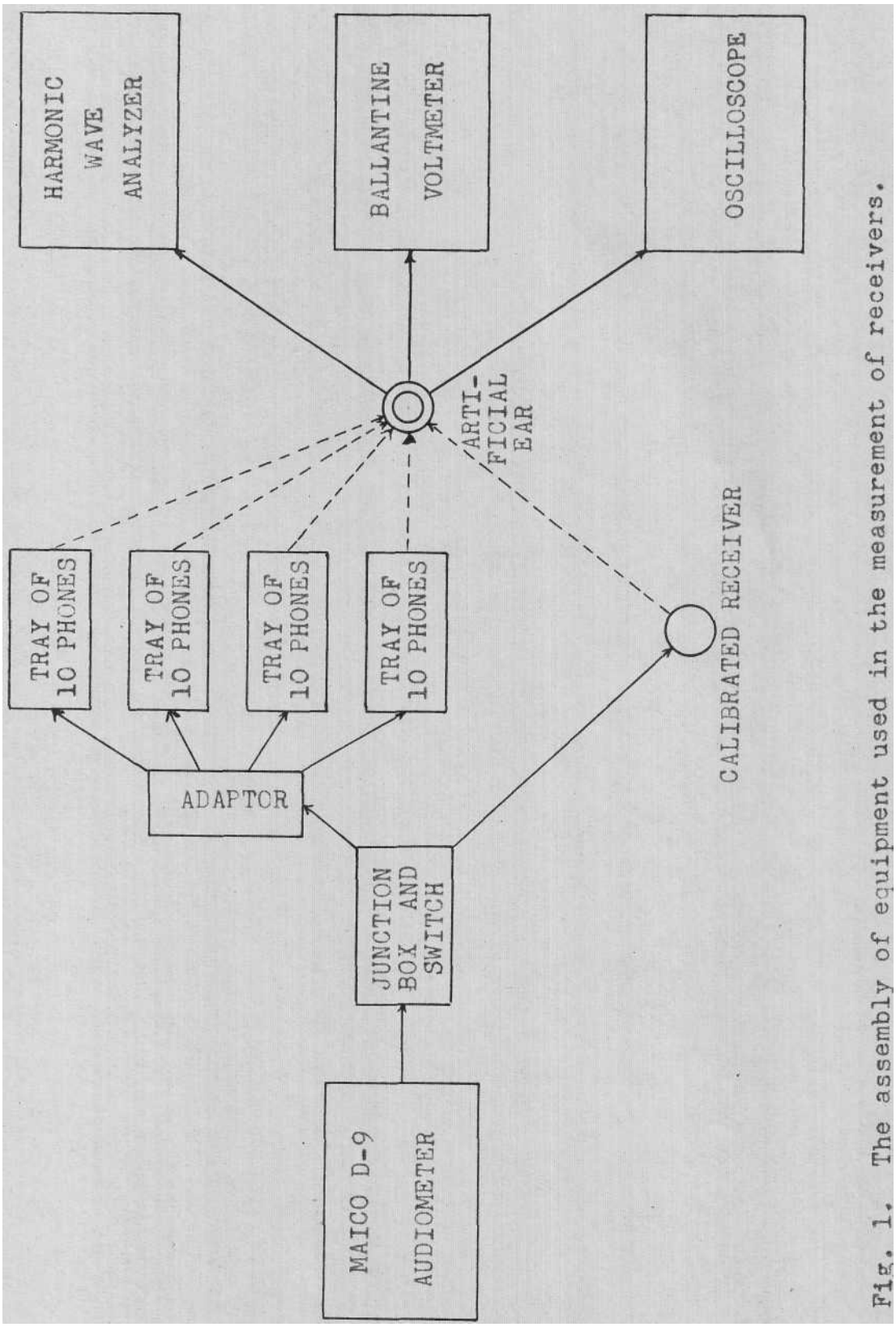

Fig. 1. The assembly of equipment used in the measurement of receivers.

to the manufacturers specifications. The junction box was specially constructed for this research so that the output of the audiometer could be switched from the calibrated receiver to the set of group receivers without changing the phone plugs. The adaptor made it possible for the leads from the four trays of phones to be consolidated into one lead which was connected to the junction box. The output of the artificial ear was connected to the harmonic wave analyzer, the voltmeter, and the oscilloscope. The oscilloscope was included in the circuit to note the pattern of the wave with different types and degrees of distortion. All 40 phones were numbered so that data could be compiled for each individual phone. The battery power supply for the artificial ear was tested regularly during the experimentation to maintain the manufacturer's specifications. The phones were placed upon the artificial ear in the same manner, as nearly as possible, each time. The standard weight, 600 grams, was then placed on top of the phone. The equipment was set up in a quiet room, eight by 10 feet, in which the noise level was approximately 32 db, as measured by the General Radio Sound Level Meter, Type 759-B.

Distortion. To fall within the specifications of the American Medical Association, tonal purity must be such that all harmonics and overtones are at least 25 db lower in intensity than the fundamental or test tone.

Ten of the 40 earphones, selected at random, were tested for tonal purity with the harmonic wave analyzer. This instrument is a frequency-selective, wide-range voltmeter whose selectivity is variable. The selectivity of the instrument is controlled by the Half Band Width Control which is graduated from 30 to 145 cps. The selectivity characteristic of the instrument is such that all frequencies beyond the frequency separation from the center frequency, represented by the Half Band Width, are attenuated by 40 db (99 per cent). Since this study was concerned with center frequencies only, the narrowest band width, 30 cps, was used. The instrument attenuated by 99 per cent all frequencies 30 cps below and above the particular frequency the experimenter was testing.

The attenuator of the audiometer was set at 80 db for each of the seven frequencies whose harmonic content was being measured. Each of the ten receivers was placed successively on the artificial ear, which transmitted the electrical energy to the harmonic wave analyzer where it was read in millivolts. The acoustic output of each fundamental frequency and five of its overtones were measured. Since the limit of the harmonic wave analyzer was 16 kilocycles, it was not possible to measure beyond the fifth harmonic of 2896, the third harmonic of 4096, and the fundamental of 8192.

The readings for the frequencies and their harmonics are given in Table 3. The blank spaces represent readings of less than one millivolt, the smallest reading obtainable with the harmonic wave analyzer. When two or more voltage readings for one frequency were obtained, they were inserted in the formula,

$$N_{db} = 20 \log_{10} V_1/V_2 \qquad (3)$$

In five of the 21 instances in which overtones were measurable, the difference between the fundamental and overtone was less than 25 db. These excursions within the 25 db limit all occurred at 256 cps. With one exception, all voltages for the harmonics of the other frequencies were below the sensitivity of the instrument. In summary, three receivers of the 10 receivers tested did not meet speclfl-cations set forth by the American Medical Association .

These specifications also require that the noise level due to alternating current hum, commutator ripple, or any other cause be so low that it is inaudible to a normal hearing person in the presence of the test tone produced at any attenuator setting at any frequency. The experimenter, who has normal hearing, found no audible hum when a signal was present in the receivers used in this study.

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[2] It is possible that these deviations could have been the result of either the electro-acoustical characteristics of the receivers or the electrical characteristics of the audiometer or a combination of both.

Table 3. The harmonic distortion, measured in volts, present in 10 randomly-selected receivers.

Frequency	Harmonics	Phones No. 1	No. 14	No. 30	No. 29	No. 24
256	1	.21	.52	.35	.15	.7
	2	.014*	.02	.009	.012*	.005
	3	.018*	.014	.008	.015*	.007
	4					
	5					
	6					
51?	1	.3	.46	.22	.25	.12
	2	.003				
	3					
	4					
	5					
	6					
1024	1	.125	.2	.062	.12	.054
	2					
	3					
	4					
	5					
	6					
2048	1	.175	.17	.11	.125	.088
	2					
	3					
	4					
	5					
	6					
2896	1	.145	.105	.04	.078	.032
	2					
	3					
	4					
	5					
4096	1	.53	.7	.75	.72	.62
	2					
	3					
8192	1	.185	.32	.44	.18	.105

*indicates there is less than 25 db between the fundamental and harmonic.

Table 3 (Continued). The harmonic distortion, measured in volts, present in 10 randomly-selected receivers.

Frequency	Harmonics	Phones No. 19	Phones No. 3	Phones No. 33	Phones No. 38	Phones No, H
256	1	.21	1.1	.32	.31	.25
	2	.008	.01	.012	.022*	.01
	3	.006	.012	.01	.015	.01
	4					
	5					
512	1	.19	.2	.27	.5	.27
	2					
	3					
	4					
	5					
	6					
1024	1	.05	.025	.074	.22	.75
	2					
	3					
2048	1	.11	.125	.077	.088	.078
	2					
	3					
	4					
	6					
2896	1	.03	.046	.04	.028	.038
	2					
	3					
	4					
	5					
4096	1	.37	1.1	.76	.5	.67
	2					
	3					
8192	1	.125	.32	.2	.35	.3

*indicates there is less than 25 db between the fundamental and harmonic.

Linearity. For every five db step increase or decrease in output by the audiometer, there should be a corresponding five db increase or decrease in output in the earphones. In order to verify this or to determine whether the differences discovered fell within the tolerance allowed, a measure of linearity was made. This was accomplished with the same 10 phones that were used in the distortion study. Each of the phones was placed successively on the artificial ear, and readings were obtained from the highest intensity output of the audiometer toward the lowest intensity output, until the limit of the artificial ear was reached. The Ballantine Voltmeter has a logarithmic scale, making possible direct db readings.

In a report of the Council of Physical Medicine of the American Medical Association entitled "Minimum Requirements For Acceptable Audiometers" is stated: "The difference in measured intensity levels corresponding to two adjacent settings shall not vary from five db by more than plus or minus one db for any frequency" (3). The sample of 10 receivers did not meet this requirement in 14 instances. The tolerance specifications provide a range of four to six db in the receiver for each five db step on the attenuator dial. The range found in this study was 3.7 to 5.5 db with a mean of 4.7 db (Table 4). Eight of the 10 receivers tested did not conform to the standards of the American Medical Association . In each case, the difference in

Table 4. The measurement of linearity in 10 randomly-selected receivers.

Frequency	Phones No. 1	No. 14	*No.* 30	No. 29	No. 24
256		0.0 .4	0.0	0.0	0.0 0.0 - .2 0.0
512	0.0 - .1 .4 .4	0.0 .2 .3 .1.	0.0 - .4 .1 .2	0.0 - .8 .1	0.0 -.1 .2 *.2*
1024	0.0 - .1 .4	0.0 - .2 - .2 .3	0.0 - .3 -.1	0.0 - .5 .1 .1	0.0 - a - *,2*
2048	0.0 - .5 - .5 .2 .1	0.0 - .4 - .7 0.0 0.0	0.0 - .5 - .6 0.0	0.0- - .5 - .7 0.0	0.0 - .7 - .4
	0.0 - .6 - .8 - .2	0.0 - .7 - .7	0.0 - .3	0.0 - .9 - .3	0.0
4096	0.0 - .6 - 9 - .2	0.0 -1.1* - .4 -1.0	0.0 1.2* - .5 -1.1*	0.0 -1.0 - .7 -1.0 0.0	0.0 -1.1* - .4 -1.1* .1
8192	0.0	0.0 .2	0.0 - .3	0.0	

*indicates five db plus or minus one db standard was not met.

Table 4- (Continued). The measurement of linearity in 10 randomly-selected receivers.

Frequency	Phones No. 19	No. 3	No. 33	No. *38*	No. 10
256	0,0	0.0 0.0	0.0		0.0
512	0.0 .1 0.0 .4	0.0 .4 .1 .5	0.0 .2 .4	0.0 *.2* 0.0	0.0 .2 .1
1024	0.0 - .2 .1	0.0 - .3 - .1 - .6	0.0 - .3 - .1	0.0 - .2 - .3 .3	0.0 - .2 - .3 .3
2048	0.0 - .5 - .5 .1	0.0 - .5 - .5 .1	0.0 - .5 - .4	0.0 - .7 - .4	0.0 - .5 - .6
2896	0.0	0.0 - .5	0.0	0.0	0.0
4096	0.0 -1.1* - .7 1.1* - .3	0.0 -1.1* - .6 1.1* .2	0.0 - .7 -1.3* .3 -1.0	0.0 -1.3* - *.8* 1.1* - .5	0.0 -1.1* - .5 1.2*
8192	0.0	0.0	0.0	0.0 0.0	0.0 - .1

*indicates five db plus or minus one db standard was not met.

measured intensity levels corresponding to two adjacent settings was less than the four db required. Also, it may be noted that all violations occurred at 4096 cps.

Intensity. Generally, a circuit of multiple phones requires more power to produce desired signal levels than a circuit of one phone requires to produce the same levels. Some frequencies require less power than others to produce the same signal level. Furthermore, if the group phones are not matched, the amount of power required to produce a signal level for one particular frequency may vary from phone to phone. For this reason, it was necessary to obtain the correction factor needed to balance or equate each group phone at each frequency, in terms of intensity, with a respect to a standard or calibrated phone. In other words, in order to produce in the group phones the db values equivalent to a given signal level in the calibrated phone at each frequency, the attenuator settings must be increased. The amount of this increase for each group phone at each frequency was determined by using the artificial ear. The procedure and results of these measurements are contained in Appendix B.

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3 It is possible that these deviations could have been the result of either the electro-acoustical characteristics of the receivers or the electrical characteristics of the audiometer or a combination of both.

Summary The receivers used in this study were not perfectly matched, nor did a few of them meet the specifications of the American Medical Association with regard to linearity and distortion. These receivers are typical of those specifically manufactured for use with the Massachusetts Hearing Test. Since these phones are typical of those being used by public school speech and hearing therapists and others interested in group pure tone audiometrics, the experimenter felt that such available phones should be employed to measure the efficiency and validity of the Purdue Modified Massachusetts Hearing Test.

PROCEDURE

Subjects

The subjects used in this study were enrolled in Klondike School, a public school in Tippecanoe County, Indiana, and in four public schools in Lafayette, Indiana, The choice of the schools to be tested was governed only by convenience. There were 143 children tested in the four schools in Lafayette and 352 children tested in Klondike School. There was no systematic selection of pupils to be tested, since every child present the day of the test was included in the testing routine. No effort was made to eliminate the mentally slow, even though their presence in some cases may have adversely affected the efficiency of the tests.

Administration of Hearing Tests

The Purdue Modified Massachusetts Hearing Test. The Purdue Modified Massachusetts Hearing Test was administered to the children in Klondike School on the first day of the test week. The sound level in the testing room was 45-55 db, as measured by a General Radio Sound Level Meter, Type 759-B. The signal level for the frequencies used in the test, 256, 512, 1024, 2048, 2296, and 4096, was 20 db above normal threshold. These frequencies and the 20 db signal level were the result of a pilot study reported in Appendix C.

The following; procedure was used to administer the group pure tone test. As the subjects entered the room, they were handed a test blank (Appendix D) and a smaller form to be used as an example (Appendix E). The experimenter had previously drawn on the blackboard a replied of the test form. This was shown to the pupils with the following Instructions:

> Today I want to find out how well you hear. There will be musical tones or notes coming through the earphones. If you hear them, underline "yes" on the answer sheet; if you do not hear anything, underline "no". Sometimes you will hear the sound, and sometimes you will not hear it. The sound is not there every time. You have to listen carefully and decide whether or not you hear it. First we start at the top of the page where it says Left Ear. I will say, "Column A, number one." Then you listen carefully, and if you hear the sound, underline "yes" opposite number one in column A; if you do not hear it, underline "no". Then I'll say "Number two," and you listen carefully. If you hear the sound, underline "yes" opposite number two; if you do not hear it, underline "no". When we finish number six, I will say, "Column B, number one," and we do the same thing for the numbers from one to six under column B. Next we do columns C, D, E, and F. When we have finished the top half of the paner, we will begin the bottom half, under Right Ear. But before we start, let's check to see if you all understand, by doing the example printed on the small piece of paper. First you have to put on the earphones that are on the table in front of you. There is a red earphone and a gray earphone. Everyone put the red earphone on his left ear. Check your neighbors' earphones to make sure they have them on correctly (the experimenter checks this also). Now that everyone is ready, take the small piece of paper and begin. "Number one. Number two.. ."

The example was 256 cps at a 20 db level. The tones were presented according to the plan shown in Appendix F. When the example was completed, the students were asked to

put it aside and take the large test blanks. With an admonition against looking at other papers, the test was begun. The columns on the large answer sheet correspond to the frequencies 256, 512, 1024, 2048, 2896, and 4096 in that order. The master sheet for the test is given in Appendix G, Approximately 10 minutes were required to test 40 children simultaneously. The signal and non-signal intervals were three seconds in length, and the intervals were kept constant whether or not a signal was presented. Initial practice with a stop watch and periodic checks enabled the experimenter to maintain the proper signal and non-signal intervals. There was no time delay associated with the use of the tone interrupter. The tone interrupter was kept permanently in the "On" position. A switch box, located in the circuit shown in Figure 2, made possible sharp and well-defined signal intervals.

Two methods were used to score the Purdue Modified Massachusetts Hearing Test. Because the test was graded by means of a template, the first method was called the template method. With this method, a frequency was failed if more than one out of the six responses for that frequency was incorrectly identified. It was felt that one mistake could result from inattention, noise, etc. The criterion for a significant hearing loss was a failure on two or more frequencies for the total test or, in other words, both ears.

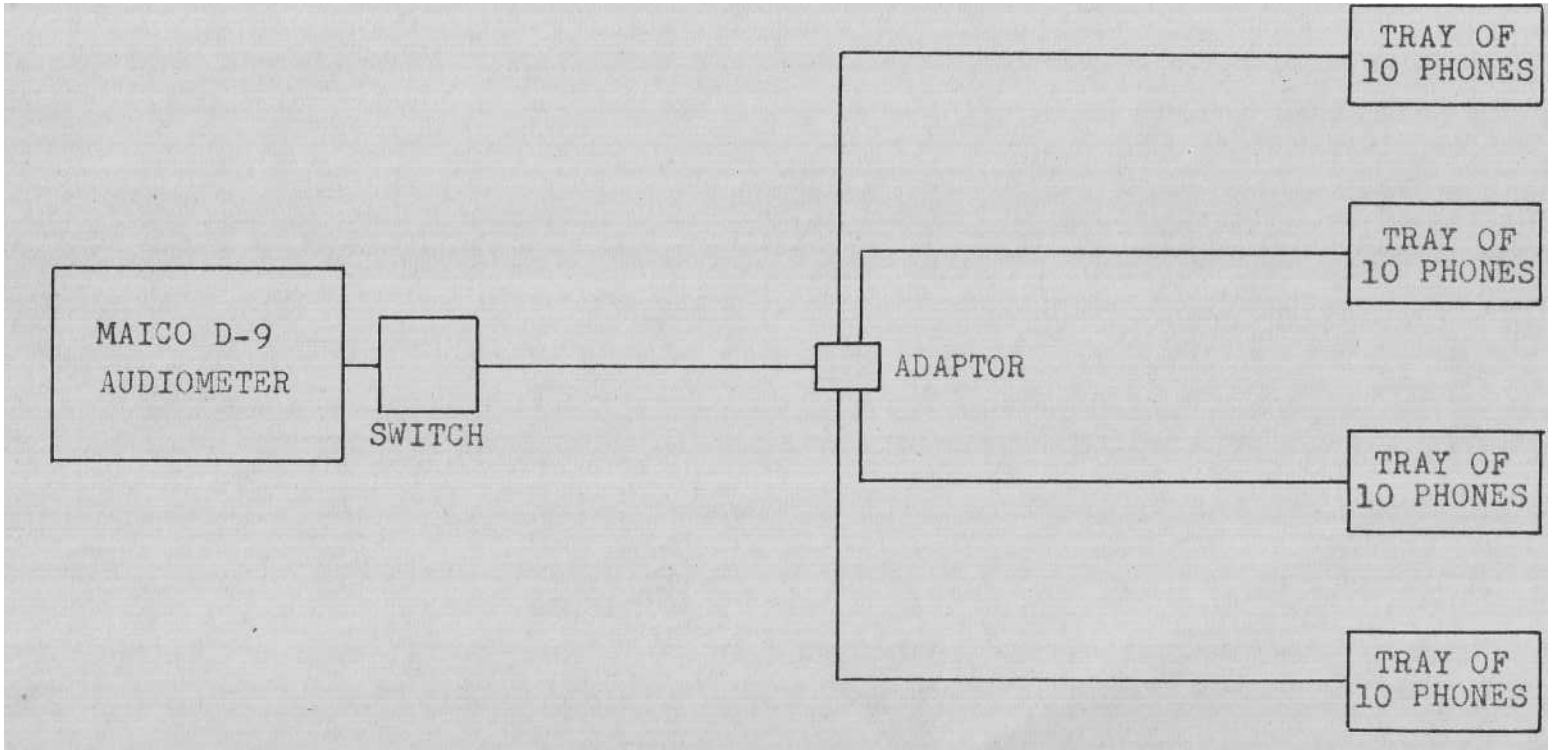

Fig. 2. The arrangement of the Purdue Modified Massachusetts Hearing test equipment in the testing situation.

The second method of scoring was that developed by Johnston (12) in which he had the children sum the number of "noes" for each ear. If either of those totals differed from the correct totals by more than two, the test was considered failed. Since this experimenter had added more frequencies to the test, the test was considered failed if the totals in either column differed by more than three from the correct totals. In this study the experimenter graded all test papers.

The Individual Pure Tone Test. On the second and third days of the test week, the children in Klondike School were given individual pure tone screening tests. The testing was conducted with the Maico D-9 audiometer and its calibrated receiver in the same quiet school room that was used for the prroup pure tone test. The screening level was 20 db, and thresholds were obtained for those frequencies which were failed. The following technique was used for the individual pure tone screening: (a) the frequencies 256, 51?, 1024, 2048, 2896, and 4096 were tested in that order; (b) the tone was presented at 20 db, and if the listener signaled that it was heard, it was rechecked before proceeding to the next frequency; (c) if the signal was not heard at 20 db, the signal level was increased until the signal was heard; and (d) the signal level was then manipulated above and below threshold, until a point was reached at which the subject responded to one signal level

at least 50 per cent of the time.

A significant hearing loss on the individual pure tone tnst resulted if the thresholds for two or more frequencies were Greater than 20 db.

The Western Electric 4-C Test. The Western Electric 4-C Test was presented to the children in Klondike School the fourth day of the test week. The room used for testing was the same as that used previously. The 4-C earphones were checked subjectively to make certain the output was uniform. The test record, Columbia Record KS 10087, was a recording of a woman's voice reciting columns of two digit numbers, each two digit number progressively attenuated by three db, so that in each column the first and loudest began at 30 db above threshold and the last ended three db below threshold. The subjects responded by writing the numbers on a specially prepared test blank as they were heard (Appendix H). Forty pupils were tested simultaneously.

The 4-C test papers were graded in three ways. The first method of grading followed the criterion recommended by Gardner (8). In grades three through six, a pupil passed if he had, for each ear, two whole numbers at the 12 db level correct, and all digits above (higher db levels) in those two columns correct. In grades seven through 12, a pupil passed if he had, for each ear, two whole numbers on the nine db level correct, and all digits above (higher

db levels) in those two columns correct.

The second method of scoring the 4-C Test was called, for clarity and convenience, the Alpha method. The test papers were scored in the manner recommended by Gardner, with the exception that a cutting score at the 21 db level was used instead of cutting scores at the 12 and nine db levels. In grades three through 12, a pupil passed if he had, for each ear, two whole numbers at the 21 db level correct, and all digits above (higher db levels) in those two columns correct.

The third method of scoring the 4-C Test was called the Beta method. In grades three through 12, a pupil passed if he had, for each ear, one whole number at the 21 db level correct, and all digits above (higher db levels) in that column correct.

The Second Administration of the Purdue Modified Massachusetts Hearing Test. The Purdue Modified Massachusetts Hearing Test was administered a second time to the children in Klondike School on the fifth day of the test week. The difference between this test and the first one was only a change in master sheets (Appendix I). The template and Johnston methods were used to score this test also.

METHOD OF DATA ANALYSIS

In judging the performance of the group tests, the analysis suggested by Newby (14) was used. To determine the presence or absence of significant hearing losses revealed by the group tests, the subjects were tested individually with pure tones. A comparison of the group tests with the individual test was made, using the tetrachoric table. The tetrachoric table, which permits rapid examination of the data, is illustrated in Figure 3 with the cell limits as defined by Newby. Percentages entered in cells a and (i indicate agreement between the group and individual tests. Percentages entered in cells b and c_ indicate disagreement between the group and individual tests. The smaller the percentages in the latter two cells, the more efficient is the group test, since cell c_ indicates subjects who have significant losses, but who were missed by the group test, and cell b indicates subjects who do not have significant losses, but who must be needlessly retested.

	Individual Test	
	% showing significant loss	% showing no significant loss
% showing significant loss	a	b . 0 - 25 %
% showing no significant loss	c 0 - 5 %	d

70

Fig. 3. The tetrachoric table: a means of presenting a pass-fail classification of subjects with respect to methods of testing or scoring [after Newby (14Q.

RESULTS

The Individual Pure Tone Test

The individual pure tone test was included in the experimental procedure to determine the efficiency and validity of the other tests used. The results of this test appear in every table in which efficiency is reported.

The Purdue Modified Massachusetts Hearing Test

The Template Scoring Method. The results of the first administration of the Purdue Modified Massachusetts Hearing Test, scored with a template, and the results of the individual pure tone test were placed in a tetrachoric table for comparison (Table 5). Two schools grades were combined as a convenient way of determining the efficiency of the Purdue Modified Massachusetts Hearing Test at various age levels. Efficiency was considered in terms of the proportions in cells b and C, the number of students incorrectly classified. Newby (14) suggested that an efficient test would have less than 25 per cent of the sample in cell b, students failing the group test and passing the individual test, and less than five per cent in cell C, students passing the group test and failing the individual test. Cell b represents students who do not have significant losses, but who must be needlessly retested, while cell C represents students who have significant losses

Table 5. The efficiency of the Purdue Modified Massachusetts Hearing Test, scored with the template method.

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		$	15	3-4
			6.6	12.4	
			a	b	
Pass	N		1	97	
			.8	30.2	
			c	d	

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		4	9	5-6
			4.0	9.1	
			a	b	
Pass	N		0	36	
				86.9	
			c	d	

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		5	3	7-3
	%		6.3	4.0	
			a	b	
Pass	N		2	64	
	%		2.7	36.5	
			c	d	

Table 5 (Continued). The efficiency of the Purdue Modified Massachusetts Hearing Test, scored with the template method,

Individual Test

Group Test			Fail	Pass	
Fail	N	0 (a)	3 (b)	Grades
	%		8.6	
Pass	N	0 (c)	32 (d)	9-10
	%		91.4	

Individual Test

Group Test			Fail	Pass	
Fail	N	1 (a)	1 (b)	Grades
	%	4.3	4.3	
Pass	N	0 (c)	21 (d)	11-12
	%		91.3	

Individual Test

Group Test			Fail	Pass	
Fail	N	18 (a)	31 (b)	Grades
	%	5.1		
Pass	N	3 (c)	300 (d)	3-12
	%	0.8	85.2	

which are not discovered by the group test. For the total test, cells b and 2 were well within the limits set by Newby. Less than one per cent of the students had significant losses which were not discovered by the Purdue Modified Massachusetts Hearing Test, scored with a template, and only 8.8 per cent of the students would have been needlessly retested. The Purdue Modified Massachusetts Hearing Test, scored in this manner, was considered an efficient tool for discovering hearing losses in a sample of primary and secondary school children.

The validity of the Purdue Modified Massachusetts Hearing Test, scored with a template, was considered in terms of the number of persons correctly classified by that test when compared with the individual pure tone test results. Three hundred and eighteen subjects, or 90.3 per cent, were correctly classified while 34 subjects, or 9.6 per cent, were incorrectly classified.

In the b cells in Table 5, the proportion of subjects failing the group test and passing the individual test varied among the grades from four per cent to 12.4 per cent, with the percentage for the whole school being 8.8 per cent. The highest figure, 12.4 per cent, was for grades three and four. Since the other cells remained fairly stable, variability was considered only with respect to cell b, the cell representing the students having to be

needlessly retested. The magnitude of variation from school to school is illustrated in Appendix J.

The Johnston Scoring Method. The results of the first administration of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the results of the individual pure tone test are presented in Table 6, Less than one per cent of the students had hearing losses which were not detected, and only 6.6 per cent of the students would have been needlessly retested. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, was an efficient tool for discovering the hearing losses in a sample of primary and secondary school children.

The validity of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, was indicated by the proportion of students correctly classified, 93.5 per cent.

Ths percentages in cell b from grade to grade ranged from 1.4 to 10.7 per cent, with the percentage for the whole school being six per cent. The variation present from school to school when the Johnston scoring method was used is illustrated in Appendix J.

A Comparison of the Template and Johnston Scoring Methods. In order to determine which method of scoring,the template method or the Johnston method, yielded the more valid

Table 6. The efficiency of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method.

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		13		3-4
	%	6.6 a	b 10.7		
Pass	N	c 1	d 99		
	%	.8	31.3		

Individual Test

Group Test			Fail	Pass	Grades
Fail	N	4	5		5-6
	%	4.0 a	b 5.0		
Pass	N	c 0	d 90		
	%		90.9		

Individual Test.

Groun Test			Fail	Pass	Grades
Fail	N	6	1		
	%	8.1 a	b 1.4		
Pass	N	c 1	d 66		
		1.4	39.2		

Table 6 (Continued]. The efficiency of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method.

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		0	1	9-10
	%	a		2.8	
Pass	N	c	0	b d 34	
	%			97.1	

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		1	1	11-12
	%	a	4.4	b 4.4	
Pass	N	c	0	d 21	
	%			91.3	

Individual Test

Group Test			Fail	Pass	Grades
Fail	N		19	21	3-12
	%	a	5.4	b 6.0	
Pass	N	c	2	d 310	
	%		.6	88.1	

results, the test papers scored with those two methods were compared with the individual pure tone test results (Table 7). Eleven students incorrectly classified by the template method were properly classified by the Johnston method. No students incorrectly classified by the Johnston method were correctly classified by the template method. Substituting the values in Table 7 in the chi-square formula for correlated proportions with the correction for continuity,

$$x^2 = \frac{(|b-c| -1)^2}{b+c} \quad x^2 = \frac{(|11-0| -1)^2}{11+0} = 9.09 \qquad (7)$$

With one degree of freedom, this figure was significant at the one per cent level. The Johnston method of scoring the Purdue Modified Massachusetts Hearing Test classified correctly a significantly greater proportion of students than did the template method.

The Western Electric 4-C Test

The Western Electric 4-C Test had been administered to the school children the fourth day of the week in which the other tests were administered. A comparison was made with the individual pure tone test results to determine the efficiency and validity of the 4-C Test with each method of scoring.

The Gardner Method of Scoring. The Western Electric 4-C Test, scored with the Gardner method, fell within the limits

Table 7. A comparison of the Johnston and template methods of scoring the Purdue Modified Massachusetts Hearing Test, considering performance on the individual pure tone test.

		Incorrectly Classified	Correctly Classified	**Total**	
Template Method of Scoring	Incorrectly Classified	23	11	34	N
		6.5	3.1	9.6	%
	Correctly Classified	0	318	318	N
			90.3	90.3	%
	Total	23	329	352	N
		6.5	93.4	99.9	%

of efficiency recommended by Newby (Table 3). Sixty-four students, or 19.9 per cent, would have been needlessly re-tested, and seven students, or 2.2 per cent, had hearing losses that were not discovered. The validity of the Western Electric 4-C Test, scored with this method, was indicated by the proportion of students correctly classified, 77.9 per cent

The Alpha Method of Scoring. The Western Electric 4-C Test, scored with the Alpha method, fell within the limits of efficiency recommended by Newby (Table 9). Twenty-one students, or 6.5 per cent, would have been needlessly retested, and 15 students, or 4.7 per cent, had hearing losses that were not discovered. The validity of the Western Electric 4-C Test scored with this method, was indicated by the proportion of students correctly classified, 88.9 per cent.

The Beta Method of Scoring. The Western Electric 4-C Test, scored with the Beta method, fell within the limits of efficiency recommended by Newby (Table 10). Six students, or 1.9 per cent, would have been needlessly retested, and 15 students, or 4.7 per cent, had hearing losses that were not discovered. .The validity of the Western Electric 4-C Test, scored with this method, was indicated by the proportion of students correctly classified, 93.5 per cent.

A. Comparison of the Western Electric 4-C Scoring Methods. In order to determine which method of scoring the Western

Table 8. The efficiency of the Western Electric 4-G Test, scored with the Gardner method.

Individual Test

4-C Test			Fail	Pass	Grades
	Fail	N	*5* (a)	34 (b)	3-4
		%	4.4	29.3	
	Pass	N	4 (c)	71 (d)	
		%	3.5	62.3	

Individual Test

4-C Test			Fail	Pass	Grades
	Fail	N	3 (a)	16 (b)	5-6
		%	3.2	17.0	
	Pass	N	1 (c)	74 (d)	
		%	1.1	78.7	

Individual Test

4-C Test			Fail	Pass	Grades
	Fail	N	5 (a)	8 (b)	7-8
		%	7.1	11.4	
	Pass	N	2 (c)	55 (d)	
		%	2.9	78.6	

Table 8 (Continued). The efficiency of the Western Electric 4-C Test, scored with the Gardner method.

Grades 9-10

4-C Test		Individual Test: Fail	Individual Test: Pass
Fail	N	0	4
	%	a	b 17.4
Pass	N	0 C	d 19
	%		82.6

Grades 11-12

4-C Test		Individual Test: Fail	Individual Test: Pass
Fail	N	1	2
	%	a	b 9.5
Pass	N	0 c	d 18
	%		35.7

Grades 3-12

4-C Test		Individual Test: Fail	Individual Test: Pass
Fail	N	14	64
	%	4.3 a	b 19.9
Pass	N	7 c	d 237
	%	2.2	73.6

Table 9. The efficiency of the Western Electric 4-C Test, scored with the Alpha method.

			Individual Test: Fail	Individual Test: Pass	
4-C Test	Fail	N	3	13	Grades 3-4
		%	2.6 a	b 11.4	
	Pass	N	c 6	d 92	
		%	5.3	30.7	

			Individual Test: Fail	Individual Test: Pass	
4-C Test	Fail	N	1	6	Grades 5-6
		%	1.1 a	b 6.4	
	Pass	N	3 c	d 84	
		%	3.2	39.4	

			Individual Test: Fail	Individual Test: Pass	
4-C Test	Fail	N	2	. 2	Grades 7-3
		%	2.9 a	b 2.9	
	Pass	N	c 5	d 61	
		%	7.1	37.1	

Table 9 (Continued). The efficiency of the Western Electric 4-C Test, scored with the Alpha method.

Individual Test

4-C Test			Fail	Pass	Grades
	Fail	N	0	0	9-10
		%	a	b	
	Pass	N	0 c	d 23	
		%		100.0	

Individual Test

4-C Test			Fail	Pass	Grades
	Fail	N	0	0	11-12
		%	a	b	
	Pass	N	c 1	d 20	
		%	4.3	95.2	

Individual Test

4-C Test			Fail	Pass	Grades
	Fail	N	6	21	3-12
		%	1.9 a	b 6.5	
	Pass	N	c 15	d 230	
		%	4.7	37.0	

Table 10. The efficiency of the Western Electric 4-C Test, scored with the Beta method.

Grades 3-4

4-C Test			Individual Test: Fail	Individual Test: Pass
Fail	N		3	4
	%		2.6 (a)	3.5 (b)
Pass	N		6 (c)	101 (d)
	%		5.3	28.6

Grades 5-6

4-C Test			Individual Test: Fail	Individual Test: Pass
Fail	N		1	1
	%		1.1 (a)	1.1 (b)
Pass	N		3 (c)	39 (d)
	%		3.2	94.7

Grades

4-C Test			Individual Test: Fail	Individual Test: Pass
Fail	N		2	1
			2.9 (a)	1.4 (b)
Pass	N		5 (c)	62 (d)
			7.1	

Table 10 (Continued). The efficiency of the Western Electric 4-C Test, scored with the Beta method.

Inaividual Test

4-C Test		Fail	Pass	Grades
Fail	N.	0	0	9-10
	%	a	b	
Pass	N	0	23	
	%	c	d 100.0	

Individual Test

4-C Test		Fail	Pass	Grades
Fail	N	0	0	11-12
	%	a	b	
Pass	N	1	20	
	%	c	d 95.2	

Individual Test

4-C Test		Fail	Pass	Grades
Fail-	N	6	6	3-12
	1.9	a	b 1.9	
Pass	N	15	295	
	%	c 4.7	d 91.6	

Electric 4-C Test was the more valid, each method of scoring was compared with the others and with the individual pure tone test. When the Gardner and Alpha methods of scoring the Western Electric 4-C Test were compared with the individual pure tone test (Table 11), 43 students incorrectly classified by the Gardner method were properly classified by the Alpha method. Eight students incorrectly classified by the Alpha method were properly classified by the Gardner method. Substituting the values in Table 11 in the chi-souare formula for correlated proportions with the correction for continuity,

$$\chi^2 = \frac{(|43-8| -1)^2}{43+8} = 22.7$$

With one degree of freedom, this figure was significant at the one per cent level. The Western Electric 4-C Test, scored with the Alpha method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Gardner method.

When the Gardner and Beta methods of scoring the Western Electric 4-C Test were compared with the individual pure tone test (Table 12), 58 students incorrectly classified by the Gardner method were properly classified by the Beta method. Eight students incorrectly classified by the Beta method were properly classified by the Gardner method. Substituting the values in Table 12 in the chi-square

Table 11. A comparison of the Alpha and Gardner methods of scoring- the Western Electric 4-C Test, considering performance on the individual pure tone test.

		Western Electric 4-C Test Scored With The Alpha Method			
		Incorrectly Classified	Correctly Classified	Total	
Western Electric 4-C Test Scored With The Gardner Method	Incorrectly Classified	28	43	71	N
		8.7	13.4	22.1	%
	Correctly Classified	2.5	243	251	N
			75.5	78.0	%
	Total	36	286	322	N
		11.2	88.9	100.0	

Table 12. A comparison of the Beta and Gardner methods of scoring the Western Electric 4-C Teat considering performance on the individual pure tone test.

		Western Electric 4-C Test Scored With The Beta Method		
		Incorrectly Classified	Correctly Classified	Total
Western Electric 4-C Test Scored With The Gardner Method	Incorrectly Classified	13 4.0	53 18.0	71 N 22.0 %
	Correctly Classified	8 2.5	243 75.5	251 N 73.0 %
	Total	21 6.5	301 93.5	*322* N 100.0 %

formula for correlated proportions with the correction for continuity,

$$\chi^2 = \frac{(|58-8| - 1)^2}{58+8} = 36.5$$

With one degree of freedom, this figure was significant at the one per cent level. The Beta method of scoring the 4-C Test correctly classified a significantly greater proportion of students than did the Gardner method of scoring the 4-C Test.

When the Alpha and Beta methods of scoring the Western Electric 4-C Test were compared with the individual pure tone test (Table 13), 15 students incorrectly classified by the Alpha method were correctly classified by the Beta method. No students incorrectly classified by the Beta method were correctly classified by the Alpha method. Substituting the values in Table 13 in the chi-square formula for correlated proportions with the correction for continuity,

$$\chi^2 = \frac{(|15 - 0| - 1)^2}{58+8} = 13.1$$

With one degree of freedom, this figure was significant at the one per cent level. The Beta method of scoring the Western Electric 4-0 Test correctly classified a significantly greater proportion of students than did the Alpha method of scoring the Western Electric 4-C Test.

Table 13. A comparison of the Alpha and Beta methods of scoring the Western Electric 4-C Teat, considering performance on the individual pure tone test.

		Western Electric 4-C Test Scored With The Beta Method		
		Incorrectly Classified	Correctly Classified	Total
Western Electric 4-C Test Scored With The Alpha Method	Incorrectly Classified	21 6.5	15 4.7	36 N 11.2 %
	Correctly-Classified	0	286 88.8	286 N 88.8 %
	Total	21 6.5	301 93.5	322 N 100.0 %

The Second Administration of the Purdue Modified Massachusetts Hearing Test

The Template Scoring Method. The second administration of the Purdue Modified Massachusetts Hearing Test was included in the experimental procedure to obtain a measure of test-retest reliability. Table 14 is a comparison of the results of the first and second administrations of the Purdue Modified Massachusetts Hearing Test, both scored with a template. Elghty-eipht per cent of the subjects performed identically on both tests. In other words, if they passed the test the first time, they passed it the second time; if they failed the test the first time, they failed the second time also. Twelve per cent received a different classification on each test. If they failed the first test, they passed the second test; if they passed the first test, they failed the retest. The 88 per cent figure represents the "repeatibility" of the group test. To measure the reliability the group test, an individual test, a group test, a second group test, and an individual test, in that order, would have had to have been given within a few days of each other. In that way, differences due to a real change in hearing from the time of one group test to that of a second group test would have been discovered and would not have been allowed to decrease the reliability. Unfortunately, a measure of reliability was not obtained in this study since a second individual test was not given.

Table 14. The results of the first and second administrations of the Purdue Modified Massachusetts Hearing Test, both scored with the template method.

Group Test 11

Group Test 1			Fail	Pass	Grades
Fail	N		16 (a)	7 (b)	3-4
	%		13.2	5.8	
Pass	N		12 (c)	36 (d)	
	%		9.9	71.1	

Group Test 11

Group Test 1			Fail	Pass	Grades
Fail	N		9 (a)	4 (b)	5-6
	%		9.1	4.0	
Pass	N		6 (c)	30 (d)	
	%		6.1	80.8	

Group Test 11

Group Test 1			Fail	Pass	Grades
Fail	N		6 (a)	2 (b)	7-3
	%		3.1	2.7	
Pass	N		7 (c)	59 (d)	
	%		9.5	79.7	

Table 14 (Continued). The results of the first and second administrations of the Purdue Modified Massachusetts Hear-inpr Test, both scored with the template method.

Group rest 11

Group Test 1		Fail	Pass	Grades
Fail	N	2	1	
	%	5.7 a	b 2.9	
Pass	N	1 c	d 31	9-10
	%	2.9	38.6	

Group Test 11

Group Test 1		Fail	Pass	Grades
Pail	N	1	1	
	%	4.3 a	b 4.3	
Pass	N	0	d 21	11-12
	%		91.3	

Group Test 11

Group Test 1		Fail	Pass	Grades
Fail	N	34	15	
	%	9.7 a	4.3 b	
Pass	N	26 c	d 277	3-12
	%	7.4	78.7	

A chi-square test was applied to these data to determine if there were a difference between the first administration of the Purdue Modified Massachusetts Hearing Test and the second administration of the Purdue Modified Massachusetts Hearing Test, both scored with a template. Substituting the values in Table 14 in the formula for correlated proportions with the correction for continuity,

$$X^2 = \frac{(|15-26|-1)^2}{15+26} = 2.44$$

With one degree of freedom, this figure was not significant at the five per cent level. There was no significant difference between the first administration of the Purdue Modified Massachusetts Hearing Test and the second administration of the Purdue Modified Massachusetts Hearing Test, both scored with the template method, in the proportions of students passed.

The Johnston Scoring Method. Table 15 is a comparison of the results of the first and second administrations of the Purdue Modified Massachusetts Hearing Test, both scored with the Johnston method. Ninety per cent of the students performed identically on both tests. Ten per cent of the students either failed the first test and passed the second test or passed the first test and failed the second test. Since a second individual test was not given, it is not known what part of this inconsistency was due to a real change of hearing from one testing time to another.

Table 15. The results of the first and second administrations of the Purdue Modified Massachu

setts Hearing Test, both scored with the Johnston method.

Group Test 11

Group Test 1		Fail	Pass
Fail	N	13	9
	%	10.7 [a]	[b] 7.4
Pass	N	[c] 9	[d] 90
	%	7.4	74.4

Grades 3-4

Group Test 11

Group Test 1		Fail	Pass
Fail	N	*8*	1
	%	*8.1* [a]	[b] 1.0
Pass	N	6 [c]	[d] 84
	%	6.1	84.5

Grades 5-6

Group Test 11

Group Test 1		Fail	Pass
Fail	N	4	3
	%	5.4 [a]	[b] 4.0
Pass	N	[c] 4	[d] 63
	%	5.4	85.1

Grades 7-8

Table 15 (Continued). The results of the first and second administrations of the Purdue Modified Massachusetts Hearing Test, both scored with the Johnston Method.

Group Test 11

Group Test 1		Fail	Pass	Grades
Fail	N	1	0	
	%	2.9		
Pass	N	1	33	9-1C
	%	2.9	94.3	

Group Test 11

Group Test 1		Fail	Pass	Grades
Fail	N	1	1	
	%	4.3	4.3	
Pass	N	0	21	11-12
	%		91.3	

Group Test 11

Group Test 1		Fail	Pass	Grades
Fail	N	27	14	
	%	7.6	**4.0**	
Pass	N	20	291	3-12
	%	5.7	82.7	

A chi-square test was applied to the data to determine if there were a difference between the first administration of the Purdue Modified Massachusetts Hearing Test and the second administration of the Purdue Modified Massachusetts Hearing Test, both scored with the Johnston method. Substituting the values in Table 15 in the chi-square formula for correlated proportions with the correction for continuity,

$$\chi^2 = \frac{(|14 - 20| - 1)}{14 + 20} = .73$$

With one degree of freedom, this figure was not significant at the five per cent level. There was no significant difference between the first and second administrations of the Purdue Modified Massachusetts Hearing Test, both scored with the Johnston method, in the proportions of students passed.

A Comparison of the Group Hearing Test Results

In order to determine which test and scoring method yielded the more valid results, the first administration of the Purdue Modified Massachusetts Hearing Test and the Western Electric 4-C Test, both scored with the various methods, were compared with each other and with the individual pure tone test (Table 16). The results were:

(1) The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a significantly greater proportion of students than did the

			The Western Electric 4-C Test					
			Gardner Method		Alpha Method		Beta Method	
			Incorrectly Classified	Correctly Classified	Incorrectly Classified	Correctly-Classified	Incorrectly Classified	Correctly Classified
Purdue Modified Massachusetts Hearing Test	Johnston Method	Incorrectly Classified	*8*	*9*	5	12	3	14
		Correctly Classified	63	242	31	274	18	287
		X^2	39.0*		7.5*		.281	
	Template Method	Incorrectly Classified	12	16	8	20	5	23
		Correctly Classified	59	235	28	266	16	278
		X^2	23.5*		1.0		.92	

Table 16. A comparison of the group tests, considering performance on the individual cure tone test. The figures marked with an asterisk were significant at the one per cent level.

Western Electric 4-C Test, scored with the Gardner method.

(2) The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Alpha method.

(3) There was no significant difference between the Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-C Test, scored with the Beta method, in the proportions of students correctly classified.

(4) The Purdue Modified Massachusetts Hearing test, scored with the template method, correctly classified a significantly greater proportion cf students than did the Western Electric 4-C Test, scored with the Gardner method.

(5) There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the template method, and the Western Electric 4-C Test, scored with the Alpha method, in the proportions of students correctly classified.

(6) There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the template method, and the Western Electric 4-C Test, scored with the Beta method, in the proportions of students correctly classified.

The primary purpose of a hearing test is to discover those persons that have an impairment of hearing. Since

the Johnston method of scoring the Purdue Modified Massachusetts Hearing Test and the Beta method of scoring the Western Electric 4-C Test were the best methods of scoring those tests, it would be advantageous to know how well these tests achieved their purpose. From Tables 6 and 10 it was noted that 21 persons failed the individual pure tone test. The Western Electric 4-C Test, scored with the Beta method, discovered six of these persons with hearing losses, or 28.6 per cent of the total of 21 persons with a hearing- impairment. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered 19 of these persons with hearing losses, or 90.5 per cent of the total of 21 persons with an impairment of hearing. When these two tests were compared with the individual pure tone test, considering only the 21 students with an impairment of hearing, the results pictured in Table 17 were obtained. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered 13 students with hearing- losses that were not detected by the Western Electric 4-C Test, scored with the Beta method. The Western Electric 4-C Test, scored with the Beta method, did not discover any students with hearing losses that were not detected by the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method. Substituting the values in Table 17 in the chi-square formula for correlated proportions with the correction for continuity,

Table 17. A comparison of the Johnston and Beta methods of scoring the group tests, considering performance on the individual pure tone test, when only the students with hearing losses Were used.

Purdue Modified Massachusetts Hearing Test Scored With The Johnston Method

		Hearing Losses Not Discovered	Hearing Losses Discovered	Total	
Western Electric 4-C Test Scored With The Beta Method	Hearing Losses Not Discovered	2	13	15	N
		9.5	61.9	71.4	%
	Hearing Losses Discovered	0	6	6	N
			28.6	28.6	%
	Total	2	19	21	N
		9.5	90.5	100.0	%

$$x^2 = \frac{(|13 - 0| - 1)^2}{13 + 0} = 11.1$$

With one degree of freedom, this figure was significant at the one per cent level. There was a significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-0 Test, scored with the Beta method, in the proportions of students having hearing losses which were discovered. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered a significantly greater proportion of the students having an impairment of hearing.

When the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-C Test, scored with the Alpha method, were compared with the individual pure tone test, considering only the 21 students with an impairment of hearing, the results in Table 18 were obtained. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered 13 students with hearing losses that were not detected by the Western Electric 4-C Test, scored with the Alpha method. The Western Electric 4-C Test, scored with the Alpha method, did not discover any students with hearing losses that were not detected by the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method. Substituting the values in Table 18 in the chi-square formula for correlated

Table 18. A comparison of the Johnston and Alpha methods of scoring the group tests, considering performance on the individual pure tone test, when only the students with hearing losses were used.

Purdue Modified Massachusetts Hearing Test Scored With The Johnston Method

		Hearing Losses Not Discovered	Hearing Losses Discovered	Total
Western Electric *4-C* Test Scored With The Alpha Method	Hearing Losses Not Discovered	2	13	15 N
		9.5	61.9	71.4 %
	Hearing Losses Discovered	0	6	6 N
			28.6	*28.6* %
	Total	*2*	19	21 N
		9.5	90.5	100.0 %

proportions with the correction for continuity,

$$X^2 = \frac{(|13 - 0| - 1)^2}{13+0} = 11.1$$

With one degree of freedom, this figure was significant at the one per cent level. There was a significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-C Test, scored with the Alpha method, in the proportions of students having hearing losses which were discovered. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered a significantly greater proportion of the students having an impairment of hearing.

When the Western Electric 4-C Test, scored with the Gardner method, and the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, were compared with the individual pure tone test, considering only the 21 students with an impairment of hearing, the results in Table 19 were obtained. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered five students with hearing losses which were not detected by the Wastern Electric 4-C Test, scored with the Gardner method. The Western Electric 4-C Test, scored with the Gardner method, did not discover any students with hearing losses that were not detected by the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method. Since these figures were too small to be treated with the

Table 19. A comparison of the Johnston and Gardner methods of scoring the group tests, considering performance on the individual pure tone test, when only the students with hearing losses were used.

Purdue Modified Massachusetts Hearing Test

Scored With The Johnston Method

		Hearing Losses Not Discovered	Hearing Losses Discovered	Total
Western Electric 4-C Test Scored With The Gardner Method	Hearing Losses Not Discovered	2 9.5	5	7 N 33.3 %
	Hearing Losses Discovered	0	14 66.6	14 N 66.6 %
	Total	2 9.5	19 90.4	21 N 99.9 %

chi-square test, the binomial expansion was used to evaluate the data. The probability of the distribution occuring by chance alone was 6.2 per cent. Since the probability did not meet the five per cent level of significance, it was concluded that there was no significant difference between the Western Electric 4-C Test, scored with the Gardner method, and the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, in the proportions of students having: hearing losses which were discovered. An inspection of the data in Table 19 suggests that, with an increase in the sample of hard of hearing subjects, the difference between the two tests could be significant at the five per cent level or better.

SUMMARY OP RESULTS

This study was undertaken to investigate the value of two group tests of hearing when used with elementary and secondary school children. The obtained results indicate that, within the limits of this study, i.e., experimental design, sample, procedure, equipment, statistical treatment, etc., the following summary may be offered:

1. An acceptable level for testing with the Purdue Modified Massachusetts Hearing Test was a 15 db level, so judged by loudness balancing, plus an attenuator increase of five db (Appendix C).

2. When compared with the individual pure tone test, the validity of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, was 93.5 per cent, the proportion of students correctly classified.

3. The test-retest reliability of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, was 90.3 per cent.

4. When compared with the individual pure tone test, the efficiency of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, was such that 0.6 per cent of the students had hearing losses which were not discovered, and six per cent of the students would have been needlessly retested.

5. When compared with the individual pure tone test,

the validity of the Purdue Modified Massachusetts Hearing Test, scored with the template method, was 90.3 per cent, the proportion of students correctly classified.

6. The test-retest reliability of the Purdue Modified Massachusetts Hearing Test, scored with the template method, was 88.4 per cent.

7. When compared with the individual pure tone test, the efficiency of the Purdue Modified Massachusetts Hearing Test, scored with the template method, was such that 0.8 per cent of the students had hearing losses which were not discovered, and 8.8 per cent of the students would have been needlessly retested.

8. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a significantly greater proportion of students than did the Purdue Modified Massachusetts Hearing Test, scored with a template.

9. When compared with the individual pure tone test, the validity of the Western Electric 4-C Test, scored with the Gardner method, was 77.9 per cent, the proportion of students correctly classified.

10. When compared with the individual pure tone test, the efficiency of the Western Electric 4-C Test, scored with the Gardner method, was such that 2.2 per cent of the students had hearing losses which were not discovered, and 19.9 per cent of the students would have been needlessly

retested.

11. When compared with the individual pure tone test, the validity of the Western Electric 4-C Test, scored with the Alpha method, was 88.9 per cent, the proportion of students correctly classified.

12. When compared with the individual pure tone test, the efficiency of the Western Electric 4-C Test, scored with the Alpha method, was such that 4.7 per cent of the students had hearing losses which were not discovered and 6.5 per cent of the students would have been needlessly retested.

13. When compared with the individual pure tone test, the validity of the Western Electric 4-C Test, scored with the Beta method, was 93.5 per cent, the proportion of students correctly classified.

14. When compared with the individual pure tone test, the efficiency of the Western Electric 4-C Test, scored with the Beta method, was such that 4.7 per cent of the students had hearing losses which were not discovered, and 1.9 per cent of the students would have been needlessly retested.

15. The Western Electric 4-C Test, scored with the Alpha method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Gardner method.

16. The Western Electric 4-C Test, scored with the

Beta method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Alpha method.

17. The Western Electric 4-C Test, scored with the Beta method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Gardner method.

18. The Purdue Modified Massachusetts Hearing Test, scored with the template method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Gardner method.

19. There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the template method, and the Western Electric 4-C Test, scored with the Alpha method, in the proportions of students correctly classified.

20. There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the template method, and the Western Electric 4-C Test, scored with the Beta method, in the proportions of students correctly classified.

21. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Gardner method.

22. The Purdue Modified Massachusetts Hearing Test,

scored with the Johnston method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Alpha method.

23. There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-0 Test, scored with the Beta method, in the proportions of students correctly classified.

24. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered a significantly greater proportion of the students having an impairment of hearing than did the Western Electric 4-C Test, scored with the Beta method.

25. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered a significantly greater proportion of the students having an impairment of hearing than did the Western Electric 4-C Test, scored with the Alpha method.

26. There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-C Test, scored with the Gardner method, in the proportions of students having hearing losses which were discovered.

CONCLUSIONS

The Purdue Modified Massachusetts Hearing Test, scored with either the Johnston or template method, proved to be en efficient and valid instrument. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a significantly greater proportion of students than did the Purdue Modified Massachusetts Hearing Test, scored with the template method. In actual practice it is recommended that the Johnston method of scoring be used since it proved to be not only more efficient and valid, but also more rapid than the template method.

The Beta method of scoring the Western Electric 4-C Test was more efficient and valid than either the Gardner or Alpha method. The Western Electric 4-C Test, scored with the Beta method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with either the Gardner or Alpha method. The increase in cutting score from nine and 12 db, as in the Gardner method, to 21 db, as in the Alpha and Beta methods, resulted in a more efficient test, in Newby's sense, but not as many pupils with hearing losses were detected.

The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a

significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Gardner method. However, there was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-C Test, scored with the Gardner method, in the proportions of students having hearing impairments which were discovered.

The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, correctly classified a significantly greater proportion of students than did the Western Electric 4-C Test, scored with the Alpha method. Also, the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered a significantly greater proportion of students who had an impairment of hearing than did the Western Electric 4-C Test, scored with the Alpha method.

There was no significant difference between the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, and the Western Electric 4-C Test, scored with the Beta method, in the proportions of students correctly classified. However, the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, discovered a significantly greater proportion of the students who had an impairment of hearing than did the Western Electric 4-C Test, scored with the Beta method.

A good hearing test should: (a) correctly classify a large proportion of the sample tested; and (b) discover a large proportion of the sample having an impairment of hearing. The Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, met both of these criteria satisfactorily. No single method of scoring the Western Electric 4-C Test was able to match the performance of the Purdue Modified Massachusetts Hearing Test, scored with the Johnston method, on both of these criteria.

A P P E N D I C E S

BIBLIOGRAPHY

1. Audio Development Company. The Artificial Ear, Model D5153.

2. Becker, M. A., An Investigation of the Efficiency of a. Modified Form of the Massachusetts Group Pure Tone Screening Test As"Used in the Syracuse University Freshman Testlng Program. Master of Arts Thesis, Syracuse University, 1951.

3. Beranek, Leo L., Acoustic Measurements. New York: John Wiley and Sons, 1950.

4. Ciocco, Antonio and Palmer, Carroll E., The Hearing of School Children; A Statistical Study of Audio-metric and Clinical Records. Monographs of the Society for Research in Child Development. National Research Council Publication, Vol. 6, No. 3, 1941.

5. Dahl, Loraine A., Public School Audiometry: Principles and Methods. Danville: Interstate, 1949.

6. DiCarlo, Louis M. and Gardner, Eric F., The Efficiency of the Massachusetts Pure Tone Screening Test as Adapted for a University Testing Program. Journal of Speech and Hearing Disorders. 1953, 18, 175-182.

7. Edwards, Allen L., Experimental Design in Psychological Research. New York: Rinehart and Company, 1950.

8. Gardner, W. H., Instructions for Conducting Audiometer Tests. Washington! American Hearing Society.

9. Gardner, W. H., Report of the Committee on Hard of Hearing Children of the American Hearing Society. Hearing News. 1950, 18, 5-8.

10. Harris, J. Donald, Group Audiometry. Journal of the Acoustical Society of America. 1945, 17, 73-761

11. Hewlett Packard Corporation. Instruction Manual, Harmonic Wave Analyzer, Model 300A.

12. Johnston, P. W., The Massachusetts Hearing Test. Journal of the Acoustical Society of America. 1948, 20, 697-703.

13. Newby, Hayes A., A Group Pure Tone Hearing Test For Use In The Public Schools. Doctor of Philosophy Thesis, State University of Iowa, Iowa City, June 1947.

14. Newby, Hayes A., Evaluating the efficiency of Group Screening Tests of Hearing. Journal of Speech and Hearing Disorders, 1948, 12, 236-240.

15. Newhart, Horace, Audiometric Testing and Hearing Conservation in the Public Schools. Journal of Speech and Hearing Disorders. 1943, 8, 237-242.

16. Newhart, H. and Reger, S. N., Syllabus of Audiometric Procedure in the Administration of a Program for the Conservation of Hearing of School Children. Supplement to the Transactions of the American Academy of Ophthalmology and Otolaryngology. 1940.

17. Peterson, Gordon E., The Pure Tone Screen Test of Hearing. Journal of Speech Disorders. 1944, 9, 114-120. =

13. Reger, S. N. and Newby, H. A., A Group Pure Tone Hearing Test. Journal of Speech Disorders. 1947, 12,

19. Rodin, Frank H., A Survey of the Hearing of School Children in San Francisco. Archives of Otolaryneology. 1930, 11, 463-474.

20. Spilka, B. and Steer, M. D., Incidence of Speech and Hearing- Deficiency in the General Population and Schools of the U. 1951. Purdue University Speech and Hearing Clinic Research Staff Report Ho. 2. Unpublished, but Mimeographed, 1951.

21. Steinburg, J. C, Montgomery, H. C, and Gardner, M. B., Results of the World's Fair Hearing Tests. Journal of the Acoustical Society of America. 1940, 12, 291-301.*

22. Sullivan, Margaret, Auditory Acuity and Its Relation to Defective Speech. Journal of Speech Disorders. 1944, 9, 127-130.

23. Watson, L. E. and Tolan, T. T., Hearing Tests and Hearing Instruments. Baltimore: The Williams and Wilkins Company, 1949.

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