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Relationship between minimal hearing loss and academic achievement

Linda R. Kundert
The University of Montana

THE RELATIONSHIP BETWEEN

MINIMAL HEARING LOSS AND ACADEMIC ACHIEVEMENT

By

Linda Kundert

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Approved by:

Robert B. Chaney

Chairman, Board of Examiners

John M. Stewart

Dean, Graduate School

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INTRODUCTION

The importance of hearing-conservation programs for the preservation of hearing and the prevention of hearing loss has been recognized, particularly the role of identification audiometry for the detection of significant losses in school-age children. However, relatively little concern has been elicited regarding minimal hearing loss, an average loss between 5 and 25 dB[1] across the speech frequency range, and its possible effects. This situation probably exists because routine hearing-conservation programs, particularly the identification audiometry portion, have not been designed to detect losses of this small magnitude. As a result, any relationship such a loss may have to academic achievement would be overlooked. This study attempted to determine if such a relationship does, in fact, exist.

THE PROBLEM AND PURPOSE

Historically, a typical hearing-conservation program for school-age children is expected to provide at least the following components:

1) prevention of hearing loss,
2) identification of hearing losses which exist,
3) diagnosis of hearing losses to determine their type and severity,
4) medical and educational treatment, and
5) medical and educational follow-up.

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[1]For the purpose of this study, all decibel readings are related to ISO standards; therefore, where ASA standards are quoted, they have been converted into ISO standards to the nearest 5 dB.

All too often schools do not have meaningful programs, but only that portion of a conservation program known as identification or hearing-screening programs. Typically, these identification programs have been designed merely to identify hearing losses without any attempt to determine severity, type, responsibility for, or treatment of any losses discovered. Darley (1961) proceeded to justify these limits:

> Identification audiometry is only one important aspect of a hearing conservation program, that limited part of it planned specifically for the most efficient and earliest possible detection of those persons whose hearing behavior suggests that they warrant further, more definitive examination (p. 9).

The program of identification audiometry, as it is usually performed, consists of the following steps:

1) An initial sweeptest or screening test on a pass-fail basis.

   a) No less than four, and preferably five, frequencies are usually recommended. These frequencies are: 500, 1000, 2000, 4000, and 6000 Hz (Darley, 1961). In the interest of efficiency and economy of time, however, only three frequencies are often employed in one of the following combinations: 500, 1000, and 2000 Hz; 1000, 2000, and 4000 Hz; or 500, 1000, and 4000 Hz.

   b) An intensity level of 20 dB is recommended in a sweeptest or screening test for the following frequencies: 1000, 2000, and 6000 Hz and 25 dB at 4000 Hz. Darley (1961) suggests these intensity levels since ". . . disability in understanding speech in some situations begins at about 25 dB above audiometric zero (Darley, 1961, p. 31)." Therefore, screening at a level of 20 dB ". . . results in a clear labeling of the person who has a 25 dB hearing loss as warranting further attention (Darley, 1961, p. 21)."

2) A second screening test with the same criteria within one or two weeks for those failing the initial test.

3) A referral for threshold evaluation of those children failing the second screening test.

At this stage in a true hearing-conservation program, a follow-up program should be initiated to insure that the diagnostic, educational, and medical needs of the child with impaired hearing are met (Sommers, 1966, and Darley, 1961).

The 1960 National Conference on Identification Audiometry has recommended all children in kindergarten and grades 1, 2, and 3 be tested annually along with all new students to the school. Frequent testing during the early years of schooling implements earlier educational and medical treatment for the hearing impaired child. In following years, testing need not be so frequent, although the interval between tests should not exceed three years.

The specific goal of identification audiometry in school-age children, therefore, is to discover any hearing losses so that whatever other available services, such as medical treatment and educational remediation, may be provided.

What identification audiometry programs of this type do not do is identify the existence of minimal hearing losses which tend to be overlooked since they have typically been categorized as being "within normal limits." Such minimal losses, therefore, often go undetected by routine identification audiometry. As a result, the child with a minimal loss may be experiencing more difficulty than the child with "normal hearing" since Eagles, Wishik, Doerfler, Melnick, and Levine (1963) have shown that more than 65% of the children in a given class will have hearing levels better than 0 dB with some hearing as well as -15 dB. Thus it is possible to have an average hearing level as much as 35 dB poorer than some of the children in the class and still be labeled as "normally hearing." The teacher, and possibly the child, may thus be unaware of any problem. Curry (1950) found that teachers were ineffective in identifying children with hearing losses. Children with a minimal hearing loss are often judged by teachers as slow learners, underachievers, and as behavioral and emotional problems (Sommers, 1966, and Goetzinger, Harrison, and Baer, 1964). In cases where unnoticed minimal hearing losses exist, speech and language development may not reach the level of acoustically unimpaired children, thereby, potentially affecting their academic performance (Goetzinger, Harrison, and Baer, 1964); at the very least, the demands on the child's attentiveness would seem to be increased.

As a further complicating factor in identification audiometry, the screening typically does not take place in an adequate acoustic environment such as a sound-treated room or booth. As a result, excessive ambient noise emanating from the environment may sometimes result in the raising of screening levels to eliminate over-referral of children with normal hearing. However, this also results in "passing" children who would normally have "failed" the screening test at the recommended intensity level, particularly those children with hearing poorer than even those with minimal losses.

Typical identification programs not only fail to identify minimal hearing losses per se, but historically, they have also proved to be inadequate in identifying related pathologies. For instance, medically treatable otological pathologies, which may cause a hearing loss, are often not identified by identification programs. According to Eagles, et al. (1963), and Jordan and Eagles (1961), children with otoscopic abnormalities exhibited less sensitive hearing levels than those without abnormalities; however, the minimal hearing losses due to medically treatable factors such as obstructions of the auditory canal, perforations of the tympanic membrane, and infections are often not great enough to be identified by typical identification procedures. When screened at 20 dB, dry perforations were not identified sixty percent of the time; serous otitis media was not identified eighty-five percent of the time (Jordan and Eagles, 1961).

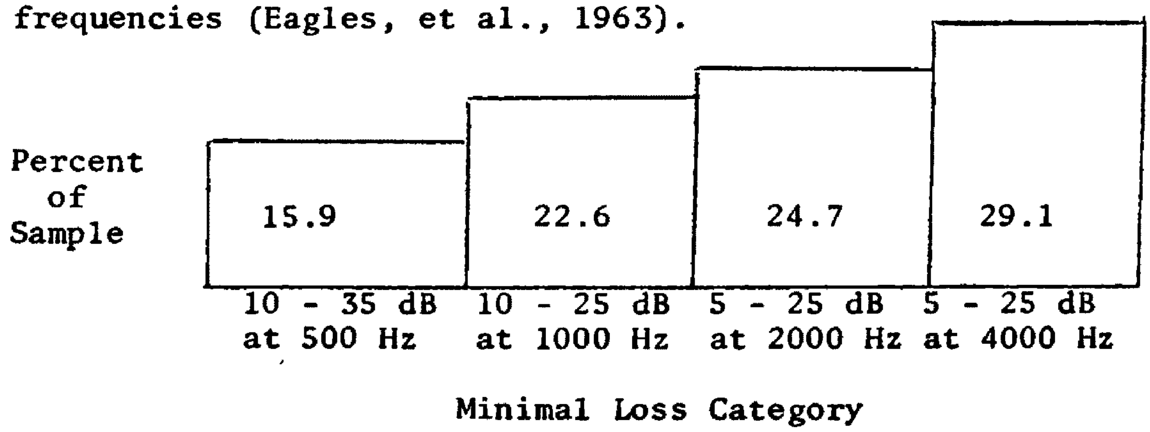
Eagles, et al. (1963), found 15.2% of the children tested exhibited otological abnormalities; 20% of these abnormalities were current pathologies while 80% exhibited signs of past pathologies. The greatest depression of sensitivity occurred in the presence of acute and chronic disease while those with signs of healed or past disease showed comparatively more sensitive hearing levels. Those children with an abnormality in one ear generally had better hearing levels than those with abnormalities of both ears.

The most significant signs related to less sensitive hearing levels were earache and ear discharge. The degree of lessened sensitivity was greater when combined with infection whether present or past. Frequency of earaches or discharge was also associated with the depression of auditory acuity levels. The presence of both problems was related to less sensitive levels more frequently than were just earaches. If surgery has been performed to relieve earaches or discharge, levels tended to be more sensitive than if no surgery was performed (Eagles, et al., 1963). Therefore, surgery to correct otological abnormalities which are related to minimal hearing losses will improve hearing sensitivity if they are discovered and referred.

It is clearly evident that although the major goal of identification audiometry is to detect existing hearing losses, identification programs have failed to single out a significant category of hearing loss that has been shown to have a definite relationship to otological pathology and at least a suggestion of relationship to academic achievement as may be seen in the following.

Studies of degrees of hearing loss in the school-age population have occasionally classified children into minimal loss categories as well as into more severe categories. Weber, McGovern, and Zink (1967), in a study in Colorado of 1000 children, kindergarten to grade 12, over a five-year period from 1960 to 1965, found that from 46% to 59.5% in various years had losses of 25 dB or less. This study also revealed 12.6% of the losses were flat with variations of 10 dB or less per octave and 9.5% revealed a downward slope of 5 to 10 dB per octave but not exceeding 30 dB at the point of maximum loss. The study by Eagles, et al., (1963) revealed approximately twenty-four percent of the children tested had hearing losses which could be classified as minimal (see Figure 1).

Figure 1. Percent of sample having minimal hearing losses at four frequencies (Eagles, et al., 1963).



Although the figures of the two studies are somewhat discrepant, it is evident that a significant population exists whose hearing may be classified in the minimal hearing loss category. Typically, however, little attention has been given to losses in this range since they are within the present classification of "normal limits."

A survey of the literature reveals several studies relating hearing loss and academic achievement which have used populations of deaf or severely hard-of-hearing children from residential schools. The effects of hearing loss on academic achievement is clearly evident in these studies. According to Myklebust (1966), children who have been deaf from early life are retarded at least three years in educational achievement. In the National Study, cited by Myklebust (1964), which compared scores of normally hearing children and deaf children on the Columbia Vocabulary Test, the deaf children were severely retarded at all age levels.

> Comparatively, the child with profound deafness shows much less progression and growth in the acquisition of reading vocabulary. As he reaches the age at which the hearing child completes high school, his ability to read is below that of the average nine years old child, or below the third grade level. These results indicate that when he complete his regular schooling, the deaf child is retarded seven to eight years in reading vocabulary (p. 278).

Although the deaf child's reading vocabulary is severely retarded, his total educational achievement is not as severely affected; however, such a deficit in this important "tool" subject does influence his academic achievement.

Data from the Annual Survey of Hearing Impaired Children and Youth (1969) reported by Gentile and DiFrancensca categorized 12,000 students by chronological age and hearing threshold level. According to the data, the majority of students whose hearing loss was between 30 and 60 dB had poorer grade equivalents than children with normal hearing of the same age. For example, on the Intermediate I Battery of the Stanford Achievement Test, the majority of sixteen-year-old students with a loss no worse than 60 dB fell below the fourth grade equivalent.

Davis and Silverman (1970) cite several studies which also indicate that academic achievement is affected by hearing loss:

1) Hall and Fusfeld reported that educational achievement level of students entering Gallaudet College was from 9.2 mean grade equivalent in 1929 to 10.0 in 1932.

2) Boatner (1964) reported a grade level achievement of 8.2 for those over 16 years of age who received academic diplomas from residential schools for the deaf.

3) The Babbidge report indicated that of 920 students leaving residential schools between 1963 and 1964, no student achieved a median seventh-grade level at any age.

It is not unreasonable to postulate that hearing thresholds exist along a continuum. If a severe hearing loss or deafness results in academic deprivation to a severe degree, it may be hypothesized that a minimal hearing loss will also affect a child's academic achievement, although to a lesser degree. Given the poor acoustic environments of many classrooms, therefore, it is not unreasonable to assume that a child who hears as much as 25 dB poorer than many of his peers may simply "miss" much of what is being said. And thus he might be expected to show, at least to some degree, some academic deprivation.

The problem, therefore, was to determine whether a relationship can be shown between academic achievement and minimal hearing loss. Although the children with minimal losses apparently may not possess hearing acuity as acute as that of their "normal-hearing" classmates, their hearing still may be classified as "good" since their hearing levels fall "within normal limits." Such a problem, resulting from a minimal loss, may be related to poorer academic achievement, especially in language areas of vocabulary and reading. It was postulated, however, that academic achievement, as a whole, may be affected due to the predominence of oral, verbal instructions in the early grades and the effects of the resulting deficits in the "tool" subjects.

In order to determine whether such a relationship can be shown to exist, the following hypotheses were put forth:

1) the incidence of children with minimal hearing losses will be greater below the class median than above on the vocabulary subtest of the Iowa Tests of Basic Skills.

2) the incidence of children with minimal hearing losses will be greater below the class median than above on the reading comprehension subtest of the Iowa Tests of Basic Skills.

3) the incidence of children with minimal hearing losses will be greater below the class median than above on the composite academic achievement score of the Iowa Tests of Basic Skills.

DEFINITIONS OF TERMS

"Academic achievement" is defined as the composite score for all subtests on the Iowa Tests of Basic Skills for each child within the sample.

"Reading comprehension" is the score achieved on the reading comprehension subtest of the Iowa Tests of Basic Skills for each child within the sample.

"Vocabulary" is the score achieved on the vocabulary subtest of the Iowa Tests of Basic Skills for each child within the sample.

The "median" is the score dividing the upper and lower halves of the class. Since scores equaling the median score occurred above the median or the scores on each side were equal, it was arbitrarily set, for the purposes of this study, just above all scores equal to the median.

"Minimal hearing loss," for the purposes of this study, is defined as pure tone thresholds by air conduction occurring within the following ISO limits:

10-35 dB at 500 Hz
10-25 dB at 1000 Hz
5-25 dB at 2000 Hz

An individual was placed in this category if his pure tone threshold responses for all three frequencies occurred within the above described range in the better ear which was determined by pure tone averages. The better limits were derived by converting the mean hearing level of the male population for the right ear obtained in the study by Eagles, et al. (1963), into ISO standards to the nearest 5 dB. The right ear and the male sex were arbitrarily selected for determining the limits for this study since no significant difference was found between ears and since the greatest difference of 2.5 dB between sexes was not considered to be clinically significant by Eagles, et al., (1963). This impression may be obtained from an inspection of the mean hearing levels in each ear of both sexes displayed in Table 1. The poorer limits were defined by the typical cut-off limits for the category of normal hearing.

Table 1. Mean Hearing Levels for Otoscopically Normal Children Classified by Sex of Child, Frequency, and Ear Tested (Eagles, et al., 1963, p. 197).

Frequency	Mean Hearing Level in dB for Males		Mean Hearing Level in dB for Females	
	Right Ear	Left Ear	Right Ear	Left Ear
250	5.9	4.9	6.2	5.4
500	7.8	7.4	7.2	7.0
1000	5.8	5.8	5.5	5.2
2000	4.8	5.2	4.6	4.2
4000	3.1	3.9	1.9	3.8
6000	9.0	10.0	6.9	7.4

CHAPTER II

EXPERIMENTAL PROCEDURE

The academic achievement scores of the thirty-seven (37) subjects exhibiting minimal hearing losses were compared to those of their ninety-eight (98) peers with normal hearing.

SUBJECTS

The sample for this investigation consisted of children from six regular fourth grade classrooms from three low socio-economic schools, as classified by school administrators of the Missoula, Montana, School District #1. Individual class enrollments ranged from twenty (20) to twenty-six (26); the total number in the sample equaled 135 children. The fourth grade was selected in order to minimize validity problems which might occur with this particular test in the third grade (the earliest grade in which it is administered). Schools from low socio-economic areas were used in order to minimize the effect socio-economic status might have on minimal hearing loss and academic achievement. It was also recognized that intelligence would be a potent factor in academic achievement; it was hoped, therefore, that the choice of lower socio-economic classes would tend to minimize the range of intellectual variability.

TESTS

The desired scores achieved on the Iowa Tests of Basic Skills were obtained from the school records for each of the children after all audiometric testing had been completed. This test was selected for estimating academic achievement because: 1) it is administered to all children in grades 3 through 9 in the Missoula, Montana, Public Schools, 2) it has established time limits for each subtest, 3) the directions read by the teacher are standardized, 4) the test was standardized on a stratified random sample of the United States, and 5) national norms are available.

A pure tone audiometric threshold examination by air conduction for three frequencies (500, 1000, and 2000 Hz) was administered to each of the children by a student with at least twelve quarter hours of audiology which included clinical experience. A modification of the Hughson-Westlake technique, an ascending technique of threshold determination, was employed (see Appendix A). Only air conduction results were obtained since it was not the purpose of this study to make audiological diagnosis from these findings. The threshold tests were used for the identification of minimal hearing losses. The three frequencies were chosen since they sampled the speech range.

EQUIPMENT

All subjects had their hearing tested in sound-treated booths housed in the mobile unit belonging to the University of Montana Speech and Hearing Clinic in order to limit the level of ambient noise which might interfere with accurate threshold measurement. Two Beltone audiometers, Model 15-C and Model 10-D, calibrated to ISO 1964 reference levels were employed for the hearing testing. The audiometers were calibrated with an artificial ear before testing began. After the testing was completed, they were again calibrated and found not to deviate from the original calibration by 5 dB or more. At the beginning of each testing period, the examiner tested her own hearing on the audiometers to determine whether they remained in calibration. Tones were presented through TDH-39 earphones in aural domes.

TASK

Each child was seen separately in one of the sound-treated booths of the mobile unit. The examiners instructed each child as follows:

> We are going to see how well you hear. You are going to hear some tones through these earphones. When you hear a tone on the right side (touch righ ear), raise your right hand high and keep it up as long as you hear the tone. What will you do if you hear the tone on this side? (touch left ear). (If the child did not raise his left hand, the examiner touched that arm and said, "You'd raise this hand for as long as you heard the tone.")

If the child did not appear to understand the directions, the examiner repeated the procedure until he was positive the child comprehended the task. During periods of recess, when ambient noise levels might possibly have interfered with the evaluation of threshold levels, testing was discontinued by the examiners until the noise level was reduced to a degree that it would not interfere with the measurement of accurate thresholds.

Pure tone averages were computed for each ear of each child in order to determine which was his "better" ear; he was then classified as having a minimal hearing loss or no hearing loss by the better ear. If the pure tone averages for both ears were equal, the right ear was arbitrarily selected as the "better" ear. All those children with greater than minimal hearing losses in the better ear were eliminated from the study (see Appendix B, Table I).

The raw scores and percentile rankings for the vocabulary and reading comprehension subtests and for the composite achievement were collected for each child after all audiometric testing for all schools in the study had been completed. The raw scores and percentile rankings were then rank ordered by class in order to determine the median for each class and the positioning of those with minimal hearing losses (see Appendix B, Table II).

CHAPTER III

RESULTS AND DISCUSSION

It was hypothesized in this investigation that a minimal hearing loss would affect academic achievement as measured by three sections of the Iowa Tests of Basic Skills:

a) vocabulary
b) reading comprehension
c) composite academic achievement.

The experimental hypotheses for this study are as follows:

Hypothesis A: the incidence of children with minimal hearing losses will be greater below the class median than above on the vocabulary subtest of the Iowa Tests of Basic Skills.

Hypothesis B: the incidence of children with minimal hearing losses will be greater below the class median than above on the reading comprehension subtest of the Iowa Tests of Basic Skills.

Hypothesis C: the incidence of children with minimal hearing losses will be greater below the class median than above on the composite academic achievement score on the Iowa Tests of Basic Skills.

The null hypotheses, as a result, are:

Null Hypothesis A: the incidence of children with minimal hearing losses will be equal above and below the class median on the vocabulary subtest of the Iowa Tests of Basic Skills.

Null Hypothesis B: the incidence of children with minimal hearing losses will be equal above and below the median on the reading comprehension subtest of the Iowa Tests of Basic Skills.

Null Hypothesis C: the incidence of children with minimal hearing losses will be equal and below the class median on the composite academic achievement score on the Iowa Tests of Basic Skills.

The chi-square was chosen as the statistical test because the sample consisted of two discrete classes, and was dichotomized as having a minimal hearing loss or no hearing loss and as having achievement scores above or below the median. In view of the large number of interacting factors affecting academic achievement, of which hearing loss may only be one, the significance level of .10 was selected in order to avoid the possibility of not rejecting the null hypotheses when, in fact, they should have been rejected. It was realized, however, that the possibility of accepting the experimental hypotheses, when they should have been rejected, was increased. In this particular study, however, it appeared that the risk of rejecting the null hypotheses, and thereby indicating a relationship exists between academic achievement and minimal hearing loss, would be fare less detrimental than assuming that no difference occurs in academic achievement between children with minimal hearing losses and those with normal hearing.

This criterion (a significance level of .10) was applied to the statistical evaluation of the hypotheses. The analysis was made on the total sample.

RESULTS

In using the chi-square evaluation to compare the incidence with which children with minimal hearing losses were found above and below the class median of achievement scores, no significant difference was noted at the .10 level of significance between children with minimal hearing loss and those with no hearing loss on the vocabulary subtest on composite academic achievement. Therefore, hypothesis A and hypothesis C were rejected. However, a significant difference resulted at the .10 level between children with minimal hearing loss and those with normal hearing on the reading comprehension subtest; as a result, hypothesis B (reading comprehension) was not rejected. The results are displayed in Table 2.

Table 2. Chi-square analysis of the frequency with which children with minimal hearing loss and those with normal hearing are found above and below their class median score on three divisions of the Iowa Tests of Basic Skills.

Test	Minimal Hearing Loss		Normal Hearing		df	χ^2
	Above Median	Below Median	Above Median	Below Median		
Vocabulary	15	22	47	51	1	.599
Reading Comprehension	13	24	52	46	1	3.436*
Composite Achievement	16	21	45	53	1	.073

*p<.10

Since the analysis of the incidence with which children with minimal hearing losses are found above and below the class median was significant only in the area of reading comprehension, it appeared that the achievement scores of children with minimal hearing losses might reveal more information concerning the hypothesized relationship between minimal hearing loss and academic achievement. The hypotheses were, therefore, revised as follows:

> Hypothesis A': the mean score of children with minimal hearing losses will be poorer than the mean score of children with normal hearing both above and below the median on the vocabulary subtest of the Iowa Tests of Basic Skills.

> Hypothesis B': the mean score of children with minimal hearing losses will be poorer than the mean score of children with normal hearing both above and below the median on the reading comprehension subtest of the Iowa Tests of Basic Skills.

Hypothesis C': the mean score of children with minimal hearing losses will be poorer than the mean score of children with normal hearing both above and below the median on the composite academic achievement score of the Iowa Tests of Basic Skills.

The chi-square analysis, comparing the mean achievement scores above and below the class median of children with minimal losses and of those with normal hearing, resulted in no statistically significant difference at the .10 level when applied to all three measures of achievement. Therefore, the hypotheses for all three measures of academic achievement were rejected when applied to the total sample. The results are shown in Table 3.

Table 3. Chi-square analysis of mean achievement scores above and below the class median score of children with minimal hearing loss and children with normal hearing on three divisions of the Iowa Tests of Basic Skills.

Test	Minimal Hearing Loss		Normal Hearing		df	X^2
	Mean Above Median	Mean Below Median	Mean Above Median	Mean Below Median		
Vocabulary	49.533	31.727	48.979	33.961	1	.137
Reading Comprehension	52.462	31.833	47.75	32.413	1	.59
Composite Achievement	47.5	33.905	47.8	35.415	1	.021

*$p<.10$

The t-test was then applied to the differences of the mean scores of children with minimal hearing loss and of those with normal hearing without regard to their position relative to their class median on all three areas of achievement. Using this procedure, the difference between the mean scores of children with minimal hearing losses was statistically significant at the .10 level for hypothesis A' (vocabulary), and was, therefore, not rejected. Neither of the *t*-values for hypothesis B' (reading comprehension) nor C' (composite academic achievement) were significant at that level and were, therefore, rejected when applied to the total sample. The results of the *t*-test are reported in Table 4.

Table 4. Means and *t*-values of difference scores between children with minimal hearing losses and children with normal hearing on three divisions of the Iowa Tests of Basic Skills.

Test	Means		df	t
	Minimal Hearing Loss	Normal Hearing		
Vocabulary	38.946	41.112	133	.952*
Reading Comprehension	39.081	40.551	133	.623
Composite Achievement	39.784	41.102	133	.748

*p<.10

Although the results of the statistical analyses do not coincide on all measures, the percentages of the occurrence of minimal hearing loss within the sample were high enough to be considered worthy of notice. The percentages are displayed in Table 5.

Table 5. Percentages of minimal hearing loss within the sample population.

Population	N	Percent
School A	10	25.0
Class 1	6	30.0
Class 2	4	20.0
School B	12	25.0
Class 3	7	26.9
Class 4	5	22.7
School C	15	31.9
Class 5	6	25.0
Class 6	9	39.1
Total	135	27.4

DISCUSSION

According to the results of this study, the academic achievement of children with minimal hearing losses, as a whole, was not affected to a significant degree by a minimal loss. However, analysis of the data indicated that the language areas of vocabulary and reading comprehension are affected to a significant degree by a minimal loss as hypothesized. However, these latter relationships remain somewhat tenuous since the first chi-square analysis resulted in a significant relationship between minimal hearing loss and reading comprehension (hypothesis B) while the second chi-square analysis resulted in the rejection of all three hypotheses (A', B', and C'). The relationship between vocabulary and minimal hearing loss (hypothesis A') proved to be significant when the _t_-test was applied.

The relationship of academic achievement to minimal hearing loss may prove to be significant to a greater degree of several sources of variability are controlled which were not accounted for in this study. The main factor which may have had a significant effect, but was not controlled, was that of intelligence. The data revealed that children with minimal hearing losses occurred randomly throughout their classes; the occurrences ranged from three of the four highest ranked scores in one class to four of the lowest ranked scores in another. Therefore, intelligence may play a large role and should be controlled in future studies.

Socio-economic status may have also played a larger role than accounted for since so many other variables interact in the low-income group used in this study such as environmental stimulation, less stress on academic achievement, and untreated minor medical problems.

The grade level selected for this investigation may have also been a vital factor; had a higher grade level been chosen, the difference in the mean scores between those with minimal hearing losses and those with normal hearing may have been widened due to the effect of a hearing loss over a period of school years.

Also, the threshold measurements may have been more reliable, not deviating more than 5 dB, with an older population. As much as 10 to 15 dB variation may have occurred with the young population used in this study.

The significance of the relationship between minimal hearing loss and the vocabulary and the reading comprehension measurements leads to some educational implications. Lindquist and Hieronymus (1956) state in their Manual for Administrators, Supervisors, and Counselors (Iowa Tests of Basic Skills):

> A pupil's vocabulary depends to a large extent upon richness of language experiences in his home background and upon incidental in-school and out-of-school language experiences. It also depends on the richness of experiences in the school program, but in most schools, pupils receive very little instruction specifically designed to increase their "word power" (p. 52).

It is evident, therefore, that the child with a minimal hearing loss is deprived in vocabulary-building situations, not only in the school situation, but in his everyday experiences. This source of deprivation is particularly significant when research has indicated that vocabulary was predictive of achievement on the Iowa Tests of Basic Skills in reading and spelling (Stroud, Blommer, and Lauber, 1957); vocabulary is also the single best predictor of success in social studies, reading, science, and arithmetic in the ninth grade (Conklin and Dockrell, 1967). Since the child with a minimal hearing loss does not typically receive specific help in vocabulary skills in the classroom, the educational gap between the child with a minimal hearing loss and the child with normal hearing is probably increased. In a study cited by Myklebust (1966), the degree of retardation on the Columbia Vocabulary Test increased with age in children with hearing impairments; in children with normal hearing, vocabulary increases with age. It would appear from this information that retardation in vocabulary resulting from a minimal hearing loss has long-term educational implications.

According to Myklebust (1966), measurements of reading comprehension are often made on the assumption ". . . that if the child can choose the proper word or phrase, he comprehends the meaning. Such an assumption is valid for normal children, for children who have a wealth of language at their disposal . . . (p. 275)." He states that this does not happen with the deaf child who often makes his choice by matching words from the selection of possible answers to the paragraph or sentence instead of responding to the meaning of the total paragraph. Lindquist and Hieronymus (1956) support this contention stating that ". . . short-response items are more likely to be answerable through a process of matching words . . . without any real understanding (p. 54)." As a result, on the Iowa Tests of Basic Skills, the reading comprehension subtests employ somewhat longer items. Therefore, it appears the child with a minimal hearing loss may well be handicapped in reading comprehension, first of all, because he lacks the "wealth of language" since he may be deprived in vocabulary-building situations, and secondly, because he may need to depend on matching words, at least to some extent for measures of comprehension. Since reading is the main source of the acquisition of knowledge in most formal methods of education, the long-term educational implications, again, are powerful.

The results of this investigation suggest that a relationship exists between minimal hearing loss and achievement in vocabulary and reading comprehension. It did not appear that academic achievement, as a whole, is affected. Due to the fact that all statistical analyses did not coincide and, thereby, establish a strong case for the relationship between minimal hearing loss and the three areas of academic achievement, the possibility cannot be eliminated that a child with a minimal hearing loss may have achieved a higher ranking in his class had he not possessed a hearing loss. Therefore, it may be beneficial to treat this child as if, in fact, his loss does have a significant affect on his academic achievement. In this instance, it appears that it may be less detrimental to err in the direction of conservative management, rather than to attribute no significance to this category of hearing loss, when it may, in fact, have an effect.

CHAPTER IV

SUMMARY

This study was designed to test the relationship between minimal hearing loss and academic achievement, particularly in the language areas of vocabulary and reading comprehension.

Pure tone threshold examinations by air conduction were administered to 135 children and the achievement scores and percentile rankings for three divisions of the Iowa Tests of Basic Skills (vocabulary, reading comprehension, and composite achievement) were obtained from school records for each child.

Within this sample, thirty-seven (37) children exhibited thresholds in the minimal hearing loss category while ninety-eight (98) had normal hearing. Thus, 27.4% of the sample used in this study possessed minimal hearing losses. A chi-square analysis of the incidence of children with minimal hearing losses occurring above and below the median revealed a significant relationship between minimal hearing loss and achievement in reading comprehension. The relationship between minimal hearing loss and achievement in vocabulary was statistically significant when _t_-tests were applied. When the chi-square analysis was applied to the mean scores of children with minimal hearing loss above and below the median, the results were not statistically significant in any of the areas measured.

Since the results of this investigation tend to suggest that a relationship may exist between minimal hearing loss and achievement in vocabulary and reading comprehension, the educational implications are numerous and powerful when deprivation in these "tool" subjects is considered.

Although the results indicate minimal hearing losses may affect academic achievement in some areas, more stringent controls are needed in future studies in order to demonstrate a relationship to other areas of academic achievement.

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APPENDICES

APPENDIX A

Procedures for Hearing Threshold Evaluations

Appendix A

PROCEDURES FOR HEARING THRESHOLD EVALUATIONS GIVEN TO EACH EXAMINER

1. Directions to the child are as follows. "We are going to see how well you hear. You are going to hear the tones through these earphones. When you hear a tone on the right side (touch right ear), raise your right hand high and keep it up as long as you hear the tone. What will you do if you hear the tone on this side? (touch left ear)." (If the child does not raise his left hand, touch that arm and say "You'd raise this hand for as long as you heard the tone.") IF THE CHILD DOES NOT APPEAR TO UNDERSTAND THE DIRECTIONS, REPEAT THEM UNTIL YOU ARE POSITIVE THAT HE DOES.

2. Employ the Hughson-Westlake technique as modified according to the following directions:

    1. The duration of the tone should not be less than one second or more than two seconds.

    2. Ascend in steps of 10 dB until the child responds.

    3. Then descend 10 dB and again begin ascent in 5 dB steps until he responds again.

    4. Descend 10 dB again and repeat procedure #3.

    5. Discontinue when you are confident the child has heard the tone.

3. Obtain thresholds by air conduction in both ears for the following frequencies: 500, 1000, and 2000 Hz. Test in the following order:

500 R
1000 R
2000 R
2000 L
1000 L
500 L

APPENDIX B

Raw Data for Hearing Thresholds

and Academic Achievement

TABLE I
PURE TONE THRESHOLD RESULTS FOR 500, 1000, and 2000 Hz
AND THE PURE TONE AVERAGE FOR EACH EAR

Subject	Ear	500	1000	2000	PTA
* 1	R	20	10	10	13.3
	L	10	10	10	10.0
2	R	15	10	5	10.0
	L	5	5	0	3.3
3	R	15	5	0	6.6
	L	10	0	0	3.3
4	R	5	5	0	3.3
	L	0	10	0	3.3
* 5	R	20	20	5	15.0
	L	15	10	15	13.3
* 6	R	10	10	5	8.3
	L	5	10	10	8.3
7	R	10	10	0	6.6
	L	10	5	0	5.0
8	R	15	15	10	13.3
	L	0	0	10	3.3
9	R	15	5	10	10.0
	L	10	5	15	10.0
10	R	15	0	10	8.3
	L	5	0	5	3.3
11	R	15	5	5	8.3
	L	5	0	0	1.6
12	R	0	5	0	1.6
	L	0	10	10	6.6
13	R	10	5	0	5.0
	L	10	5	5	6.6
* 14	R	40	30	45	38.3
	L	10	10	15	11.6
15	R	20	0	0	6.6
	L	20	5	5	10.0
* 16	R	35	15	5	18.3
	L	20	15	5	13.3
17	R	10	5	0	5.0
	L	5	0	0	1.6
* 18	R	30	25	10	21.6
	L	10	10	10	10.0
19	R	15	5	0	6.6
	L	15	5	0	6.6
20	R	10	10	5	8.3
	L	5	0	0	1.6
21	R	20	15	5	13.3
	L	15	10	0	8.3

*Indicates subject with minimal hearing loss.

Subject	Ear	500	1000	2000	PTA
22	R	10	0	10	6.6
	L	10	5	0	5.0
23	R	15	0	0	5.0
	L	10	0	0	3.3
24	R	20	5	0	8.3
	L	10	10	0	6.6
25	R	5	5	0	3.3
	L	10	5	5	6.6
* 26	R	20	15	5	13.3
	L	50	40	40	43.3
27	R	15	15	10	13.3
	L	10	5	5	6.6
28	R	25	5	0	10.0
	L	15	5	0	6.6
29	R	15	15	0	10.0
	L	5	5	0	3.3
* 30	R	35	15	15	21.6
	L	20	10	15	15.0
* 31	R	15	10	5	10.0
	L	20	5	5	10.0
32	R	10	5	0	5.0
	L	15	5	0	6.6
33	R	15	5	5	8.3
	L	10	5	5	6.6
34	R	15	5	0	6.6
	L	20	5	0	8.3
35	R	10	5	5	6.6
	L	5	5	0	3.3
36	R	25	15	10	16.6
	L	5	5	10	6.6
37	R	15	5	0	6.6
	L	10	5	0	5.0
38	R	15	10	5	10.0
	L	15	0	10	8.6
* 39	R	15	10	10	11.6
	L	35	20	15	23.3
40	R	15	10	0	8.3
	L	20	15	10	15.3
41	R	15	5	10	10.0
	L	20	10	5	11.6
42	R	15	0	5	6.6
	L	5	0	0	1.6
43	R	20	0	0	6.6
	L	30	5	5	13.3
* 44	R	15	15	5	11.6
	L	15	15	5	11.6
45	R	10	5	0	5.0
	L	0	0	0	0.0
46	R	15	20	0	13.3
	L	15	5	15	11.6

Subject		Ear	500	1000	2000	PTA
*	47	R	40	5	20	21.6
		L	15	10	15	13.3
	48	R	10	5	10	8.3
		L	10	10	5	8.3
	49	R	10	5	0	5.0
		L	5	5	0	3.3
	50	R	0	0	0	0.0
		L	0	0	0	0.0
*	51	R	25	15	15	18.3
		L	15	15	15	15.0
*	52	R	25	25	20	23.3
		L	20	25	25	23.3
	53	R	15	0	15	10.0
		L	10	5	5	6.6
	54	R	5	5	5	5.0
		L	10	10	10	10.0
*	55	R	25	25	5	18.3
		L	15	10	10	11.6
	56	R	15	0	0	5.0
		L	15	0	5	6.6
	57	R	10	10	5	8.3
		L	5	10	5	6.6
	58	R	15	5	0	6.6
		L	15	5	0	6.6
	59	R	25	15	10	16.6
		L	5	0	5	3.3
*	60	R	35	25	10	23.3
		L	25	20	15	20.0
*	61	R	35	15	25	25.0
		L	25	10	20	18.3
	62	R	15	5	0	6.6
		L	5	5	5	5.0
	63	R	15	5	0	6.6
		L	10	10	5	8.3
	64	R	10	10	5	8.3
		L	5	5	0	3.3
	65	R	10	5	5	6.6
		L	15	5	25	15.0
	66	R	10	5	0	5.0
		L	.5	5	0	3.3
	67	R	15	10	0	8.3
		L	15	5	0	6.6
	68	R	5	0	10	5.0
		L	5	0	0	1.6
	69	R	15	10	5	10.0
		L	5	5	5	5.0
*	70	R	20	15	20	18.3
		L	10	10	15	11.6
	71	R	15	5	0	6.6
		L	10	0	0	3.3

	Subject	Ear	500	1000	2000	PTA
	72	R	5	5	5	5.0
		L	5	0	5	3.3
	73	R	10	10	5	8.3
		L	5	5	5	5.0
	74	R	15	5	0	6.6
		L	25	5	5	11.6
	75	R	5	5	0	3.3
		L	5	5	0	3.3
*	76	R	25	20	15	20.0
		L	65	80	65	70.0
	77	R	5	5	5	5.0
		L	10	5	5	6.6
	78	R	15	5	5	8.3
		L	10	5	0	5.0
*	79	R	15	10	5	10.0
		L	15	10	5	10.0
	80	R	5	5	0	3.3
		L	5	0	0	1.6
	81	R	10	10	5	8.3
		L	0	0	0	0.0
*	82	R	20	10	5	11.6
		L	25	20	30	25.0
	83	R	5	10	5	6.6
		L	5	10	0	5.0
	84	R	20	5	5	10.0
		L	15	5	10	10.0
	85	R	10	10	5	8.3
		L	0	0	0	0.0
*	86	R	35	35	30	33.3
		L	35	20	5	20.0
	87	R	15	0	0	5.0
		L	5	5	0	3.3
	88	R	10	5	0	5.0
		L	10	5	0	5.0
	89	R	10	5	0	5.0
		L	10	0	0	3.3
	90	R	5	0	0	1.6
		L	10	10	0	6.6
	91	R	15	10	0	8.3
		L	5	0	5	3.3
*	92	R	30	25	10	21.6
		L	30	30	10	23.3
	93	R	10	0	0	3.3
		L	10	5	0	5.0
*	94	R	20	10	5	11.6
		L	15	15	20	16.6
	95	R	25	10	20	18.3
		L	5	10	5	6.6
	96	R	10	5	0	5.0
		L	10	10	0	6.6

Subject	Ear	500	1000	2000	PTA
97	R	5	0	0	1.6
	L	5	5	0	3.3
* 98	R	30	20	10	20.0
	L	20	25	25	23.3
99	R	25	10	5	13.3
	L	5	5	10	6.6
100	R	20	20	30	23.3
	L	5	0	5	3.3
* 101	R	25	25	15	21.6
	L	20	15	5	13.3
102	R	5	0	5	3.3
	L	5	0	0	1.6
103	R	5	0	0	1.6
	L	15	5	10	10.0
104	R	15	5	0	6.6
	L	10	5	10	8.3
105	R	5	0	0	1.6
	L	5	0	0	1.6
106	R	5	5	5	5.0
	L	5	5	5	5.0
* 107	R	20	10	10	13.3
	L	15	15	20	16.6
108	R	10	5	5	6.6
	L	10	0	0	3.3
109	R	5	0	0	1.6
	L	0	0	0	0.0
110	R	30	10	0	13.3
	L	5	10	20	11.6
111	R	25	10	0	11.6
	L	0	10	0	3.3
* 112	R	25	25	20	23.3
	L	25	20	25	23.3
113	R	10	5	0	5.0
	L	5	0	0	1.6
* 114	R	30	15	5	16.6
	L	15	15	20	16.6
* 115	R	25	25	35	28.3
	L	20	10	15	15.0
116	R	5	5	5	5.0
	L	10	10	15	11.6
117	R	15	10	0	8.3
	L	0	0	0	0.0
* 118	R	15	10	10	11.6
	L	15	10	10	11.6
119	R	5	5	10	3.3
	L	5	5	5	5.0
120	R	15	15	0	10.0
	L	15	15	0	10.0

	Subject	Ear	500	1000	2000	PTA
	121	R	35	35	30	33.3
		L	15	5	5	8.3
	122	R	5	10	0	5.0
		L	0	0	0	0.0
*	123	R	20	10	5	11.6
		L	15	10	15	13.3
*	124	R	25	15	15	18.5
		L	15	15	20	16.6
	125	R	5	15	5	8.3
		L	5	5	5	5.0
*	126	R	20	20	5	15.0
		L	25	15	5	15.0
*	127	R	20	25	30	25.0
		L	15	15	5	11.6
*	128	R	20	30	35	28.3
		L	20	15	20	18.3
	129	R	5	5	5	5.0
		L	10	5	0	5.0
	130	R	20	10	0	10.0
		L	10	5	10	8.3
	131	R	5	0	10	5.0
		L	5	5	5	5.0
	132	R	10	5	15	10.0
		L	10	5	5	6.6
*	133	R	10	10	10	10.0
		L	30	20	10	20.0
	134	R	20	10	5	11.6
		L	0	0	0	0.0
	135	R	20	5	10	11.6
		L	25	10	5	13.3

TABLE II (A)
PERCENTILE RANKS, RAW SCORES, AND CLASS MEDIANS ON THE VOCABULARY SUBTEST OF THE IOWA TESTS OF BASIC SKILLS

School A

Class 1			Class 2		
Subject	Percen-tile	Raw Score	Subject	Percen-tile	Raw Score
13	99	69	27	97	64
* 1	97	64	38	96	62
* 6	92	58	25	76	50
* 14	92	58	33	76	50
11	85	54	28	74	49
* 5	83	53	37	71	48
7	83	53	* 30	68	47
4	74	49	34	68	47
12	74	49	* 26	65	46
9	68	47	21	38	37
15	68	47	23	36	36
* 16	46	40	40	31	34
17	46	40	* 31	27	32
20	46	40	29	22	30
8	44	39	22	18	28
* 18	44	39	32	14	26
3	38	37	35	14	26
2	31	34	36	14	26
10	27	32	* 39	10	24
19	27	32	24	7	22

*Indicates subject with minimal hearing loss.

TABLE II (A)

School B

Class 3			Class 4		
Subject	Percentile	Raw Score	Subject	Percentile	Raw Score
63	99	69	87	81	52
42	96	62	72	65	46
43	96	62	71	58	44
* 44	94	60	85	38	37
65	94	60	74	31	34
49	85	54	78	31	34
66	83	53	* 76	22	30
58	74	49	84	22	30
46	71	48	* 70	18	28
50	71	48	83	18	28
* 61	71	48	68	14	26
48	68	47	69	14	26
57	68	47	73	14	26
* 60	68	47	80	14	26
64	68	47	* 86	14	26
59	65	46	81	10	24
54	55	43	88	10	24
56	49	41	75	7	22
45	46	40	* 79	7	22
53	44	39	* 82	7	22
* 47	38	37	67	6	21
* 51	38	37	77	2	18
41	31	34			
62	27	32			
* 52	14	26			
* 55	14	26			

TABLE II (A)

School C

Class 5			Class 6		
Subject	Percentile	Raw Score	Subject	Percentile	Raw Score
95	94	60	* 118	94	60
103	76	50	135	92	58
111	76	50	* 114	86	53
* 94	74	49	125	74	49
108	74	49	130	68	47
* 112	71	48	132	68	47
93	68	47	120	58	44
109	68	47	129	55	43
106	68	47	122	49	41
90	65	46	* 124	49	41
96	55	43	113	46	40
100	55	43	* 128	46	40
102	49	41	119	44	39
* 107	49	41	121	38	37
89	46	40	* 126	38	37
91	46	40	116	36	36
97	46	40	* 123	36	36
104	31	34	117	27	32
* 98	27	32	* 127	27	32
105	27	32	* 133	22	30
110	27	32	134	22	30
* 92	22	30	131	18	28
* 101	18	28	* 115	1	14
99	14	26			

TABLE II (B)

PERCENTILE RANKINGS, RAW SCORES, AND CLASS MEDIANS ON THE READING COMPREHENSION SUBTEST OF THE IOWA TESTS OF BASIC SKILLS

School A

Class 1			Class 2		
Subject	Percen-tile	Raw Score	Subject	Percen-tile	Raw Score
13	99	72	33	95	63
* 1	96	64	27	91	59
* 6	86	56	37	85	55
* 14	86	56	* 30	62	45
11	83	54	34	59	44
4	81	53	23	45	39
12	75	50	36	42	38
15	75	50	25	39	37
* 5	70	48	* 26	39	37
20	59	44	28	37	36
* 18	56	43	24	34	35
9	45	39	40	31	34
8	42	38	29	27	32
2	37	36	* 31	27	32
7	37	36	32	27	32
3	29	33	22	25	31
17	29	33	35	18	28
10	27	32	21	8	23
19	14	26	38	5	21
* 16	3	20	* 39	3	20

TABLE II (B)

School B

Class 3			Class 4		
Subject	Percen-tile	Raw Score	Subject	Percen-tile	Raw Score
63	99	70	87	81	53
* 44	98	67	72	50	41
49	98	68	85	50	41
66	94	62	71	39	37
43	89	58	84	39	37
46	83	54	74	37	36
* 60	81	53	68	31	34
59	79	52	77	27	32
* 61	75	50	81	27	32
65	72	49	88	27	32
42	70	48	* 70	25	31
48	70	48	* 79	25	31
58	65	46	* 86	25	31
* 47	62	45	69	22	30
54	59	44	67	18	28
62	56	43	75	14	26
50	42	38	* 76	14	26
56	42	38	83	14	26
41	37	36	73	12	25
* 52	37	36	* 82	10	24
57	37	36	78	6	22
45	34	35	80	6	22
* 51	29	33			
53	27	32			
64	22	30			
* 55	1	18			

TABLE II (B)

School C

Class 5			Class 6		
Subject	Percen-tile	Raw Score	Subject	Percen-tile	Raw Score
102	83	54	* 118	89	58
103	83	54	* 114	88	57
109	81	53	135	79	52
95	75	50	120	70	48
100	72	49	121	70	48
108	72	49	* 123	70	48
89	67	47	113	62	45
93	67	47	119	56	43
106	65	46	125	56	43
111	62	45	130	56	43
91	56	43	* 126	50	41
* 112	56	43	131	50	41
96	53	42	* 128	42	38
97	53	42	132	42	38
90	50	41	134	39	37
* 94	48	40	* 133	37	36
* 92	42	38	122	34	35
* 101	42	38	* 124	34	35
104	37	36	116	22	30
110	31	34	117	14	26
* 98	34	35	129	10	24
* 107	27	32	* 127	8	23
99	22	30	* 115	1	18
105	1	15			

TABLE II (C)
PERCENTILE RANKINGS, RAW SCORES, AND CLASS MEDIANS ON THE COMPOSITE ACHIEVEMENT OF THE IOWA TESTS OF BASIC SKILLS

School A

Class 1			Class 2		
Subject	Percen-tile	Raw Score	Subject	Percen-tile	Raw Score
13	99	69	33	97	62
* 1	92	57	27	92	57
* 6	85	53	37	78	50
11	80	51	25	75	49
12	75	49	34	72	48
* 14	75	49	38	57	43
4	72	48	* 30	54	42
* 5	60	44	* 26	51	41
15	60	44	28	51	41
2	54	42	29	45	39
7	51	41	36	45	39
10	51	41	23	42	38
* 18	51	41	40	38	37
20	51	41	35	35	36
8	48	40	* 31	26	33
9	45	39	32	19	31
3	32	35	21	16	30
17	29	34	24	16	30
* 16	22	32	22	13	29
19	22	32	* 39	7	27

TABLE II (C)

School B

Class 3			Class 4		
Subject	Percentile	Raw Score	Subject	Percentile	Raw Score
63	97	62	87	57	43
49	96	60	85	42	38
43	92	57	72	42	38
65	91	56	71	35	36
* 44	89	55	74	35	36
66	87	54	84	35	36
46	83	52	* 70	26	33
58	80	51	88	22	32
* 61	78	50	67	16	30
48	75	49	68	16	30
59	72	48	69	16	30
42	69	47	* 76	16	30
54	66	46	81	16	30
* 47	57	43	83	16	30
50	57	43	73	13	29
* 60	57	43	75	13	29
56	51	41	77	10	28
* 51	48	40	* 86	10	28
62	45	39	78	7	27
64	45	39	* 79	7	27
53	42	38	80	7	27
41	38	37	* 82	7	27
45	35	36			
57	35	36			
* 52	29	34			
* 55	7	27			

TABLE II (C)

School C

Class 5			Class 6		
Subject	Percen-tile	Raw Score	Subject	Percen-tile	Raw Score
95	87	54	* 118	97	62
103	78	50	* 114	80	51
109	78	50	113	69	47
100	75	49	* 128	66	46
111	72	48	135	66	46
93	69	47	120	63	45
108	69	47	* 126	63	45
90	60	44	* 123	60	44
* 94	60	44	* 124	60	44
102	60	44	121	57	43
106	57	43	130	54	42
89	54	42	132	54	42
* 112	54	42	125	51	41
104	51	41	* 133	48	40
91	48	40	134	45	39
97	45	39	129	42	38
110	42	38	119	38	37
* 98	38	37	116	35	36
* 107	38	37	131	35	36
96	35	36	122	29	34
* 92	32	35	* 127	26	33
* 101	29	34	117	16	30
99	19	31	* 115	2	22
105	3	24			