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A study of classroom noise as a factor which effects the auditory discrimination performance of primary grade children.

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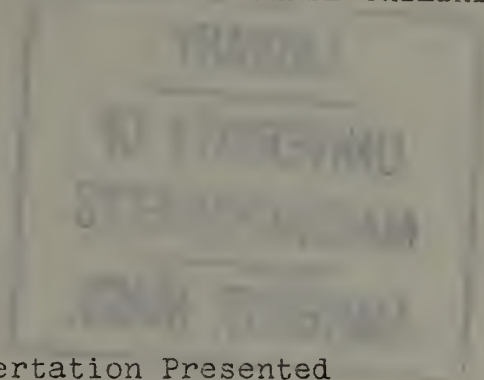
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A STUDY OF CLASSROOM NOISE AS A FACTOR
WHICH EFFECTS THE AUDITORY DISCRIMINATION
PERFORMANCE OF PRIMARY GRADE CHILDREN



A dissertation Presented

by

Linda Weissbrodt Nober

Submitted to the Graduate School of the
University of Massachusetts in
partial fulfillment of the requirements for the degree of
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October, 1972

Reading

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A Dissertation

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Chapter I

The Problem

Statement of the Problem:

The purpose of this study was to determine whether classroom noise effects the auditory discrimination performance of children in the primary grades. Auditory discrimination is the act of discerning the differences among sounds (Good, 1959). It is related to the acquisition of reading skills and normative speaking skills in children (Wepman, 1958, 1960; Christine and Christine, 1964).

A variety of standardized tests have been constructed to measure and evaluate auditory discrimination performance in children (Auditory Discrimination Test, by Wepman, Sound Discrimination Test, by Templin, Picture Discrimination Test, by Mecham and Jex; etc.) and in adults (Auditory Test W-22 (PB), by Hirsh; Rhyme Test, by Fairbanks; Modified Rhyme Test by House; etc.). These tests were designed and are typically administered in a one-to-one, client-clinician protocol. Directions for administering most of the tests prescribe that they be given in a "quiet environment". Speech

therapists and reading specialists are the professional personnel in schools and clinics who most frequently administer the tests (Wepman, 1960). The physical environment in which these tests are administered are typically small, relatively isolated or even sound treated rooms of schools or clinics (Berry, 1969). In reality however, the ongoing functional auditory discrimination activities in which children participate occur in the classroom, under demonstrably different environmental noise levels.

The psychoacoustic literature describes the effects of increased noise levels in communication, and the possible interference effects on speech intelligibility. These alterations of speech intelligibility most often result when the spectral composition of the noise background overlaps with the speech spectrum range, e.g. 300-3000 Hz (Webster, 1964, 1969). The background noise may serve as a "masking signal". The actual learning environment relative to auditory discrimination is demonstrably different than the test environment, in which the evaluation of a particular child's performance is made.

This study compared the auditory discrimination test scores of small groups of primary grade children when the Wepman Auditory Discrimination Test (Wepman ADT) was administered under two listening conditions: (1) simulated classroom noise, and (2) the relative quiet of an individual test room. Specifically, two questions were of interest: (1) would the auditory discrimination performance differ under these two noise conditions, and (2) if so, would the performances be consistent among three groups of primary grade children, e.g. children with (a) speech defects, (b) reading problems, and (c) those children whose speech and reading were designated as normal.

To answer these questions the following null-hypotheses were projected:

Hypothesis I

There are no significant differences in the auditory discrimination performance of primary grade children when they are tested individually under noise conditions that simulate the relatively high levels found in classrooms, and when they are tested individually under the quiet conditions found in special teacher rooms in elementary schools.

Hypothesis II

There are no significant differences in the auditory discrimination performance of primary grade children relative to groups of children:

- (a) whose speech and reading are considered normal,
- (b) a second group of children with speech defects, and,
- (c) a third group of children with reading problems,

when these children are tested individually under noise conditions that simulate the relatively high levels found in classrooms, and when they are tested individually under the relatively quiet conditions found in special teacher rooms in elementary schools.

In order to examine these hypotheses experimentally, 39 elementary school children in attendance at four different schools within the Amherst-Pelham Regional School District were selected randomly by the staff of the district. The 39 subjects were divided into three groups of 13 subjects each, designated as normal, speech defective, or reading retarded, based on classroom teacher and pupil personnel services staff evaluations of their general, speech, and reading performances. Evaluations were based on the standardized tests used by the district.

Sound level readings were made in four classrooms in the four elementary schools. In addition, sound level readings were made in the four special teacher rooms in the four elementary schools. After analyzing the level and spectrum of the noise in these rooms, a tape recording of another classroom was made. This 20 minute tape recording was similar in level and spectrum to the measurements which had been obtained for the four classrooms, and was available as the "noise simulation" instrument for all subjects.

The two equated forms of the Wepman ADT were then administered to all of the subjects following a randomized order of presentation. One form was administered in the quiet listening condition of the special teacher room, and the other form was administered in the same room with the tape recorded noise amplified to 64.7 dBA (the mean dBA for the four classrooms).

The results of these two presentations were given as number of errors and pass-fail data. Both sets of data were analyzed by the University of Massachusetts

Computer Center, employing a Mixed Design, Analysis of Variance (Myers, 1972). The results of the performance scores of the 39 subjects based on the Wepman ADT having been presented in quiet and noise could be compared. The results of the three groups of subjects (13 each) could be compared for the same two listening conditions.

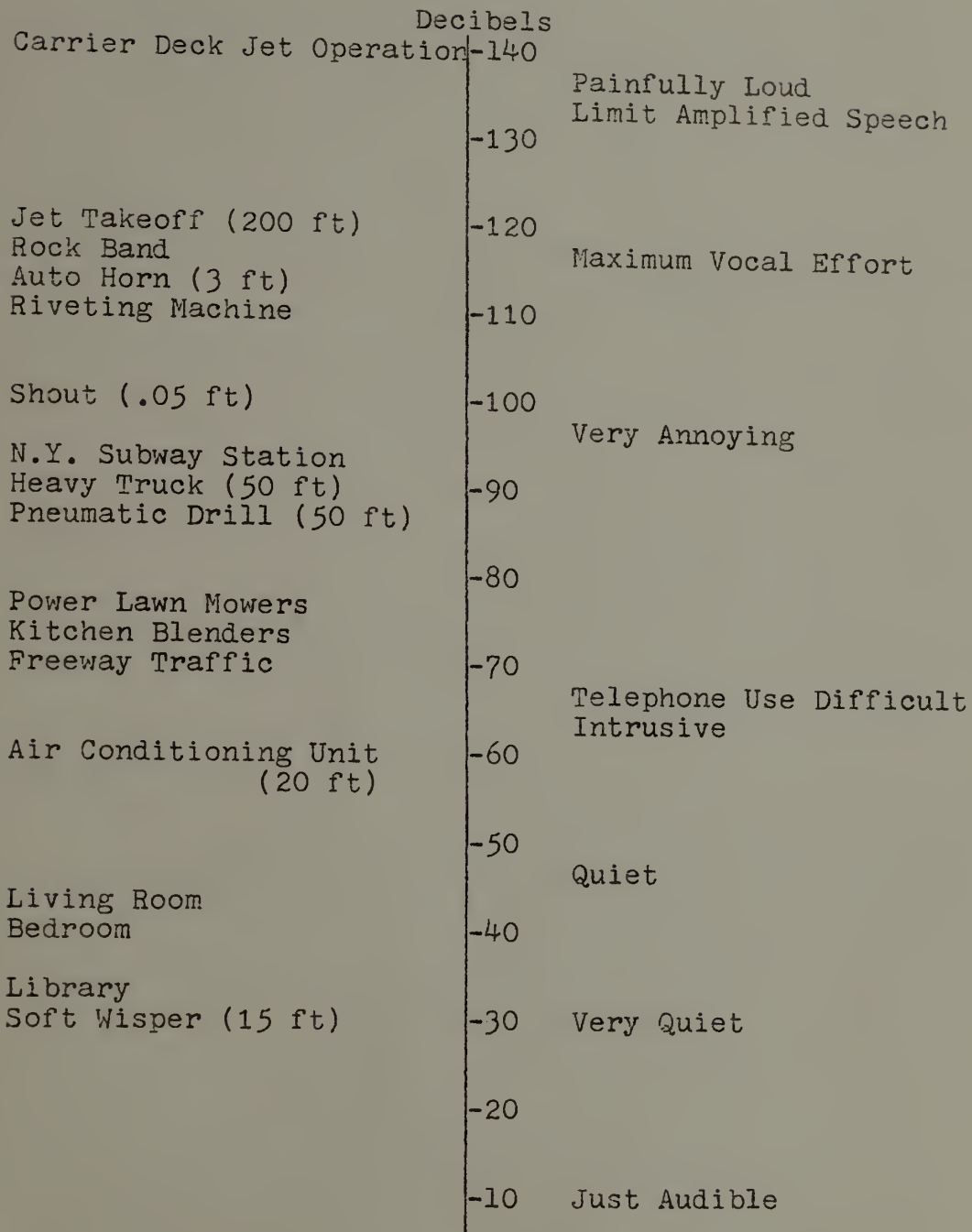
Importance of the Study:

Among the most current concerns of government, education and citizen's groups, is the awareness of the imposition of noise as an environmental pollutant (New York Times, 9/3/72). Continued exposure to excessive noise can produce permanent physical changes in humans (Ward, 1969). Financial support from federal and private agencies has been expended in order to understand better the effects of noise as a societal problem (New York Times, 9/3/72, 9/17/72). Although the national awareness does include the effects of noise in cities and community design, the concern usually does not focus on the learning situation in which the average child is placed for a good number of hours each day. Few controlled studies have been undertaken to study the effects of noise on children. This study purported to determine the effects of classroom noise on the performance ability of primary grade children relative to their auditory discrimination. (See Figure 1).

At present, it is a goal of education to at-

Figure 1

Sound Levels and Human Response *



* Source: New York Times, 9/3/72
Council of Environmental Quality

tempt to reduce the numbers of children within the schools who fail to acquire adequate reading skills (Duggins, 1971; Nemeth, 1971). In addition, aiding children with communication problems, so that they can better cope with the verbal atmosphere of the society, is another significant goal (Goldstein, 1972). Although a direct and causal relationship between good reading ability and auditory discrimination or between good articulatory ability and auditory discrimination has not been demonstrated consistently, there is evidence of a trend in this direction (Winitz, 1969; Durrell, 1956). Therefore, it was reasonable to assume that any reduction in auditory discrimination performance could have deleterious effects on reading and speech, particularly with certain children who display marginal performance.

The inclusion of two groups of children with school problems, and perhaps with difficulties in the area of auditory discrimination, should determine whether testing procedures should be altered for these children. It is hoped that ultimately, the infor-

mation this study will yield, will be of importance for the classroom teacher, and help the teacher to structure the learning sessions which center on listening and discrimination activities so that those children with difficulties will have a better opportunity to succeed with the skill.

Definition of Terms:

A. Terms Relative to the Hypotheses:

1. auditory discrimination performance:

The Wepman ADT was selected as the standardized test to measure the child's ability to discern phonetic differences among sounds. This test is the most widely used test of auditory discrimination used with children (Buros, 1965). It has 40 matched pairs of phonemes which are identified as "the same" or "not the same". There are two equated test forms (test-retest reliability $+0.91$), Wepman, 1958).

2. noise conditions of classrooms:

Sound level measurements were obtained for four different classrooms in four different elementary schools within the Amherst-Pelham Regional School District. These values were determined by means of standard procedures, utilizing specialized instrumentation. Mean sound levels were obtained after sampling different activities on a number of occasions

for the different classrooms.

3. normal subject group:

Subjects were selected by the classroom teachers, language arts staff, and speech and hearing staff. Subjects had no demonstrable school problems, and were within normal limits for their age and grade placement in other parameters.

4. primary grade children:

Children in attendance at the Amherst-Pelham Regional School District, grades kindergarten through grade two, between five and eight years of age, in accordance with the manual of directions for the Wepman ADT (Wepman, 1958).

5. quiet listening condition:

Sound level measurements obtained in the special teacher rooms in the same four schools in which classroom sound level readings were taken. The same procedures were followed.

6. reading problem subject group:

Subjects were selected by the classroom

teachers and language arts staff. Subjects were chosen who evidenced poor reading skills relative to their grade placement. These subjects had normal speech and were normal for their age in other parameters.

7. simulated classroom noise:

A tape recording of the ongoing activities in a typical classroom was made. This classroom contained none of the subjects. The tape recording was analyzed and found to have the level and spectral characteristics similar to those of the four classrooms from which the original sound level measurements were obtained.

8. speech defective subject group:

Subjects were selected by the speech and hearing staff who evidenced articulatory defects of a functional origin. The subjects had no reading problems, and were considered normal for their age in other parameters.

B. Additional Terms Used in the Report:

1. acoustic spectrum:

"The distribution of the intensity of the various frequency components of a sound" (Wood, 1971).

2. amplifier:

"A device that enlarges changes in energy" (Hirsch, 1952).

3. Articulation Index (AI):

"A weighted fraction representing, for given speech and noise conditions, the effective proportion of the normal speech signal which is available to the listener for conveying speech intelligibility" (Kingsbury and Taylor, 1967).

4. auditory discrimination:

(1) "The act of discerning the differences among sounds, especially the sound making up words; the distinguishing of one word or word part from another;

(2) the ability to distinguish among sounds of different pitch or intensity" (Good, 1959).

(3) "The ability to discriminate between sounds of different frequency, intensity, and pressure pattern components; the ability to distinguish one speech sound from another" (Wood, 1971).

5. decibel (dB):

"A logarithmic ratio unit indicating by what proportion one intensity level differs from another" (Wood, 1971).

6. figure-ground perceptions:

"Pertaining to a phenomenon evidenced in the tendency of highly shaped configurations to stand out as figures and the rest of the perceptual image to fall into the background; figure-ground phenomena are related to the forces and periphery of awareness" (Good, 1959).

7. frequency:

"The number of cycles per second of a wave or other periodic phenomenon" (Wood, 1971).

8. Hertz (Hz):

"A unit of vibration frequency adopted inter-

nationally to replace the term cycles per second" (Wood, 1971).

9. intensity:

"The magnitude or degree of tension, activity or energy; refers to the measurement of energy flow acting to produce a sound wave" (Wood, 1971).

10. masking:

(1) "The effect by which one sound causes a second sound to become less audible, by co-existing with it " (Good, 1959).

(2) "The amount by which the threshold of audibility is raised by the presence of another sound; the unit customarily used is the decibel" (Hirsh, 1952).

(3) "A partial or complete obscuring of a tone by the simultaneous presentation in one or both ears of another sound" (Wood, 1971).

11. noise:

(1) "Psychologically, an unwanted sound, physically, an erratic, non-periodic, intermittent and statistically random vibratory activity" (Wood, 1971).

(2) "Any undesired sound" (Hirsh, 1952).

12. psychoacoustics:

"Is that branch of psychophysics that has to do with acoustic stimuli" (Hirsh, 1952).

13. screening:

"Audiometric screening is a method or group of methods designed to separate individuals whose thresholds lie above the normal from those whose thresholds lie at or below the normal threshold" (Hirsh, 1952).

14. signal to noise ratio (S/N):

"The relationship between the intensity of speech and the intensity of noise in a particular communicative situation" (Wood, 1971).

15. sound level meter:

"An instrument including a microphone, an amplifier, an output meter, and frequency networks, for the measurement of noise and sound levels in a specific manner" (Hirsh, 1952).

16. speech intelligibility/discrimination:

"The degree to which one is able to hear and

recognize acoustic differences among all the phonemes in speech to the extent that the speech is perceived as intelligible. Phonetically Balanced Word Lists (PB Scores) is one audiometric test used to measure an individual's speech intelligibility" (Wood, 1971).

17. Speech Interference Level (SIL):

Developed by Beranek in 1947, "a simplified substitute for AI which assesses only the noise fraction of the average of the octave bands at 500, 1000 and 2000 Hz. It can be combined with speech to equate to AI" (Webster, 1969).

18. Sweep Check Test:

"An audiometric method for screening possible hearing loss cases by testing for auditory responses to different frequencies presented at a constant intensity level" (Wood, 1971).

19. Volume Level Meter (VU Meter):

"A voltmeter that is specifically designed for monitoring speech and music" (Hirsh, 1952).

Chapter II

Review of the Literature and Related Research

Intorduction:

Many disciplines contribute information which is relevant to this study of classroom noise and its effects on auditory discrimination performance of primary grade children. Architecture, child development, education, educational psychology, engineering, environmental science, experimental psychology, neurology, psychoacoustics, public health, reading, speech pathology and audiology are the disciplines which impart information. Representative studies and descriptions of significant research will be described as follows:

- A. Noise and Its Effects on Speech Intelligibility,
- B. Classroom Noise Levels,
- C. Studies of Historical Importance to Auditory Discrimination,
- D. Relationship of Auditory Discrimination to Speech Defects and Reading Problems,
- E. Recent Studies Utilizing the Wepman ADT and Different Populations.

A. Noise and Its Effects on Speech Intelligibility:

Among the important parameters of hearing is the ability to discern sounds in the presence of noise, e.g. the signal to noise ratio (S/N). The experimental psychology literature, as well as the literature in audiology and acoustics, is replete with references describing this relationship (Peterson and Gross, 1963; Harris, 1957; Rettinger, 1968; Baron, 1970). A normal hearing person is immersed in a world of many simultaneously occurring sounds or competing messages, during his listening activities. This presence of imposed environmental sound provides the person with the monitoring system at what Ramsdell refers to as "the primitive level of hearing" (Newby, 1964). Children and adults are able to discern sounds at both "the warning and symbolic levels of hearing". This ability to separate perception of the desired sound (signal) from the surrounding or background noise effects behavior (Berry, 1969). When noise (unwanted sound) of any kind interferes with the listener's ability to hear another sound, "masking" is said to occur (Newby, 1964). Masking is an ongoing auditory experience, as we are

bathed in environmental noise, some of which can be physically, psychologically or perceptually debilitating. Auditory perception research has been conducted concerning the practical problems of improving the audibility of speech (auditory discrimination) in the presence of noise. These experiments have shown that speech intelligibility is effected by interfering or competing noise (Jerger, 1963). However, almost all of the research has been conducted with adults as subjects; few researchers employed a population of young children. Licklider and Miller, (1951), Black, (1957), and Bilger, (1958) have been responsible for some of the basic studies which describe the effects of noise on speech intelligibility. Webster (1969), summarized the present information regarding the ability to communicate by voice in the presence of noise. The determinants are:

- (1) the level and spectrum of the noise, which can be fairly well specified by the Speech Interference Level (SIL), based on octaves centered at 500, 1000, 2000 Hz;
- (2) the voice level of the talker;
- (3) the distance between the talker's mouth and the listener's ear (both of

which are accounted for in the Articulation Index (AI and SIL calculations);
(4) the vocabulary used.

Webster also discussed the voice level of the speaker and its effect on speech intelligibility. He concluded that to be intelligible, speech must be heard, and ". . . within reason, the louder the speech is spoken or amplified, the more intelligible the speech. But when the voice exceeds a 'very loud' level, the intelligibility decreases."

Myklebust (1971), writing on childhood aphasia, described the normal process of auditory figure-ground perception. He described the conglomerate of sound in the field and the necessity of the child to accurately discern the important signal from the background signals. This ability, frequently disturbed in children with learning disabilities, hyperkinesis, and brain injury, has also been suspect in children with more limited or less demonstrable disturbances of reading or speaking. Figure-ground disturbances are difficult to diagnose, and in an effort to distinguish which children display these difficulties, Berry (1969) suggested giving all oral

discrimination tests in a background of noise, to simulate the listening conditions. Her position stressed the need to ascertain whether individual children under special consideration are able to perform the tasks of discrimination in the functional noise situation. Audiological tests are typically administered with masking conditions to simulate the functional interference of ongoing noise.

Siegenthaler (1967), conducted a study of auditory figure-ground ability in children four to eleven years of age. The results indicated that discrimination ability for boys improves as a function of age, following the pattern of more sophisticated hearing ability and other psycho-physical attributes. However, four to five year old boys and girls performed about equally well on auditory discrimination tasks, according to this study.

B. Classroom Noise Levels:

It is a difficult task to ascertain "average noise levels" in elementary school classrooms. Architectural standard for construction sites and individual rooms, (lecture versus music) are discussed in the literature (Knudsen and Harris, 1950). In 1970, engineer Stratton Hammon was called upon to testify in a law suit concerning road and truck noise and their effects on the school building; he was unable to produce references to support either position in the case (Hammon, 1970). Few references indicate standardized measures concerning noise levels in schools when the classrooms are occupied by a full compliment of children. The architectural plans upon which most schools are constructed hope to achieve a maximum of 40-50 dB, as measured by a sound level meter in an empty classroom (Knudsen and Harris, 1950). Few figures are available which regulate the quality and quantity of the noise levels with the addition of 25-100 children present in the room.

Kingsbury and Taylor (1967) described the lack of building codes in terms of the acoustic environment of school buildings relative to the codes est-

ablished for the visual environment of schools. The authors supported the importance of two factors; reverberation time and speech articulation, as measured by the Articulation Index (AI). They also advised using carpet as an excellent acoustic material to ". . . not only act as absorption, but as a sound deadening material by stopping the sound at its source." Kingsbury and Taylor encouraged the use of AI as opposed to SIL. They proposed an AI value which corresponds to a 90 % PB Score. They concluded: ". . . it is true that the human ear can effectively perceive speech in high noise levels. But it is likewise true, that to do so, requires a high concentration and motivation level."

In a later article, Kingsbury and Strumpf (1969) described the guidelines and testing procedures which they concluded would maximize hearing conditions in school classrooms. Using the Modified Rhyme Test as a discrimination testing instrument in two different size classrooms, with comparable furnishings (except carpeting in one classroom) the authors were able to ascertain a noise level of 66 dB as the upper

limit of tolerance for the speech signal to be effective with normal hearing adult listeners. The two classrooms did not differ significantly at these noise levels, in spite of one classroom measuring 33' x 21', and the other measuring 63' x 32'. The absorptive materials which both rooms contained apparently minimized the effects associated with size variations. The absorptive materials included: fibrous panels for the ceiling, painted concrete blocks for the walls, heavy curtains as drapes for the windows, upholstered furniture and carpeting.

In an attempt to seek placement for hard-of-hearing students within normal classrooms, Sanders (1965) investigated the noise conditions of normal school classrooms. He sampled 47 classrooms in 15 different schools ranging from kindergarten to classes in high schools. Repetitive measures were taken in all the classrooms under empty and occupied conditions. Sanders' data is summarized as follows:

<u>School</u>	<u>X dB Empty</u>	<u>X dB Occupied</u>
Kindergarten	58	69
Elementary	56	59
High School	55	62
Units for Partially Deaf	42	52

The mean classroom noise level obtained by Sanders was 63 dB re: SPL. The spectrum of the noise followed Fletcher's (1953) thesis: ". . . that to specify the noise in a room one need only to give the total intensity level as read on a sound level meter and then assume the spectrum curve given by Hoth (1941)." Sanders concluded that noise levels in kindergartens were considerably higher than in upper grades of elementary schools, probably due to the nature of the activities in a kindergarten program. Elementary and high school noise levels were considered more tolerable for the users of hearing aids. The information concerning the source of classroom noise pointed to the fact that it was the noise generated within the schools which was responsible for the high levels which were recorded, rather than outside

noise, due to placement of highways, community noise, etc.. Sanders continued: " . . . The results of this study indicate a marked discrepancy between noise conditions in the clinic situation and noise conditions in the school classroom. This discrepancy is greatest in kindergarten rooms."

C. Studies of Historical Importance to Auditory
Discrimination:

During the 1930's, experimental studies began to appear which attempted to isolate the factors which contributed to high achievement in reading. Parallel to these studies, investigations were undertaken which attempted to show relationships between audition, articulation and perceptual skills. Auditory discrimination was one of the factors which was studied most intensely by differing disciplines.

Rizzo (1939) summarized the early studies in reading, which consistently paired "good reading ability" with "good auditory discrimination ". A large number of studies were implemented at Boston University under the direction of Donal Durrell, in order to delineate information regarding auditory discrimination abilities of good readers and poor readers. These Boston studies have become standard references in the study of auditory discrimination and it's relation to reading achievement, although definitive findings were difficult to pinpoint (Harrington and Durrell, 1955). Due to the consistent trend in auditory discrimination

and good reading ability, attempts were made to utilize auditory discrimination test scores as predictive measures of success in reading or failure to achieve good reading skills.

To this end, Wepman developed his auditory discrimination test in 1958 to be used as a predictive measure with both speech defective and reading defective populations. His test is widely used by groups of professionals who function with speech defective and reading defective populations, although supportive data for use of the test as a predictive measure is lacking. Dykstra (1966) summarized the previous research on auditory discrimination and reading achievement, and attempted a more definitive study on a large population in order to elicit predictive values for selected subtests of the Gates-McGinitie Reading Inventory, the Murphy-Durrell Reading Inventory, and the Monroe Reading Aptitude Tests. Dykstra's results indicated that these subtests of auditory discrimination skill are inferior to intelligence tests as predictive measures of reading ability.

Speech pathologists rely on the results of auditory discrimination tests as an aid to therapy planning and evaluation. Generally, clinicians have recognized the need to incorporate auditory discrimination exercises during sound training sessions (Van Riper, 1963; Berry and Eisenson, 1956). Winitz (1969) has attempted to intergrate the research relating to speech defective children's abilities to perform auditory discrimination tasks. He discussed at length the research on speech sound discrimination and articulation performance. His review summarized the previous experiments by describing categories of articulatory difficulties and the discrimination abilities of children who display the difficulties. The summary indicated significant differences of normal speaking children versus articulatory problem children but no differences between similar groups of adults. Winitz then postulated:

. . . since discrimination skills have been found to increase with age, and since the discrimination scores of articulatory defective children are lower than the discrimination scores of non-articulatory defective children it might be inferred that speech sound

discrimination is a maturational process which is often delayed. An alternative inference might be made. After some point in time, (probably two years) speech sound discrimination scores reflect the speech sound experience of children so that the results of speech sound discrimination tests that are administered to articulatory defective children may reflect primarily the effect of a large amount of faulty speech sound learning...Articulatory experience will affect later discrimination.

Winitz's summary and explanation of the "poor speech model" have been incorporated into clinical practice in speech therapy.

The most widely accepted standardized test of auditory discrimination to be used with young children is the Wepman ADT. DiCarlo's evaluation of the test in Buros' Mental Measurement Yearbook (1965), states that it is: ". . . a quick and accurate assessment of auditory discrimination among children five to eight years of age . . . it is easy to administer and score . . . the specificity of the task eliminates the contamination of performance by auditory memory span." This review concurs with statements in the manual of the test concerning the independence of intelligence, cultural factors, and/or experiential learning on the cog-

native aspects of the material. Therefore, the test is usually given without regard to matching subjects by intelligence or cultural background. During the last five years, however, this area of cultural universality has come under review by the new data presented by linguists and socio-linguists (Labov, 1970; Shuy, 1970; Baratz, 1969). (See section E-Recent Studies)

The concepts the Wepman ADT measures continue to be explored in experiments concerned with reading skill and articulatory skill, and it is to date the most acceptable test of this perceptual ability.

D. The Relationship of Auditory Discrimination to
Speech Defects and Reading Problems:

Deficiency in reading has been described as ". . . the foremost educational problem in the history of the nation," by the former Acting U.S. Commissioner of Education, Dr. T.H. Bell (1970). Statistics only hint at the real scope of the problem of reading retardation since the terms used to describe and categorize reading ability are not universal, e.g. deficiency, retardation, problem, etc.. Nevertheless, it is estimated that between 15-25 % of school age children have reading difficulties (Allen, 1969). During the past half century countless studies have attempted to focus on the behavioral or physical characteristics of students who succeed in acquiring these skills as compared with those students who display difficulty in acquiring these skills. Diagnostic tests number in the hundreds, and packaged materials of programmed lessons are plentiful (Buros, 1968).

Among the most intensively explored aspects of reading skill is "readiness" and "beginning reading" (Monroe, 1951; Jenkins, 1958; Orme, 1958; Monroe and

Rogers, 1964; Anderson, 1968). According to these investigators, success in beginning reading is somewhat dependent upon intelligence, vocabulary, visual discrimination and auditory discrimination. Pre-reading activities emphasize visual and auditory discrimination. Typically, auditory discrimination is more emphasized in the phonic approach to the teaching of beginning reading, while visual discrimination is more emphasized in the sight-word method approach (Hay and Wingo, 1948; Gans, 1964; Spache, 1963; Monroe and Rogers, 1964).

The literature abounds with studies which have attempted to demonstrate a relationship between auditory discrimination and beginning reading achievement. Although there are few definitive studies, it has been demonstrated that good auditory discrimination is a correlate of good reading ability (Wepman, 1960; Dykstra, 1966; Christine and Christine, 1964). The continued emphasis on auditory discrimination attests to the interest specialists in reading perceive as one avenue for exploration which might yield significant

results in improving reading skills on a national level.
(See Section E - Recent Studies)

Listening, as a skill of beginning reading, is related to auditory discrimination but not synonymous with it. Witty, (1966), reviewed the literature regarding the importance of listening behavior for young children. He described studies which estimated that children devote 57.5 % of classroom time to listening (Witt, 1950). He emphasized that efforts be made to teach children to listen effectively. In 1958, Witty and Sizemore conducted several studies which attempted to relate listening behavior to learning (1959a). In these studies, learning through listening or reading appeared to be of equal success. But it was clear that learning could be enhanced through simultaneous use of visual and auditory approaches (1959a). Witty and Sizemore (1959b) were able to show that for younger pupils, auditory presentations were more successful. Visual approaches were more successful with higher age levels. This information is consistent with the research relating auditory discrimination to beginning

reading. Listening behavior follows a similar maturational scale of importance in perspective to other dimensions of hearing.

Children with speech and hearing difficulties comprise about five percent of the school age population (ASHA, 1970). The types of defects which cumulatively effect this population include articulatory defects, stuttering, hearing deficiencies, voice problems, cleft palate speech, cerebral palsy speech, and delayed speech development. The incidence includes some 1,000,000 children within the public schools of the nation (Berry and Eisenson, 1956). Of this total, by far the largest group are considered to have articulatory defects of a functional origin. This total represents about three per cent, or 30,000 children (Berry and Eisenson, 1956).

When a child displays speech difficulty and is evaluated by a professional clinician in a school or clinic, he is usually given a battery of diagnostic tests (Johnson, Darley and Spriestersbach, 1952). It is typical for a test of auditory discrimination to be included in this battery, since it is estimated that

50-80 % of all children with speech and hearing problems also have difficulty in auditory discrimination (Wepman, 1960).

It is apparent that both groups of children, those with speech and hearing problems, and those with reading problems, are more apt to have difficulties in the area of auditory discrimination, than children who do not display such difficulties. The general fields of reading remediation and speech therapy are concerned with individual children's ability to discern auditorily individual sounds, phonemes, sound blends, phonic units, etc.. Both disciplines rely on standardized tests which purport to measure the child's auditory discrimination ability. Durrell (1956) reported the incidence of cases of reading retardation who scored poorly on tests of auditory discrimination to number 20-50 %. Speech defective children who score poorly on tests of auditory discrimination are reported to number 50-80 % (Wepman, 1958). These figures appear vague in light of the sophisticated level of testing procedures.

The literature stresses that although no causal relationships can be demonstrated at present,

there does appear to be a superior auditory discrimination ability among good readers as compared with poor readers (Bond and Tinker, 1967). Similarly, normal speaking children tend to score better on tests of auditory discrimination than do speech defective children (DiCarlo, 1948; Winitz, 1969).

E. Recent Studies Utilizing the Wepman ADT and Different Populations:

The Wepman ADT continues to be used as an experimental research instrument with different populations and conditions of presentation. Some of the more interesting and related studies which have been undertaken during the past decade, follow.

Christine and Christine (1964) described their attempts to confirm the theories of Betts (1957) and Eames (1950). These theories asserted that faulty articulation and reading retardation had a common cause, and that basic to the etiology of both was poor auditory discrimination ability. The researchers demonstrated that administering the Wepman ADT to three groups of children (labeled - normal, poor readers and poor speakers), and subjecting the data to simple random analysis, provided the information which was in agreement with the above theories, and in agreement with the information provided by Wepman (1958) in the manual for the test.

Merrell (1969) conducted an extensive study using the Wepman ADT in an attempt to modify the test

for use as a group test instrument. He also compared groups of subjects classified as Caucasian and Negro of differing socio-economic background in order to determine differences in auditory discrimination ability. His results indicated that the group modification of the Wepman ADT was not interchangeable with the original test format. There were significant differences in the auditory discrimination test scores in the groups of children from different socio-economic backgrounds. Intelligence was not a factor in the matching of subjects. The tape recordings which were used for the group presentation were made by the same speaker for all socio-economic and linguistic backgrounds.

Brickner (1968) hypothesized that the environment of disadvantaged youth produced so much noise that ". . . a blocking of individual sounds occurs." She contended that auditory discrimination ability could be improved with a sequence of planned listening activities to be used with Head Start children. Her sample was not pre-tested, no noise measures were actually taken, and it was difficult to determine whether this group of disadvantaged children had been truly

effected by the undetermined quantity of noise in their environment.

The most recent studies which attempted to relate auditory discrimination ability to success in reading or speaking focused on primary grade children of differing socio-economic class, dialect or linguistic background. Collier (1968) working in New York City, attempted to distinguish between auditory discrimination ability for initial and final consonant pairs. Utilizing the Wepman ADT the author separated the test into parts which reflect discrimination of initial consonants and final consonants in order to determine if there were differences in the abilities of disadvantaged children. The results indicated that final consonant discrimination was significantly poorer, a factor which is supported by other research. The author then postulated that his population did not have poor auditory discrimination ability, but, rather, that as a group, the subjects did not treat the final parts of words as effective stimuli. This is consistent with the information on phonological patterns of Negro non-standard dialect (Labov, 1970). The overall test

scores which were obtained indicated that the children had poor auditory discrimination, but the author concluded that these results were invalid.

In an attempt to distinguish between phonemic and non-phonemic auditory discrimination ability, Oakland (1969) administered the Wepman ADT as well as discrimination test of pure tone auditory stimuli to groups of socio-economically different children. The non-phonemic test was included in an effort to eliminate the dialect interference as a possible variable. The results of this study indicated that in each instance, there was a correlation of good auditory discrimination ability with the gradients of socio-economic background. These results differ from those reviewed by Collier (1968).

Wilcox (1969); Rudegair and Kamil (1970); and Politzer (1971) attempted to deal with the effects of the imposition of dialect on auditory discrimination test scores of young children who spoke Negro non-standard dialect. In summary, their results indicated that dialect did impose a listening problem to young children, that tape recordings of dialectal readings

of the items which comprise the Wepman ADT were superior to standard English readings, and that the one-to-one presentation in the listener's dialect was the superior method of accurately assessing auditory discrimination performance.

Marquardt and Saxman (1972) examined the relationship between language comprehension and auditory discrimination in kindergarten children with proficient articulation and kindergarten children with articulatory difficulties. Utilizing the Wepman ADT and the Carrow Auditory Test of Language Comprehension, the authors found the articulatory error group inferior to the non-articulatory error group in direct proportion to the number and severity of the articulation problems of the children. Both auditory discrimination and language comprehension, as measured by the two test instruments, were effected. The authors supported the argument that children with numerous articulation errors show syntax performance deficits for their age because of the underdeveloped syntax knowledge. The population which comprised the articulatory error group was considered to be profoundly defective.

Summary:

In conclusion, the literature fails to indicate that auditory discrimination has been studied in classroom noise situations, with groups of normal, speech defective or reading retarded children in the primary grades. The Wepman ADT is continuously used as the test instrument best suited to primary grade children. It appeared that there is a correlation between the degree of defectiveness and the inadequacy of auditory discrimination performance based on the experimental populations described above. The wealth of psychoacoustic data available in the literature relative to audition mitigated that auditory discrimination values elicited in a quiet listening condition could not serve as valid indices of the same performance in a noise environment. Therefore, it was important to determine if this could be borne out experimentally, since auditory discrimination scores obtained in quiet might hold little or no relevance as predictive measures of auditory discrimination performance in the classroom.

Chapter III

Methods and Procedures

Subjects:

Three groups of 13 students each were selected as subjects; groups were designated as: (1) normal, (2) speech defective, (3) reading retarded. Selection of each group of 13 was made randomly from a total of 56 students who were evaluated by the district pupil personnel services department and classroom teachers as meeting the appropriate criteria.

Specifically these criteria were:

Normal Group. Eligible children were those in Crocker Farm, Marks Meadow, South Amherst, and Wildwood schools who ranged from 5-8 years of age, were of normal intelligence (as estimated by the school testing procedures), had not repeated a grade, had no history of emotional or physical health disturbances, demonstrated normal hearing acuity by passing a screening test at 25 dB ISO at frequencies 500-4000 Hz (Belton 10C Audiometer), had not been given a Wepman ADT within their current school year. In addition, students classified as candidates for the normal group had to demon-

strate normal reading level (indicated by scoring on grade level on the Gates-McGinitie Reading Tests or scoring with a positive profile on the DeHirsh Battery), and normal speech (indicated by scoring at age level on the Templin-Darley Articulation Screening Test). Speech Defective. Eligible children for this group displayed the same characteristics as the normal group above, except for speech proficiency. Potential subjects were designated by district speech and hearing therapists as having defective articulation and being unable to score at age level on the Templin-Darley Articulation Screening Test; they were also receiving speech therapy within the school speech and hearing program or at the University of Massachusetts Communication Disorders Clinic. Such children were free from contributing pathologies, however, and despite their defective articulation were judged to be moderately articulatory defective and generally intelligible in their conversational speech. The Templin-Darley Articulation Screening Test is comprised of fifty items which require spontaneous oral responses to picture stimuli. Scoring for this screening test is

determined by the number of correct responses the subject gives to English phonemes in the initial, medial and final positions. Each potential subject scored inadequately on this test for his age level (mean cutoff level - 35 correct) before he was considered eligible for the speech defective group. This standardized test of articulation is widely used in public school speech therapy programs (Winitz, 1969).

Reading Retarded Group. Eligible children for this group displayed the same characteristics as the normal group above except for reading level. Standardized tests were used to categorize potential subjects into the reading retarded group. Potential second grade level subjects demonstrated reading levels of one year below grade level on the Gates-McGinitie Reading Tests, the Metropolitan Reading Test, or both. First graders and kindergarten children qualified when their profile scores on the DeHirsh Battery were considered by the reading specialists of the district as warranting special reading instruction.

The total 39 subjects selected (three groups of 13 subjects each) displayed various relevant char-

acteristics. Sex distribution by school is shown in Table 1 along with the population totals from which the sample was selected. As indicated, 24 of the subjects were male and 16 were female. The larger number of males reflects the national incidence of reading and speech problems (2-4:1) (Cohn and Cohn, 1967; Berry and Eisenson, 1956). The male - female distribution of the three groups was: normal - 6 males, 7 females; speech - 9 males, 4 females; reading - 8 males, 5 females. As indicated above, the subjects were selected from the four elementary schools within the district in which noise level measures and recordings were made. The age range of the subjects was 5.1 years to 7.11 years at the time of testing, with a mean age for all three groups of 6.8 years (6.9 for males, 6.7 for females) commensurate with the directions in the manual for administering the Wepman ADT. The distribution of mean ages according to groups was: normal - 6.8 years, speech - 6.9 years, reading - 7.0 years.

Although not all classrooms within the district are delineated by grade equivalents, each child within

Table 1

Male-Female Distribution According to School Attendance

<u>School</u>	<u>Males</u>	<u>Females</u>	<u>Total Population Kindergarten - 3</u>
Crocker Farm	8	10	273
Marks Meadow	7	1	201
South Amherst	2	1	85
Wildwood	6	4	464
<hr/>			
Totals	23	16	1,023
<hr/>			

the district is categorized as to grade level according to the number of years spent in attendance. According to these criteria, the distribution of subjects by grades was: kindergarten - 2, first grade - 13, second grade - 24. (See Table 2).

The I.Q. scores available are depicted in Table 3. The mean I.Q. was 111.6, and when I.Q. means of the groups were estimated, they indicated: normal - 113.2, speech - 111.8, reading - 109.1. The I.Q. scores were estimated by the district as determined by the results of the Peabody Picture Vocabulary Test, part of the DeHirsh Battery which was administered to all students during their kindergarten year.

Grade level scores for reading level were determined by utilizing the results of the DeHirsh Battery for kindergarten and first grade children, and the Gates-McGinitie Reading Tests for second grade children. The mean scores of the Gates-McGinitie Reading Test can be depicted as in Table 4. The mean grade level was 1.42 for all subjects.

Table 2
Distribution of Subjects According to Grade Placement

<u>Group</u>	<u>Kinder- garten</u>	<u>First</u>	<u>Second</u>
Normal		5	8
Speech	2	5	6
Reading		3	10
<hr/>			
Totals	2	13	24
<hr/>			

Table 3
Total and Group Available I.Q. Scores

<u>Group</u>	<u>Number Available</u>	<u>Mean</u>	<u>Range</u>
Normal	10/13	113.2	89-132
Speech	7/13	111.8	91-143
Reading	7/13	109.1	97-125
<hr/>			
Totals	24/13	111.6	89-143
<hr/>			

Table 4

Total and Group Grade Level Means of Gates-McGinitie
Reading Tests

<u>Group</u>	<u>Number Available</u>	<u>Grade Level</u>
Normal	7/13	1.56
Speech	6/13	1.76
Reading	7/13	.89
<hr/>		
Totals	20/39	1.42
<hr/>		

Sound Level Measurements:

In order to ascertain average classroom noise levels within primary grades in the Amherst-Pelham Regional School District, a number of noise level readings were taken in each of the four classrooms of the four elementary schools. All sound level measures were taken using a Bruel and Kjaer (Type 2204) sound level meter, with a condenser microphone (Bruel and Kjaer Type 4132) in conjunction with a random incidence corrector (Bruel and Kjaer Type UA0055). The A-weighting network was selected as the appropriate scale as it most closely duplicated the frequency response of the human ear. This scale is also the most typically used when sound level measurements are to be used as an estimate of psychological or physical effects of noise on humans.

Four different classrooms, one in each of the four schools, were selected by the district staff, as being representative of primary grade settings within the district. Sound level readings were taken in three different positions within each of the representative classrooms during the reading and language arts periods.

(Each classroom was visited on two different dates yielding a total of 24 readings.) The mean sound levels of the six replications in each classroom during the specified periods (3 positions on 2 different days) were: Crocker Farm - 63.5 dBA, Marks Meadow - 63.2 dBA, South Amherst - 66.3 dBA, Wildwood - 66.0 dBA. The overall mean was 64.7 dBA.

(See Table 5)

In addition to the A- weighting scale measures, eight different octave band analyses were done in the classrooms during the same activities. Two analyses were made from one central position in each room on the same two dates. These octave band readings indicated that the distribution of sound energy across frequency was similar in each of the four classrooms.

(See Table 6 and Figure 2)

The special teacher room in each school is used by the speech therapist, special reading teacher and/or school counselor, as an individual work room. As these special rooms are used for administration of auditory discrimination tests, sound level measurements

Table 5
 Mean Sound Levels of the Four Classrooms *

Position	Crocker Farm	Marks Meadow	South Amherst	Wild- wood
I	60.0	62.0	65.0	64.0
II	66.0	65.5	65.0	64.5
III	64.5	62.0	69.0	69.5
Means	63.5	63.2	66.3	66.0

Overall mean = 64.7 dBA

* all units dBA

Table 6

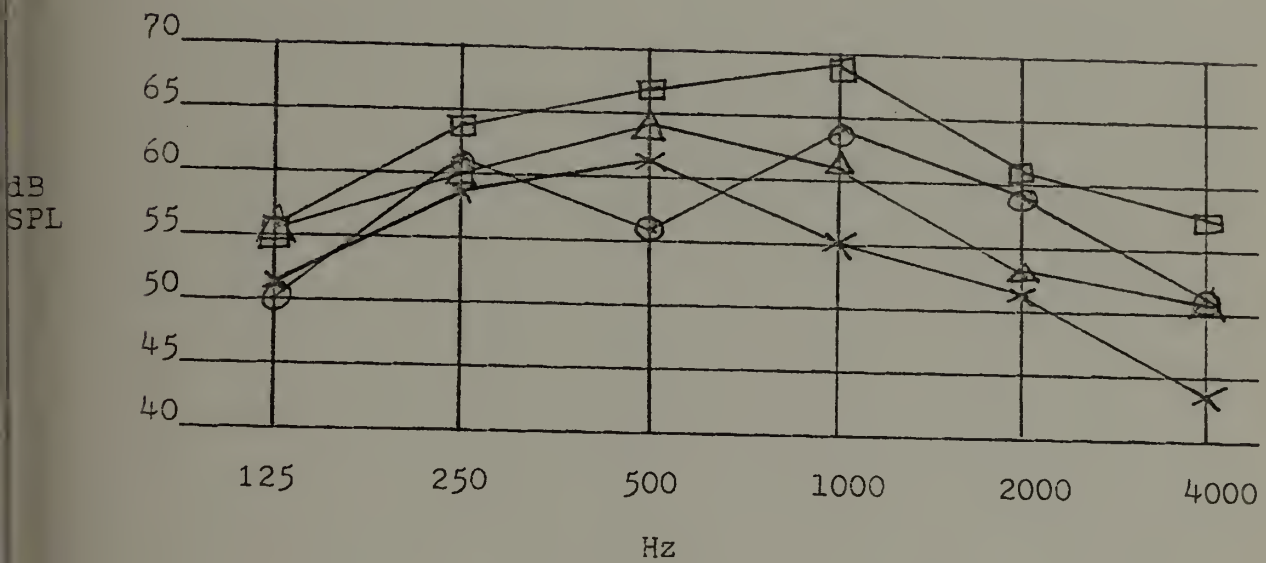
Mean Values for Octave Band Measures for the Four Classrooms*

Frequency	Crocker Farm	Marks Meadow	South Amherst	Wild- wood	Mean
125	52.5	50.0	55.0	55.5	53.3
250	58.5	60.0	64.0	60.5	60.8
500	61.5	56.5	67.0	64.0	62.3
1000	55.0	64.0	69.5	62.0	62.6
2000	52.0	59.0	62.0	53.0	56.5
4000	43.5	51.5	58.0	52.0	51.3

* all units SPL

Figure 2

Mean Values for Octave Band Measures for the Four Classrooms



X = Crocker Farm

O = Marks Meadow

□ = South Amherst

Δ = Wildwood

were made in them following procedures similar to those made in the classrooms. A-weighting readings were made in three different positions in the special teacher rooms, in all but one of the schools; because of scheduling difficulties, only two measurements could be made in the South Amherst room. All measurements were made with rooms unoccupied, except for the experimenter, as this best simulated the background noise conditions under which a single student's auditory discrimination performance is inventoried. The results of the 22 readings are shown in Table 7. Mean levels for each room were: Crocker Farm - 32.3, Marks Meadow - 42.3, South Amherst - 43.5, Wildwood - 40.1 (all values dBA). The overall mean for the A-weighted measurements was 39.5 dBA. The special teacher room at Crocker Farm school yielded a considerably lower reading (10 dBA, see Table 7), than the other three schools, probably because it was designed as a sound treated speech and hearing therapy room with sand between the wall of the contiguous rooms and special acoustical materials on the ceiling and walls. The effectiveness of this special

Table 7
 Mean Sound Level of Special Teacher Rooms *

Position	Crocker Farm	Marks Meadow	South Amherst	Wild- wood
I	36.5	44.0	44.0	39.0
II	30.5	45.0	43.0	37.5
III	30.0	38.0	not available	44.0
Means	32.3	42.3	43.5	40.1

Overall mean = 39.5 dBA

* all units dBA

construction is shown by the attenuation of high frequency energy in this room relative to the special teacher rooms in the other schools.

Octave band readings were also taken for the special teacher rooms. The results of the measurements taken on two different days from one central position in each room are shown in Table 8. These data indicated that the energy distribution of the noise across frequency was similar in all the special teacher rooms.

Comparison of Table 5 and Table 7 indicated that the mean A-weighted sound levels in the classrooms were considerably higher than in the unoccupied special teacher rooms (64.7 and 39.5 dBA, respectively). Comparison of the octave band distribution of energy between the four classrooms and the four special teacher rooms can be illustrated as shown in Figure 4.

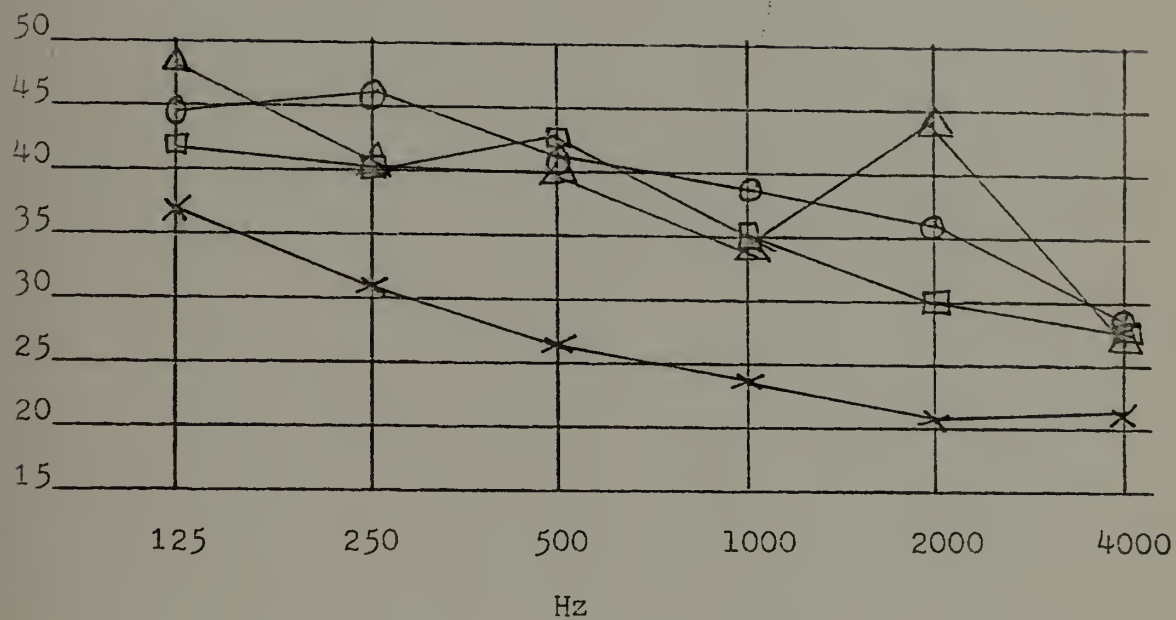
As noted above, experimental testing procedures necessitated that classroom levels be simulated in the special teacher rooms. Toward this end, a tape recording of 20 minutes duration was made in a separate classroom housing students in grades 2-4 (not one from which

Table 8
 Mean Values for Octave Band Measures for
 the Four Special Teacher Rooms *

Frequency	Cracker Farm	Marks Meadow	South Amherst	Wild- wood	Mean
125	37.0	45.0	43.5	48.5	43.5
250	31.0	46.5	41.0	40.0	39.6
500	26.0	41.0	43.5	40.5	37.7
1000	24.5	39.0	35.5	33.0	33.0
2000	20.0	36.5	31.5	45.5	33.5
4000	21.5	29.0	29.0	29.5	27.2

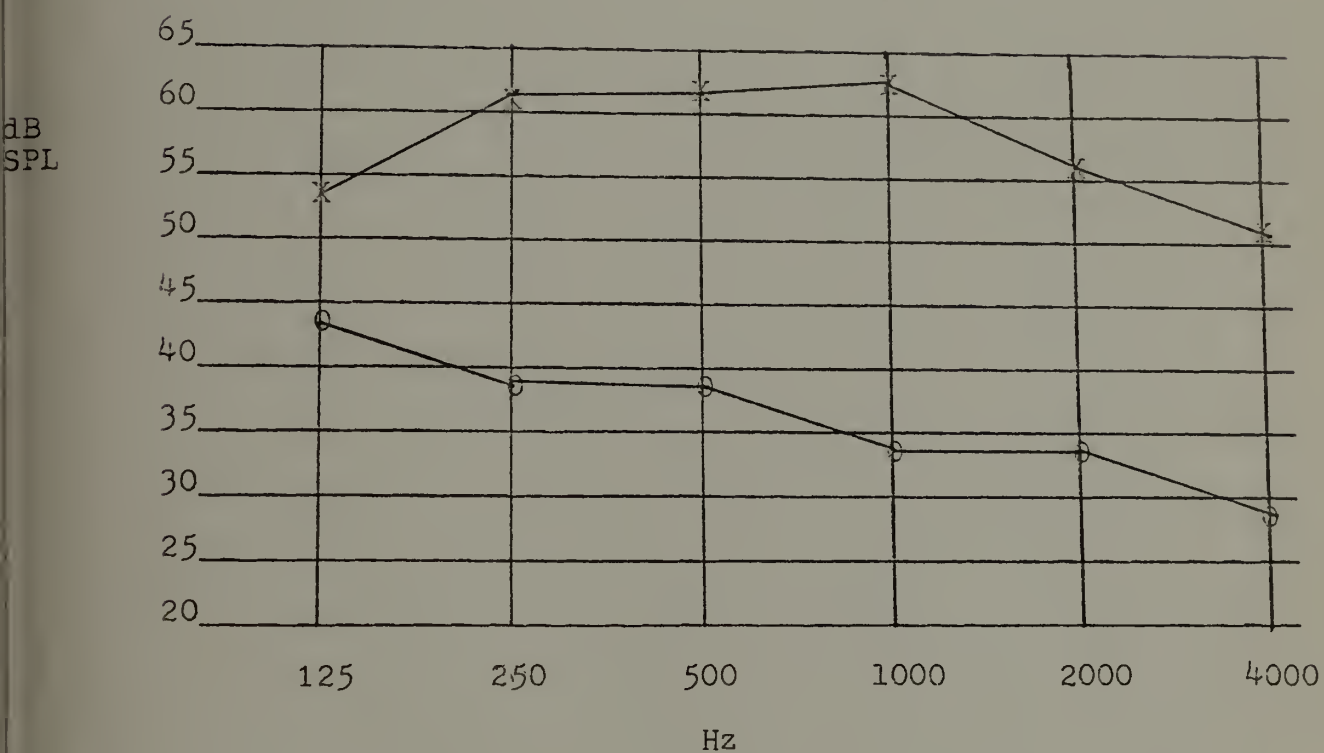
* all units SPL

Figure 3
 Mean Values for Octave Band Measures for the Four
 Special Teacher Rooms



- X = Crocker Farm
 O = Marks Meadow
 □ = South Amherst
 △ = Wildwood

Figure 4
Mean Octave Band Values of Four Classrooms and Four
Special Teacher Rooms



X = Classrooms

O = Special Teacher Rooms

potential subjects were selected). The Communication Sciences Laboratory within the Communication Disorders Area of the Department of Speech, University of Massachusetts, provided the equipment which was necessary to obtain and evaluate the tape recording. Instrumentation for recording included an Ampex PR-10 tape deck which received the output of the Bruel and Kjaer sound pressure level meter and associated microphone (see Figure 5 for block diagram). The actual weighted sound level of the noise during recording averaged 66.0 dBA (± 6 dBA) over the 20 minute duration. The instrumentation used in making this level as a function of time analysis included the same tape deck, the A- scale weighting network of an octave band analyzer (Bruel and Kjaer Type 2112) and a graphic level recorder (Bruel and Kjaer Type 2305). The block diagram is shown in Figure 6.

The degree to which the recording was representative of the octave band configuration of the noise in the classrooms from which the subjects were chosen is shown in Figure 7. The octave band analysis of the

Figure 5
Block Diagram of Instrumentation
Used in Recording Classroom Noise

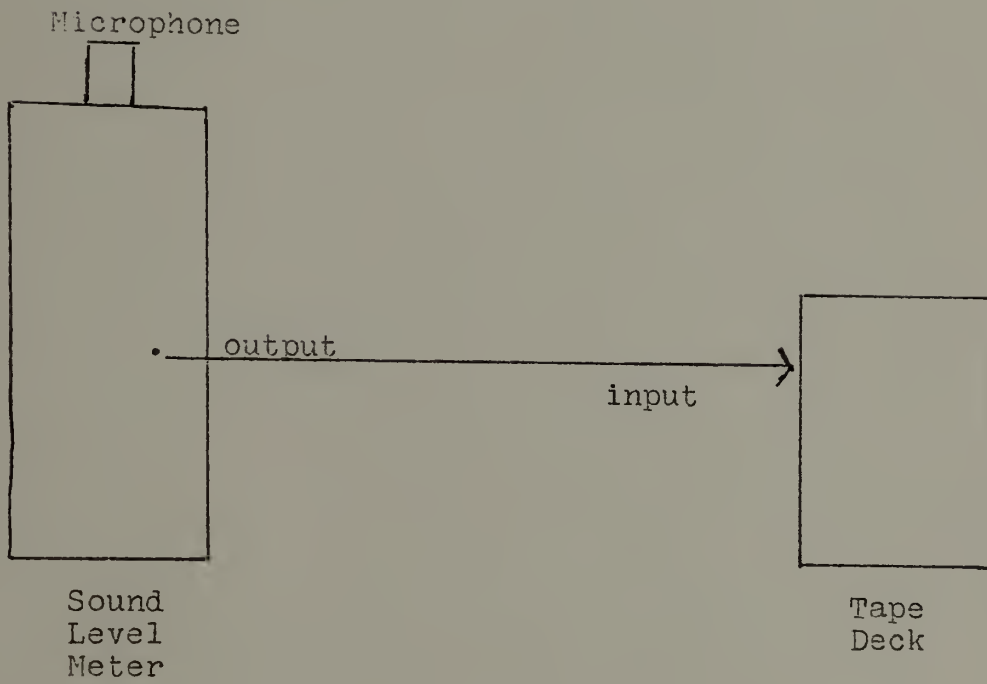


Figure 6
Block Diagram of Instrumentation Used to
Measure Variation in Sound Over Time

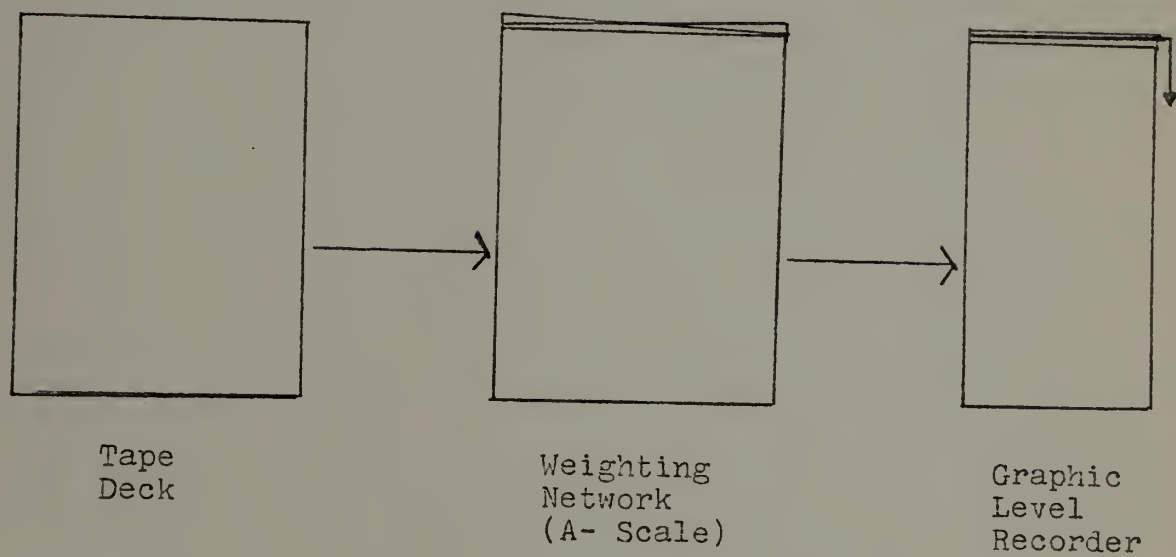
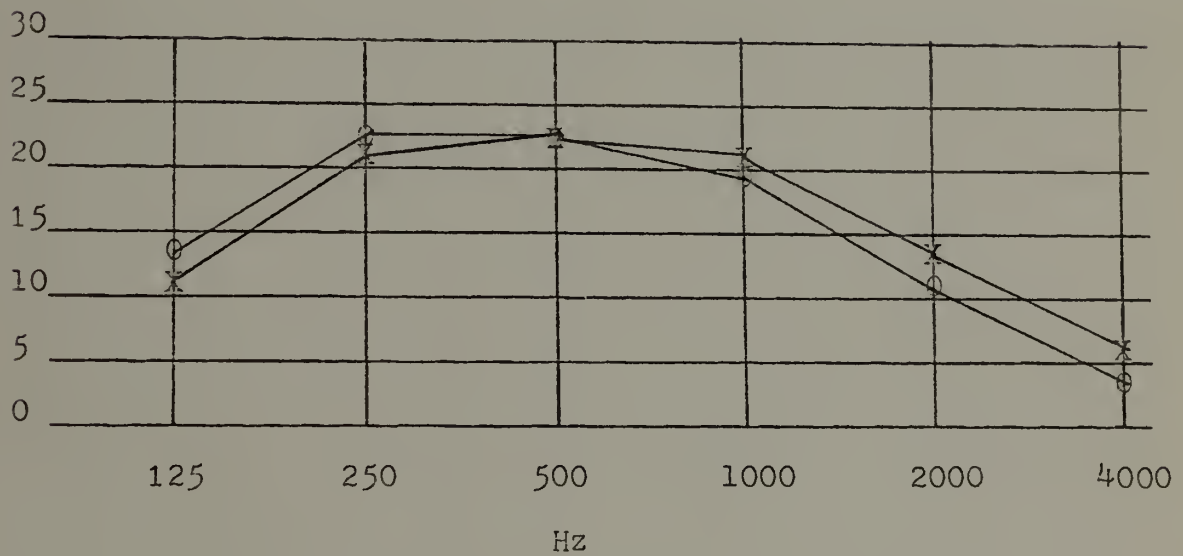


Figure 7

Mean Octave Band Values of Noise in the Four Classrooms
and Tape Recorded Noise Samples



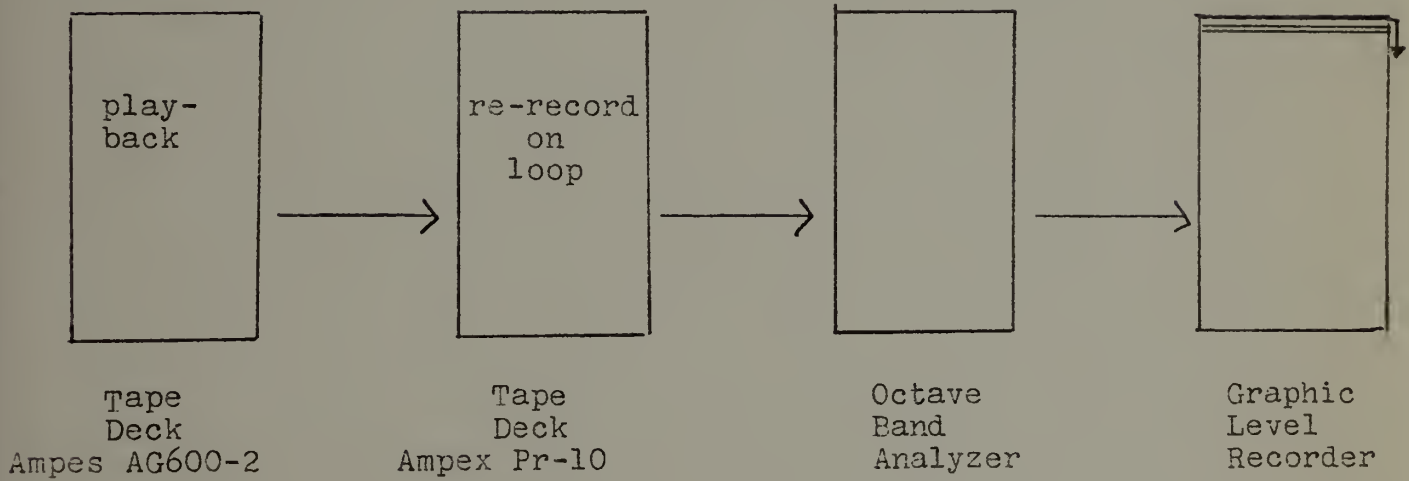
X = Classrooms

O = Tape Recording

recorded noise used two tape decks (Ampex PR-10 and Ampex AG600-2) along with the weighting system of an octave band analyzer (Bruel and Kjaer Type 2112) in conjunction with a graphic level recorder (Bruel and Kjaer Type 2305). A block diagram of the instrumentation used in this evaluation is shown in Figure 8.

(Thus, an accurate representation of typical classroom noise was available to be used by all subjects during the noise listening condition. Each subject would be unable to recognize peer interaction but would be familiar with the recorded material.) No subject would have an advantage or disadvantage in the noise listening condition.

Figure 8
Block Diagram of Instrumentation Used in
Octave Band Analysis of Recorded Noise



Test Materials:

The Wepman ADT was administered to each subject as the instrument by which auditory discrimination performance would be evaluated. Each form of the Wepman ADT (form I and form II) is comprised of 40 word pairs which are matched for length. Every possible match of phonemes used in English is included in the test. Each form consists of 30 pairs of words which differ in a single phoneme and ten word pairs which do not differ that are false choices. Comparisons are made between thirteen initial consonants, thirteen final consonants, four medial vowels, and the ten false choices. The subject is required to respond to the examiner's oral recitation of the word pairs by saying "the same" or "not the same", or an equivalent response. Several example items are included. The subject is to be seated so as to be unable to see the examiner's face. The total administration time is approximately ten minutes per form. The scoring system is based on age and number of errors. In order for a subject to be considered "inadequate" in auditory discrimination, the following scoring schedule must be met for the thirty

discrimination items:

<u>Age</u>	<u>Number of Errors</u>
a. 5 year olds	greater than 6
b. 6 year olds	greater than 5
c. 7 year olds	greater than 4
d. 8 year olds	greater than 3

All tests showing a score greater than 15, or a false choice value greater than 3 are considered invalid (Wepman, 1958).

Order of presentation of the two listening conditions e.g. quiet and noise, and the two test forms was controlled by random assignment for the four order of presentations, which were:

1. Form I, quiet - Form II, noise
2. Form I, noise - Form II, quiet
3. Form II, quiet - Form I, noise
4. Form II, noise - Form I, quiet.

The 39 subjects selected for the study were administered both forms of the Wepman ADT in a single session of about 25 minutes. One form was administered in the quiet listening condition, (i.e. with no external

noise introduced into the special teacher room), the other form in the noise listening condition, (i.e. with external noise at 64.7 dBA introduced into the special teacher room). The noise was presented via a Wollensak Tape Recorder (Model T-1500). Prior to testing in the noise condition, the level of the noise was set at 64.7 dBA measured at the position of the subject. This adjustment was made by monitoring the output of the tape recorder with the sound level meter during playback of a 500 Hz tone which had been inserted at the beginning of the noise tape for calibration purposes. The tone had been recorded at the same sound level as the noise signal, i.e. ± 6 dBA from the upper and lower intensity limits, and provided a quicker and more accurate method of adjusting the output of the recorded noise to the specified level.

Statistical Analysis:

Two sets of data were available for statistical analysis: (1) the absolute numerical values, based on number of errors; and, (2) the pass-fail values, based on number of errors and age (see description for scoring the Wepman ADT). Due to the scale of errors which are required for a given child to achieve a "fail" score, it is possible for a given child to obtain an absolute numerical increase in scoring between the two listening conditions, and still not fail the test under either condition. Since the functional use of the Wepman ADT by the classroom teacher is most often used on the basis of "failing" rather than numerical values, it seemed appropriate to deal with the pass-fail data as well as the numerical error score values.

Therefore, both the number of error scores and the pass-fail data were tested by an analysis of variance, mixed design with separate between and within subject variability separately tested (Myers, 1972). The data were particularly well suited for this analysis design as the three groups were each given the same

treatments, the groups were equal in size, the subjects within each group were chosen "at random" from a larger selection of available subjects, different test forms were used for each treatment, and the treatments were given randomly in regard to listening conditions, forms, and groups. These conditions assume homogeneity of variance and this design is particularly well suited for these variables.

In this particular statistical design, the main effects of the listening factor and the groups factor were tested separately. Interaction effects on the variability of each measure were reflected in the magnitude of the factor interactions.

In addition, three group t-tests were computed for the number of error means. Three chi square analyses were computed for the group pass-fail data.

Chapter IV

Results and Discussion

Two sets of data were basic to this study; (1) the raw scores, given as number of errors, and, (2) the pass-fail scores based on the number of errors and age. Tables 9 and 10 depict the scores of all 39 subjects relative to the two listening conditions; the quiet treatment and the noise treatment for the three subject groups, i.e. normal, speech defective, and reading retarded. The subject numbers in Tables 9 and 10 designate the randomized order of presentations for the Wepman ADT forms (I and II) and the listening conditions (quiet and noise).

Hypothesis I

There are no significant differences in the auditory discrimination performance of primary grade children when they are tested individually under noise conditions which simulate the relatively high levels found in classrooms, and when they are tested individually under the relatively quiet conditions found in special teacher rooms in elementary schools.

The grand mean (number of errors) performance score on the Wepman ADT for the total population

Table 9

Auditory Discrimination Raw Scores (Number of Errors) of Subjects in the Quiet and Noise listening Conditions for the Normal, Speech Defective and Reading Retarded Groups.

	Normal		Speech			Reading			
	SS	Quiet	Noise	SS	Quiet	Noise	SS	Quiet	Noise
1		6	9	2	6	8	3	3	7
5		5	5	4	5	5	17	6	7
6		3	7	7	11	13	18	6	7
8		1	6	11	1	4	22	4	8
9		5	8	12	3	7	24	3	8
10		2	6	13	6	12	25	4	9
14		4	6	20	4	10	26	3	5
15		2	3	23	12	8	29	4	7
16		4	2	27	8	10	32	2	6
19		3	4	31	1	6	33	5	7
21		5	4	35	4	5	34	3	9
28		3	4	38	4	3	36	4	6
30		5	10	39	4	3	37	2	9
Mean		3.69	5.69		5.31	7.23		3.77	7.31
Range		1-6	2-10		1-12	3-13		2-6	5-9

Table 10

Auditory Discrimination Pass-Fail Distribution of Subjects in Quiet and Noise Listening Conditions for Normal, Speech Defective and Reading Retarded Groups.

A. Normal			B. Speech			C. Reading		
SS	Quiet	Noise	SS	Quiet	Noise	SS	Quiet	Noise
1	F	F	2	F	F	3	P	F
5	F	F	4	F	F	17	F	F
6	P	F	7	F	F	18	F	F
8	P	F	11	P	F	22	P	F
9	P	F	12	P	F	24	P	F
10	P	F	13	F	F	25	P	F
14	P	F	20	P	F	26	P	F
15	P	P	23	F	F	29	P	F
16	P	P	27	F	F	32	P	F
19	P	P	31	P	F	33	F	F
21	F	F	35	P	P	34	P	F
28	P	P	38	F	P	36	P	F
30	P	F	39	F	P	37	P	F
Fail	3	9		8	10		3	13
Pass	10	4		5	3		10	0

groups and conditions pooled was 5.50. The listening condition mean error scores were 4.26 for the quiet condition, and 6.74 for the noise condition (see Table 11). The range values of these same parameters are depicted in Table 11. The grand mean range of errors was 1-13 relative to groups and conditions pooled. The range of errors for the quiet condition was 1-12, and the range of errors for the noise condition was 2-13, groups pooled.

This main effect was tested with the Within subjects listening condition (L) variable of the mixed design, analysis of variance (see Table 12). The F-ratio of 41.7 was statistically significant beyond the .01 level of confidence ($p < .01$), enabling Hypothesis I to be rejected.

Thus, the overall means (Table 11) of 4.26 and 6.74 (groups pooled) can be interpreted as reflecting viable differences in auditory discrimination performance between listening conditions of relative quiet and simulated classroom noise.

The statistically large F-ratio for the Within

Table 11

Mean Number of Errors and Ranges of Auditory Discrimination Scores for the Normal, Speech Defective and Reading Retarded Groups in Quiet and Noise Listening Conditions.

A. Means

Conditions	Normal	Speech	Reading	Total
Noise	5.69	7.23	7.31	6.74
Quiet	3.69	5.31	3.77	4.26
Total	4.69	6.27	5.54	5.50

B. Ranges of Number of Subjects
who Failed

Conditions	Normal	Speech	Reading	Total
Noise	2-10	3-13	5-9	2-13
Quiet	1-6	1-12	2-6	1-12
Total	1-10	1-13	2-9	1-13

Table 12

Summary of Mixed Design, Analysis of Variance of Number of Errors in Auditory Discrimination Performance in the Quiet and Noise Listening Conditions of the Normal, Speech Defective and Reading Retarded Groups.

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Square	F
Between S				
G	2	32.3846	16.1923	1.986
S(G)	36	293.6154	8.1560	
Within S				
L	1	120.6282	120.6282	41.7**
GL	2	10.7949	5.3974	1.866
SL(G)	36	104.0769	2.8910	

** significant beyond the .01 level of confidence

subjects listening (L) main effect, ($p < .01$) was also confirmed by a mixed design, analysis of variance employing the pass-fail data; in this instance the F-ratio was 26.6 ($p < .01$), (see Table 13). Thus, the dichotomized scores listed in Table 14 of 0.1795 and 0.6410 (proportion passed) for the noise and quiet conditions respectively (groups pooled) can be interpreted as reflecting real auditory discrimination performance differences between simulated classroom noise and the relative quiet of the special teacher rooms. Indeed, it can be assumed that the collective group fail scores of 32, versus the collective group fail scores of 14, (noise versus quiet) are significant differences with this criterion of adequate-inadequate performance.

Hypothesis II

There are no significant differences in the auditory discrimination performance of primary grade children relative to groups of children:

- (a) whose speech and reading are considered normal,
- (b) a second group of children with speech defects, and,
- (c) a third group of children with reading problems,

when these children are tested individually under noise conditions which simulate the relatively high levels found in classrooms, and when they are tested individually under the relatively quiet conditions found in special teacher rooms in elementary schools.

Table 13

Summary of Mixed Design, Analysis of Variance of the Auditory Discrimination Pass-Fail Performance in Quiet and Noise Listening Conditions for the Normal, Speech Defective and Reading Retarded Groups.

Source of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F
Between S				
G	2	0.7179	0.3590	1.805
S(G)	36	7.1538	0.1987	
Within S				
L	1	4.1538	4.1538	26.6**
GL	2	1.2308	0.6154	3.94*
SL(G)	36	5.6154	0.1560	

** significant beyond the .01 level of confidence

* significant beyond the .05 level of confidence

Table 14

Pass-Fail Auditory Discrimination Values for the Normal Speech Defective and Reading Retarded Groups in the Quiet and Noise Listening Conditions.

A. Dichotomized Scores

(proportion passed)

Condition	Normal	Speech	Reading	Total
Noise	0.3077	0.2308	0.0000	0.1795
Quiet	0.7692	0.3846	0.7692	0.6410
Total	0.5385	0.3077	0.3846	0.4103

B. Numbers Failed

Condition	Normal	Speech	Reading	Total
Noise	9	10	13	32
Quiet	3	8	3	14
Total	12	18	16	46

In order to find out which of the three groups, if not all, precipitated the statistically significant total group error score, mean differences between the quiet and noise main effects treatments (Table 11), three one way t-tests were conducted for each of the three groups (see Table 15). The t-values of 2.584 for the normal group, and 7.077 for the reading group, were both significant beyond the .01 level of confidence, but the speech group t-value of 1.476 failed to reach statistical significance. The differences in error score means for the normal and reading retarded groups reflected real differences in subject performance when the Wepman ADT was administered in the special teacher rooms under the quiet listening condition versus administration of the Wepman ADT under the simulated noise listening condition. Thus, Hypothesis II (a) and II (c) were rejected. Hypothesis II (b) was not rejected.

Inspection of the means and ranges in Table 11 suggests why the speech defective group failed to reach statistical significance although the trend was in this direction, i.e. poorer performance in noise than in quiet. The relatively high 5.31 quiet value

Table 15

Numerical t-scores for the Normal, Speech Defective and Reading Retarded Groups for the Quiet and Noise Listening Conditions.

Groups	df	t	p
Normal	24	2.584	$p < .01$
Speech defective	24	1.476	n.s.
Reading retarded	24	7.077	$p < .01$

(mean number of errors) of the speech group compared to the 3.69 quiet value of the normal group and the 3.77 quiet value of the reading group, represents a larger proportion of the 7.23 noise value of the speech group than did the other two quiet means when they were compared similarly to their respective noise values (5.69 - normal, and 7.31 - reading). Thus, the quiet values speech group score represented 74 % of the noise value ($5.31/7.23$). while the quiet normal group score represented 65 % of the noise value, and the quiet reading value represented 51% of the noise value. Said another way, the arithmetic compliment of these percentage values suggested that the speech group had the least percentage of mean number of error score changes relative to the quiet and noise listening conditions.

Further clarification of this issue is seen in the range values, depicted in Table 11. The widest dispersion of scores was in the speech group, e.g. 1-13 (conditions pooled) while the normal and reading group range values were relatively narrower with values of 1-10 and 2-9 respectively. The greatest dispersion occurred in the quiet listening condition for the speech

where the range was 1-12. The 1-6 and 2-6 ranges for the normal and reading retarded groups respectively, in the quiet listening condition were notably smaller.

The tests for group differences with the pass-fail data were performed with the chi square distribution. The three chi square analyses for the pass-fail data were performed for the three groups (see Table 16). The analysis yielded 5.76, 4.54 and 20.54 for the normal, speech defective and reading retarded groups respectively. Only the reading group (20.54) value reached statistical significance ($p < .01$). However, the trend for the other two groups was always in the direction of increased fail performances in the noise condition, e.g. a total of 9 versus 4 for the normal group, 10 versus 3 for the speech group. The overwhelming 13 versus 0 for the reading group caused the $p < .05$ significant interaction of the group and listening conditions variables in the mixed analysis of variance (see Table 13). This interaction is graphically depicted (Figures 9 and 10) by the steeper and unparallel rise of the reading group error function from the quiet listening condition to the noise

Table 16

Chi Square Distribution of the Pass-Fail Performance of the Auditory Discrimination Values for the Quiet and Noise Listening Conditions for the Normal, Speech Defective and Reading Retarded Groups.

A. Normal

	PP	PF	FP	FF
O	4	6	0	3
E	3.25	3.25	3.25	3.25

$$\chi^2 = 5.76$$

B. Speech Defective

	PP	PF	FP	FF
O	1	4	2	6
E	3.25	3.25	3.25	3.25

$$\chi^2 = 4.54$$

C. Reading Retarded

	PP	PF	FP	FF
O	0	10	0	3
E	3.25	3.25	3.25	3.25

$$\chi^2 = 20.54^{**}$$

**p < .01

Figure 9

Graphic Representation of Number of Error Means for the Normal, Speech Defective and Reading Retarded Groups, in the Quiet and Noise Listening Conditions.

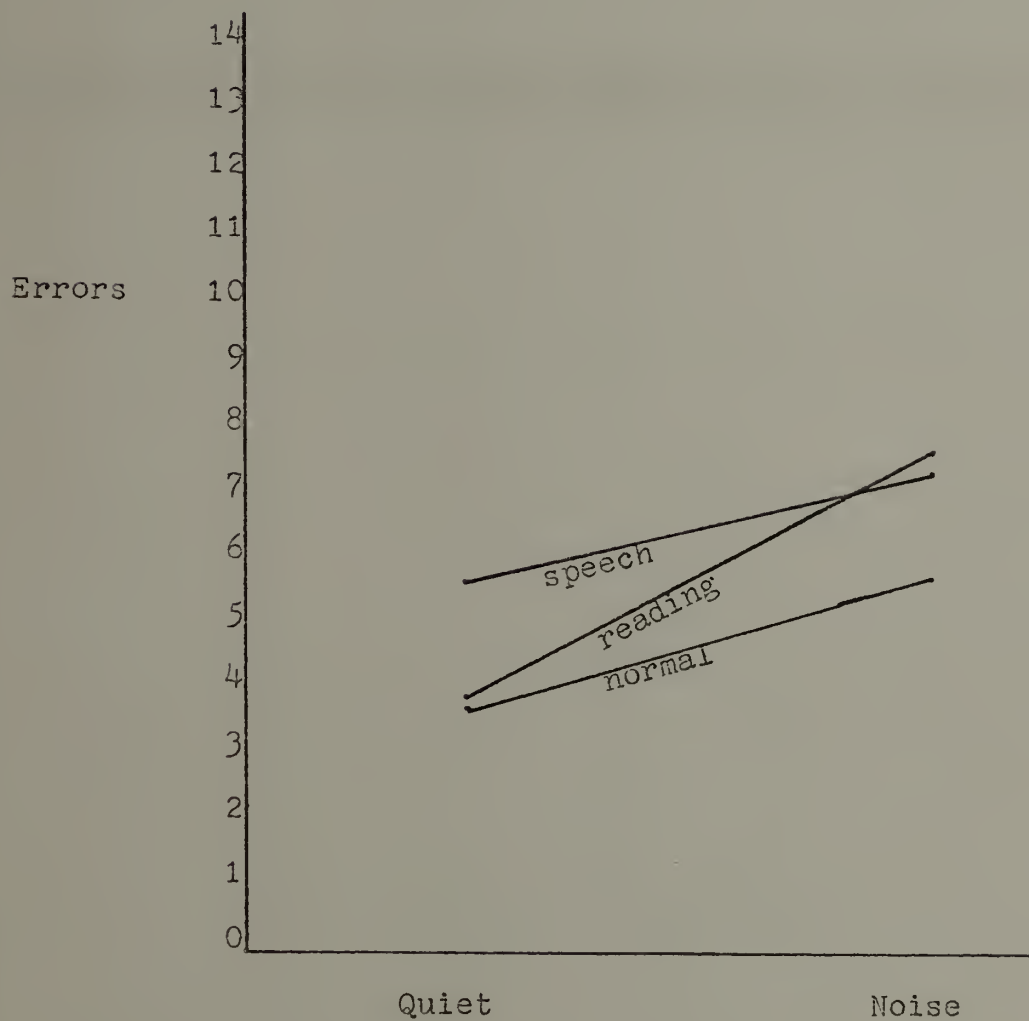
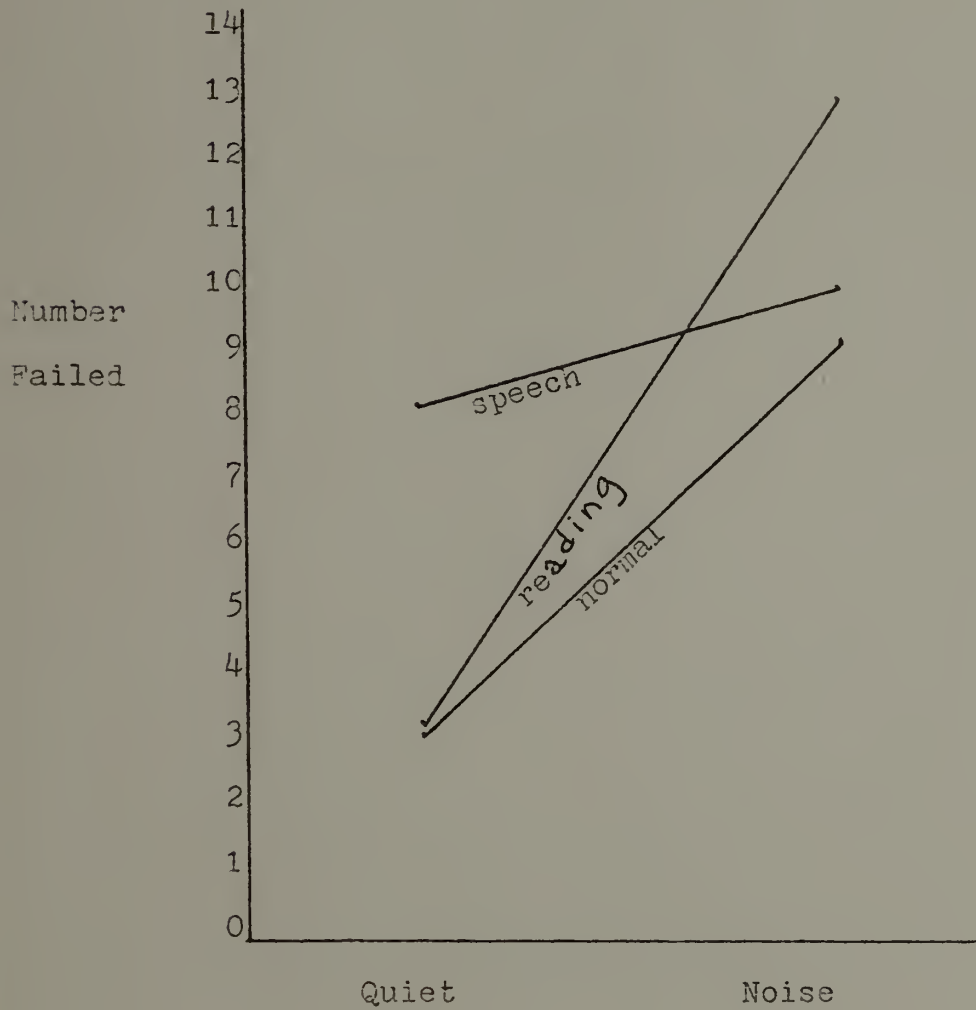


Figure 10

Graphic Representation of the Pass-Fail Means for the Normal, Speech Defective and Reading Retarded Groups, in the Quiet and Noise Listening Conditions.



listening condition relative to the error function of both the normal and speech groups. Indeed, the number of errors for the reading group in noise surpassed that of the speech group resulting in the crossing of their function lines.

The non-significant normal group pass-fail data chi square value (1.48, see Table 16), was not in keeping with the t-test (see Table 15) for the number of errors data which showed statistical significance between the normal group means relative to the quiet and noise listening conditions. Thus, these comparable data suggested that while the number of error means showed statistically significant differences, the pass-fail categorizations of the subjects on the Wepman ADT showed no real differences. Thus, the reading group, in this chi square analysis of the pass-fail data was the only group where the performance became significantly poorer in noise than in quiet. The other two groups showed a trend in this direction, but without statistical significance. In other words, the imposing performance of the reading group rendered the Within (L) variable of the pass-fail mixed design, analysis of variance to be significant.

Therefore, when the pass-fail criteria were applied to the Between groups data, Hypothesis II (a) and II (b) could not be rejected. Only Hypothesis II (c) could be rejected.

The most formidable and imposing result of this study is the prevailing difference in auditory discrimination performance of primary grade children obtained during the quiet listening condition as opposed to the simulated classroom noise listening condition. It is reasonable to assert that the auditory discrimination scores elicited in a quiet listening test environment do not reflect the performance that can be expected in the noise infested classroom environment where the crucial listening-learning is to occur. The implication then, is that auditory discrimination performance predictions are only appropriate for the conditions in which the scores were elicited.

The failure to achieve either raw score differences of pass-fail criteria differences in auditory discrimination with the group variable in either the quiet or noise listening condition was somewhat unexpected. The raw score F-ratio was 1.99 (Table 12) and the pass-fail F-ratio was 1.80 (Table 13). Indeed there

is evidence in the literature that auditory discrimination differences among different populations have been demonstrated (Christine and Christine, 1964; Wepman, 1958). In this study, the Wepman ADT failed to differentiate among these groups. However, there is also support in the literature that other investigators have failed to find the Wepman ADT a differentiating test among groups classified as reading problems, speech problems, etc., (Dykstra, 1966, Prins, 1963).

In spite of the lack of statistical significance in differences among the groups when the listening variable was held constant, there was impressive statistical differentiation in both the total experimental population, and in the normal and reading retarded groups when they were tested in the noise versus the quiet listening conditions.

Chapter V

Summary and Implications

Summary:

The purpose of this study was to determine whether classroom noise would adversely effect the auditory discrimination performance of primary grade children. The Wepman ADT was the standardized test selected as the measurement instrument to assess auditory discrimination performance. This test was designed as an individual test, to be administered in a one-to-one, clinic-client protocol, in a quiet environment, usually a small individual therapy room. However, the ongoing auditory discrimination activities of young children, usually take place in the classroom under different environmental noise conditions. The psychoacoustic literature has demonstrated that amplification of background noise effects speech intelligibility. In order to ascertain whether classroom noise serves as a masking signal to the intelligibility of speech in an auditory discrimination activity, the following hypotheses were formulated and tested:

Hypothesis I

There are no significant differences in the auditory discrimination performance of primary grade children when they are tested individually under noise conditions that simulate the relatively high levels found in classrooms and when they are tested individually under the relatively quiet conditions found in special teacher rooms in elementary schools.

Hypothesis II

There are no significant differences in the auditory discrimination performance of primary grade children relative to groups of children:

- (a) whose speech and reading are considered normal,
- (b) a second group of children with speech defects, and,
- (c) a third group of children with reading problems,

when these children are tested individually under noise conditions that simulate the relatively high levels found in classrooms, and when they are tested individually under the relatively quiet conditions found in special teacher rooms in elementary schools.

It was apparent that although special emphasis is currently being extended toward better understanding of noise pollution on societal and community problems, little concern has been extended regarding noise imposition on children. Although a direct, causal relationship between

good reading ability and auditory discrimination or good articulatory ability and auditory discrimination has not been demonstrated consistently, there is evidence of a trend in this direction. Therefore, it was reasonable to assume that any reduction in auditory discrimination performance could have deleterious effects on speech and reading performance.

The ability to discern sound in the presence of noise S/N, is an important parameter of hearing. If noise interferes with the listener's perception of speech, masking occurs (Jerger, 1963). The ability to communicate by voice in the presence of noise is determined by:

- (1) the level and spectrum of the noise,
- (2) the voice level of the speaker,
- (3) the distance between the speaker and the listener,
- (4) the vocabulary used (Webster, 1969).

Little research has been conducted with children as the experimental population, although Myklebust (1971) and Ferry (1969) advocated giving oral tests in a noise

background in order to delineate children with figure-ground disturbances.

Average classroom noise levels have not been determined relative to occupied and empty room conditions; nor have standards for construction relative to the acoustic environment of classrooms been determined (Hammon, 1970; Knudsen and Harris, 1950; Kingsbury and Taylor, 1967). In one study Kingsbury and Strumpf (1969) advocated a 66 dB noise level as the upper limit which could be expected to maintain adequate speech intelligibility. Sanders (1965) demonstrated varied noise level readings for varied grade level classrooms and stressed the greater noise level he found in the kindergarten and primary grade classrooms, where listening activities are most critical to learning.

Between 1930 and 1950, experiments were conducted which attempted to isolate differences between good and poor readers and good and poor speakers. Auditory discrimination was shown to be related to both skills (Harrington and Durrell, 1965; Winitz, 1969). Auditory discrimination test scores served as predictive measures of success in reading and speaking with the publication

of the Wepman ADT (1958). Inconsistent data precluded the continued use of such tests as predictive measures (Dykstra, 1966); however, the Wepman ADT continues to be used clinically and experimentally as the most widely accepted test of auditory discrimination performance. The incidence of cases of reading retardation who scored poorly on auditory discrimination tests was reported as 20-50 % (Durrell, 1956). Similarly, the incidence of speech defective children who scored poorly on auditory discrimination tests was reported as 50-80 % (Wepman, 1960).

The literature failed to indicate that auditory discrimination was studied in classroom noise situations, particularly as the test scores related to groups of normal, speech defective and reading retarded children in the primary grades.

To this end, 39 children divided into three groups of 13 subjects each were designated as: (1) normal, (2) speech defective, and (3) reading retarded. Subjects were selected at random by the appropriate staff of the pupil personnel services department of the

of the Amherst-Pelham Regional School District in conjunction with classroom teachers and the experimenter. The distribution of subjects included 23 males and 16 females ranging in age from 5.1 years to 7.11 years at the time of testing. Grade placement was: kindergarten - 2, first grade - 13, second grade - 24, which is commensurate with the directions for the Wepman ADT. The mean I.Q. of the subjects was 111.6, the mean score on the Gates-McGinitie Reading Test was 1.42 (grade level), the mean score on the Templin-Darley Articulation Screening Test was 40 (number correct).

Sound level measurements were taken in four different classrooms of four different schools within the district on two different days. The overall mean sound level obtained was 64.7 dBA. Sound level measurements were also taken in the same four schools in each of the special teacher rooms, following the established procedure. The overall mean noise level in these special teacher rooms was 39.5 dBA. Experimental testing procedures necessitated that classroom noise levels be simulated in the special teacher rooms. A tape recording

of 20 minutes duration was made in a separate classroom. This tape recording was representative of the spectrum and level of classroom noise obtained in the four classrooms in which the initial sound level measurements were taken, although none of the subjects was in attendance in this classroom. Thus, an accurate representation of typical classroom noise was available to all subjects. Order of presentation of the two listening conditions and the two test forms which comprise the Wepman ADT was controlled by random assignment of the four order of presentations.

Two sets of data were available for statistical analysis: (1) number of auditory discrimination errors, and, (2) pass-fail outcome values. Both sets of data were tested by a mixed design, analysis of variance with separate Between and Within subjects variability tested separately (Myers, 1972). In addition, three group t-tests were computed for the number of error means, and three group chi square analyses were computed for the pass-fail data.

The results of these analyses can be summarized as follows:

(1) The group means for the number of error scores rel-

ative to the three groups in the quiet and noise listening conditions were: (a) normal - 3.69, 5.69; (b) speech - 5.31, 7.23; (c) reading - 3.77, 7.31. These values yielded overall group means of 4.25 in quiet and 6.74 in noise, with an overall group mean of 5.50, number of errors. The F-ratio of 41.7 of the Within subjects mixed analysis of variance was significant beyond the .01 level of confidence, which indicated that the total population performance was more adequate in quiet than in noise.

(2) These results were replicated when the pass-fail data were computed with the mixed design analysis of variance, yielding an F-ratio of 26.6 for the Within subjects analysis (significant at the .01 level of confidence). Therefore, Hypothesis I was rejected.

(3) Hypotheses II (a), II (b), and II (c) were tested to determine whether group differences could be demonstrated. t-tests yielded values of 2.584 for the normal group, 1.476 for the speech group, and 7.077 for the reading group. Both the normal and reading group values were significant at the .01 level of confidence so Hypotheses II (a) and II (c) were rejected. Hypothesis

II (b) could not be rejected. The data for the three groups, however, did follow the trend of greater group difficulty in the noise listening condition than in the quiet listening condition.

(4) Analysis of the pass-fail data using the chi square procedure yielded χ^2 of 5.76 for the normal group, 4.54 for the speech group, and 20.54 for the reading group. Only the reading group chi square value (20.54) was significant at the .01 level of confidence. Thus, in this instance of the pass-fail data, Hypothesis II (c) was rejected. Hypotheses II (a) and II (b) were not rejected.

The most formidable and imposing result of this study was the prevailing difference in auditory discrimination performance of primary grade children obtained during the quiet listening condition as opposed to the noise listening condition. It was also possible to state that the auditory discrimination scores elicited in a quiet listening condition did not reflect the performance which could be expected in the noise infested classroom environment.

Implications:

The results of this study were expected based on the plethora of research in audition and psycho-acoustics that demonstrates that auditory perception is adversely altered in the presence of noise. This study supports the results of the limited number of studies which have employed children as the experimental population. In testing this specific aspect of auditory perception, it has been possible to show that a well constructed test, standardized in quiet, and universally used as an index of a child's auditory discrimination performance may not serve as a valid index for a given child's performance within the classroom setting where the listening-learning activities actually occur. Classroom teachers can be cautioned to interpret the results of the Wepman ADT with reservation, especially for students with marginal performance in reading.

There are potential implications for the reading retarded students in regard to figure-ground perception, especially when the background noise levels become perceptually competitive with the foreground signals. In other words, as signal to noise ratios (S/N) drift

toward the negative continuum, auditory discrimination deteriorates. This observation is pathognomonic to children with learning disabilities, particularly if they have brain damage. Thus, there may be pertinent, diagnostic implications to auditory perceptual performance relative to quiet and noise conditions, i.e. different S/N ratios. Diagnostic tests of this nature have not been devised for auditory perception as they have been for visual perception to assess foreground-background performance.

Another implication of this study pertains to remedial therapy. Perhaps one possible reason why young children do well in remedial speech therapy and remedial reading programs, relates to the one-to-one therapist student arrangement. In these instances, there are inadvertent shifts from the noisy classroom to the relative quiet of a small therapy room where remediation is carried out. Further investigation is warranted to explore this contingency.

In this study, there was a trend for the normal group to perform more adequately in quiet or noise than the speech defective or reading retarded group,

although the results failed to reach statistical significance. Perhaps the available speech defective children population was limited by the degree of articulatory inadequacy which students in a public school setting demonstrate. The subjects who were selected displayed only moderate articulatory proficiency while the literature suggests that there is a correlation between the severity of articulatory deficiency and auditory discrimination performance. A speech defective group which is selected from speech and hearing clinics, where children display a greater degree of deficiency of more serious articulatory handicaps, might have produced different results.

The following implications for further study can be made:

- (1) This study should be replicated employing a population of children who are diagnosed as "learning disabled". The literature describes children with learning impairments as frequently displaying inadequacies in figure-ground relationships.
- (2) This study should be replicated employing a population of sensori-neural hearing impaired children. There

are diagnostic precedences for systematically assessing the imposition of masking on hearing impaired subjects.

(3) This study should be replicated employing a population of reading defective students with differing degrees of retardation, i.e. marginal, moderate, profound. Since the reading group in this study consistently showed the greatest difficulty in the noise situation, further investigations are warranted.

(4) This study should be conducted in school districts which clearly delineate "open classrooms" versus "traditional classrooms", in order to determine whether the noise levels obtained in these two settings differ from each other, and whether noise level adaptation occurs in the learning situation as it does in other settings.

(5) This study should be replicated employing a population of bilingual children, where the phonemic differences of the teacher and the students may further interfere with auditory discrimination performance.

(6) This study should be replicated in different physical environments (urban versus rural) in order to determine whether or not community noise changes the sound level measurements obtained in classrooms.

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