THE EFFECTS OF CLASSROOM NOISE ON THE ACQUISITION RATE OF A SIGHT VOCABULARY BY KINDERGARTEN CHILDREN

by

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ABSTRACT

This study investigated the efficiency with which kindergarten children acquired a sight vocabulary in a quiet condition with no planned noise (Quiet 60-70 db) and in one of three conditions (Noise 60-70 db, Noise 70-80 db, Noise 80-90 db) in which a recording of classroom type noise was played. The two levels of sex and the four experimental conditions generated a two by four mixed measures factorial design.

Each subject met individually with the experimenter in a small room in the school, was pre-tested on the four sight words, given one pre-training trial, then trained to a criterion of two successive error-less trials. The dependent variable was the number of trials taken by each subject to reach criterion. Data collected on those subjects who knew one or more of the four words on the pre-test, or failed to reach criterion before 20 trials were not included in the statistical test of significant difference.

Since the hypothesis of homogeneity of variance was tested and rejected, a parametric test of significant difference using the analysis of variance method was not applied to the data. A non-parametric test of significant difference (Kruskal-Wallis one-way analysis of variance by ranks) was applied to the data which revealed no significant difference. However, fewer subjects failed to learn the words in the quieter conditions than in the noisier conditions. Suggestions for further research of the effects of noise on human

behaviour were also proposed.

Examiners: [redacted]

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CHAPTER I

STATEMENT OF THE PROBLEM

Purpose of the Study

The purpose of the study was to determine the effects of classroom noise on the acquisition of selected sight words by kindergarten children in a one-to-one tutorial situation.

Significance of the Study

While researchers have long inquired into the effects of classroom noise on school performance, much concern has been generated by a recent interest in ecology. Environmentalists have argued that noise is a form of pollution and a serious hazard to the health and welfare of the population. Okuma (1974) reported that the effects of noise have led to the formation of a "500-member nationwide Federation of Noise Victims based in Yokohama" (p. 16). The Federation estimated that "between two million and three million Japanese are affected in various ways by unbearable noise" (p. 16). It was further suggested that in some extreme instances noise has been related to suicide and homicide.

Educators have been exposed to claims for a need for acoustic control in the classrooms and schools. Unfortunately, consistency of results across experimental studies has not been established.

Studies implementing a variety of levels and conditions of noise have reported instances where noise influenced test performance and attending behaviour of students enrolled at universities, military schools, secondary schools and elementary schools, while similar studies have reported no effect. Some evidence has been offered to suggest that noise may affect the efficiency with which young children learn to

solve problems. Some experimental findings also suggest young children learn a sight vocabulary more slowly under noisy conditions. A measure of acquisition rate, such as the number of trials to attain a criterion, may offer a sensitive index for determining some of the effects of noise on human behaviour.

Underlying Assumptions

One component of learning entails the repetition of a desired response in the presence of an appropriate stimulus. Corequisite to repetition is attention (looking, listening) to that which is being practised. Thus, conditions that affect attention affect learning, and probably also the rate at which behaviour is acquired. If extraneous stimulation, such as classroom noise, results in a weakening of attention (distraction), learning may be inhibited. However, if attention is strengthened to compete with extraneous stimulation, learning may be facilitated. It would be beneficial to know the conditions under which classroom noise inhibits or facilitates acquisition rate.

Hypotheses

For this study the independent variables were (1) sex of the subjects and (2) four experimental noise conditions (quiet = 60-70 db[1]; noise = 60-70 db; noise = 70-80 db; noise = 80-90 db). The dependent variable was the number of trials taken to learn the four sight words

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[1]No planned noise

telephone, house, ball, car to a criterion of two successive errorless trials. The two levels of sex and the four experimental conditions generated a two by four, mixed-measures, factorial design. The alpha value was set at the .05 level of confidence.

The following hypothesis was generated and tested by the study: There will be significant differences in the mean number of trials to criterion between:

i. The sex of subjects

ii. The four experimental conditions

Limitations of the Study

The results of this study are limited in their interpretation and generalization by several factors. First, children participating in this study attended kindergarten in Victoria, British Columbia, Canada. Second, they met with the researcher individually in a small medical or storage room rather than in the classroom. Third, noise external to the experimental room was beyond the control of the researcher. Fourth, past experiences of the children were beyond the control of the researcher. And fifth, the researcher was aware of the particular condition of noise during the procedure.

Definition of Terms

The following terms appeared frequently throughout this study. They were defined as follows:

Learning: Learning was defined as the rate with which a behaviour is acquired.

Criterion or Mastery: two successive trials in which all four stimulus words were recognized and a perfect score attained for the subject.

Acquisition Rate: the number of trials required by the subject to attain criterion.

Sight or Stimulus Words: (1) telephone, (2) house, (3) ball, (4) car.

Verbal Response Repertoire: the sum total of all verbal responses which may be evidenced in the subjects.

Sight Vocabulary: the sum total of all verbal responses under control of non-auditory verbal stimuli: i.e. printed words.

Noise. Noise was defined as unwanted sound.

Classroom noise: that auditory pattern of stimuli recorded in a classroom during an activity period with 20 children ranging in age from six to twelve years.

White noise: (1) noise of a statistically random nature having equal energy per unit frequency bandwidth over a specific frequency band.
(2) a heterogeneous mixture of sound waves extending over a wide frequency range.

Masking noise: the amount by which the threshold of audibility of a sound is raised by the presence of another (masking) sound.

Threshold of change: ± 3 db as measured by a sound pressure meter.

Decibel (db): (1) a unit of level which denotes the ratio between two quantities that are proportional to power; the number of decibels corresponding to the ratio of two amounts of power is ten times the logarithm to the base ten of the ratio.

(2) the power based on a standard of pressure.

Standard of Pressure: 0 db = 0.0002 dynes/cm^2.

Sound Pressure Level (S.P.L.): the loudness of sound as measured by a sound pressure meter.

Music/Sound Level Meter: An instrument for measuring decibels. Realistic Cat. no. 33-1028 (A-weighting).

Acoustic: explicitly designates that which has characteristics associated with sound waves.

Experimental Conditions. The four experimental conditions were (1) quiet = 60-70 db[1], (2) noise = 60-70 db, (3) noise = 70-80 db, and (4) noise = 80-90 db.

Condition a: a sound pressure level reading between 60 and 70 decibels (mean = 65 db) without the tape of classroom noise being played. The sound level was of the conversation between the experimenter and the subject, without

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[1]No planned noise

background noise.

Condition b: a sound pressure level reading between 60 and 70 decibels (mean = 65 db) with the tape of classroom noise being played.

Condition c: a sound pressure level reading between 70 and 80 decibels (mean = 75 db) with the tape of classroom noise being played.

Condition d: a sound pressure level reading between 80 and 90 decibels (mean = 85 db) with the tape of classroom noise being played.

CHAPTER II

REVIEW OF RELATED LITERATURE

The review within this chapter was restricted to research studies which dealt with an attempt to discover how noise affects (1) affective behaviour (Krathwohl, 1956) such as attending to or receiving information, and (2) cognitive behaviour (Bloom, 1956) such as recalling, analyzing, or synthesizing information. Studies such as Steven's (1941) which have dealt with the effects of noise on psychomotor behaviour have not been included in the review.

Introduction

Over the last decade, increasing emphasis has been placed on the need to control classroom noise. Some educators have deemed noise as "inescapable" and have suggested focussing "not /on/ noise itself, but learning how to communicate effectively in its presence" (Smith, 1962, p. 80). Other educators have identified noise as "our third pollution" and have suggested that it has been demonstrated to be "a serious and present health hazard" (Konopa and Zimmering, 1972, p. 116).

Some educators have stressed the identification and control of sources of noise in classrooms and schools. McKay (1964) and Cavanaugh (1964) have described several acoustic problems occuring in schools which may be dealt with effectively through thoughtful planning of new structures and modification of present structures. However, acoustic control of noise may not always be financially possible, particularly in older schools. One alternative to the expense of remodelling schools, has been the application of operant conditioning principles to the problem of reducing the level of noise generated by normal classroom activity.

Riffel (1972) experimentally demonstrated that noise level in an elementary school classroom could be reduced by the application of these principles.

However, before generating methods of controlling classroom noise, it would be helpful to know in what ways noise does indeed affect human behaviour. Unfortunately, research on the effects of noise does not appear to have generated consistent results related to classroom performance from which conclusions and decisions may be drawn.

The Effects of Noise on Affective Behaviour

Affect or affective development has generally been described in terms of feelings, attitudes, and motives which act to propel behaviour. Affect may be inferred from particular classes of overt behaviour such as attending and responding. Krathwohl (1956) described five major levels or classes of affective behaviour ranging in ascending order from receiving or attending through to characterization. Attending behaviour, looking, listening, and responding behaviour, have been of particular interest to investigators of the effects of noise. Although the focus of the researchers has been on affective behaviour, they have been aware that both cognitive and psychomotor behaviour may occur simultaneously with affective behaviour.

Early research into the distracting effects of noise was carried out by Tinker (1925) and by Hovey (1928). Tinker reported that performance on the Otis Intelligence Test was depressed for subjects falling in the upper quartile and increased for the remainder of the subjects. However, Hovey reported that higher mental processes were

not adversely affected by noise. He suggested that no relationship between susceptability to noise and intelligence existed and reported that no individual differences were observed. He concluded that "true mental ability /was/ more nearly approximated under distraction than under standard conditions" (p. 581).

Broadbent (1955) in a review of literature on the effects of noise, suggested that:

> no man can react simultaneously to all stimuli which are affecting his sense-organs. He deals only with part of them, and the rest are ignored. But he cannot hold indefinitely, and as time goes on he will occasionally shift attention away from his work and back again...these momentary shifts become more frequent when a high intensity noise is present. When they occur they will cause a mistake or a slow reaction, but between them, the man may work as well as ever (p. 544).

Perhaps an information loss, i.e. interferance, occurs during the period of inattention, thus inhibiting the performance of the individual.

More recently, Kahneman (1973) suggested that the Yerkes-Dodson Law could be applied to the effects of noise on performance. Within this law, performance quality has been described as an inverted U-shaped function of noise level (arousal). As the noise level first increases so does the quality of performance to an optimal point, and then begins to decrease with further increments of noise level. Kahneman suggested that:

> a state of high arousal is associated with the following effects: (1) narrowing of attention; (2) increased lability of attention; (3) difficulties in controlling attention by fine discriminations; and (4) systematic changes of strategy in various tasks. On the other hand,

> a state of extremely low arousal may cause: (1) failure to adopt a task set; (2) a failure in the evaluation of one's performance, resulting in an insufficient adjustment of the investment of capacity to the demands of the task (p. 42).

Both Broadbent (1955) and Kahneman (1973) have pointed to change in attending behaviour as a result of excessive noise. The change in attention may then be relected by a change in performance.

The Effects of Noise on Vigilance. Vigilance has been described in terms of alertness or attention and has been measured by the efficiency with which subjects monitor a stepping hand of a blank-faced clock (Mackworth's Clock Test) (Jerison, 1959). The task called for the identification of an infrequently occuring double jump in the movement of the hand. A simple task involved observing a single clock, whereas a complex task involved observing two or more clocks simultaneously. Tasks called for simultaneous monitoring of flashing lights have also been implemented in this research area. These were the two major indices of vigilance employed by Jerison (1954, 1957, 1959) in a series of experiments to determine performance variables that may be adversely affected by noise.

Jerison (1954) attempted to discover the influence of noise on paced performance on a complex counting task under noise and quiet conditions. The task entailed keeping track of the frequency with which three lights flashed at differing rates, by pressing a key after a particular number of flashes had occured. Twenty-four male undergraduate students were assigned to one of two experimental groups. Twelve worked for one of the two hours in white noise (a heterogeneous mixture of sound waves extending over a wide frequency range at 110 decibels) while twelve

worked for two hours in relative quiet (Sound Pressure Level was not reported). The two groups were found to be significantly different, noise and time having a detrimental effect on performance. It was concluded that deterioration in performance may have resulted from (1) fatigue induced by noise, or (2) directly from the distracting effects of noise. Jerison further suggested that a memory function may also be involved.

In a later study, Jerison (1957) examined the effects of two levels of masking noise (79 db and 112 db) on the performance of 20 paid volunteer undergraduate students monitoring a single Mackworth Clock. Two sessions occured a week apart and counter-balance procedures were employed to control for possible order effects. The results revealed no significant effects between the experimental conditions. A one-clock test entailed performance related to "alterness + focussing," while performance on a two-clock test called for "alertness + flexibility" (p. 1165). Jerison suggested that flexibility of attention may be susceptible to interference from noise.

Jerison (1959) conducted three further experiments related to vigilance under noise. Subjects were paid volunteer male undergraduate students, randomly assigned to one of two groups. Each subject was tested individually through three work sessions with intervals of one week between sessions. Subgroups were counter-balanced against possible order effects. Masking noise was similar to that used in the previous study. Sound Pressure Levels in the quiet conditions were: 83 db in Experiment I, and 77 db in Experiments II and III, and in the noise conditions: 114 db in Experiment I, and 111.5 db in Experiments II and III.

Experiment I was conducted to examine the effects of noise performance

on a long, complex, vigilance task (monitoring three Mackworth Clocks simultaneously). Results revealed a significant interaction ($p < .05$) between the rate of change of performance for the two sessions (session by time at work interaction). Jerison suggested that performance did not decrease as a result of fatigue alone.

Experiment II was a replication of an earlier experiment (Jerison, 1954). Results suggested that work on a complex task over a two hour period resulted in a progressive reduction in performance. However, when subjects began the task in a quiet situation, performance was not depressed when noise was introduced later. These findings supported those of Broadbent (1958).

Experiment III was included in Experiment II, where subjects also pressed a key when they felt that intervals of ten minutes had passed. Judgements of time were found to be significantly better in the quiet condition than in the noise condition.

Jerison concluded that changes in vigilance occurring over time affected performance under noise, but not under quiet conditions. Results from this series of studies by Jerison suggest that noise interfered with attending behaviour, defined in terms of vigilance, on a difficult or complex task, but not necessarily on an easy or simple task.

Changes in Attention Under Noise. Changes in attention effected by noise may result in an information loss occurring during the period of non-attending behaviour. Woodhead (1964a, 1964b, 1966) conducted a series of experiments to determine the effects of noise on changes in attending behaviour.

These experiments focussed on discovering the effects of noise on shifting of attention during the performance of two simultaneous tasks. It was found that noise resulted in a widened difference in performance during the task of monitoring two unequally occurring features of a visual display (Woodhead, 1964a).

In another study (Woodhead, 1964b) subjects were given arithmetic problems consisting of memorization and calculation. Subjects, 84 men enlisted in the Royal Navy, were given the task of memorizing a six digit number, remembering it, then subtracting it from a four digit number. Noise was recorded rocket firing bursts with a peak intensity of 100 db, and presented either during the memorization period or the calculation period. Noise presented during the memorization period resulted in more errors, whereas noise presented during the calculation period produced a lower rate of work, gradually increasing over the session. Performance may have been affected by the amount of practice received. Woodhead suggested that "the effects of a burst of noise depend upon its relationship with different parts of the task" (p. 633). It was concluded that the effects of noise on perception and learning were not the same as during calculation. Subsequently, another experiment was conducted to isolate the effects of noise on memorization and searching behaviour.

Woodhead (1966) found that noise affected memorization but not searching behaviour. She suggested that "although noise does not always induce a redistribution of attention given to a visual display, when it does so, attention is likely to shift further toward the preferred activity" (p. 229).

Winnick and Learner (1963) examined the effects of noise on incidental and intentional learning by 80 introductory psychology students randomly assigned to four groups of 20. The task required learning to a criterion of one errorless trial, twelve girls' names presented on a memory drum, with one colour matched with two names (six colours in total). Subjects were instructed to memorize names, with no mention of the colours being made. The independent variables were: (1) a control condition with no noise, (2) a recording of 135 girls' names playing, (3) a recording of classical music playing, and (4) selections from a variety of radio programmes playing. Sound Pressure Levels were not reported. A post test consisted of matching each name with its correct colour. Results did not reveal a significant difference at the $p < .01$ level of confidence. However, the researchers concluded that incidental learning was less susceptible to outside interference from unwanted sound than intentional learning. Initial learning rates were included in a later covariate analysis which did not reveal a significant difference.

Samuel (1964) attempted to test the hypothesis that, under noise conditions, performance related to a shift in attention would be lower than performance not requiring a shift in attention. Five female and five male volunteer students were randomly assigned to each of four experimental conditions generating a two by two factorial design. In the shift condition, subjects added two digits presented from two separate sources, while in the non-shift condition the digits were presented from a single source. White noise was presented to the subjects through earphones at 110 db in the noise condition and at 80

db in the quiet condition. Results revealed that performance requiring a shift in attention was superior in noise as compared to performance in the quiet condition.

Samuel concluded that the following four factors may be helpful in describing the influence of noise in the shift condition: (1) level of arousal, (2) compensatory effort, (3) deleterious effects of apparatus noise, and (4) lack of auditory feedback (p. 267). It was suggested that further research was needed to isolate the effects of noise on change in performance variables.

More recently, Turnure (1970) investigated problem solving by three age levels of young children under three conditions of distraction. It was hypothesized that distractors would inhibit performance of younger children and facilitate performance of older children. Five children were matched on Chronological Age and I.Q. score, then assigned to each cell of a three (age) by three (condition) by two (sex) factorial design. The three age groups were five and a half, six and a half, and seven and a half years, while the three experimental conditions were (1) mirror distraction, (2) sound distraction, and (3) no distraction. A fourth possible condition, sound and mirror distraction, was not included in this design. The sound distraction consisted of a phonograph recording (unspecified) playing at an average level of 60 db. Other Sound Pressure Levels were not reported. The task involved selecting the odd stimulus from an array of three geometric shapes presented simultaneously. Since 60 trials were given to each subject, overlearning did not appear to be of concern to the investigator. Non-attending behaviour was defined as the frequency of glances by a subject

away from the stimuli.

Results revealed that the sound condition consistently depressed performance. Subjects in the mirror condition spent twice as much time glancing away from the stimuli as those in the sound and control conditions. The researcher appeared to be primarily concerned with results generated in the mirror condition and their developmental implications. Further analysis of the data collected in the noise condition was not reported.

In summary, noise appears to be related to changes in attention. If the subject does not attend to that which is to be learned, but to other stimuli, an information loss may occur. This information loss may also be related to momentary shifts or changes in attention as suggested by Broadbent (1955).

The Effects of Noise on Auditory Discrimination. A large amount of classroom learning class for verbal instruction. If classroom noise is at a level which masks the speech of the teacher, the children may not be able to discriminate or even hear the salient auditory stimuli patterns and thus performance may be depressed.

Both long term and short term effects of noise on auditory discrimination have been investigated. For example, Cohen, Glass and Singer (1973) investigated the relationship between noise level in the home and the performance of auditory and verbal skills by 54 elementary school children. This sample was divided into two groups: (1) those residing more than four years in the area (primary sample), and (2) those residing less than three years in the area (secondary sample). Cohen, Glass, and

Singer described their population as follows:

> All children in the sample lived in the Bridge Apartments built in 1964 on bridges spanning interstate 95 in the upper part of Manhatten in New York City. The apartment building consisted of four 32-story aluminum towers. Open highway vents and vertical surfaces of the building produced high noise levels and an "echo chamber" effect (p. 410).

Sound Pressure Levels were determined which were reported to empirically support the use of the number of the floor on which the children lived as the index of noisiness. The Wepman Auditory Discrimination Test and the Metropolitan Achievement Test were administered individually to each subject. Results indicated a positive correlation between the number of the floor on which the subjects lived and auditory discrimination test scores ($r = +.48$, $df = 32$, $p < .01$) for the primary sample. Correlations between the sub-test of the reading and auditory discrimination scores were all significant at the .01 level of confidence for the primary sample, but not for the secondary sample.

It was concluded that "apartment noise level accounts for a substantial proportion of the variance /23%/ in auditory discrimination and the latter variable contributes significantly to the variance in reading achievement" (p. 418). While children may learn to "tune out" noise, it was suggested that deficits in both auditory and verbal skills may leave a detrimental effect.

Nober (1973) also used the Wepman Auditory Discrimination Test in an investigation of the effects of noise. Parallel forms of this test were given to normal, speech defective, and reading retarded, five to eight year old children. Both forms A and B were randomly administered

across both noise and quiet conditions. The quiet condition (Sound Pressure Level was not reported) took place in a special teaching room. The noise condition took place in the same room with a recording of classroom noise playing (64.7 db). An analysis of variance revealed a significant difference ($p < .01$) favouring the quiet condition over the noise condition. In comparing the scores, Nober concluded that auditory perception was affected adversely by noise and that testing in a quiet situation may not generate data representative of performance in the classroom.

Guertin (1959) also attempted to answer a similar question related to noise during testing procedures: "How important is it for the clinician to minimize auditory distraction while giving the Digit Span Test (Wechsler Bellevue I) so as to permit maximum concentration and attention?" (p. 349). Forty-eight psychiatric patients were required to recall a forward set and backward set of digits once with noise and once without noise. A statistical test of significance was not reported, however, Guertin concluded that noise had a less distracting effect on digit span than had been formerly assumed by clinicians. The generalizability of these results is suspect because of the particular sample used, and the lack of a statistical test of significant difference.

Summary of the Effects of Noise on Affective Behaviour

Some of the research on the effects of noise on affective behaviour reviewed in this section appears to be limited in terms of (1) adequate control procedures, (3) appropriate statistical analysis of data, (4) selection of performance variables, (5) reporting and selection of noise levels, and (4) interpretation of results. For example, in one study

(Guertin, 1959), a test of significant difference was not applied to the data collected on a limited sample of subjects, then generalizations about the effects of noise on performance during testing procedures were made. In other studies (Turnure, 1970; Jerison, 1954; Cohen, Glass and Singer, 1973) univariate tests of significant differences were applied to sets of data requiring multivariate analysis. If the total experimenal error were to increase by repeated, independent statistical tests, or the assumptions of orthogonality or independence of data sets and homogeneity of variance were violated, then the probability of any significant results, by chance alone, would increase.

Measurement of performance variables generally called for analysis of data collected on: (1) the number of correct responses, (2) frequency of errors or omissions, or (3) the amount of time spent on or attending to the task. A possible analysis of data collected on learning rates was not included in the studies by Winnick and Learner (1973) and by Turnure (1970). This may have been due to the lack of control for over-learning produced by a fixed number of trials during the acquisition stages of these studies. Neither of these studies included more than two levels of the independent variable (levels of noise) equidistant along the same auditory stimulus continuum which may reveal a possible non-linear relationship between noise level and performance. Furthermore, Winnick and Learner based their conclusions on results which only "approached" the level of significance stated for the study.

Quiet control conditions (Samuel, 1964; Jerison, 1957) and specific Sound Pressure Levels (Winnick and Learner, 1963; Jerison, 1954; Turnure, 1970) were not included in any of the studies. Failure to report noise

levels was predominantly in the no noise or quiet conditions, while low level white noise was presented to subjects in the control condition rather than no noise at all. This may have been due to the difficulty in controlling noise external to the experimental situation.

Some results appear to be consistant across most of the studies reviewed in this section. For example, noise level appears to be related to auditory discrimination (Cohen, Glass, and Singer, 1973; Nober, 1973). Findings by Jerison (1954, 1957, 1959) Woodhead (1964a, 1964b, 1966) and Samuel (1964) supported the hypotheses of both Broadbent (1955) and Kahneman (1973) that noise disrupts or interferes with attending behaviour, resulting in depressed performance scores. However, Kahneman's hypothesis, that the quality of performance is a quadratic function of the amount of arousal induced by noise, has not been investigated.

An examination of acquisition rate under a controlled quiet condition and several levels of noise (at equal perceptual intervals) along a single auditory continuum appears to be warranted in further research on the effects of noise on human behaviour.

The Effects of Noise on Cognitive Behaviour

Cognition or cognitive development can be defined as the act of processing information and cognition may be inferred from particular classes of overt behaviour such as applying, analyzing, or sythesizing information. Bloom (1956) has described six major levels or classes of cognitive behaviour ranging in ascending order from knowledge through to evaluation. Both formal (standardized) and informal (non-standardized) instruments have been employed in measuring cognitive behaviour.

Although the focus of the research reviewed in this section has been on cognitive processes, both affective and psychomotor behaviour may occur simultaneously with cognitive behaviour.

In an early review of the literature, Hartman (1946) suggested that the "efficiency of all kinds of mental work /cognition/ especially the more complex varieties, is generally noticeably lower /under noisy conditions/", that is, not withstanding individual differences, performance is generally inhibited in a noisy situation (p. 149). Research by Morgan (1916), Flexner (1932), Catharine (1936), Hsaio (1937), Brown (1938) as well as several other early investigators, demonstrated an inhibitory effect of noise on performance. Hartman concluded that as the difficulty of the task increased, so did the detrimental effects of noise. Later research tended to support this hypothesis.

The Effects of Noise on Easy and Difficult Tasks. Jerison (1955, 1957, 1959) reported that noise had no effect on a simple or easy vigilance or monitoring task, but did tend to depress performance on a complex or difficult vigilance task. However, Park and Payne (1963) found a significant difference between performance on easy and difficult division problems, but not between the noise conditions. Forty college students were randomly assigned to four groups generating a two (noise level) by two (task difficulty) factorial design. Noise level in the quiet condition varied from 50 to 70 db and from 98 to 108 db in the noisy condition where noise was produced by an air horn. It was observed that increased noise level generated larger variance for the easy problem group, but not for the difficult problem group. It was suggested that both sets of division problems may have been easy for the

subjects.

Boggs and Simon (1968) attempted to discover the effects of noise on tasks of varying complexity. Twenty-four male and twenty-four female students in an introductory psychology class performed two tasks simultaneously under quiet and under noisy conditions with order effects controlled. Half of the subjects performed the primary task and half the secondary task. The primary task (psychomotor) was presented at two levels of complexity, while the secondary (cognitive) task was held constant. The primary task called for a four-choice reaction-time task. After a warning light was presented, subjects responded to one of four lights by pressing the appropriate switch. Lights corresponded with switches in the simple condition, but not in the complex condition. The secondary task consisted of identifying odd-even sequences of numbers presented auditorially. Noise consisted of 90, five second bursts of 92 db recorded noise produced by a bandsaw over each of two, ten-minute runs. Sound Pressure Level during the quiet condition was not reported. The dependent variables were: (1) reaction time on the primary task, and (2) errors on the secondary task. No errors were made on the primary task. The only significant difference related to the primary task was between the first and second run, the first being slower than the second. Perhaps, efficiency in reaction time was a function of the amount of practice received. On the secondary task, the main effects of noise and complexity of task were both significant as well as their interaction ($p < .01$). It was concluded that noise produced a decrement in performance as a function of task complexity. Boggs and Simon suggested that "noise effects may have gone undetected in much previous research for a

lack of sensitive criterion measure" (p. 152). This may well have been the case with later research as well.

In summary, even though difficulty has been encountered in discriminating between easy (simple) and difficult (complex) tasks, performance appears to be depressed by noise on a difficult task, but not on an easy task. The form or type of noise may also be an important variable in these studies.

The Effects of Intermittent Noise. Unwanted sound may occur in many forms such as continuous or intermittent noise. White noise (a heterogeneous mixture of sound waves extending over a wide frequency range) has been considered one form of continuous noise, while infrequently or randomly occurring bursts of sound have been considered one form of intermittent noise.

Smith (1951) investigated the effects of intermittent loud noise on the performance of 52 male and 17 female students. Half of the sample was given the Minnesota Clerical Test under 100 db intermittent bursts of noise, while the other half were tested in a control situation (Sound Pressure Level was not reported). Smith reported that under the noise condition the number of items attempted and the number of errors committed was greater than under the control condition. He concluded that intermittent noise resulted in an increment in response rate, however, the quality of the response decreased.

Woodhead (1964b) reported that bursts of noise during memorization adversely affected calculation of arithmetic problems. In an earlier study, Woodhead (1959) found that repeated bursts of noise affected decision-making behaviour, but only immediately after the onset of each

burst of noise. No effect was observed during the inter-noise burst intervals. Subjects and noise were similar to those reported by Woodhead (1964b). The task entailed matching moving cards (digits) to a standard. However, neither of these experiments examined the effects of exposure to intermittent noise over an extended period of time. Perhaps subjects would adapt or adjust to long periods of intermittent noise, thus producing a gradual increment in performance quality.

Sanders (1961) investigated test performance on an easy test (Bourdon-Wiesma Cancelling Test) and on a difficult test (Kaepelin Addition Test) under two conditions of noise. White noise was presented via earphones at 75 db in an intermittent noise condition and at 70 db in a continuous or constant noise condition. Forty air force personnel were randomly assigned to the four conditions and tested over a period of two days. Subjects in group one worked under intermittent noise on both days, those in group two worked under continuous noise on both days, those in group three worked under intermittent noise on the first day and under continuous noise on the second day, and those in group four worked under continuous noise on the first day and under intermittent noise on the second day. Each test was administered twice on the different days. Sanders found that for the difficult task the variance quotient was significantly larger under intermittent noise than under continuous noise ($p < .05$). However, the large number of *t*-tests (32) applied to the data may have resulted in an increase in the probability of any significant differences by chance alone.

Lehman, Creswell, and Huffman (1965) attempted to assess the effects

of different forms of noise on psychological performance and energy expenditure. Eighteen male university students were given equivalent test forms of mathematical computation and reading comprehension under three conditions of recorded noise. In the quiet condition the noise level was from 20 to 25 db, in the normal condition 45 to 55 db of music and white noise, and in the high noise condition, noise from various sources such as radio, television, air hammer, and phonograph was played from 75 to 85 db, with an intermittent siren at varying frequencies. Reading comprehension was measured by the Cooperative English Test, mathematical computation by ten addition problems, and energy expenditure by oxygen consumption determined by a Sanborn Metabulator. An analysis of variance disclosed that mathematical performance was superior in the quiet condition ($p < .05$) and progressively decreased with increments in noise level. Reading scores were found to be superior in the quiet condition as compared to the high noise condition. However, the difference between the quiet and normal conditions was not significant. It was also reported that more time was needed to complete the mathematical computation under the high noise condition. Oxygen consumption was found to increase with the level of noise. Each set of data was treated by a separate statistical test of significance. It was suggested that the use of music to mask noise in classrooms and schools was not supported in this study. It was further recommended that attention should be given to controlling and eliminating unwanted sound.

More recently the effects of four conditions of noise on the performance of 80 mentally retarded children was investigated by

Joiner and Kottmeyer (1971). The four conditions were (1) no noise, (2) a typical classroom background, (3) a typical classroom background noise plus noise episodes, and (4) noise episodes alone. Sound Pressure Levels were reported as ranging from 0 to 70 db for the study, but individual group levels were not reported. The task required the identification of three digits presented visually at either a 1/10 or 1/100 second duration. Results revealed a significant difference ($p < .01$) in the number of correct responses under the four conditions with the no noise condition producing the best performance and the condition with noise episodes alone producing the worst performance. Further analysis revealed an interaction between the noise conditions and the duration of the stimulus presentation. Joiner and Kottmeyer concluded that noise suppressed performance, particularly when the stimulus duration was increased.

In summary, it has been found that with normal and retarded populations, intermittent noise tends to suppress performance to a greater extent than either continuous noise or no noise.

The Effects of Noise on Retention. If attending behaviour is interrupted by unwanted sound, and the information to be learned is not acquired, the retention of such information may also be affected. However, it is also possible that unwanted sound may directly affect storage and recall of that information.

Broadbent (1958) investigated the effects of noise on performance on a subtraction task emphasizing short term recall by 18 men enlisted in the Royal Navy. The task called for remembering a six digit number, then subtracting a four digit number from it. The task was repeated on two successive days. Subjects were assigned to one of the follow-

ing three groups: (70 db noise on both days (QQ), (2) 70 db noise on the first day and 100 db noise on the second (QN), and (3) 100 db noise on the first and 70 db on the second (NQ). A fourth possible condition (NN) was not included in the design. Noise was defined as "uninterrupted, equal-energy per octave, machinery noise"(p. 825). Results from the first day revealed no significant differences. Three differing sets of results were found on the second day. The least affected group worked first in 70 db noise, then in 100 db noise (QN), and the greatest depression of performance was in the group who worked in 100 db noise, then in 70 db noise (NQ). Total between variance for all groups was significant at the .05 level of confidence, while the only significant individual group comparisons were between the NQ and QQ groups. When the QQ and QN groups were covaried on the first day's performance, a significant difference was observed ($p < .05$). Broadbent suggested that the performance of

> (1)...a group working in noise deteriorates more than a group working in quiet, even though both groups have previously performed a full session in quiet previously; (2) that one of two groups working in quiet, the one which had previously been working in noise deteriorates more than the one which had always worked in quiet (p. 826).

It was concluded that an interruption of attention in one situation may result in further interruption of attention in a similar situation occurring later.

Miller (1957) examined the effects of two conditions of noise on retention of visual and auditoral presentations of information by 48

male college students. Noise was similar to that produced by a jet aircraft (111 db, flat frequency spectrum to 6000 cycles/second). Sound Pressure Level was not reported for the control condition. The information presented either verbally or visually included: (1) a list of words, (2) a set of meaningful statements and (3) a series of dial settings. Comparisons (F ratios) of recall performance did not reveal significant differences. Miller concluded that the intensity and frequency of noise employed in the study did not appear to significantly affect the recall of information acquired auditorally or visually. However, task difficulty may have been easy in all three activities for the particular subjects tested, as Park and Payne (1963) suggested in their study.

Although retention was considered an important factor in the two studies, the specific effects of noise on retention were not isolated. However, interruption of attention by noise may be related to (1) forgetting and (2) a higher probability of information loss from shifts in attention (Jerison, 1954; Broadbent, 1955).

The Effects of Music on Performance. During a school day, intermittent noise caused by activity inside or outside the classroom (e.g. class movement in the halls, janitorial or school maintenance services) may be masked by continuous sound. Music may act to mask out these unwanted bursts of noise and therefore reduce their detrimental effects on performance. However, Lehman, Creswell, and Huffman (1965) found that music may have a depressing effect on performance and suggested a re-examination before being introduced in the school and classroom.

Eddelbute (1971) compared the effects of (1) silence, (2) background music, and (3) white noise on the performance of 97 university students working in programmed text books. The subjects were randomly assigned to the three conditions of noise and to three programmed texts forming a total of nine groups. Before and after each treatment session the Moods Adjective Checklist was administered to each subject, and the Rokeach Dogmatism Scale was administered after the final session. Results revealed no significant difference in the performance on the programmed materials under the three conditions. However, changes in mood appeared to be related to the auditory conditions. The particular tests of significant difference applied to the data were not reported. Eddelbute suggested that further research was needed in this area.

Vernetti and Jacobs (1972) investigated the effects of classical music to mask (masking noise is related to the amount by which the threshold of audibility of a sound is raised by the presence of another sound) background noise with 53 children believed to have learning disabilities. The subjects computed arithmetic problems under alternating conditions of noise and noise masked with music. An analysis of variance revealed no significant difference between the groups in performance. It was concluded that special classrooms used to eliminate extraneous noise were unnecessary for children with learning disabilities. However, since a control (no noise condition) was not incorporated in this design, generalizations may be limited.

In the studies reviewed here, music to mask noise did not result in improvement in performance. However, some changes in mood appeared to be related to the type or form of auditory stimulation used.

The Effects of Noise in the Classroom. Only a small portion of research on the effects of noise has been carried out in actual classroom or classroom type situations. This may be due to the difficulty in developing a well controlled experimental design which does not seriously reduce the generalizability of results.

Sanders (1965) measured noise levels in kindergarten, intermediate, and secondary school classrooms to determine the effectiveness of hearing aids for partially deaf children. Measurement of Sound Pressure Level was made in these normal classroom and in units for the partially deaf. In fifteen schools (47 classrooms) and a total of 3,616 obervations were made. An analysis of variance revealed a significant difference ($p < .01$) among the four types of classrooms. The intensity and variability of noise level was found to be greatest in kindergarten classrooms (mean = 69 db, S.D. = 8.5). Sanders suggested that teachers need to be aware of the limitations imposed by background noise in the use of the hearing aid with young children, and recommended further research into the effects of classroom noise on school performance in order to evaluate the benefit of the hearing aid with children having hearing impairments.

Samture (1969) reported that third grade children, especially boys, performed significantly better under noise conditions than under a control condition. Three parallel forms of The Metropolitan Reading Test of Achievement were administered to the same subjects as follows: (1) Form A under regular classroom noise, (2) Form B under constant noise from a record (orchestration), and (3) From C under intermittent noise from a record playing at varying intensities. Sound Pressure

Levels were not reported. The 18 independent t-tests applied to the data may have increased the probability of significant differences produced by change alone. Variance generated by the fixed order of presentation and the differences in test form was not accounted for in this design. Samture concluded that a combination of factors and conditions (unspecified) produced better performance under the noise conditions. This apparent reversal (noise facilitating rather than depressing performance) may be related to the possible quadratic nature of the function suggested by Kahneman (1973).

Slater (1968) used 267 seventh grade children to investigate the effects of three levels of noise (quiet = 45-50 db, average = 55-70 db, and noisy = 75-90 db) in a classroom situation (homework or test type condition) and in an experimental situation (on the school stage). Noise used was similar to that found in schools, but with the addition of white noise in the experimental conditions. The subjects were administered Form Three of the reading test, Sequential Test of Educational Progress. Subjects were also equated for ability by pre-testing them on part One of an alternate form of the test, then matched to form groups. It appears that more than a single analysis of variance was applied to the data (p. 242). However, no significant differences among any of the groups were revealed. Slater concluded that under these particular conditions, noise had no measurable effect on performance. Slater suggested another experiment to reveal any effects of noise over time. This experiment was later carried out by Kassinove (1972).

In Kassinove's study (1972) 40 grade three and 40 grade six

children worked individually on a series of addition or division problems in a quiet condition, or one of several conditions of noise (Sound Pressure Levels were not reported). Performance was measured by: (1) mean response time, (2) variability of response time, (3) probability of incorrect responses, (4) correct responses, (5) frequency of two second intervals of not looking at the work sheet, and (6) changes in these behaviours over time. The independent variables were: (1) no auditory stimulation, (2) recording of Danny Kaye telling a series of Hans Christian Andersen Stories, (3) music, and (4) "less discriminable multiple stimuli" (p. 527). Arithmetic achievement scores were used to divide each grade into high and low ability groups. The grade three subjects were given easy and difficult addition problems, while the grade six subjects were given easy and difficult division problems. Analysis of variance (a repeated univariate analysis rather than a multivariate analysis) revealed no significant differences either immediately or over time. Kassinove concluded that moderate levels of noise did not significantly affect the arithmetic performance of elementary school children and cautioned that:

> Complaints that noise interferes with education would have to be supported by experimental data before schools or parents should be coerced into spending vast sums of money to eliminate such noise (p. 530).

Ollila and Chamberlain (manuscript submitted for publication, 1975) examined the effects of classroom noise on the effectiveness of two methods of presenting a sight vocabulary to kindergarten children. A sample of 120 children were randomly assigned to four groups of girls and four groups of boys, each containing 15 subjects. Classroom noise was played at 70 db in the noisy condition, but not in the quiet condition

(60 db). Four words were learned to a criterion of two successive correct trials either with the word presented alone, or the word presented with the corresponding object. An analysis of variance by planned orthogonal comparisons revealed a significant difference ($p < .05$) favouring the girls trained by the word-alone method in the quiet condition over girls trained by the word-object method in the noise condition. No other significant differences were found. It was suggested that teachers should recognize that a possible detrimental effect on learning may be generated by the interaction between noise level and the particular instructional materials employed.

In brief, results have not led to a consistent set of conclusions. Depending on the form and the particular performance measured used, noise may have an effect on classroom performance.

Summary of the Effects of Noise on Cognitive Behaviour. Some of the research of the effects of noise on cognitive behaviour reviewed in this section appear to be limited in terms of: (1) control procedures, (2) appropriate data analysis, (3) reporting and selection of noise levels, and (4) interpretation of results. For example, repeated independent statistical tests of significant differences (*t*-test, *F* ratio) have been applied to data sets which may not have been orthogonal (independent and uncorrelated). The total experimental error within each of these studies (Smith, 1951; Sanders, 1961; Lehman, Creswell, and Huffman, 1965; Miller, 1957; Eddelbute, 1971; Vernetti and Jacobs, 1972; Samture, 1969; Slater, 1968; Kassinove, 1972; Broadbent, 1958) may have increased the probability that significant results were

produced by chance alone.

Several studies (Joiner and Kottmeyer, 1971; Boggs and Simon, 1963; Miller, 1957; Samture, 1969) did not report all noise levels, particularly in the control conditions while others (Sanders, 1961; Vernetti and Jacobs, 1972) did not include a quiet, no noise control condition. The experimental design used by Samture (1969) failed to account for the variance generated by order of testing and form of tests.

Neither Lehman, Creswell, and Huffman (1965), Joiner and Kottmeyer (1971), nor Ollila and Chamberlain (manuscript submitted for publication, 1975) included the possibility of more than two noise conditions equidistant along the same auditory stimulus continuum. Generalizations made by Vernetti and Jacobs (1972) do not appear to be appropriate when considering the limitations imposed by the sample, design, and scope of the research.

Some conclusions may be drawn about the effects of noise on cognitive behaviour. It has been found that noise, particularly intermittent noise, may suppress performance on complex cognitive tasks. However, findings have not been consistent across all of the studies reviewed in this section. This may have been due to: (1) a possible non-linear component such as a quadratic one suggested by Kahneman (1973), (2) the levels and forms of noise, or (3) the sensitivity of the particular measures employed as suggested by Boggs and Simon (1968).

Summary of the Effects of Noise on Affective and Cognitive Behaviour

Perhaps children have learned to "tune out" extraneous noise by the time they have entered school (Smith, 1962). Perhaps well designed

instructional practices result in the suppression of the effects of noise which may be detrimental to school performance. However, "tuning out" has often been considered an equal problem by teachers (Wittich and Schuller, 1967). The research reviewed on the effects of noise on affective behaviour appears to be better controlled experimentally, while research on the effects of noise on cognitive behaviour appears to be more generalizable to the school and classroom.

The affective behaviours of attending and responding appear to be prerequisite to cognition or the act of processing information. It has generally been found that when unwanted sound interferes with, or disrupts attending behaviour, performance on a cognitive task is depressed, and the rate at which behaviour is acquired decreases, thus inhibiting learning. Therefore, a measure of acquisition rate may offer a sensitive index for investigating the effects of several levels of noise on human behaviour.

CHAPTER III

EXPERIMENTAL DESIGN

The purpose of the study was to determine the effects of classroom noise on the acquisition rate of selected sight words by kindergarten children in a one-to-one tutorial situation.

Subjects

Five schools from the lower Vancouver Island Public Schools, Victoria, B.C. were used in the study. Four schools from the Victoria School District, each containing one morning and one afternoon kindergarten class, were selected by placing the names of all elementary schools on separate cards, then randomly drawing them from a box without replacement. The fifth school of the study was from the Saanich School District. Sixty-eight boys and 68 girls, five to six years of age were randomly assigned to one of the four experimental groups. Children from each kindergarten (morning and afternoon classes) were distributed randomly across all conditions. The sample was representative of low and middle socio-economic classes based on the modal age and cost of homes and their proximity to the commerical centre and industrial centre of the city.

Forty-eight children from two other schools (two morning and two afternoon classes) were randomly assigned to the four conditions for the pilot study.

Materials

Four high frequency, dissimilar stimulus words, telephone, house, ball, car were printed on 5" x 8" cards (Leroy stencil), then laminated.

These words were similar to those used in other studies (Ollila and Olson, 1972; McMorland, 1972; Strachan, 1973; Ollila and Chamberlain, manuscript submitted for publication, 1975). The level of noise for each of the four conditions was determined by a Music/Sound Level Meter (Realistic Cat. No. 33-1028). Measurement of noise level was taken from the table where the experimenter and the subject sat during the experiment (four feet from the tape recorder). Under the 60-70 db conditions, continuous visual monitoring of the Sound Pressure Level was employed to identify possible contamination from sources exterior to the testing room.

Pilot Study

The pilot study was conducted using 48 children from two schools (two morning and two afternoon kindergarten classes). The results from the pilot study were used to: (1) estimate the number of subjects who would not attain criterion, (2) estimate the number of children who already know one or more of the words, (3) estimate the number of replacement subjects needed for the study, (4) refine the procedures, (5) determine if the 80-90 db noise level was appropriate, (6) determine if the stimulus words were appropriate, and (7) determine if the method of scoring was appropriate.

Results suggested that the procedures, materials and method of data analysis were appropriate. Instructions to the subjects were revised and a time out for errors was included in the procedure.

Selection of Stimulus Words

The words telephone, house, ball, car, were selected as stimuli

words on the basis of (1) high frequency, (2) concreteness, (3) differing initial consonant, (4) differing configuration, and (5) varying lengths. It was assumed that these words would be a part of the subject's verbal response repertoire, but not a part of his sight vocabulary. This assumption was supported in the pilot study.

Assignment of the Order of Presentation of Words

Numerals were assigned to each word as follows: telephone - 1, house - 2, ball - 3, car - 4 (Figure 15). These numerals were written on cards, placed in a box, then individually drawn without replacement. The order in which they were drawn constituted one trial. The numerals were replaced in the box, and were again drawn to determine the order for the second trial. This procedure was repeated until all 20 orders were determined (Figure 16).

Design and Proposed Method of Statistical Analysis

The independent variables were the sex of the subjects and the four experimental conditions (quiet - 60-70 db[1], noise = 60-70 db, noise = 70-80 db, noise = 80-90 db). The dependent variable was the number of trials taken to learn the four sight words, telephone, house, ball, car, to a criterion of two successive errorless trials. The two levels of sex and the four experimental conditions generated a two by four mixed measures factorial design (Table 1). The alpha value was set at the .05 level of confidence.

An F-max test for homogeneity of variance will be applied to the data (Weiner, 1971, p. 207). If the hypothesis of homogeneity of variance is

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[1]No planned noise

not rejected at the .05 level of confidence, a two-way parametric Analysis of Variance will be applied to the data with a posteriori comparison (experimentwise) using the Scheffé method (Weiner, 1971). If the hypothesis of homogeneity is variance is rejected, a non-parametric analysis of variance (Kruskal-Wallis method) will be applied to the data.

Procedures

Each subject met individually with the experimenter in a small room in the school. All subjects received pre-testing, pre-training (without taped noise), and training to criterion under one of the four conditions.

Table 1. Experimental Design.

Groups	Quiet[1] 60-70 db	Noise 60-70 db	Noise 70-80 db	Noise 80-90 db
Boys	n = 17	n = 17	n = 17	n = 17
Girls	n = 17	n = 17	n = 17	n = 17

[1]No planned noise

Pre-testing. During pre-testing, the subject was told: "I would like to play a game with you to see how fast you can learn words. If you get some wrong, it doesn't matter, but you need to listen carefully. Before we start the game, let's see if you know any of the words." The experimenter presented each of the four words separately and asked the subject: "What is the name of this word?" All subjects were pre-tested on all four words using a non-correction procedure. Subjects who knew one or more of the words were not included in the data analysis.

Pre-training. During pre-training, the subject was presented with each word once, and told: "This is the word _____. What is the name of the word?" Immediately following the pre-training, the subject was told: "The game is now going to begin."

Training to Criterion. During training to criterion, the four stimulus words were presented in random order on each trial, under one of the four experimental conditions. The subject was presented with the word, then asked: "What is the name of this word?" If the appropriate response was emitted, the experimenter said "right" and proceeded to the next word. If the correct response was not emitted, the experimenter paused for five seconds, looking away from the subject and then presented the word to the subject again, and said: "This is the word _____. What is the name of this word?" At the end of each trial the correct and incorrect responses were marked on the score sheet (Figure 16) and the experimenter proceeded to the next trial. The procedure was repeated until two successive trials were completed without error, or the subject completed 20 trials without reading criterion. Data collected on the performance of subjects who failed to attain criterion were excluded

from the statistical analysis.

Special Control Procedures for Contamination

The experimenter walked with each subject to the experimental room from the kindergarten classroom, discussing the different kinds of games the subject liked to play. At the end of the experimental session, the subject was thanked for his help and told: "So the game will not be spoiled for the other children, you must promise not to say anything at all about the game to any of the other boys and girls." The experimenter walked back to the kindergarten with the subject. Teachers were asked to report any discussion of the "game" by the children. They were also asked to ensure that after each child returned to the classroom, the child became engaged in activity.

CHAPTER IV

RESULTS

For this study, the dependent variable was the number of trials taken to learn the four words telephone, house, ball, car to a criterion of two successive errorless trials. The scores and variances on the data for the eight cells are summarized in Table 2. Figure 2 presents the rates at which the words were acquired and Figure 2a presents the within c ll variances for each group. Since the observed value of the F-max statistic for homogeneity of variance was greater than the critical value ($F\text{-max}_{.99}$ /8, 16/ = 3.89) for a .01 level test, the hypothesis of homogeneity of variance was rejected ($F\text{-max}_{.99}$ /8, 16/ = 4.89). A parametric analysis of variance was not considered to be an appropriate test of significant difference and therefore was not applied to the data. In order to determine if the experimental groups were independent samples from different populations, a nonparametric test of significant difference was applied to the data (Siegel, 1956). The Kruskal-Wallis one-way analysis of variance by ranks revealed no significant difference between groups ($H = 2.739$, $df = 3$, $p < .05$).

The hypotheses presented in this study were not supported by the data.

Table 2. Mean Trials to Criterion and Variances for the Two Levels of Sex and the Four Conditions of Noise

Groups	Quiet[1] 60 - 70 db	Noise 60 - 70 db	Noise 70 - 80 db	Noise 80 - 90 db
Boys				
Mean	6.88	6.76	7.59	6.12
Variance	21.74	20.57	32.38	6.61
Girls				
Mean	4.29	5.71	7.65	6.29
Variance	14.85	20.72	30.99	17.97

[1]No planned noise

Summary Description of Data Not Included in the Analysis

The breakdown in percentages of the total number of subjects tested (N = 177) is presented in Table 3. Of the 23% (n = 41) not included in the analysis of variance, 6% were contaminated (any visual or auditory violation of an experimental condition), 8% did not learn the words (criterion was not attained before 20 trials), and 9% knew one or more of the words (pre-test). Nine percent of the total subjects not included in the analysis of variance were girls and 14% were boys. More than four times as many subjects (5.1%) were contaminated (by external noise or by teachers and teacher aides entering the experimental room) in the Quiet 60-70 db and Noise 60-70 db conditions that in the Noise 70-80 db and Noise 80-90 db conditions (1.1%). It may be expected that in this type of research, contamination from external sources may occur more frequently in the quieter conditions. It is interesting to note than more than twice as many subjects (5.7%) failed to learn the words in the Noise 70-80 db and Noise 80-90 db conditions than in the Quiet 60-70 db and Noise 60-70 db conditions (2.3%). None of the boys tested in the Noise 70-80 db condition were excluded from the statistical analysis.

CHAPTER V

DISCUSSION AND CONCLUSION

The nonparametric analysis of variance (Kruskal-Wallis) applied to the data revealed no significant effects of noise on the rate with which kindergarten children acquire an easy sight vocabulary using the form and levels of noise, the stimulus words, and the method of presentation in this study. It was found that noise neither depresses nor facilitates the rate at which an easy sight vocabulary is acquired by most kindergarten children. However, more than twice as many subjects who did not learn the words were in the combined Noise 70-80 db and Noise 80-90 db conditions as compared with the Quiet 60-70 db and Noise 60-70 db conditions. It is speculated that for some children, noise may have such an effect as to prevent them from learning the words at all.

Within Group Variability under Noise

The hypothesis of homogeneity of variance was rejected at the .01 level of confidence. Inspection of the data summarized in Table 2 suggested that the within-cell variances tended to be a function of the cell means: the larger the mean, the larger the variance. This hypothesis was tested and supported by examining the correlation ($r = .69$) between cell means and cell variances (Figure 1). For the boys, the within-cell variances tend to increase under the Noise 70-80 db condition, then decrease to the smallest variance for boys under the Noise 80-90 db condition. This trend may be observed by comparing the data presented in Figures 3, 4, 5, and 6.

The change in group variability appears to follow a similar trend

for girls. Comparison of data presented in Figures 7, 8, 9 and 10 suggests that the within-cell variances increase with the level of noise, except in the highest noise level condition (Noise 80-90 db) where the variance resembles that of the quiet condition (Quiet 60-70 db).

When the conditions are collapsed on sex, variances in the noise conditions appear to be greater than variance in the quiet condition. This trend may be observed by comparing the data presented in Figures 11, 12, 13, and 14.

It seems that the higher the noise level, the greater the variances, except in very noisy conditions where the variability seems to decrease, even though the individual cell means appear to be very similar. Perhaps attention is weakened for some individuals working in moderate amounts of noise, but strengthened in large amounts of noise to "tune out" extraneous auditory stimuli, thus reducing the variability of the group's performance.

Between Group Variability under Noise

A possible difference favouring the performance of girls working in relative quiet (Quiet 60-70 db) over that of girls working in moderate noise (Noise 70-80 db) may be observed in Figure 2. Similarly, Ollila and Chamberlain (manuscript submitted for publication, 1975) reported depressed scores for girls under noise when trained by the word-object method of presentation, but not for boys.

When the conditions are collapsed on sex, the performance in relative quiet (Quiet 60-70 db) may be superior to performance in moderate noise (Noise 70-80 db). More than twice as many children were

unable to learn the words to criterion in the noisier conditions than in the quieter conditions. This may suggest that this level of noise (Noise 70-80 db) slightly depresses performance for boys, but not to the same degree as for girls.

Implication for the Classroom and School

The results of the study offer some evidence in support of the suggestion by Konopa and Zimmering (1972) that noise adversely affects human behaviour. However, results support Smith's (1962) suggestion that most children may have learned to "tune out" extraneous stimuli by the time they enter school. Further research appears prerequisite to any large scale implimentation of perhaps costly, acoustic controls called for by McKay (1964) and Cavanaugh (1964).

Implication for Further Research

It would be of interest to educators to know if noise has an effect on the retention of information acquired in noise. Broadbent (1958) reported that under certain conditions, noise presented during task performance on one day may disrupt performance in a quiet situation on the following day, while Miller (1957) and Kassinove (1972) found no difference over time. Both the long term and short term effects of noise on performance need to be further investigated.

The data presented in Figure 2a suggest that the within group variance may be a function of the level of noise. If subjects within each condition were randomly assigned to smaller sub-cells, the variance computed for each of the smaller sub-cells, then treated as raw data for the groups, an analysis of variance using these sub-cell variances

could be applied to the data to test this hypothesis.

Noise may also differentially affect the performance of slow and fast learners, low and high ability populations, or populations from different socio-economic backgrounds. The task used in the present study included a word list which was defined as easy. Findings by Jerison (1955, 1957, 1959) and by Boggs and Simon (1968) suggest that noise may affect performance on a difficult task, but not necessarily on an easy task. The acquisition of a sight vocabulary such as house, horse, home, hose, could be considered a difficult task. Perhaps noise has an effect on the efficiency with which kindergarten children learn a difficult word list, but not an easy word list. These hypotheses may be tested by the inclusion of these independent variables as factors in further experimental designs.

Further investigation could also examine the possibility of a non-linear relationship between noise level and the quality of performance as suggested by Kahneman (1973). The change in direction of the function may be observed in Figure 2. However, the shape of this function appears to be opposite to that predicted by Kahneman's hypothesis. A trend analysis would perhaps reveal the presence of any higher order components.

Summary of Conclusions

Evidence has been offered to suggest that classroom type noise within the ranges investigated does not noticably affect the rate with which kindergarten children acquire a short and easy sight vocabulary. Moderate to loud noise levels neither facilitated nor depressed the performance of the subjects under the specifications of this study. However, more than twice as many children who failed to learn the words

were in the noisier conditions compared with children in the quieter conditions.

It has been suggested that further research is needed to isolate the interaction of classroom noise with other variables found in the school and classroom.

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APPENDIX A

STATISTICAL TABLES

Table 1. Experimental Design

Groups	Quiet[1] 60-70 db	Noise 60-70 db	Noise 70-80 db	Noise 80-90 db
Boys	n = 17	n = 17	n = 17	n = 17
Girls	n = 17	n = 17	n = 17	n = 17

[1]No planned noise

Table 2. Mean Trials to Criterion and Variances for the Two Levels of Sex and the Four Conditions of Noise.

Groups	Quiet[1] 60-70 db	Noise 60-70 db	Noise 70-80 db	Noise 80-90 db
Boys				
Mean	6.88	6.76	7.59	6.12
Variance	21.74	20.57	32.38	6.61
Girls				
Mean	4.29	5.71	7.65	6.29
Variance	14.85	20.72	30.99	17.97

[1]No planned noise

Table 3. Summary of Data Not Included in the Statistical Analysis: Percentages of the Total Number of Subjects Tested (N = 177).

Condition	Quiet 60-70db	Noise 60-70db	Noise 70-80db	Noise 80-90db	Total
Contaminated					
Boys	2.26	1.69	0.00	1.13	5.08
Girls	0.56	0.56	0.00	0.00	1.13
Boys and Girls	2.82	~~2.82~~ 2.25	0.00	1.13	6.21
Total	5.08		1.13		
Non-learners					
Boys	1.13	1.13	0.00	2.82	5.08
Girls	0.00	0.00	2.26	0.56	2.82
Boys and Girls	1.13	1.13	2.26	3.39	7.91
Total	2.26		5.65		
Knew Words					
Boys	1.13	1.69	0.00	1.13	3.95
Girls	0.56	1.13	1.69	1.62	5.08
Boys and Girls	1.69	2.82	1.69	2.82	9.04
Total	4.52		4.52		
Totals					
Boys	4.52	4.52	0.00	5.08	14.12
Girls	1.13	1.69	3.95	2.26	9.04
Boys and Girls	5.65	6.21	3.95	7.34	23.16
Total	11.86		11.30		

APPENDIX B

FIGURES

FIG. 1. The Relationship Between Cell Means and Cell Variances.

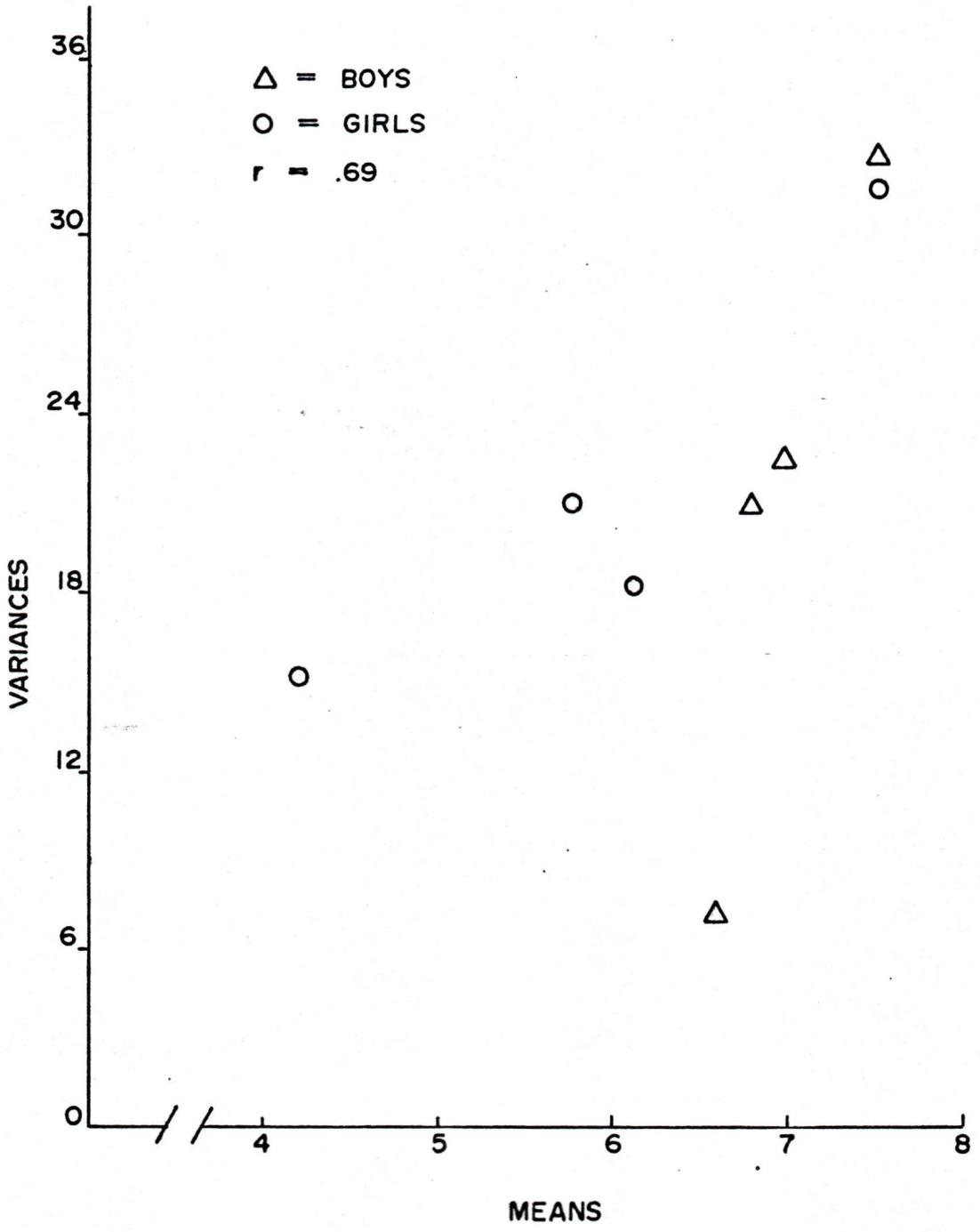
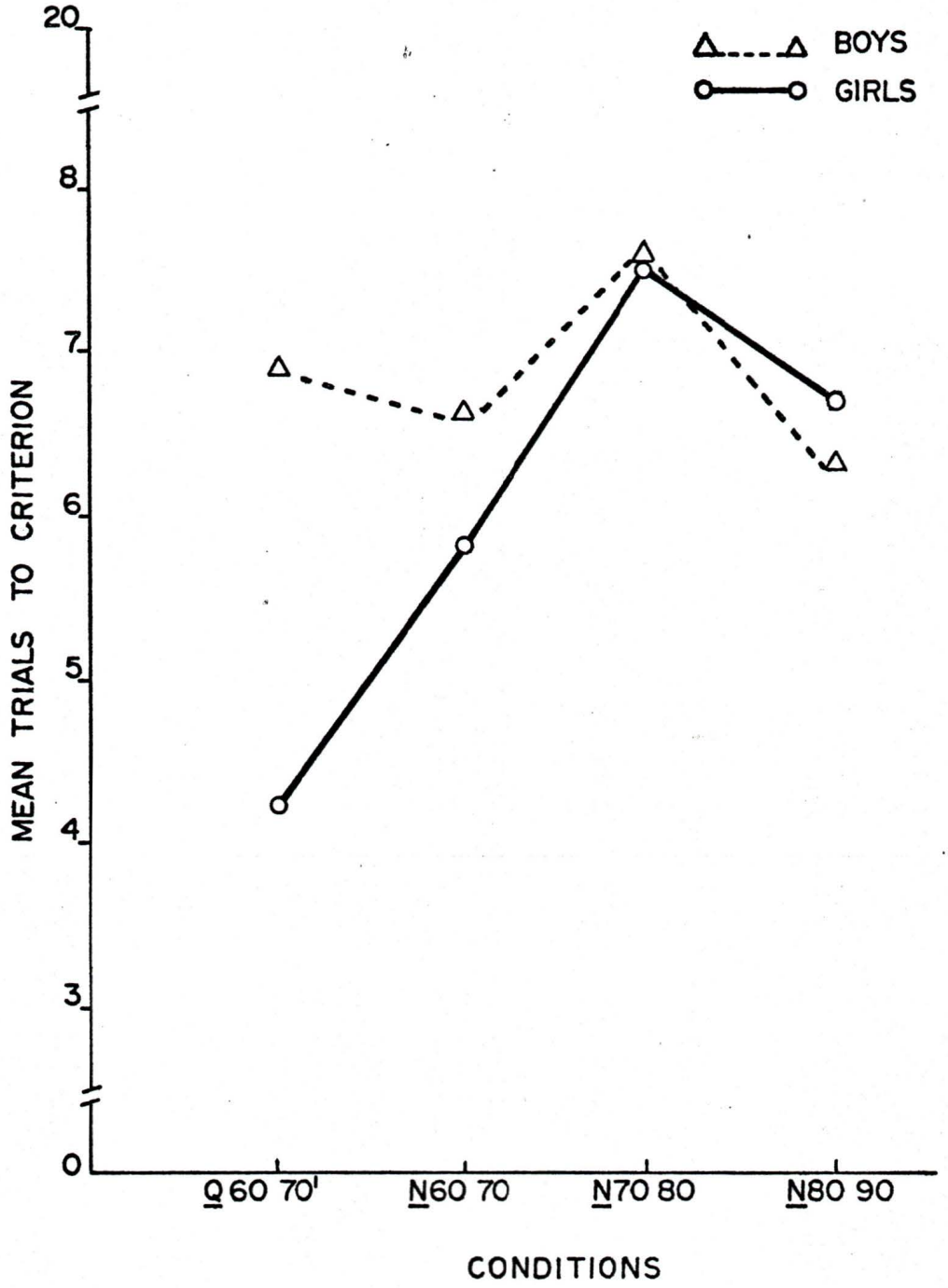
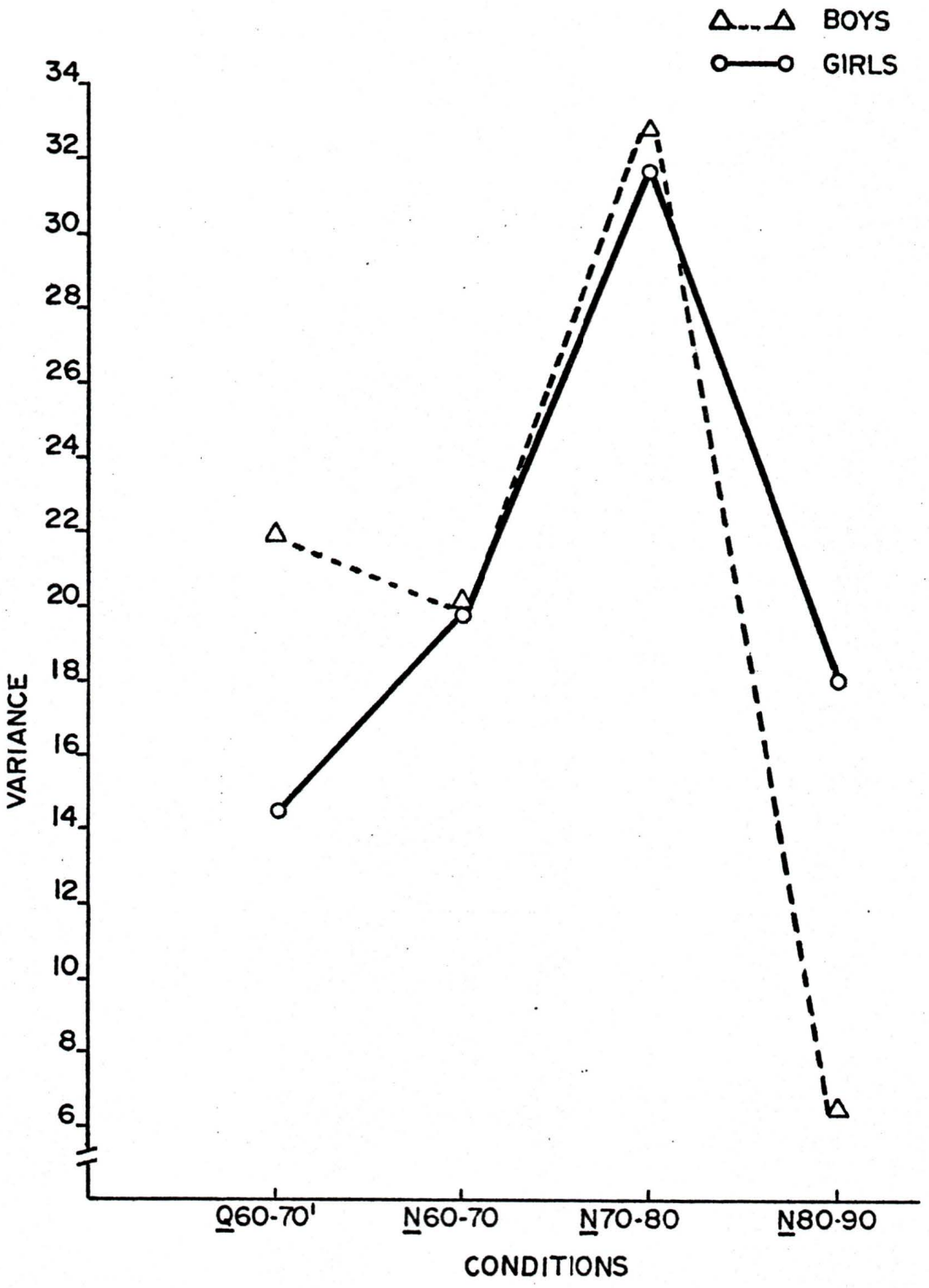


FIG. 2. The Rates at which the Words were Acquired



1 - No Planned Noise

FIG. 2a. The Within Cell Variances.



' No Planned Noise

$F\text{-}max_{.99}$ (8.16) = 4.89

FIG. 3. Performance for Boys in the Quiet 60-70 db Group.

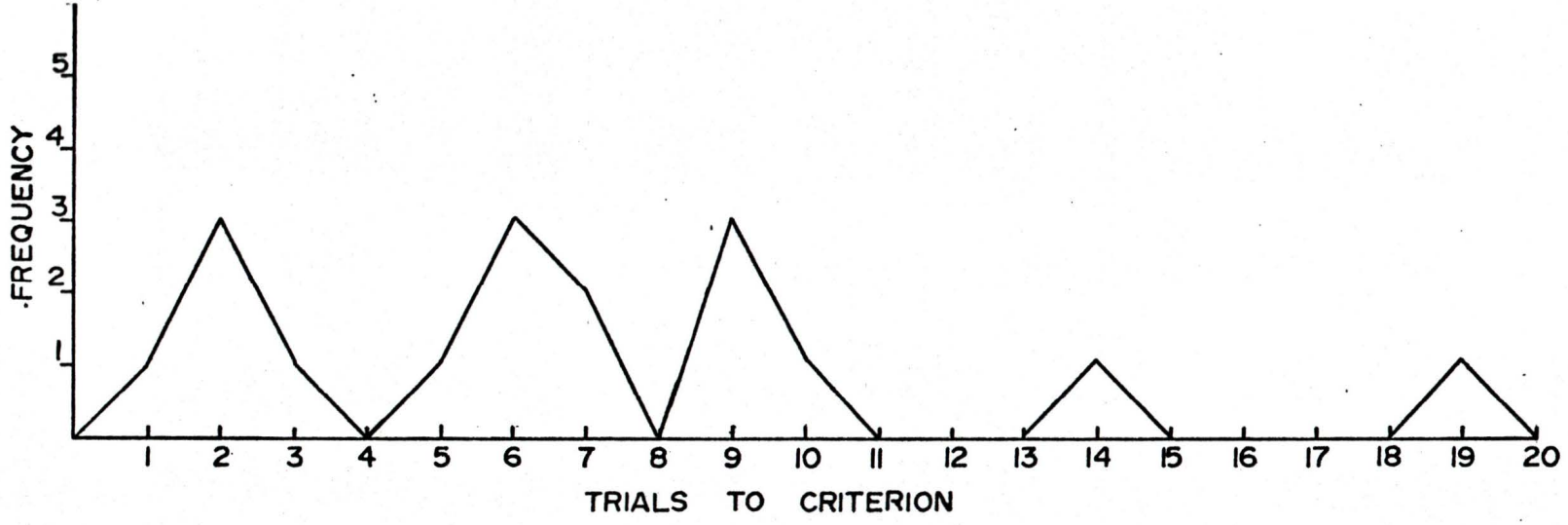


FIG. 4. Performance for Boys in the Noise 60-70 db Group.

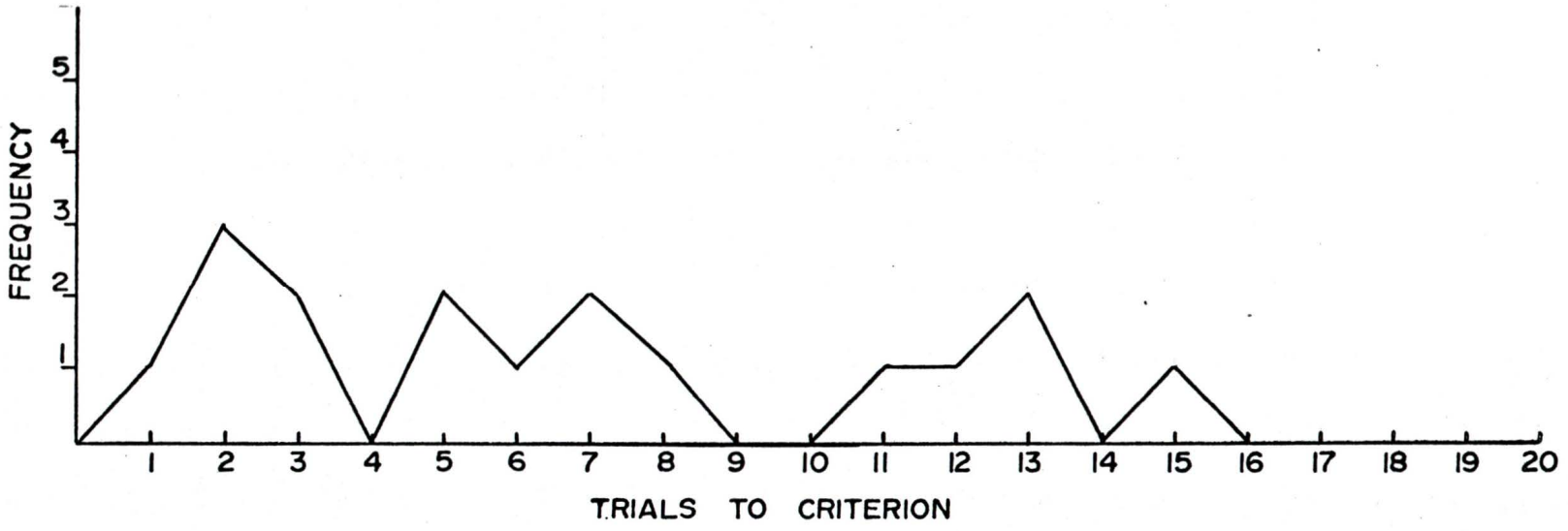


FIG. 5. Performance for Boys in the Noise 70-80 db Group.

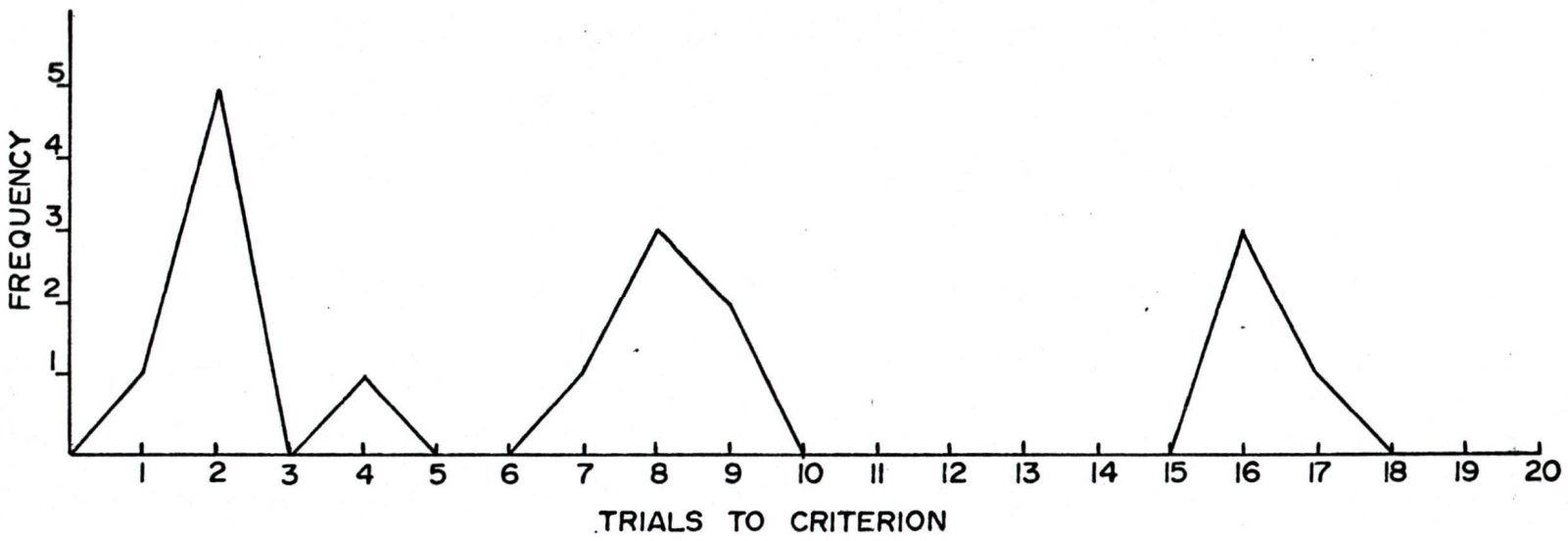


FIG. 6. Performance for Boys in the Noise 80-90db Group.

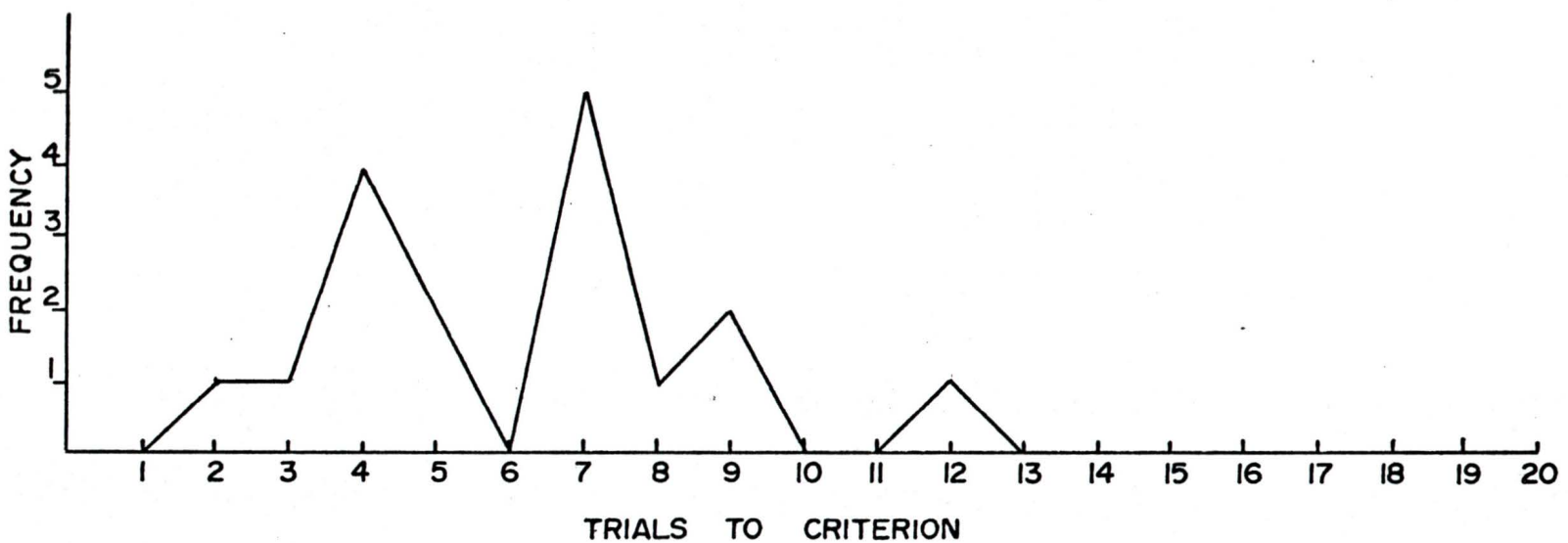


FIG. 7. Performance for Girls in the Quiet 60-70db Group.

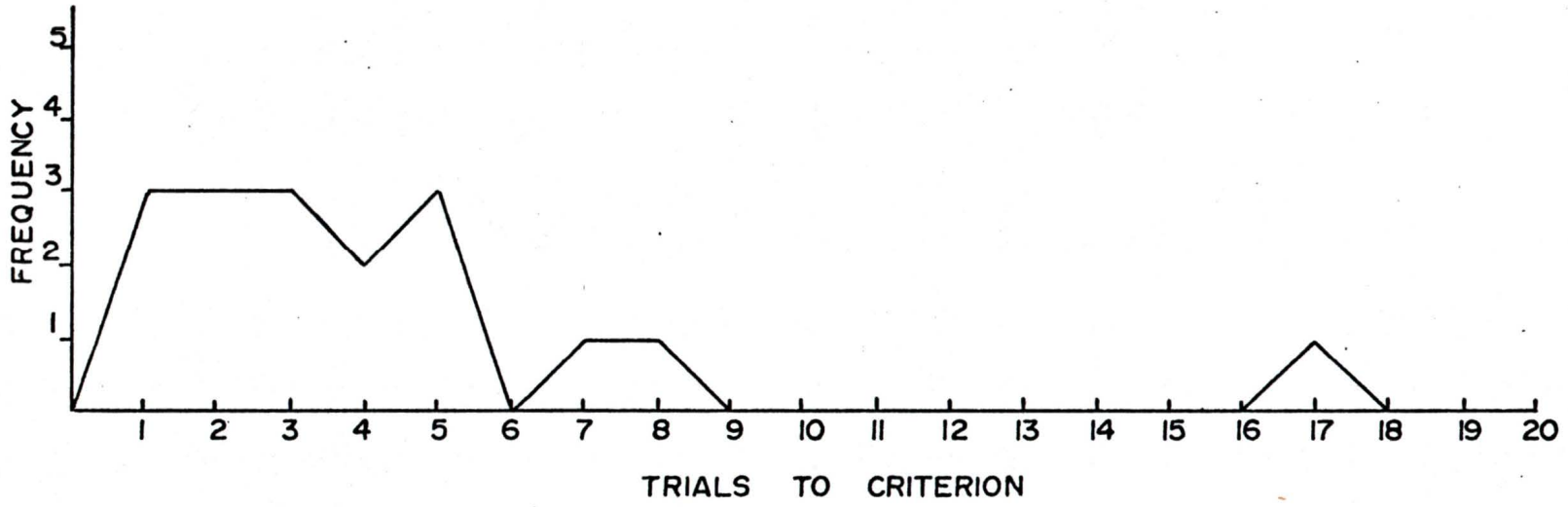


FIG. 8. Performance for Girls in the Noise 60-70 db Group.

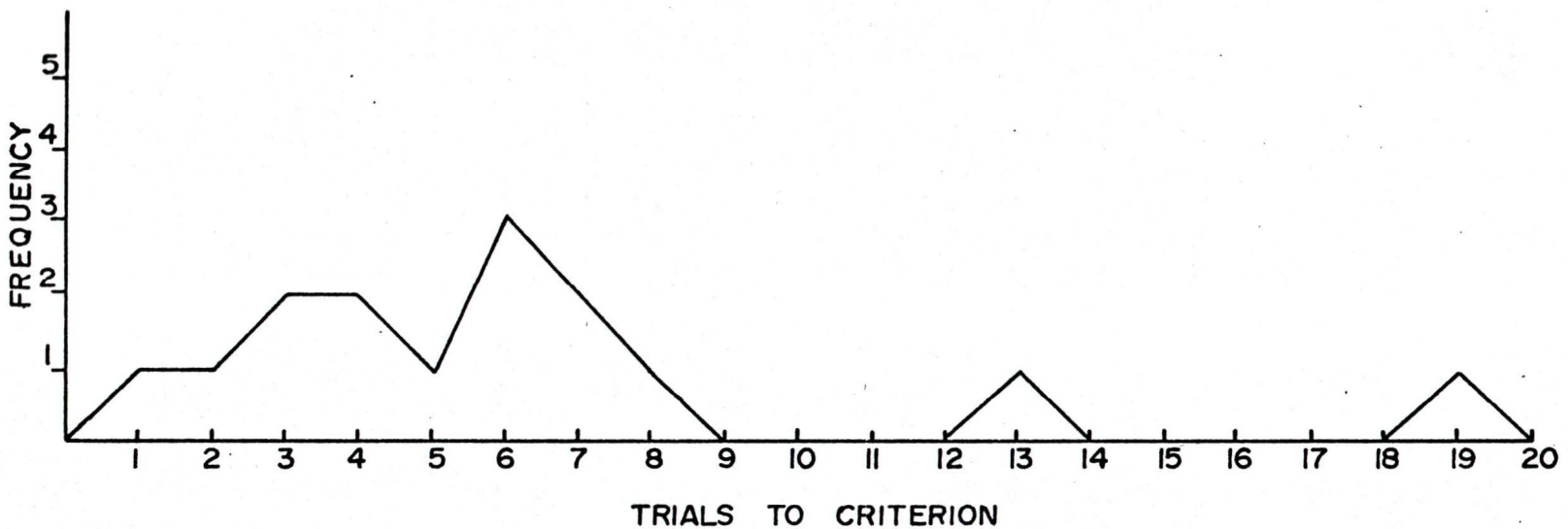


FIG. 9. Performance for Girls in the Noise 70-80db Group.

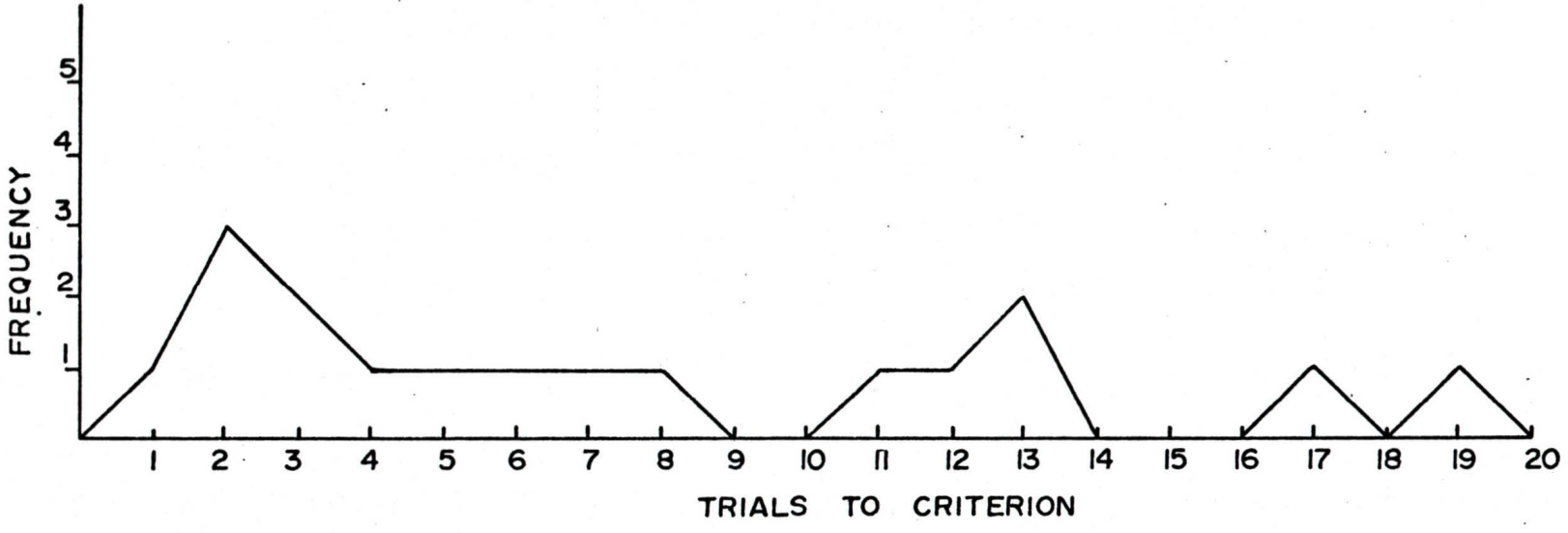


FIG. 10. Performance for Girls in the Noise 80-90 db Group.

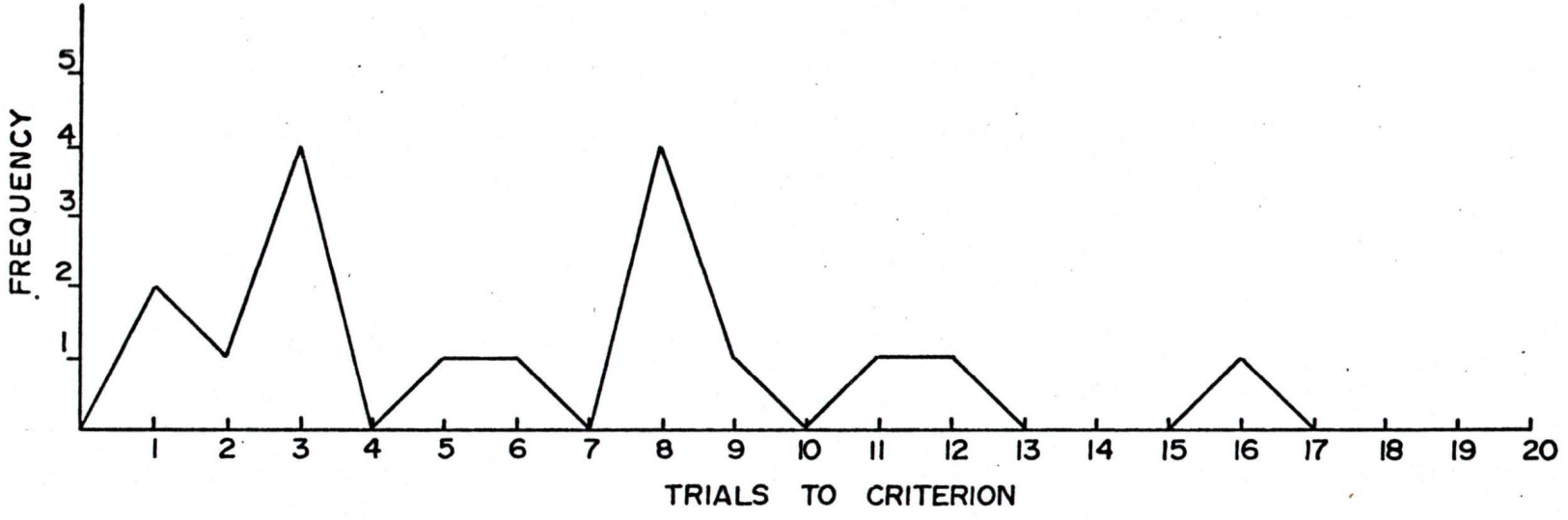


FIG. II. Total Performance in the Quiet 60-70db Group.

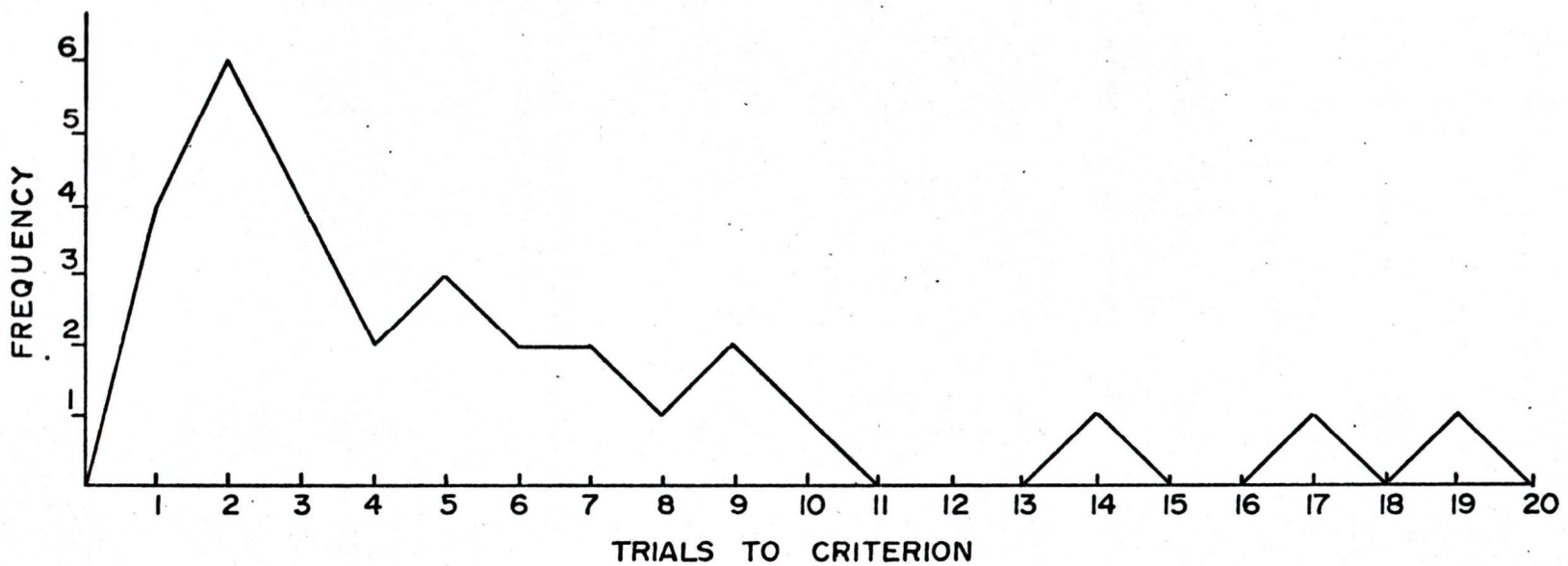


FIG. 12. Total Performance in the Noise 60-70db Group.

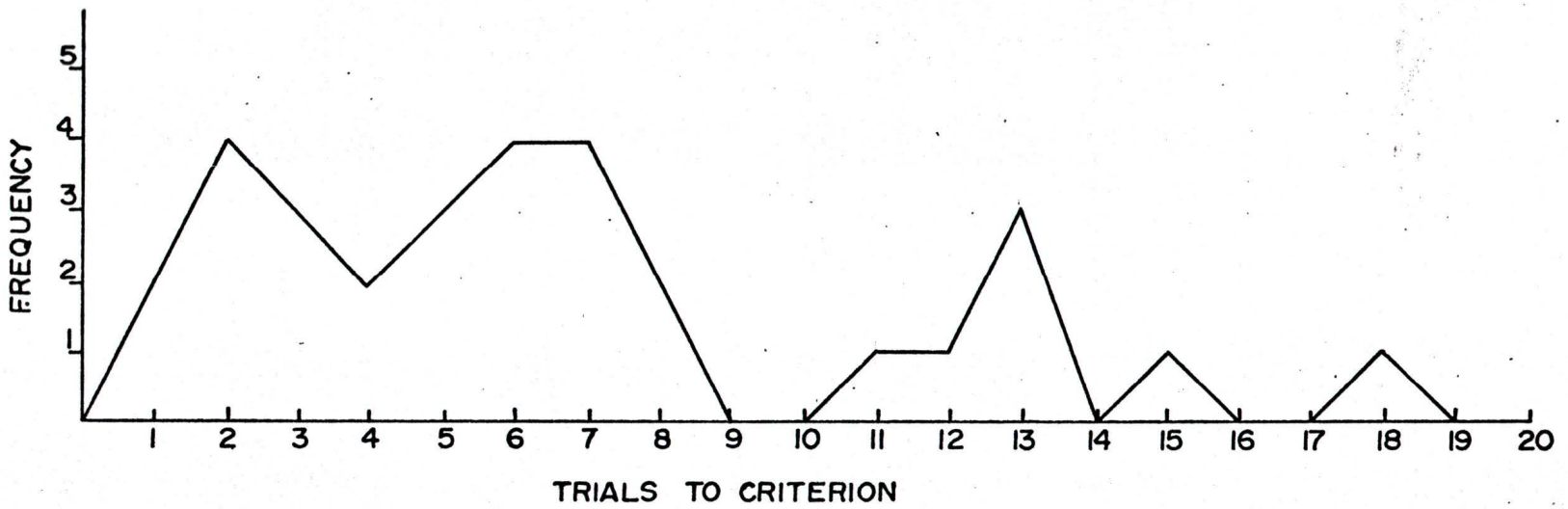


FIG. 13. Total Performance in the Noise 70-80db Group.

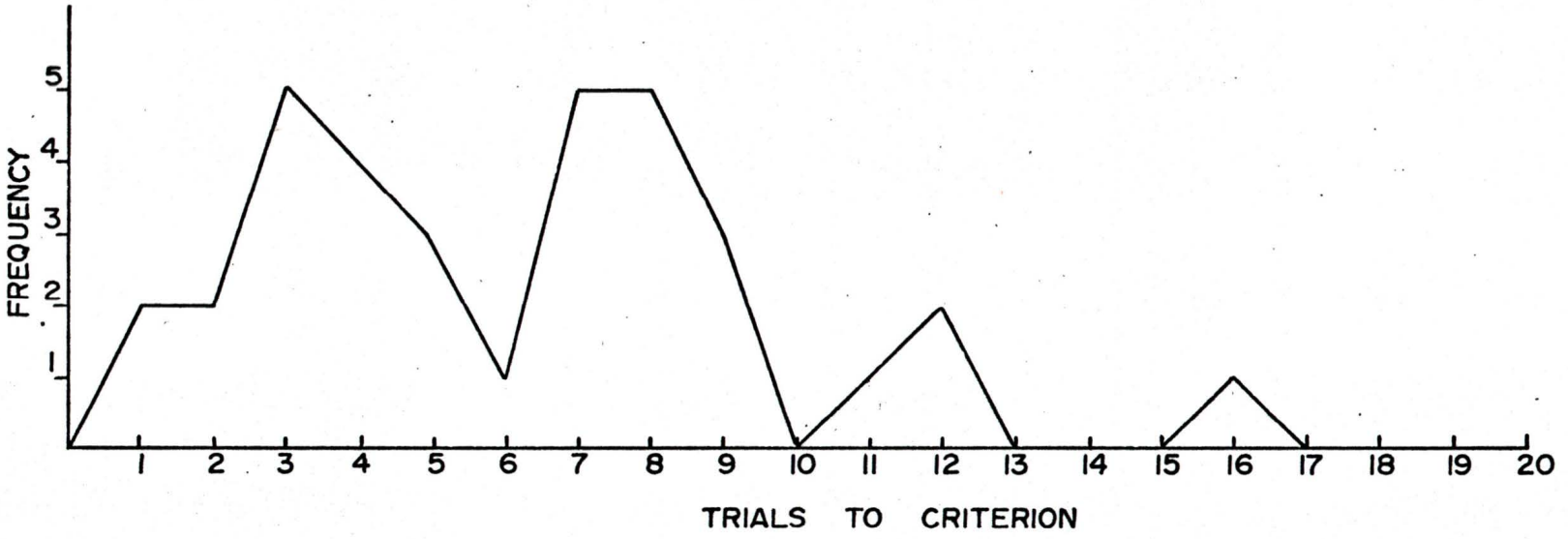


FIG. 14. Total Performance in the Noise 80-90db Group.

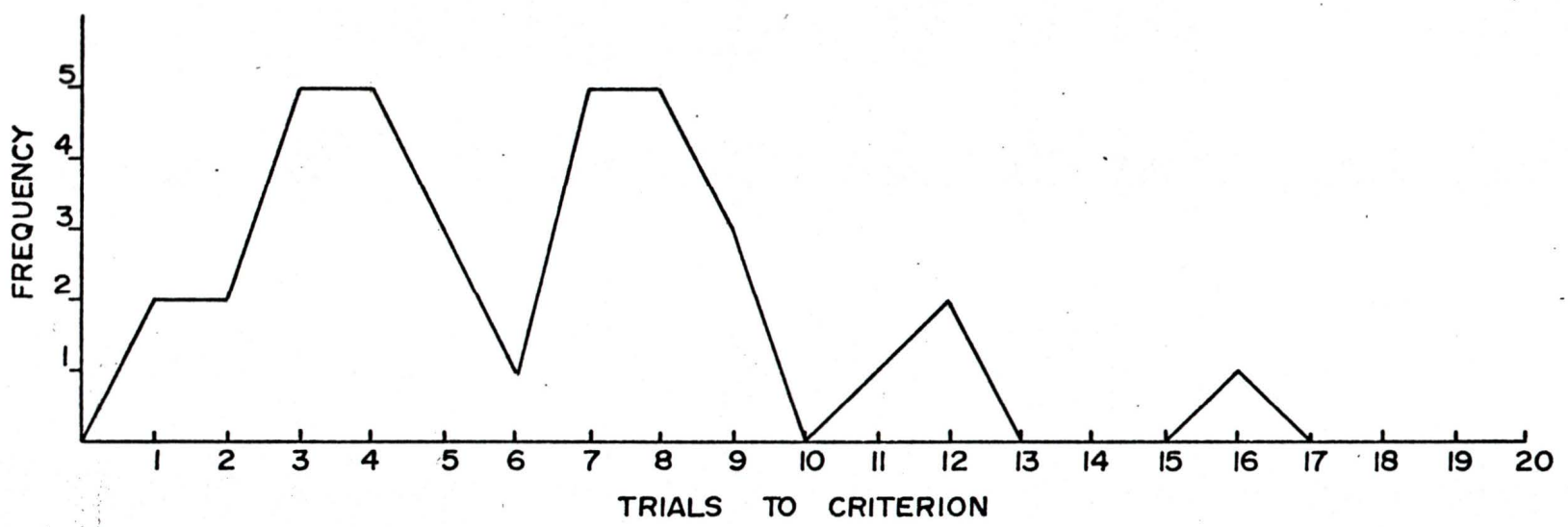


FIGURE 15 - STIMULUS WORDS

telephone

house

ball

car

FIGURE 16. SCORE SHEET

SCORE SHEET

Name _____ Date _____ School _____ Male/Female

(A) Quiet 60 - 70 db _____ (C) Noise 70 - 80 db _____

(B) Noise 60 - 70 db _____ (D) Noise 80 - 90 db _____

INSTRUCTIONS: Draw a line through each number representing the corresponding word which is missed. Criterion is achieved with two successive successful trials.

(1) telephone (2) house (3) ball (4) car

TRIAL	ORDER OF PRESENTATION	CORRECT RESPONSES
1	4 1 3 2	_____
2	1 3 4 2	_____
3	3 2 1 4	_____
4	1 4 3 2	_____
5	2 1 3 4	_____
6	4 1 2 3	_____
7	3 2 4 1	_____
8	2 1 3 4	_____
9	3 4 1 2	_____
10	4 2 3 1	_____
11	2 4 1 3	_____
12	1 4 3 2	_____
13	4 2 1 3	_____
14	4 3 2 1	_____
15	3 2 1 4	_____
16	1 3 4 2	_____
17	2 4 3 1	_____
18	1 2 4 3	_____
19	3 4 1 2	_____
20	3 4 1 2	_____

Total Trials to Criterion _____ Total Correct Responses _____

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		to	

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Ollila, L.O. & Chamberlain, L.A. The effect of noise and object on acquisition of a sight vocabulary in kindergarten children. Manuscript submitted for publication, 1975.

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April 9, 1975

Date