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# THE EFFECT OF COLOR AND GRAPHIC FORM AS STIMULUS FACTORS IN PAIRED-ASSOCIATE LEARNING

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THE EFFECT OF COLOR AND GRAPHIC FORM AS STIMULUS FACTORS

IN PAIRED-ASSOCIATE LEARNING

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## CHAPTER I

## INTRODUCTION

### Background for the Study

The types of pictures or illustrations used in learning materials have for many years been determined by the age or amount of education possessed by the learner. Normally, simplified drawings or photographs have been used in the education of elementary school students while more complex illustrations and photographs were used in the education of secondary school students or adults.

Color as an aid to learning has also been a problem of concern to educators. Some concepts demand the use of color in order to gain a full understanding of the concept. However, many areas exist where color is not a necessary component to learning. It is in these areas that the person charged with the task of instruction has traditionally had to decide, arbitrarily more often than not, if the presence of color will have an effect on learning.

In the past two decades, much has been learned

about the learning process through experimentation with the use of the paired-associate learning task. The advantage of this experimental framework has been to identify the effect of a small number of variables on actual learning while controlling other variables that influence the learning process.

## Statement of the Problem

The problem of this study was to determine whether differences exist in student perceptions of different modes of graphic representation. More specifically, the problem was to determine the effect of color and graphic form on the perception, learning, and retention of elementary and secondary students. Efforts were also made to determine the effect of sex differences and achievement differences on the learning of paired-associates.

## Limitations of the Study

An attempt was made to determine if selected learner characteristics affected the learning of paired-associates. The learner characteristics investigated were grade level, sex, and achievement level as measured by the California Test of Mental Maturity or its equivalent.

Four modes of presentation were used: (1) the simple nonchromatic mode which consisted of a black and white line drawing of an object used as a stimulus term

with a CCC[1] trigram as a response term presented simultaneously as paired-associates, (2) the simple chromatic mode which consisted of a colored line drawing of an object used as a stimulus term with a CCC trigram used as a response term presented simultaneously as paired-associates, (3) the complex nonchromatic mode which was a black and white photograph of an object used as a stimulus term with a CCC trigram used as a response term presented simultaneously as paired-associates, and (4) the complex chromatic mode which was a colored photograph of an object used as a stimulus term with a CCC trigram used as the response term presented simultaneously as paired-associates.

Subjects were randomly selected from samples taken in grade levels three, six, nine, and twelve.

## Purpose of the Study

The purpose of the study was to identify some characteristics of learners which may have an effect upon the mode of presentation of materials which are learned through association. Using this information, teachers may better know which mode of presentation would offer the student the best opportunity for efficient learning. This study was designed to be a step toward discovering useable ways to identify those students who learn

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[1]CCC is defined as a combination of three consonants which form a syllable of known "associative value" or meaningfulness.

best using simple or complex stimuli, and color or non-color stimuli.

## Questions Answered by the Study

In order to determine the effects as listed above, an attempt was made to answer the following questions in the study:

1. Did the learner's grade level effect the learning of paired-associates when they were presented by certain of the four modes?

2. Did the learner's sex effect the learning of paired-associates when they were presented by certain of the four modes?

3. Did the learner's level of achievement, as measured by the California Test of Mental Maturity, effect the learning of paired-associates when they were presented by certain of the four modes?

## The Paired-Associate Learning Task

Items were learned in pairs in the paired-associate learning task. One item served as the stimulus term or cue for its associated or response term. In this study, ten pairs of stimulus and response items were shown consecutively to the subjects for a period of eight seconds for each pair. All of the pairs shown to any one group were typical of only one of the four modes of presentation. After the subjects had seen all ten

of the pairs projected on a screen, they were shown ten stimulus terms without the response, one at a time, for eight seconds each and asked to write the CCC trigram which corresponded as a response term for that item. All items during learning and testing trials were arranged in differing random order.

CCC trigrams were used as response terms in an attempt to eliminate interference from previously learned associations for the pictures used as stimulus terms in the study. Although trigrams have different degrees of meaningfulness or associative value, an attempt was made to choose those which had a common level of difficulty. A more complete description of the above procedure may be found in Chapter III.

## Hypotheses

Nine principal null hypotheses were tested in the study:

1. There is no statistically significant difference between students of different grade levels in the rate of acquisition of any of the four modes of paired-associate learning.

2. There is no statistically significant difference between male and female students in the rate of acquisition of any of the four modes of paired-associate learning.

3. There is no statistically significant difference

between high and low achievers in the rate of acquisition of any of the four modes of paired-associate learning.

4. There is no statistically significant difference between students across grade levels in the length of retention of any of the four modes of paired-associate learning as measured by a delayed test-trial.

5. There is no statistically significant difference between male and female students in the length of retention of any of the four modes of paired-associate learning as measured by a delayed test-trial.

6. There is no statsitically significant difference between high and low achievers in the length of retention of any of the four modes of paired-associate learning tasks as measured by a delayed test-trial.

7. There is no statistically significant interaction between certain of the four modes of presentation and selected grade levels.

8. There is no statistically significant interaction between certain of the four modes of presentation and student sex differences.

9. There is no statistically significant interaction between certain of the four modes of presentation and differences in achievement level.

Six subsidiary null hypotheses were tested in the study:

1. There is no statistically significant difference

in the means of the chromatic groups versus the nonchromatic groups. (C+D vs. A+B)

2. There is no statistically significant difference between the means of the simple presentation form groups versus the complex presentation form groups. (A+C vs. B+D)

3. There is no statistically significant difference between the means of all groups receiving the simple nonchromatic form of presentation versus the complex nonchromatic groups. (A vs. B)

4. There is no statistically significant difference between the means of all groups receiving the simple chromatic mode of presentation versus those receiving the complex chromatic mode. (C vs. D)

5. There is no statistically significant difference between the means for all groups receiving the simple nonchromatic mode of presentation versus those receiving the simple chromatic mode. (A vs. C)

6. There is no statistically significant difference between the means of all groups receiving the complex chromatic mode of presentation versus those receiving the complex nonchromatic mode. (B vs. D)

## Population

The population in this study was third and sixth graders from Cleveland Elementary School, Jefferson Elementary School, and Washington Elementary School,

all located in Norman, Oklahoma. Ninth graders were selected from American History classes at Central Junior High School, Norman, Oklahoma. Subjects in the twelfth grade were selected from Norman High School, Norman, Oklahoma and Moore High School, Moore, Oklahoma. In all cases except Norman High School, entire classes were tested. From the total population of tested students, subjects were randomly drawn to secure equal numbers in each of the categories or cells. Information concerning sex, grade level, and achievement level was recorded along with scores on the paired-associate learning tasks by groups in order that subjects could be regrouped for statistical purposes.

## Statistical Treatment of the Data

Four-way Analysis of Variance (ANOVA) was used to compare each of the experimental variables: grade level, sex, achievement level, mode of presentation, and the interactions of the variables. A significant *F* ratio led to the application of a Newman-Keuls test. Differences between modes were also analyzed through the use of *t* tests.

## Outline of the Dissertation

This dissertation was divided into five chapters as follows:

Chapter I. Statement of reasons for research, statement of the problem, questions to be answered and

hypotheses to be tested, purpose of the study, and a description of the population.

Chapter II. A review of the literature.

Chapter III. A detailed description of the experiment.

Chapter IV. A statistical analysis of the data.

Chapter V. The summary of the findings and recommendations for further study.

Bibliography.

Appendices. Data and procedures.

The next chapter will review selected literature which is related to this study.

# CHAPTER II

## A REVIEW OF SELECTED LITERATURE

The present study was designed to discover the effect of color and graphic presentation form on learning. Therefore, the following review of studies is made up of those which attempted to discover if the above factors have any bearing upon learning.

### Color Preference

In 1952, a report was published concerning an experiment carried on by Mabel Rudisill to establish findings regarding children's preferences in illustrations. Five different types of illustrations were chosen representing differences in the amount of color, and the degree of realism in the form and in the color. The sample was made up of 1200 children from grade one through six and 775 adults. Results of the experiment showed that realistically colored illustrations were preferred over those which were unrealistically colored. Also, it was found that children preferred uncolored realistic illustrations to those which were unrealistically colored. Both phenomenon became stronger as the grade

level increased. However, adult choices showed that they tended to over-emphasize color per se and underemphasize the importance of other qualities.[2]

Seth Spaulding in 1952 reviewed numerous studies of children's preferences for color. Results of all were basically the same: all other factors being equal, children preferred colored illustrations to those which lacked color. Younger children tended to prefer bright colors while older children preferred softer tones. Also, most found that subject matter that related to previous experiences was preferred.[3]

## Concept Attainment through Color

Subjects were told to memorize nonsense words in association with colored geometric forms or concrete objects in an experiment carried out by Heidbreder, Bensley, and Ivy. They found that the order of attainment was: concrete object, geometric form, color, and finally number.[4] However, when the experiment was re-run without using numbers, the position of color shifted

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[2]Mabel Rudisill, "Children's Preferences for Color Versus Other Qualities in Illustrations" The Elementary School Journal, LII (April, 1952), 444-451.

[3]Seth Spaulding, "Research on Pictorial Illustration" Audio-Visual Communication Review, III (Winter, 1955), 35-45.

[4]Edna Heidbreder, Mary Louise Bensley, and Margaret Ivy, "The Attainment of Concepts: IV. Regulations and Levels" Journal of Psychology, XXV (1948), 299-329.

in the order of attainment, falling between concrete objects and geometric forms.[5]

Several experiments have been carried on where deaf and hearing children were required to match according to form and color. Deaf subjects preferred color while hearing subjects preferred form. Also, deaf subjects were better able to discriminate between subtle variations in color; hearing subjects between variations in form. Determining the cause-effect relationship is difficult. Researchers are not sure whether ability to discriminate leads to preference or preference leads to greater discrimination ability. However, it does seem clear that personal preference for color is related to performance with color.[6,7]

There is some indication that environment may also play a part in determining color/form value. Lee, in 1965, concluded that the decreasing use of color as a basis for matching at about age six may have been a function

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[5]Edna Heidbreder and Phoebe Overstreet, "The Attainment of Concepts: V. Critical Features in Context" Journal of Psychology, XXVI (1948), 45-69.

[6]Rosslyn Gaines, "Color-Form Preferences and Color-Form Discriminative Ability of Deaf and Hearing Children" Perceptual and Motor Skills, XVIII (1964), 70.

[7]Rosslyn G. Suchman and T. Trabasso, "Stimulus Preference and Cue Function in Young Children's Concept Attainment" Journal of Experimental Child Psychology, III (1966), 188-198.

of the educational system, in which the initiation of reading instruction at that time causes attention to be focused on form.[8] With the above fact in mind, Suchman carried on an experiment where the variable could be controlled. She gave several matching tasks to children ranging in age from three to fifteen from Zaria, Nigeria, and West Africa. Out of 357 test scores obtained, only 24 indicated a preference for form and no single subject selected form on all tests. Thus she dismissed the hypothesis that the change was due to physical or mental development because the transition was shown to not be universal. She speculated that color preference may be implicitly rewarding to deaf children and to people from a culture where form is not stressed as an important cue.[9]

## Color Used as a Cue

The paired-associate framework has generally been used in studies where color was studied as a contextual cue.

In an early study in 1935, Dulsky required subjects to learn pairs of nonsense words presented on two types

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[8]L. C. Lee, "Concept Utilization in Pre-School Children" Child Development, XXXVI (1965), 221-227.

[9]Rosslyn G. Suchman, "Cultural Differences in Children's Color and Form Preferences" Journal of Social Psychology, LXX (1966), 3-10.

of backgrounds: homogeneous, with different colors for each pair or the same color for all pairs, and heterogeneous, with the stimulus half of each card colored and the response half gray and vice versa. Recall was tested under three conditions, interchange of colored backgrounds, replication of the learning conditions, and change to all gray backgrounds. Recall was most accurate when the gray stimulus backgrounds and the colored response backgrounds remained the same as in the learning trials. The learning decrement was greater when response background colors were changed than when stimulus or total backgrounds were changed.[10]

Weiss and Margolius presented subjects with pairs of nonsense trigrams and simple words on different colored cards and found retention to be arranged in the following descending order: no change in stimuli or colored backgrounds, slight modification of stimuli, no change in stimuli but change in colors, and change in both stimuli and colors. Thus they noted that responses can be associated not only with the primary stimulus but also with one or more contextual stimuli, which may enhance learning.[11]

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[10]S. G. Dulsky, "The Effect of a Change of Background on Recall and Relearning" Journal of Experimental Psychology, XVIII (1935), 725-740.

[11]W. Weiss and G. Margolius, "The Effect of Context Stimuli on Learning and Retention" Journal of Experimental Psychology, XLVIII (1954), 318-322.

Underwood, Ham, and Ekstrand carried on an experiment which required subjects to recall low meaning trigrams or words on colored cards. They found that subjects could not recall low meaning trigrams when the color was removed but could recall the words after the removal of the colored background. They concluded that with unfamiliar trigrams, familiar colors became the functional stimuli, but because the adult subjects were more accustomed to responding to words than colors, the familiar words became the functional stimuli.[12]

Saltz, in his experiment in 1963, alternated testing and learning trials and presented color only during testing or only during learning. The color cues in each situation enhanced the learning. He decided that cognitive differentiation had occurred during the testing trials.[13]

The theory that form and color components of a stimulus might work together to provide a response whereas either presented singly would not formed the basis of the study by Hill and Wickens. They also wished

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[12]B. J. Underwood, Margaret Ham, and B. Ekstrand, "Cue Selection in Paired-Associate Learning" Journal of Experimental Psychology, XLVIII (1962), 318-322.

[13]E. Saltz, "Compound Stimuli in Verbal Learning: Cognitive and Sensory Differentiation Versus Stimulus Selection" Journal of Experimental Psychology, LXVI (1963), 1-5.

to find out if the components should be learned separately and then combined or learned together. They used nonsense word/color-common word pairs learned in a nonanticipation sequence to achieve findings. Those subjects who learned the components separately and then responded to a combination in final testing performed best. However, because many subjects responded correctly to only one component before the combination was made, the researchers rejected the summation theory. They concluded that two cues were more helpful only from the standpoint of providing each subject an opportunity to select his functional stimulus.[14]

An experiment conducted at the University of California at Berkeley utilized 54 undergraduate students. Subjects learned words which were surrounded by colored rectangles. Subjects were tested by having them match the enclosed word with the suitable colored rectangle or match the colored rectangle to appropriate nonsense syllables in the response half of the pair. Significant results led to the conclusion that either a direct association between color and response was formed during original learning, or that a mediational chain, color-word response, was formed.[15]

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[14]Francis A. Hill and D. D. Wickens, "The Effect of Stimulus Compounding in Paired-Associate Learning" Journal of Verbal Learning and Verbal Behavior, I (1962), 144-145.

[15]Isabel M. Birnbaum, "Context Stimuli in Verbal Learning and the Persistence of Associative Factors" Journal of Experimental Psychology, LXX (1966), 483-487.

Crannell, using black-and-white or colored stickers associated with a letter, numeral, or simple word, concluded that color cues were not useful in this situation because the tasks were too easy. In other words, differentiation on the basis of color occurs mainly in the more difficult learning tasks.[16]

Sunderland and Wickens also concluded that context cues are not used when the primary stimuli are highly discriminable. They found that the use of color did not facilitate learning simple words or nonsense syllables; but, when the color was removed, performance on the nonsense syllable list declined while performance on simple words did not change. When the primary stimuli were removed, performance on the nonsense syllable list was not affected, indicating that color was the functional stimulus, while performance on the word list dropped significantly.[17]

Jones examined the value of color as an aid to visual discrimination of words and letters among nursery school children. The task was comprised of a pair of matching tests, one in black and one with color, of six English reversal letters (p, q, u, n, d, b) followed by a second pair of matching tests in black and with color

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[16]C. W. Crannell, "Code Learning and Color" Journal of Psychology, LVIII (1964), 295-299.

[17]D. M. Sunderland and D. D. Wickens, "Context Factors in Paired-Associate Learning and Recall" Journal of Experimental Psychology, LXIII (1962), 302-306.

of six English words transposed into an unfamiliar arrangement to counteract learned reading responses. Jones concluded that without color the task was "at least three times as hard" as with color. The subjects also strongly preferred the colored test materials. The implication seems to be that color may have value both as an aid to discrimination and as a motivational device in early reading.[18]

Several studies have been conducted by Wayne Otto at the University of Wisconsin investigating the use of color in reading. One of the studies attempted to find out if color cues would enhance paired-associate learning and if any facilitative effect would differ for good and poor readers. Seventy-two pupils from grades 2, 4, and 6 learned a list of five geometric form-trigram pairs. Half of the subjects learned the list in black and white, the other half with each pair in a distinctive color. Poor readers required more trials to learn the list, and the number of learning trials decreased as grade level increased. However, the addition of color cues had no significant effect. Although not by a statistically significant amount, good readers seemed to be helped by the color cues. Also, the higher the grade level, the more benefit from the color cues. Otto

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[18]J. K. Jones, "Colour as an Aid to Visual Perception in Early Reading" British Journal of Educational Psychology, XXXV (1965), 21-27.

concluded that this phenomenon may have occurred because the geometric forms were so dissimilar that additional cues were of little help.[19]

Another experiment was carried on by Otto using 144 second graders as subjects. The stimuli were in the form of combinations of three Greek letters. Low similarity stimuli were created by using eighteen different letters for six stimuli. High similarity stimuli were formed by using three Greek letters in all possible three-letter combinations. Serial versus scrambled presentation and color versus noncolor were manipulated in the posttest situation. Results seemed to indicate that order of presentation was the most potent cue. Manipulating color also led to significant differences, but to a lesser degree. The researcher indicates that color as a cue is rather fragile and apt to be superseded by more potent cues. However, the implication seems to be that color cues are better than no cues.[20]

## Pictures as Stimuli in Paired-Associates

The purpose of an experiment by A. A. Lumsdaine was to determine the value of pictures and words as cue

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[19]Wayne Otto and Eunice Askov, The Role of Color in Learning and Instruction (Madison, Wisconsin: University of Wisconsin Center for Cognitive Learning, 1968), p. 5.

[20]Wayne Otto, "Intralist Similarity, Order of Presentation and Color in Children's Paired-Associate Learning" Psychonomic Science, IX (1967), 531-532.

and response items in paired-associate learning. This was done by forming four groups of items; with the stimulus being either a word or a picture and the response being either a word or a picture. The four variations were: word-word, word-picture, picture-word, and picture-picture. Three hundred seventh and eighth graders and one hundred-fifty college students were used as the sample. Specific instructions and samples were given prior to starting the experiment. Four familiarization trials were followed by three sets of alternating training and testing trials. Presentation was either by group or by individual. Groups were also divided into ability groups of high and low achievement. Results showed that the picture-word pattern was the most effective followed by word-word, picture-picture, and word-picture. The results were both the same for the grade school and the college groups although there was less difference between picture-word and word-word modes for the college group. Acquisition curves plotted by trials showed a steady incline of all four variations by the grade school groups while the college groups exhibited classical negative acceleration after the second trial. Analysis of variance for assessing the significance of the variance due to pair-type gave a highly significant probability of around .002. To determine differences between individual pair-types, $t$ tests were computed. Pictures were found to be superior as response terms.

It was concluded that pictures, with a greater constancy of cue pattern, have the most value in the cue position while words, with a greater variety of possible meanings, are most beneficial in the response position. The power of pictures in the cue position and words in the response position were felt to be about equal due to Pp and Ww comparisons. Overlapping the cue with the response seemed to have little importance as did rapidity of presentation. Although the findings only partially contribute to overall theory formulization, existing rote-association tasks such as foreign-language learning may well use their application.[21]

In 1969, an investigation was conducted by Smelser to determine the effect of selected learner characteristics on the mode of presentation of paired-associate learning tasks. Results of the study showed that pictorial stimuli may result in enhancing the learning of paired-associates for some groups.[22] However, the investigation did not research the differences in format which pictorial stimuli may take. One could, therefore, extend the findings of the above study by examining the effect of form of pictorial

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[21]Arthur A. Lumsdaine, "Cue and Response Functions of Pictures and Words" in Learning from Films, pp. 123-149, (May, Mark A. and Lumsdaine, Arthur A., eds., New Haven, Connecticutt: Yale University Press, 1958).

[22]Lawrence Byron Smelser, "The Effect of Selected Learner Characteristics on the Mode of Presentation of Paired-Associate Learning Tasks" (Unpublished Doctor's Dissertation, University of Oklahoma, 1969).

presentation on the learning of paired-associates.

## Summary

Some of the research reported in this chapter would seem to indicate the superiority of pictures as stimulus items in paired-associate learning. Some of the research cited has also shown that color may effect learning, at least as a secondary cue, but at best is a rather elusive learning variable. However, a lack of sufficient studies in the above areas indicate a need for further study of the type pursued in the present experiment. Also, none of the research has investigated the possibility of interaction between selected learner characteristics and the varaibles of color and graphic form.

A description of the experiment is contained in the next chapter. This discussion describes the instrument used, how it was prepared and administered, and how the data for this study was gathered.

# CHAPTER III

## PROCEDURE FOR THE EXPERIMENT

In order to carry out the experiment, an instrument had to be developed and guidelines for the administration of the test had to be set up. Chapter III details the procedureal steps involved, beginning with the preparation of the instrument to be used for the paired-associate test.

### Preparation of the Instrument

No appropriate paired-associate instrument was available, therefore, an instrument was constructed to fit the needs of the study. The instrument incorporated the four modes to be tested: (1) the simple nonchromatic mode, (2) the complex nonchromatic mode, (3) the simple chromatic mode, and (4) the complex chromatic mode. The pictures which served as the stimulus terms were selected along with the nonsense syllables which served as the response terms for the four modes. The following procedure was followed in the selection of the stimulus and response terms for the paired-associate lists.

Selection of the stimulus terms. Gates vocabulary list[23] was used as a source to supply a list of nouns recognizable by third graders. Only those nouns found on the second or third grade lists were included in the population from which the sample was drawn. A list of one hundred twenty-seven words was prepared from which 14 items were randomly drawn. Color drawings were then made of each of the fourteen objects and shown to a random sample of nine third graders to assure that each was recognizable by third graders. Each student was asked to write down the name of the object. Had any of the objects not been recognizable by all of the students, it would have been rejected. Ten of the items were kept as stimulus terms and one additional picture was kept to be used as an example.

Selection of the response terms. Nonsense syllables to be used as response terms were randomly selected from nonsense syllables of the CCC type which rated approximately 50 per cent association value or less from Witmer's list.[24] One nonsense syllable, LSD, was eliminated by the experimenter due to its probable change in association value. Also, no nonsense syllable was used that had the

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[23]Arthur I. Gates, Reading Vocabulary for the Primary Grades (New York: Teachers College, Columbia University, 1926), pp. 22-24.

[24]S. S. Stevens, Handbook of Experimental Psychology (New York: John Wiley and Sons, Inc., 1951), p. 546.

same initial consonant as any other trigram included in the list. It was hoped to minimize interference from previously learned associations to the pictures by the use of nonsense syllables. After some experimentation, it was determined that 50 per cent association value terms would yield the most discriminating results over all grade levels tested. Ten items plus one example item were randomly selected from the list.

Making the slides. Each of the nonsense syllables was randomly matched with a stimulus object. For those pairs (both nonchromatic and chromatic) which utilized drawings, the nonsense syllables were printed on the right-hand halves of 9" by 12" pieces of white poster board in 1 1/2" high block letters by a Reynolds Printasign printing device. The drawings were then made by hand on the left-hand side of the boards either with water color paints or India ink according to the mode in which each was included. A one-eighth inch wide black line was put through the middle of the board vertically to better separate the stimuli and responses. The entire cards were then photographed with a 35mm camera and color film into 2" by 2" slides. Each card was also photographed with the response side covered by a blank piece of white cardboard in order to create sets of test slides.

The slides that contained items utilizing color or black and white photographs were produced somewhat

differently. First, a 2" by 2" color slide was made of each of the objects. A slide was also made of each of the nonsense syllables after they had been printed as above. The sprocket holes and mountings were then removed from the slides (photographs and nonsense syllables), the two butted together, and rephotographed to produce one slide containing both the stimulus and response. A Honeywell Repronar copying device was used for this purpose.

The same stimuli and responses were always matched the same way regardless of the mode. In other words, the same object and nonsense trigram always accompanied each other to make up a complete item; only the appearance of the object changed, according to its mode. This was done in an effort to keep all other variables constant while manipulating the experimental variables.

In addition to creating test slides, three slides were also made to test for normal color vision. Most color blind people have dichromatic vision; they can see yellows and blues but tend to confuse reds and greens. A very few people possess achromatic vision; they are blind to all colors and see only shades of black, white, and gray. About four per cent of all males exhibit color vision deficiencies while only one per cent of females suffer from faulty color vision.[25]

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[25] The World Book Encyclopedia, 1970 edition (Chicago: Field Enterprises Educational Corporation, v. 4), p.667.

All of the color-blindness slides were copied photographically from plates and illustrations in books. All were single items from the Ishihara test for color blindness. The first slide contained a mass of dots which when viewed by a person with normal vision spelled the word "onion". The red-green color blind saw the word "color" while persons with pastel color deficiencies saw nothing.[26] The second slide revealed a "45" to red-green color blind persons while those with normal vision saw nothing.[27] An eight was seen in the final slide by people with normal vision, red-green blind saw a three, and the totally color blind saw nothing.[28]

After a complete set of all slides was obtained, they were copied on the Honeywell Repronar to create three complete sets of slides. This was done to enable the slides to be shown automatically and continuously during conduction of the experiment.

## Equipment Used for the Experiment

The equipment used in the experiment included a Kodak 800 carousel slide projector, five trays of slides, a 40" by 40" glass beaded projection screen, and booklets

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[26]Laurence H. Snyder and Paul R. David, The Principles of Heredity (Boston: D. C. Heath and Company, 1957), p. 96.

[27]Floyd L. Ruch, Psychology and Life, 5th edition (Chicago: Scott, Foresman and Company, 1958), plate VI.

[28]Ibid., plate VIII.

of answer blanks for each subject. An example of the answer blank may be found in the appendix. Grading masks were also provided for the student assistants who aided in conducting the experiment.

## Making Arrangements for the Experiment

Arrangements were made with the school superintendents in Norman, Oklahoma and Moore, Oklahoma. Principals of the participating schools were then contacted and final arrangements were made selecting and scheduling the classes to be tested. Teachers of classes to be used were apprised of the purposes of the experiment either by the principal or the experimenter.

Due to the large amount of grading to be done between trials, a number of student assistants were required. Twenty-six undergraduate education majors from the University of Oklahoma, Norman, Oklahoma were scheduled to aid in the experiment. Normally, two assistants and the experimenter were present in the classroom at all times during testing. Student assistants were given 15 minute training sessions prior to actual assistance.

## Conducting the Experiment

The learning and testing slides were shown in semi-darkened classrooms. Light was controlled in such a way as to allow subjects to be able to see to write answers while at the same time not interfering with the

clear viewing of the slides. The slides were projected onto a 40" by 40" screen located in the front of the classroom and with its bottom placed approximately 6" above the line of vision of the subjects. The projector was located just in front of the first row of seats when possible. All equipment and classroom preparations were made prior to beginning the testing period and entrance of the subjects into the classroom.

At the beginning of the testing period, answer booklets were passed out to each student. A standard set of instructions was then read to the class explaining the purpose of the experiment, how to respond to the color blindness test items, and how to fill in the regular test blanks. Subjects were told to mark a line through those boxes which corresponded to items they did not know. This procedure helped insure the correct placement of known items on the answer blanks and aided those grading the tests. A complete set of instructions used in the experiment may be found in the appendix.

Both presentation and test slides were projected on the screen for a period of eight seconds per slide. Subjects saw the entire set of learning slides four times before viewing the test slides. The experimenter manually controlled the rotation of the slide tray during the first three learning trials. After that time, the projector operated automatically, showing the learning

slides followed by the testing slides. Blanks were put in the trays to provide an eight second pause between the end of the learning trials and the beginning of the testing trials, and a fourty-eight second pause between the end of the testing trials and the onset of the next learning trials. The slides were placed in the trays in three random arrangements. This was done in an effort to control the effects of serial order on learning.

At the end of each testing trial, subjects tore off the completed answer sheet which was then collected by the experimenter or one of the student assistants. During the pause between testing trials and the following learning trials, all subjects who had responded correctly to all ten of the test items were identified and given a slip of paper which told them that they had answered all items correctly on the last test. They were also told to no longer view the slides and to put their head down on the desk. The above procedure was used as insurance against overlearning and its effects on the retention test administered later.

The experiment was continued until either all subjects had achieved a perfect set of responses or until ten testing trials had been completed. After either of the above had occurred, the projector was shut off, and the subjects were thanked for their cooperation and told not to discuss the experiment with their classmates.

All subjects were retested after a period of approximately three weeks from the date of the first testing. During the re-test or retention test activities, subjects saw each of the ten learning pairs for a period of eight seconds followed immediately by each of the ten test slides for eight seconds each. Students filled in one answer sheet in the same manner used during the original learning. Answer sheets were then collected and subjects were told that other classes had seen differing forms of the test, the exact purposes of the experiment, and allowed to ask any questions they cared to about the experiment.

## Information on Characteristics of Subjects

Information on each subject's grade level and sex was recorded from the answer sheets of the first test. Achievement level of each subject was recorded after testing from the school's permanent records. Achievement scores were classified dichotomously, either as high or low achievement. The average percentile bands of the total score (verbal and quantitative) of the School and College Ability Test, Form 2A was used in classifying subjects by achievement at Norman High School. The Lorge-Thorndike test scores of subjects were used for classification purposes at Moore High School. Achievement level was based on intelligence quotient scores of the California Test of Mental Maturity

for all ninth and sixth graders. Third grade subjects' achievement levels were determined by the total percentile score on the California Achievement Test.

A number of subjects were eliminated from the study for different reasons. Information on elimination of subjects is given in Table 1.

Table 1

ELIMINATION OF SUBJECTS BY CATEGORY

| | Grade 3 | 6 | 9 | 12 |
|---|---|---|---|---|
| Total nuber of subjects tested | 196 | 224 | 142 | 248 |
| Number of probable color blind subjects | 15 | 17 | 9 | 27 |
| Number of subjects lacking achievement scores | 22 | 33 | 8 | 21 |
| Number of subjects lacking retention test scores | 11 | 10 | 5 | 56 |
| Total loss of subjects* | 45 | 57 | 21 | 124 |
| Total useable subjects | 155 | 173 | 124 | 152 |

*The total loss value may not equal the sum of the cells due to some subjects eliminated by more than one category.

The results of the statistical analysis of the data are contained in Chapter IV.

# CHAPTER IV

## STATISTICAL ANALYSIS OF THE DATA

After the data for the study were gathered as described in Chapter III, it was divided into four subgroups: by mode of presentation, sex, achievement, and grade level. This was done in order to test the hypotheses as stated in Chapter I:

1. acquisition by grade levels.
2. acquisition by sex.
3. acquisition by achievement levels.
4. retention by grade levels.
5. retention by sex.
6. retention by achievement levels.
7. interaction of modes and grade levels.
8. interaction of modes and sex.
9. interaction of modes and achievement levels.

The data were then further subdivided by mode of presentation to test the remaining hypotheses:

1. chromatic modes versus nonchromatic modes.
2. simple modes versus complex modes.
3. the simple nonchromatic mode versus the complex nonchromatic mode.

4. the simple chromatic mode versus the complex nonchromatic mode.

5. the simple nonchromatic mode versus the simple chromatic mode.

6. the complex nonchromatic mode versus the complex chromatic mode.

The data relating to the first nine hypotheses were statistically analyzed by employing a four-way Analysis of Variance as described by Lindquist.[29] All significant F ratios obtained from the analysis of variance were followed by Newman-Keuls tests as described by Kirk.[30] The data relating to the second set of six hypotheses were statistically analyzed by employing t tests.[31]

Two basic assumptions were made in testing all hypotheses: (1) that the samples were randomly selected, and (2) that the variance of the criterion measures were homogeneous.[32] The assumption that the samples were

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[29]E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education (Boston: Houghton Mifflin Company, 1953), pp. 225-228.

[30]Roger E. Kirk, Experimental Design: Procedures for the Behavioral Sciences (Belmont, California: Wadsworth Publishing Company, Inc., 1968), pp. 91-93.

[31]George A. Ferguson, Statistical Analysis in Psychology and Education (New York: McGraw-Hill Book Company, 1959), pp. 167-169.

[32]E. F. Lindquist, op. cit., p. 73.

randomly selected was met through the subjects selection procedure. Homogeneity of variance was checked by inspection of the data. This procedure was derived from the Norton study which found that the lack of homogeneity will have little effect on the F distribution.[33]

## Analysis by Grade Levels

The first question to be answered by the study was: Did the learner's grade level effect the learning of paired-associates when they were presented by certain of the four modes? In order to answer this question, the subjects were divided into four groups according to grade level and an analysis of variance test was computed using the data obtained from the acquisition trials. The results of the test are summarized in Table 2. It can be seen through inspection of the table that a significant difference between grades was found at the .0001 level.

Because of the significant F ratio and in an effort to further isolate significant differences, a Newman-Keuls test was computed to attempt to discover significant differences between individual pairs of grade levels. Results of the Newman-Keuls test are summarized in Table 3. In order for the means to be significantly different, the difference between the means must equal or exceed the critical value determined by the number of steps between

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[33]E. F. Lindquist, op. cit., p. 86.

Table 2

SUMMARY TABLE FOR ANALYSIS OF VARIANCE OF ACQUISITION MEASURES

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A (Achvmt) | 1 | 33361.509 | 33361.509 | 99.03 | .0001 |
| B (Mode) | 3 | 338.616 | 112.872 | .36 | N. S. |
| C (Sex) | 1 | 1471.750 | 1471.750 | 4.37 | .05 |
| D (Grade) | 3 | 204689.020 | 68229.673 | 202.53 | .0001 |
| AB | 3 | 2996.295 | 998.765 | 2.96 | .05 |
| AC | 1 | 63.000 | 63.000 | .19 | N. S. |
| AD | 3 | 9221.748 | 3073.916 | 9.12 | .001 |
| BC | 3 | 250.840 | 83.613 | .25 | N. S. |
| BD | 9 | 9036.212 | 1004.024 | 2.98 | .01 |
| CD | 3 | 257.221 | 85.740 | .26 | N. S. |
| ABC | 3 | 832.124 | 277.375 | .82 | N. S. |
| ABD | 9 | 4692.306 | 521.367 | 1.55 | N. S. |
| ACD | 3 | 655.172 | 218.391 | .65 | N. S. |
| BCD | 9 | 2297.904 | 255.323 | .76 | N. S. |
| ABCD | 9 | 5218.988 | 579.888 | 1.72 | N. S. |
| w cells | 384 | 129362.572 | 336.882 | | |
| Total | 447 | 404745.277 | | | |

Note: AB = the interaction of achievement and modes, AC = the interaction of achievement and sex, etc.

Table 3

DIFFERENCES AMONG MEANS OF GRADES BY ERRORS ON ACQUISITION TRIALS

| | $\bar{X}_4$ | $\bar{X}_3$ | $\bar{X}_2$ | $\bar{X}_1$ |
|---|---|---|---|---|
| $\bar{X}_4$ = 12.87 | | 31.87* | 45.36* | 57.20* |
| $\bar{X}_3$ = 24.71 | | | 13.49* | 25.33* |
| $\bar{X}_2$ = 38.20 | | | | 11.84* |
| $\bar{X}_1$ = 70.07 | | | | |

*Significant at the .01 level.

$\bar{X}_1$ = grade three, $\bar{X}_2$ = grade six, $\bar{X}_3$ = grade nine, $\bar{X}_4$ = grade twelve.

means. It may be seen through inspection of the table that the mean of any one grade level was significantly different from the means of all other grade levels. In other words, there was a significant difference between the mean of third graders and sixth graders, ninth graders, and twelfth graders. The table may be interpreted as showing a significant difference between any selected grade-level mean and all other grade level means.

An analysis of variance was also computed to determine the differences between grade levels on the retention measure. Results of the comparison may be found in Table 4. Statistical significance of difference was also found between grade levels on the retention measure at the .0001 level.

Table 4

SUMMARY TABLE FOR ANALYSIS OF VARIANCE OF RETENTION MEASURE

| Source | df | SS | MS | F | p |
|---|---|---|---|---|---|
| A (Achvmt) | 1 | 268.770 | 268.770 | 57.442 | .001 |
| B (Mode) | 3 | 9.186 | 3.062 | .654 | N. S. |
| C (Sex) | 1 | .645 | .645 | .138 | N. S. |
| D (Grade) | 3 | 1917.650 | 639.217 | 136.614 | .0001 |
| AB | 3 | 19.256 | 6.419 | 1.372 | N. S. |
| AC | 1 | 9.985 | 9.985 | 2.134 | N. S. |
| AD | 3 | 89.328 | 29.776 | 6.364 | .01 |
| BC | 3 | 1.366 | .455 | .097 | N. S. |
| BD | 9 | 121.680 | 13.520 | 2.890 | .01 |
| CD | 3 | 7.846 | 2.615 | .559 | N. S. |
| ABC | 3 | 18.236 | 6.079 | 1.299 | N. S. |
| ABD | 9 | 40.458 | 4.495 | .961 | N. S. |
| ACD | 3 | 13.078 | 4.359 | .932 | N. S. |
| BCD | 9 | 40.607 | 4.512 | .964 | N. S. |
| ABCD | 9 | 65.818 | 7.313 | 1.563 | N. S. |
| w cells | 384 | 1796.714 | 4.679 | | |
| Total | 447 | 4420.623 | | | |

Note: AB = the interaction of achievement and modes, AC = the interaction of achievement and sex, etc.

The significant F ratio led to the computation of a Newman-Keuls test. The results, which are listed in Table 5, were the same as found on the acquisition measure with the exception that the difference between the means of the twelfth grade and the ninth grade was not significant at the .01 level. However, the ninth and twelfth grade means were significantly different at the .05 level.

Table 5

DIFFERENCES AMONG MEANS OF GRADES BY ERRORS ON THE RETENTION MEASURE

| | $\bar{X}_4$ | $\bar{X}_3$ | $\bar{X}_2$ | $\bar{X}_1$ |
|---|---|---|---|---|
| $\bar{X}_4$ = 1.438 | | .67** | 2.34* | 5.36* |
| $\bar{X}_3$ = 2.107 | | | 1.67* | 4.69* |
| $\bar{X}_2$ = 3.777 | | | | 3.02* |
| $\bar{X}_1$ = 6.795 | | | | |

*Significant at the .01 level
** Significant at the .05 level

$\bar{X}_1$ = grade three, $\bar{X}_2$ = grade six, $\bar{X}_3$ = grade nine, $\bar{X}_4$ = grade twelve.

## Analysis by Sex

The second question to be answered by the study was: Did the learner's sex effect the learning of paired-associates when they were presented by certain of the modes? In order to determine the answer to the above

question, the subjects were divided by sex and an analysis of variance computed using the data from the acquisition trials. Table 2 contains the summarization of the results of the above test and it may be seen that there was a significant difference at the .05 level in favo. of females.

Analysis of variance was also computed on sex differences as measured by the retention measure. The results of the test, shown in Table 4, indicate no significant difference between sexes on the retention measure.

## Analysis by Achievement

The third question to be answered by the study was: Did the learner's level of achievement effect the learning of paired-associates when they were presented by certain of the four modes? Subjects were divided by achievement levels and an analysis of variance computed using the scores from the acquisition trials in order to determine the answer to the above question. Results of the analysis of variance test are shown in Table 2. As shown in the table, a statistically significant difference was found between the high and low achievement groups. The high achievement groups performed better at the .0001 level.

An analysis of variance test was also computed utilizing the data obtained from the retention measure divided by achievement levels. The results of the above examination of data is shown in Table 4 and indicates a

significant difference between achievement levels at the .001 level, also in favor of the high achievement groups.

## Analysis of Grade Level and Mode Interaction

One of the purposes of the study was to determine the existence of interaction between the various modes of presentation and grade levels. The data were divided into sixteen sub-groups, one for each combination of grade levels and modes, and analysis of variance was computed. Table 2 reveals the results of the test. An interaction between grade levels and modes, significant at the .01 level, was found on the acquisition trials. A Newman-Keuls test was performed following the significant F value, the results of which are found in Table 6. Eighty comparisons among means led to significant differences at the .01 level. However, the significant difference between means 9 and 10 is the only significant difference between modes within one grade level. Figures 1 through 6 present graphical representations of the six possible comparisons between four grade levels. Figure 7 presents a graphical representation of a composite of all four grade levels. The information presented in Table 7 is concerned with the relative position of the means of the four modes of presentation within each grade level. It should be noted that third and ninth graders appeared to perform better on the simple modes while sixth and twelfth graders performed better on the complex modes.

Table 6

DIFFERENCES AMONG MEANS OF THE INTERACTION OF GRADE LEVELS BY MODES OF PRESENTATION ON ACQUISITION TRIALS

| | $\bar{X}_{12}$ | $\bar{X}_6$ | $\bar{X}_{10}$ | $\bar{X}_8$ | $\bar{X}_5$ | $\bar{X}_7$ | $\bar{X}_3$ | $\bar{X}_1$ | $\bar{X}_2$ | $\bar{X}_4$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{X}_{14}$ = 11.3 | 9.8 | 21.5* | 26.6* | 26.6* | 28.5* | 31.2* | 55.6* | 57.1* | 58.4* | 64.1* |
| $\bar{X}_{16}$ = 11.6 | | 21.1* | 26.2* | 26.2* | 28.1* | 30.8* | 55.3* | 56.7* | 58.0* | 63.7* |
| $\bar{X}_{15}$ = 13.2 | | 19.5* | 24.6* | 24.6* | 26.6* | 29.2* | 53.7* | 55.1* | 56.5* | 62.1* |
| $\bar{X}_{13}$ = 15.4 | | 17.4* | 22.5* | 22.5* | 24.4* | 27.1* | 51.5* | 53.0* | 54.3* | 60.0* |
| $\bar{X}_9$ = 19.2 | | | 18.7* | 18.7* | 20.6* | 23.3* | 47.7* | 49.2* | 50.5* | 56.2* |
| $\bar{X}_{11}$ = 20.8 | | | 17.1* | 17.1* | 19.0* | 21.6* | 46.1* | 47.6* | 48.9* | 54.6* |
| $\bar{X}_{12}$ = 21.0 | | | 16.9* | 16.9* | 18.8* | 21.4* | 45.9* | 47.4* | 48.7* | 54.4* |
| $\bar{X}_6$ = 32.7 | | | | | | | 34.2* | 35.6* | 37.0* | 42.6* |
| $\bar{X}_{10}$ = 37.9 | | | | | | | 29.0* | 30.5* | 31.8* | 37.5* |
| $\bar{X}_8$ = 37.9 | | | | | | | 29.0* | 30.5* | 31.8* | 37.5* |
| $\bar{X}_5$ = 39.8 | | | | | | | 27.1* | 28.6* | 29.9* | 35.6* |
| $\bar{X}_7$ = 42.4 | | | | | | | 24.5* | 25.9* | 27.3* | 32.9* |
| $\bar{X}_3$ = 66.9 | | | | | | | | | | |

$\bar{X}_1$ = 68.4, $\bar{X}_2$ = 69.7, $\bar{X}_4$ = 75.4

*Significant at the .01 level.

Table 6 continued

$\bar{X}_1$ = simple nonchromatic mode, third grade.

$\bar{X}_2$ = complex nonchromatic mode, third grade.

$\bar{X}_3$ = simple chromatic mode, third grade.

$\bar{X}_4$ = complex chromatic mode, third grade.

$\bar{X}_5$ = simple nonchromatic mode, sixth grade.

$\bar{X}_6$ = complex nonchromatic mode, sixth grade.

$\bar{X}_7$ = simple chromatic mode, sixth grade.

$\bar{X}_8$ = complex chromatic mode, sixth grade.

$\bar{X}_9$ = simple nonchromatic mode, ninth grade.

$\bar{X}_{10}$ = complex nonchromatic mode, ninth grade.

$\bar{X}_{11}$ = simple chromatic mode, ninth grade.

$\bar{X}_{12}$ = complex chromatic mode, ninth grade.

$\bar{X}_{13}$ = simple nonchromatic mode, twelfth grade.

$\bar{X}_{14}$ = complex nonchromatic mode, twelfth grade.

$\bar{X}_{15}$ = simple chromatic mode, twelfth grade.

$\bar{X}_{16}$ = complex chromatic mode, twelfth grade.

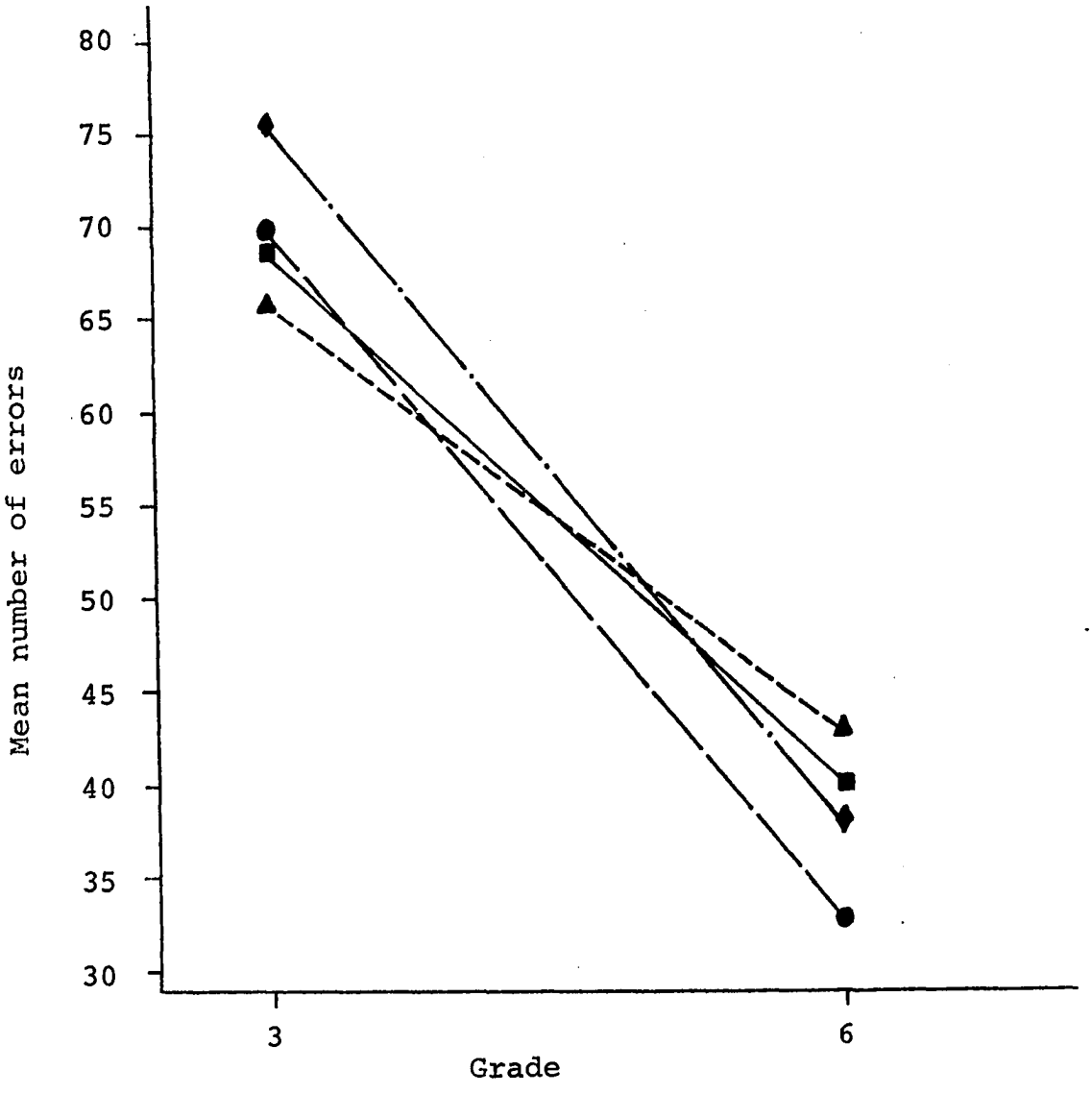


Figure 1

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES THREE AND SIX

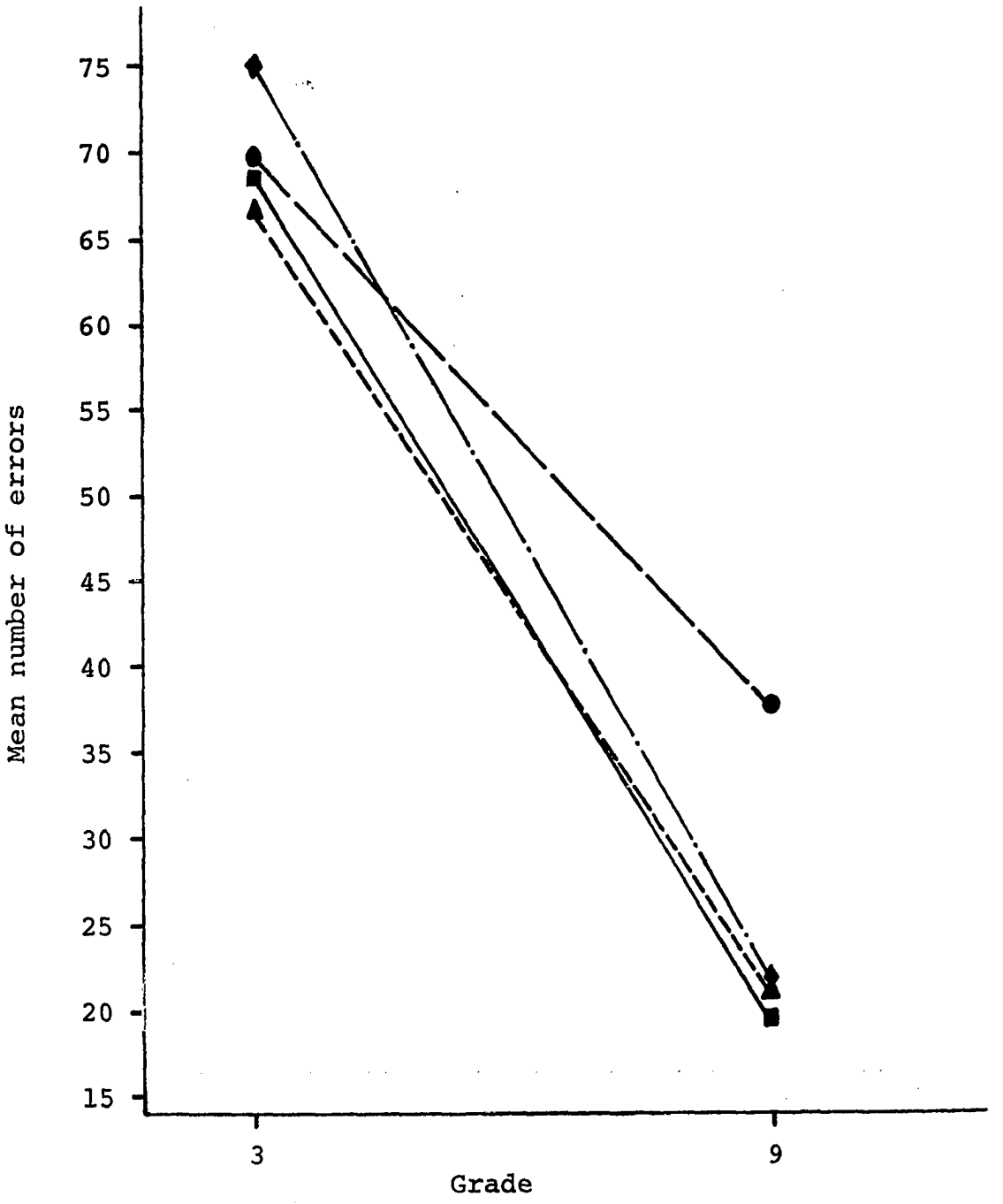


Figure 2

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES THREE AND NINE

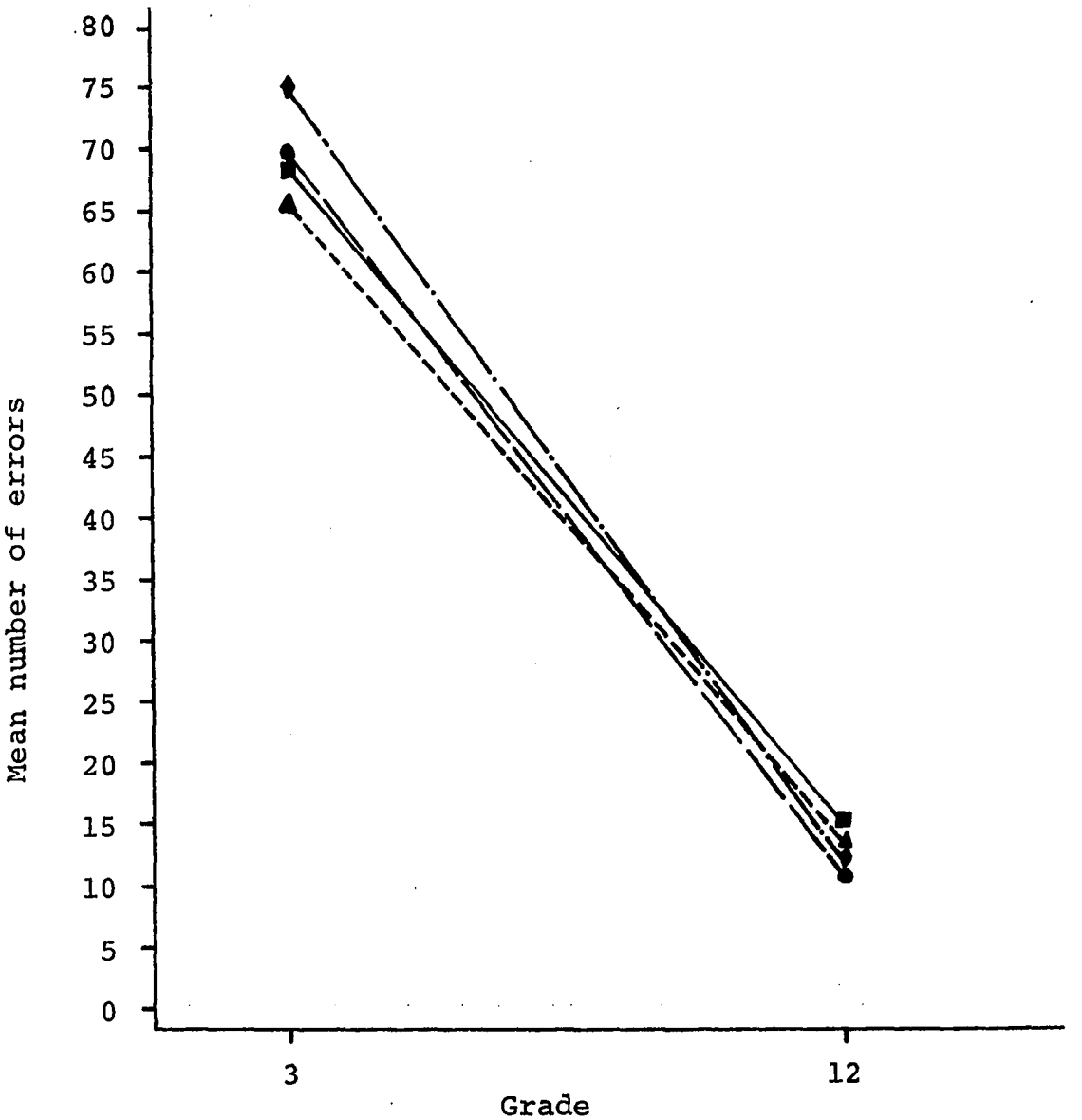


Figure 3

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES THREE AND TWELVE

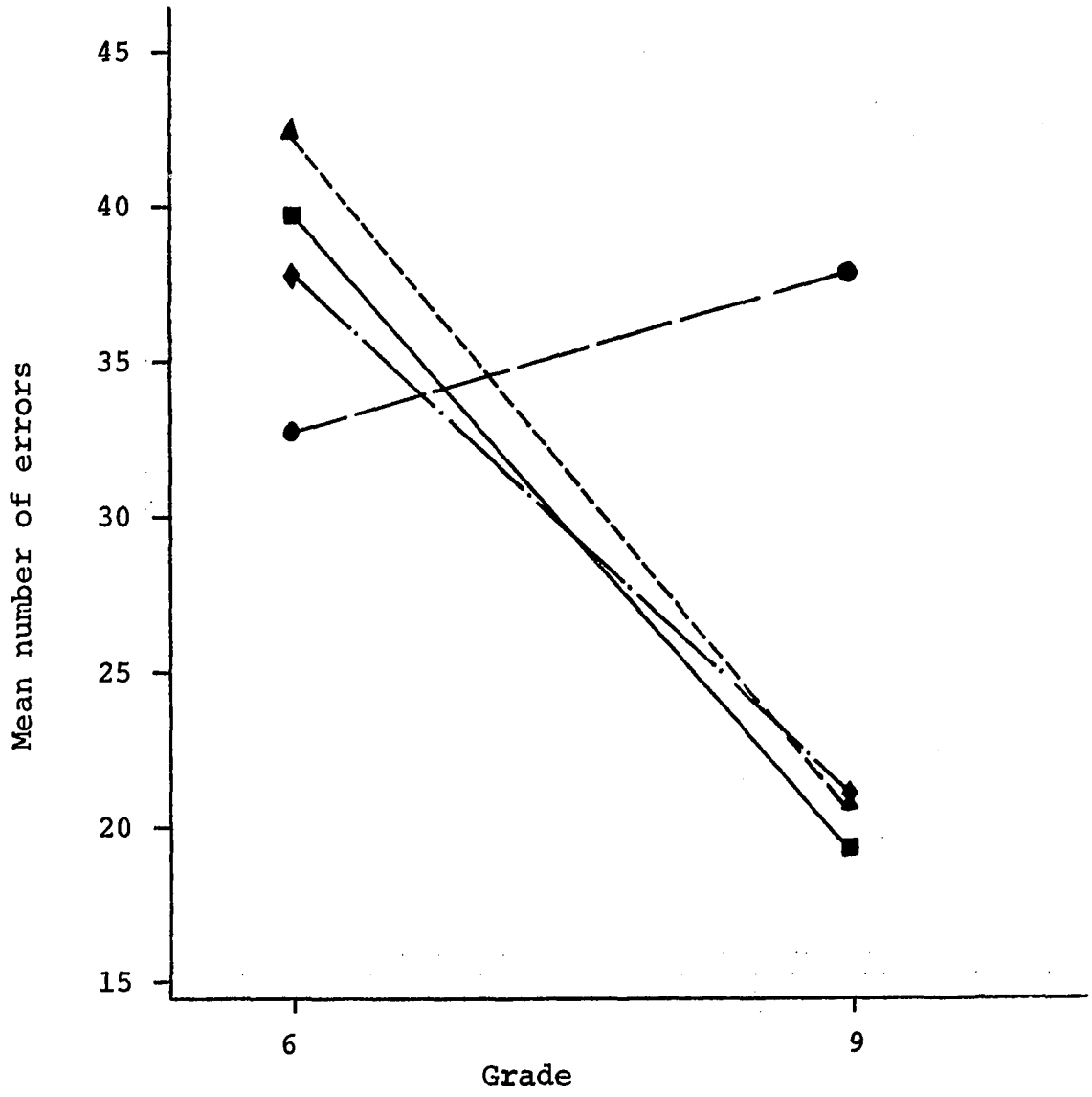


Figure 4

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES SIX AND NINE

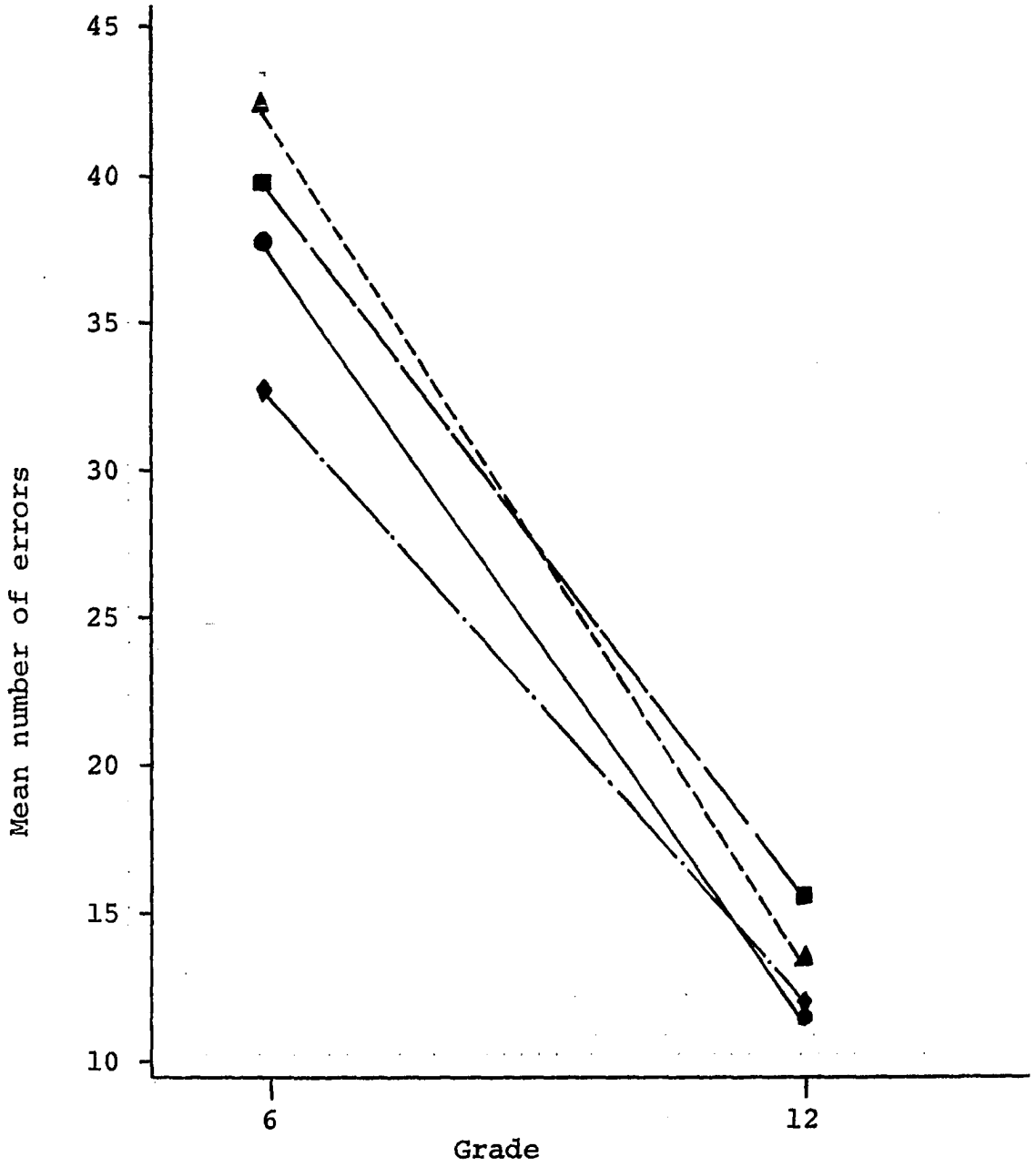


Figure 5

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES SIX AND TWELVE

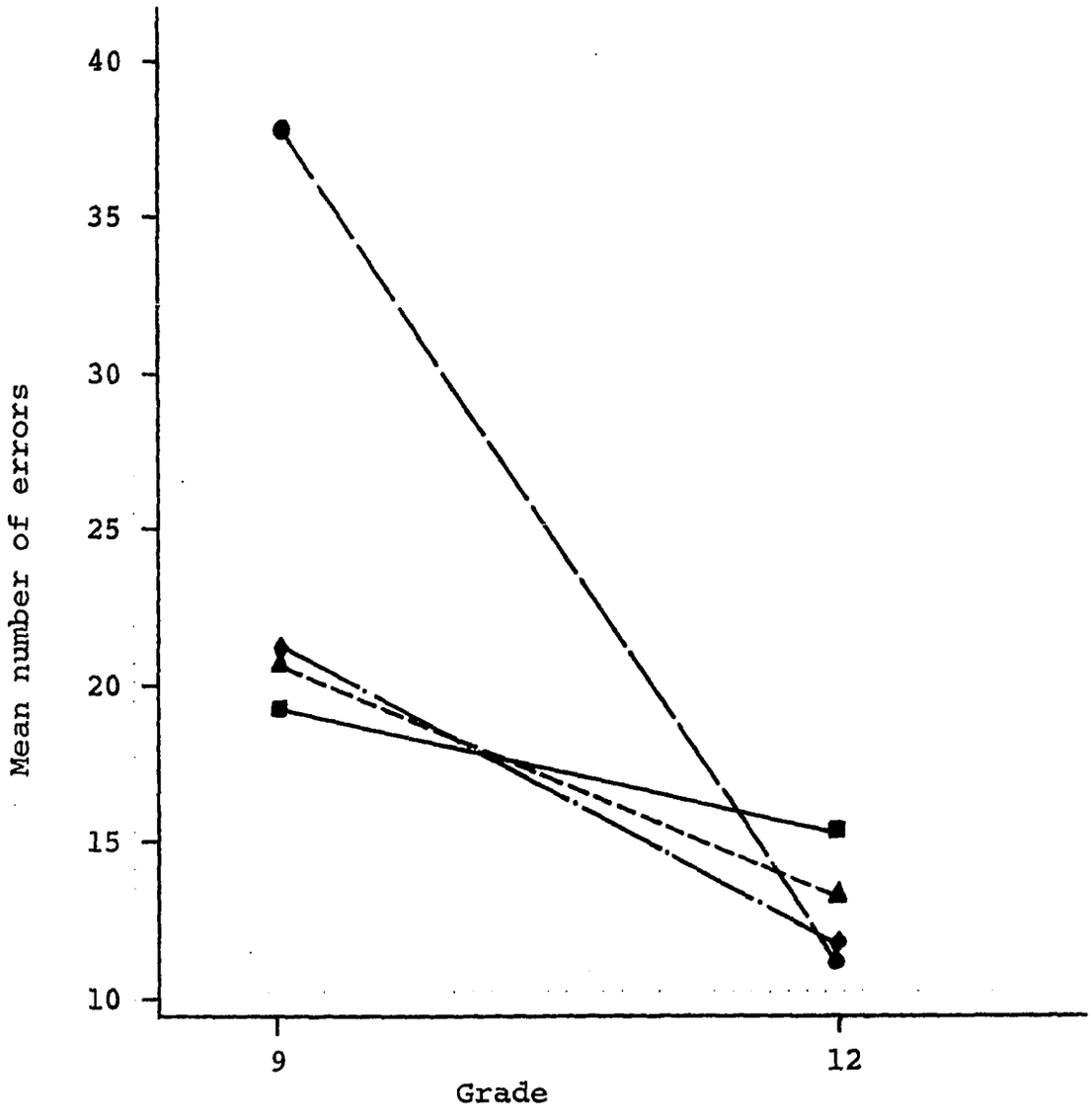


Figure 6

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES NINE AND TWELVE

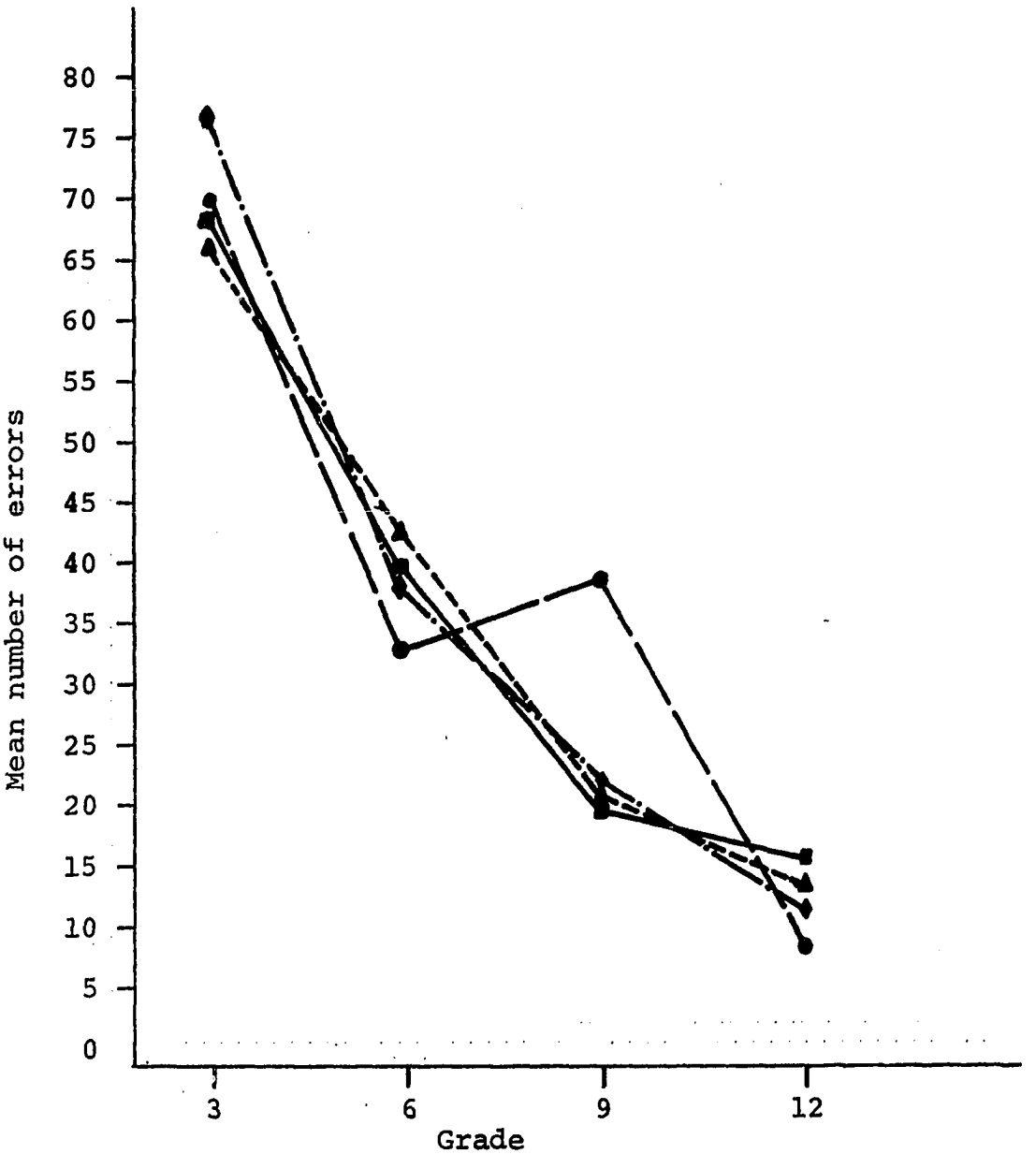


Figure 7

COMPARISON OF GRADE BY MODE INTERACTION MEANS

IN GRADES THREE THROUGH TWELVE

Table 7

POSITION OF MEANS OF MODES BY GRADE LEVELS

| | Grade 3 | 6 | 9 | 12 |
|---|---|---|---|---|
| Greatest number of errors | CC | SC | CNC | SNC |
| | CNC | SNC | CC | SC |
| | SNC | CC | SC | CC |
| Least number of errors | SC | CNC | SNC | CNC |

SNC = simple nonchromatic mode
CNC = complex nonchromatic mode
SC = simple chromatic mode
CC = complex chromatic mode

An analysis of variance on the retention measure of grade levels and modes interaction also produced a significant F ratio as evidenced in Table 4.

## Analysis of Sex and Mode Interaction

An objective of the study was to attempt to discover whether a relationship existed between the four modes of presentation and sex differences. Results of the analysis of variance computed on the acquisition trials are shown in Table 2 and fail to reveal a statistically significant interaction between the modes of presentation and sex. The analysis of variance performed on the retention data and listed in Table 4 also failed to show significance.

## Analysis of Achievement and Mode Interaction

Determining the relationship between achievement levels and modes of presentation was also an important aspect of the study. The data for the acquisition trials were re-grouped into eight sub-divisions and an analysis of variance was computed. Results may be seen in Table 2. The interaction of achievement with mode was found to be significant at the .05 level which led to the computation of a Newman-Keuls test. Results of the Newman-Keuls test are summarized in Table 8. All high achievement means were significantly different from all low achievement means. However, no high achievement means were significantly different from any other high achievement means nor any low achievement mean from any other low achievement mean.

Analysis of variance applied to the achievement by mode retention data failed to produce a significant *F* ratio. The above fact is exhibited in Table 4.

## Chromatic Groups Versus Nonchromatic Groups

An effort was made in the study to discover the presence or absence of any significant difference between the scores of the subjects who viewed either of the chromatic modes versus those who saw either of the nonchromatic modes. The effort was accomplished by computing a *t* test to test the difference between means. Summarization of the outcome is presented in Table 9.

Table 8

DIFFERENCES AMONG MEANS OF THE INTERACTION OF ACHIEVEMENT LEVELS BY MODES OF PRESENTATION ON ACQUISITION TRIALS

| | $\bar{X}_7$ | $\bar{X}_3$ | $\bar{X}_8$ | $\bar{X}_4$ | $\bar{X}_2$ | $\bar{X}_6$ |
|---|---|---|---|---|---|---|
| $\bar{X}_5 = 24.0$ | | 7.3 | 18.1* | 20.4* | 22.1* | 23.6* |
| $\bar{X}_1 = 25.2$ | | | 16.9* | 19.3* | 21.0* | 22.5* |
| $\bar{X}_7 = 30.8$ | | | 11.3* | 13.6* | 15.3* | 16.8* |
| $\bar{X}_3 = 31.3$ | | | 10.8* | 13.1* | 14.9* | 16.3* |
| $\bar{X}_8 = 42.1$ | | | | | | 5.5 |
| $\bar{X}_4 = 44.4$ | | | | | | |
| $\bar{X}_2 = 46.2$ | | | | | | |
| $\bar{X}_6 = 47.6$ | | | | | | |

*Significant at the .01 level.

$\bar{X}_1$ = High achievers, simple nonchromatic mode.

$\bar{X}_2$ = Low achievers, simple nonchromatic mode.

$\bar{X}_3$ = High achievers, complex nonchromatic mode.

$\bar{X}_4$ = Low achievers, complex nonchromatic mode.

$\bar{X}_5$ = High achievers, simple chromatic mode.

$\bar{X}_6$ = Low achievers, simple chromatic mode.

$\bar{X}_7$ = High achievers, complex chromatic mode.

$\bar{X}_8$ = Low achievers, complex chromatic mode.

Table 9

ANALYSIS OF NONCHROMATIC GROUPS VERSUS CHROMATIC GROUPS

| | Modes | |
|---|---|---|
| | Nonchromatic | Chromatic |
| N = | 224 | 224 |
| $\Sigma X$ = | 8237 | 8097 |
| $\bar{X}$ = | 36.772 | 36.147 |
| $\Sigma X^2$= | 497927 | 502353 |
| $t$ = 0.219 (Not significant) | | |

The critical value of $t$ required with 446 degrees of freedom was 1.282, consequently the value obtained from the computation was not significant.

## Simple Modes Versus Complex Modes

The mean of scores of subjects who viewed either of the simple modes of presentation was compared with the mean of those subjects who viewed either of the complex modes of presentation by the computation of a $t$ test. Results may be observed in Table 10. A critical value of $t$ of 1.282 for 446 degrees of freedom was required for significance. The $t$ value obtained from the test failed to meet or exceed the critical value.

## Comparison of Group Pairs

The analysis of variance shown in Table 2 indicates

Table 10

ANALYSIS OF SIMPLE MODES VERSUS COMPLEX MODES

| | Modes | |
|---|---|---|
| | Simple | Complex |
| N = | 224 | 224 |
| $\Sigma X$ = | 8008 | 8326 |
| $\bar{X}$ = | 35.750 | 37.170 |
| $\Sigma X^2$= | 486302 | 513978 |
| $t$ = 0.498 (Not significant) | | |

no statistically significant differences between any of the four modes of presentation. A priori $t$ tests were also computed, the results of which are given in Table 11.

Table 11

ANALYSIS OF GROUP PAIRS

| Pair type | df | $t$ value obtained | $t$ value required | Outcome |
|---|---|---|---|---|
| SNC vs. CNC | 222 | .040 | 1.282 | Not signif. |
| SC vs. CC | 222 | .348 | 1.282 | Not signif. |
| SNC vs. SC | 222 | .557 | 1.282 | Not signif. |
| CC vs. CNC | 222 | .156 | 1.282 | Not signif. |

SNC = Simple nonchromatic mode
CNC = Complex nonchromatic mode
SC = Simple chromatic mode
CC = Complex chromatic mode

As can be seen from the table, none of the t values were significant; confirming the results of the analysis of variance test.

## Summary

Analysis of the data showed a significant difference between each grade level and all other grade levels. A significant difference was also found between the performance of males and females on the acquisition trials. Subjects classified as high achievers also did significantly better than those classified as low achievers.

On the retention measure, analysis of variance also indicated significance between grade levels and between achievement levels but failed to confirm the significant difference between sexes found on the acquisition trials.

Analysis of variance also revealed significant interaction between modes by grades and modes by achievement levels on the acquisition trials. Similar results were obtained from analysis of variance applied to the retention measure. No significant interaction was found between modes and sex on either the acquisition measure or the retention test.

No significant differences were obtained from the statistical analysis of different combinations and comparisons of the means of the different modes of presentation.

Conclusions and recommendations are found in Chapter V.

# CHAPTER V

## FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

The problem of this study was to determine the effect of color and graphic form as stimulus factors in paired-associate learning. The four modes of presentation used to test the above effects were the simple nonchromatic mode, the complex nonchromatic mode, the simple chromatic mode, and the complex chromatic mode. The relationship of the different modes and selected learner characteristics was also examined. The selected learner characteristics were grade level, achievement level, and sex. Nine principal hypotheses and six subsidiary hypotheses were set up to test the above effects. The following section contains the findings for each of the hypotheses.

### Findings

Principal hypothesis 1. stated: There is no statistically significant difference between students at selected grade levels in the acquisition of any of the four modes of paired-associate learning.

The statistical treatment of the data in Chapter IV showed that a high level of statistical significance existed between the selected grade levels. The differences

between means of the four grade levels were statistically significant at all levels. Because of the significant grade level differences, hypothesis 1 was rejected at the .01 level.

Principal hypothesis 2. stated: There is no statistically significant difference between students of differing sexes in the acquisition of any of the four modes of paired-associate learning.

Through the treatment of the data, it was determined that there existed a statistically significant difference between the performance of males and females on the paired-associate learning tasks at the .05 level. Since female subjects, regardless of grade or achievement level, performed better on the acquisition trials, hypothesis 2 was rejected.

Principal hypothesis 3. stated: There is no statistically significant difference between high and low achievers in the acquisition of any of the four modes of paired-associate learning.

Treatment of the data showed that there was a statistically significant difference between high and low achievers at the .001 level. Low achievers made nearly twice as many errors in reaching the criterion on the acquisition trials when compared to the performance of all subjects classified as high achievers. Because of the significant difference, hypothesis 3 was rejected.

Principal hypothesis 4. stated: There is no statsitically

significant difference between students at selected grade levels in the length of retention of any of the four modes of paired-associate learning as measured by a delayed test-trial.

The statistical treatment of the data in Chapter IV pictured a statistically significant difference between grade levels on the retention measure at the .0001 level. Similar to the results obtained from the acquisition data, all grade levels were significantly different from each other on the retention measure. After determining the above difference, hypothesis 4 was rejected.

Principal hypothesis 5. stated: There is no statistically significant difference between male and female students in the length of retention of any of the four modes of paired-associate learning as measured by a delayed test-trial.

Analysis of the data obtained from the retention measure indicated that there existed no statistically significant difference between the performance of males and females. Therefore, hypothesis 5 was accepted that there was no difference between males and females on retention.

Principal hypothesis 6. stated: There is no statistically significant difference between high and low achievers in the length of retention of any of the four modes of the paired-associate learning tasks as measured

by a delayed test-trial.

The data, as analyzed in Chapter IV, indicated a significant difference at the .001 level between achievement levels in favor of the high achievers. The analysis caused hypothesis 6 to be rejected; that high achievers retain paired-associate learning to a higher degree than low achievers.

Principal hypothesis 7. stated: There is no statistically significant interaction between certain of the four modes of presentation and selected grade levels.

It was determined through statistical interpretation that significant interaction between modes and grades did exist on both the acquisition and retention trials. It was found that any mode within a selected grade level differed significantly from any mode within any other grade level. However, significant differences within one grade level were lacking in nearly all cases. Due to the interaction between grades and modes, hypothesis 7 was rejected.

Principal hypothesis 8. stated: There is no statistically significant interaction between certain of the four modes of presentation and student sex differences.

No significant interaction of modes and sex was found during statistical analysis on either the acquisition or retention measures. Consequently, hypothesis 8 was accepted.

Principal hypothesis 9. stated: There is no statistically significant interaction between certain of the four modes of presentation and differences in achievement level.

Statistical analysis showed statistically significant differences between any of the high achievement groups, regardless of mode, with any of the low achievement groups on the acquisition trials. However, no high achievement groups were significantly different from any other high achievement groups. The same was also true of the low achievement groups. The retention data failed to exhibit any significant interaction of mode and achievement. However, since hypothesis 9 applied mainly to the acquisition trials, it was rejected.

Subsidiary hypothesis 1. stated: There is no statistically significant difference in the means of the chromatic groups versus the nonchromatic groups.

All groups which viewed materials employing color were compared with all groups which viewed non-colored materials. No significant difference was observed and hypothesis 1 was accepted.

Subsidiary hypothesis 2. stated: There is no statistically significant difference in the means of the simple presentation form groups versus the complex presentation form groups.

Statistical analysis failed to reveal a statistically

significant difference between the two groups. Hypothesis 2 was accepted after the statistical analysis was completed.

Subsidiary hypothesis 3. stated: There is no statistically significant difference between the means of all groups receiving the simple nonchromatic form of presentation versus the complex nonchromatic groups.

After statistical analysis, hypothesis 3 was accepted due to the lack of significance of difference.

Subsidiary hypothesis 4. stated: There is no statistically significant difference between the means of all groups receiving the simple chromatic mode of presentation versus those receiving the complex chromatic mode.

After statistical analysis, it was determined that there existed no statistically significant difference between the means of the two chromatic groups. Therefore, it was shown that simplicity or complexity were not significant factors and hypothesis 5 was accepted.

Subsidiary hypothesis 5. stated: There is no statistically significant difference between the means of all groups receiving the simple nonchromatic mode of presentation versus those receiving the simple chromatic mode.

There was no statistically significant difference between the two groups as evidenced by the statistical

analysis. In other words, with the complexity of the presentation being held constant, color did not enhance the learning of the paired-associates. Consequently, the acceptance of hypothesis 5 was demanded.

Subsidiary hypothesis 6. stated: There is no statistically significant difference between the means of all groups receiving the complex chromatic mode of presentation versus those receiving the complex nonchromatic mode.

Statistical analysis failed to exhibit a significant difference between the means of the two groups. Subjects learned paired-associates equally well when black and white or color photographs were used as stimuli. After the discovery of the lack of significance, hypothesis 6 was accepted.

## Conclusions

The study failed to exhibit the superiority of any of the modes in paired-associate learning within the limits of this design. Color, the lack of color, the use of line drawings, or the use of photographs in conjunction with visual stimuli apparently had little effect on learning or retention. It might be theorized that the paired-associate tasks used in this study were of such a small degree of difficulty that color as a cue or aid to learning was of relatively little value. Also, the simplicity or complexity of the stimulus in this case seemed of little difference.

If the above is true it may be possible that the simplified drawings and illustrations found in materials used in the primary grades could just as well be replaced with photographs.

A significant interaction of modes by grade and modes by achievement was obtained. It may be concluded that the learner's grade level and achievement level should be considered as well as the mode of presentation in determining the most efficient pathway for learning.

It was found that although an interaction of sex by modes was found on the acquisition trials, none was observed in the retention measure. This may be interpreted as meaning (1) there was no difference to be obtained, (2) the difference found on the acquisition trials was due to chance error, (3) the retention measure failed to discriminate well enough to indicate a difference, or (4) males extinguish at a slower rate on paired-associates than females. Due to the fact that the acquisition measure was a collection of ten measures while the retention measure was a single test only, possibility 3 above seems most likely.

The high level of statistical significance obtained between grades indicated that the paired-associate may well be a desirable learning framework for secondary students. Conversely, the paired-associate framework may be of questionable value in the education of lower elementary students due to their apparent difficulty in creating associations.

## Recommendations

In view of the results reported in the present study, the following recommendations were made:

1. As a result of this study, the value of color in enhancing learning should not be overemphasized.

2. For students similar to those involved in the study, it is recommended that the paired-associate framework may be an appropriate teaching strategy in the secondary school for certain kinds of subject matter.

3. For students similar to those involved in the study, it is recommended that the paired-associate framework may be an appropriate teaching strategy in the education of high achievement groups in certain kinds of subject matter.

4. For students similar to those involved in the study, it is recommended that photographs or line drawings may be used equally well as visual stimuli in learning paired-associates by all age groups and ability groups.

## Recommendations for Further Study

Further study may prove fruitful in studying the variables used in this study while increasing the difficulty of the items significantly. A study of social class and paired-associate learning could be of value. Further study of paired-associate learning while manipulating the response could provide valuable results. Finally, a study

examining the student-made associations while learning paired-associates could provide valuable insights into determining how students learn.

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# APPENDIX A

Table 12

RAW DATA FOR GRADE THREE UNDER THE BLACK AND WHITE LINE DRAWING MODE

| Pupil No. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 99 | 7 |
| HM-2 | 6 | 7 | 4 | 9 | 3 | 6 | 3 | 1 | 4 | 2 | 45 | 9 |
| HM-3 | 10 | 10 | 10 | 10 | 8 | 8 | 8 | 9 | 9 | 9 | 91 | 8 |
| HM-4 | 9 | 6 | 2 | 1 | 0 | | | | | | 18 | 1 |
| HM-5 | 7 | 6 | 6 | 5 | 4 | 4 | 3 | 3 | 3 | 3 | 44 | 3 |
| HM-6 | 8 | 8 | 6 | 4 | 10 | 6 | 4 | 5 | 2 | 2 | 55 | 5 |
| HM-7 | 9 | 10 | 10 | 7 | 8 | 10 | 8 | 8 | 8 | 10 | 88 | 7 |
| LM-1 | 10 | 10 | 10 | 9 | 9 | 9 | 6 | 7 | 10 | 8 | 88 | 8 |
| LM-2 | 10 | 9 | 8 | 8 | 8 | 8 | 9 | 10 | 9 | 9 | 88 | 7 |
| LM-3 | 9 | 9 | 7 | 7 | 7 | 6 | 7 | 6 | 3 | 4 | 65 | 8 |
| LM-4 | 8 | 10 | 8 | 7 | 7 | 5 | 7 | 9 | 8 | 8 | 77 | 9 |
| LM-5 | 10 | 10 | 10 | 9 | 8 | 7 | 10 | 5 | 4 | 3 | 76 | 4 |
| LM-6 | 9 | 9 | 10 | 9 | 9 | 8 | 9 | 8 | 10 | 10 | 91 | 9 |
| LM-7 | 9 | 9 | 9 | 8 | 8 | 6 | 7 | 7 | 7 | 6 | 79 | 8 |
| HF-1 | 10 | 8 | 7 | 6 | 4 | 3 | 5 | 5 | 5 | 6 | 59 | 5 |
| HF-2 | 9 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 5 | 4 | 63 | 5 |
| HF-3 | 6 | 6 | 5 | 4 | 5 | 3 | 5 | 3 | 3 | 4 | 44 | 6 |
| HF-4 | 10 | 10 | 9 | 10 | 9 | 8 | 9 | 7 | 8 | 7 | 87 | 10 |
| HF-5 | 9 | 6 | 3 | 3 | 1 | 0 | | | | | 22 | 3 |
| HF-6 | 10 | 8 | 9 | 8 | 6 | 6 | 7 | 5 | 5 | 3 | 67 | 9 |
| HF-7 | 6 | 4 | 2 | 1 | 2 | 0 | | | | | 15 | 0 |
| LF-1 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 7 | 7 | 89 | 9 |
| LF-2 | 9 | 10 | 7 | 4 | 6 | 4 | 3 | 1 | 0 | | 44 | 4 |
| LF-3 | 10 | 10 | 9 | 10 | 8 | 9 | 8 | 9 | 7 | 5 | 85 | 8 |
| LF-4 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 7 | 7 | 92 | 9 |
| LF-5 | 10 | 10 | 8 | 7 | 6 | 7 | 6 | 6 | 5 | 6 | 71 | 7 |
| LF-6 | 9 | 10 | 10 | 9 | 10 | 10 | 10 | 8 | 8 | 7 | 91 | 7 |
| LF-7 | 10 | 9 | 8 | 8 | 8 | 9 | 8 | 7 | 7 | 7 | 81 | 5 |

HM = High achieving male
LM = Low achieving male
HM = High achieving female
LM = Low achieving female

Table 13

RAW DATA FOR GRADE THREE UNDER THE BLACK AND WHITE PHOTO MODE

| Pupil No. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 10 | 9 | 5 | 6 | 4 | 3 | 0 | | | | 37 | 4 |
| HM-2 | 10 | 9 | 8 | 9 | 10 | 8 | 10 | 9 | 9 | 10 | 92 | 6 |
| HM-3 | 10 | 8 | 9 | 5 | 7 | 6 | 7 | 5 | 7 | 5 | 69 | 5 |
| HM-4 | 8 | 10 | 3 | 3 | 1 | 1 | 2 | 0 | | | 28 | 5 |
| HM-5 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 100 | 10 |
| HM-6 | 9 | 8 | 9 | 10 | 9 | 6 | 4 | 9 | 3 | 2 | 69 | 5 |
| HM-7 | 8 | 8 | 5 | 7 | 8 | 5 | 4 | 4 | 4 | 3 | 56 | 3 |
| LM-1 | 9 | 9 | 10 | 10 | 9 | 10 | 8 | 10 | 10 | 8 | 93 | 10 |
| LM-2 | 9 | 9 | 9 | 9 | 8 | 8 | 7 | 9 | 7 | 8 | 83 | 9 |
| LM-3 | 9 | 10 | 7 | 8 | 8 | 9 | 7 | 6 | 6 | 4 | 74 | 7 |
| LM-4 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 99 | 10 |
| LM-5 | 10 | 10 | 9 | 10 | 5 | 4 | 4 | 3 | 3 | 2 | 60 | 5 |
| LM-6 | 7 | 8 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 28 | 3 |
| LM-7 | 10 | 10 | 10 | 10 | 9 | 8 | 7 | 6 | 6 | 6 | 82 | 5 |
| HF-1 | 8 | 6 | 7 | 7 | 6 | 7 | 4 | 2 | 4 | 2 | 53 | 4 |
| HF-2 | 10 | 9 | 8 | 5 | 4 | 4 | 2 | 4 | 7 | 9 | 62 | 7 |
| HF-3 | 10 | 9 | 9 | 8 | 9 | 8 | 6 | 7 | 7 | 7 | 80 | 9 |
| HF-4 | 6 | 5 | 6 | 3 | 4 | 3 | 2 | 9 | 2 | 0 | 40 | 1 |
| HF-5 | 10 | 7 | 10 | 10 | 4 | 4 | 2 | 2 | 2 | 2 | 53 | 5 |
| HF-6 | 10 | 10 | 7 | 9 | 9 | 7 | 10 | 8 | 8 | 10 | 88 | 10 |
| HF-7 | 9 | 8 | 9 | 7 | 9 | 5 | 4 | 8 | 1 | 1 | 61 | 5 |
| LF-1 | 10 | 10 | 6 | 6 | 7 | 5 | 4 | 4 | 7 | 3 | 62 | 7 |
| LF-2 | 9 | 10 | 10 | 10 | 8 | 6 | 6 | 6 | 5 | 5 | 75 | 9 |
| LF-3 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 100 | 10 |
| LF-4 | 10 | 8 | 8 | 6 | 8 | 6 | 6 | 4 | 5 | 5 | 66 | 5 |
| LF-5 | 10 | 9 | 10 | 9 | 8 | 10 | 6 | 4 | 3 | 3 | 72 | 4 |
| LF-6 | 9 | 10 | 10 | 9 | 10 | 10 | 10 | 8 | 8 | 7 | 91 | 7 |
| LF-7 | 10 | 10 | 9 | 8 | 8 | 8 | 7 | 6 | 6 | 5 | 78 | 7 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 14

RAW DATA FOR GRADE THREE UNDER THE COLORED LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 9 | 8 | 7 | 9 | 4 | 5 | 4 | 1 | 1 | 3 | 51 | 6 |
| HM-2 | 9 | 10 | 7 | 4 | 3 | 4 | 2 | 1 | 0 | | 40 | 4 |
| HM-3 | 10 | 9 | 5 | 7 | 5 | 7 | 6 | 2 | 2 | 5 | 58 | 6 |
| HM-4 | 8 | 7 | 4 | 2 | 0 | | | | | | 21 | 9 |
| HM-5 | 8 | 8 | 6 | 6 | 3 | 7 | 7 | 10 | 10 | 8 | 73 | 8 |
| HM-6 | 10 | 10 | 6 | 5 | 5 | 8 | 4 | 3 | 3 | 2 | 56 | 3 |
| HM-7 | 10 | 10 | 9 | 7 | 9 | 8 | 8 | 10 | 8 | 7 | 86 | 3 |
| LM-1 | 10 | 10 | 10 | 10 | 9 | 9 | 8 | 9 | 8 | 8 | 91 | 6 |
| LM-2 | 8 | 8 | 6 | 6 | 3 | 7 | 7 | 10 | 10 | 8 | 73 | 8 |
| LM-3 | 6 | 7 | 6 | 7 | 6 | 5 | 6 | 5 | 6 | 6 | 60 | 5 |
| LM-4 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 10 | 98 | 6 |
| LM-5 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 99 | 9 |
| LM-6 | 10 | 10 | 10 | 7 | 8 | 6 | 5 | 3 | 3 | 2 | 64 | 9 |
| LM-7 | 10 | 10 | 10 | 10 | 9 | 9 | 10 | 7 | 7 | 9 | 91 | 10 |
| HF-1 | 8 | 10 | 6 | 7 | 5 | 4 | 3 | 1 | 0 | | 44 | 3 |
| HF-2 | 8 | 9 | 8 | 7 | 7 | 7 | 7 | 8 | 5 | 6 | 72 | 8 |
| HF-3 | 6 | 6 | 3 | 1 | 0 | | | | | | 16 | 6 |
| HF-4 | 9 | 10 | 9 | 9 | 10 | 5 | 9 | 8 | 7 | 8 | 84 | 10 |
| HF-5 | 10 | 10 | 10 | 7 | 6 | 5 | 2 | 4 | 4 | 6 | 64 | 6 |
| HF-6 | 10 | 10 | 5 | 7 | 8 | 5 | 3 | 4 | 4 | 1 | 57 | 3 |
| HF-7 | 8 | 9 | 6 | 6 | 2 | 2 | 4 | 2 | 0 | | 39 | 5 |
| LF-1 | 10 | 8 | 9 | 9 | 8 | 7 | 7 | 10 | 6 | 10 | 84 | 9 |
| LF-2 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 99 | 10 |
| LF-3 | 5 | 5 | 4 | 3 | 1 | 1 | 1 | 0 | | | 20 | 6 |
| LF-4 | 10 | 10 | 9 | 10 | 8 | 9 | 7 | 7 | 8 | 9 | 87 | 8 |
| LF-5 | 10 | 9 | 10 | 7 | 8 | 7 | 4 | 5 | 8 | 2 | 70 | 8 |
| LF-6 | 9 | 10 | 9 | 8 | 9 | 6 | 6 | 7 | 8 | 8 | 80 | 9 |
| LF-7 | 10 | 10 | 10 | 9 | 10 | 10 | 9 | 9 | 9 | 10 | 96 | 9 |

HM = High achieveing male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 15

RAW DATA FOR GRADE THREE UNDER THE COLORED PHOTO MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 9 | 10 | 9 | 9 | 7 | 9 | 10 | 8 | 9 | 7 | 87 | 10 |
| HM-2 | 10 | 10 | 10 | 9 | 9 | 7 | 9 | 9 | 7 | 6 | 86 | 8 |
| HM-3 | 9 | 10 | 9 | 9 | 9 | 8 | 3 | 10 | 4 | 4 | 75 | 5 |
| HM-4 | 10 | 10 | 8 | 9 | 6 | 2 | 0 | | | | 45 | 4 |
| HM-5 | 10 | 9 | 9 | 8 | 8 | 7 | 5 | 8 | 7 | 5 | 76 | 7 |
| HM-6 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 9 | 9 | 9 | 96 | 10 |
| HM-7 | 9 | 10 | 10 | 7 | 7 | 3 | 5 | 4 | 3 | 2 | 60 | 6 |
| LM-1 | 10 | 10 | 9 | 9 | 7 | 7 | 7 | 6 | 6 | 7 | 78 | 7 |
| LM-2 | 8 | 9 | 9 | 9 | 9 | 8 | 7 | 9 | 6 | 6 | 80 | 8 |
| LM-3 | 10 | 10 | 9 | 10 | 10 | 7 | 8 | 9 | 6 | 8 | 87 | 10 |
| LM-4 | 10 | 9 | 9 | 7 | 8 | 7 | 7 | 7 | 6 | 6 | 76 | 7 |
| LM-5 | 9 | 9 | 8 | 8 | 7 | 7 | 8 | 9 | 6 | 6 | 77 | 8 |
| LM-6 | 10 | 10 | 8 | 7 | 7 | 8 | 7 | 6 | 7 | 8 | 78 | 9 |
| LM-7 | 7 | 6 | 7 | 6 | 7 | 5 | 5 | 5 | 6 | 6 | 60 | 3 |
| HF-1 | 10 | 9 | 9 | 9 | 8 | 8 | 8 | 6 | 6 | 6 | 79 | 8 |
| HF-2 | 10 | 6 | 4 | 3 | 4 | 2 | 2 | 10 | 2 | 1 | 44 | 4 |
| HF-3 | 10 | 10 | 10 | 10 | 10 | 7 | 8 | 7 | 8 | 8 | 88 | 10 |
| HF-4 | 10 | 10 | 10 | 10 | 9 | 8 | 6 | 6 | 5 | 5 | 79 | 9 |
| HF-5 | 10 | 10 | 7 | 7 | 6 | 5 | 3 | 3 | 2 | 0 | 53 | 5 |
| HF-6 | 10 | 10 | 9 | 10 | 9 | 7 | 8 | 10 | 8 | 8 | 89 | 9 |
| HF-7 | 10 | 9 | 8 | 9 | 7 | 8 | 8 | 7 | 7 | 6 | 79 | 9 |
| LF-1 | 9 | 10 | 8 | 7 | 7 | 7 | 7 | 8 | 7 | 7 | 77 | 9 |
| LF-2 | 10 | 10 | 8 | 8 | 8 | 6 | 9 | 8 | 7 | 8 | 82 | 8 |
| LF-3 | 10 | 10 | 9 | 7 | 8 | 6 | 7 | 9 | 8 | 8 | 82 | 8 |
| LF-4 | 9 | 10 | 8 | 10 | 9 | 9 | 6 | 6 | 6 | 8 | 81 | 9 |
| LF-5 | 10 | 10 | 10 | 10 | 10 | 9 | 8 | 9 | 9 | 10 | 95 | 9 |
| LF-6 | 10 | 9 | 7 | 9 | 5 | 4 | 4 | 3 | 1 | 1 | 53 | 6 |
| LF-7 | 8 | 7 | 5 | 6 | 8 | 6 | 6 | 8 | 8 | 6 | 68 | 7 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 16

RAW DATA FOR GRADE SIX UNDER THE BLACK AND WHITE LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 3 | 2 | 1 | 1 | 0 | | | | | | 7 | 2 |
| HM-2 | 9 | 1 | 1 | 0 | | | | | | | 11 | 1 |
| HM-3 | 8 | 8 | 9 | 6 | 5 | 3 | 10 | 3 | 2 | 1 | 55 | 6 |
| HM-4 | 6 | 6 | 1 | 0 | | | | | | | 13 | 1 |
| HM-5 | 9 | 9 | 9 | 9 | 6 | 8 | 7 | 6 | 6 | 6 | 75 | 6 |
| HM-6 | 1 | 1 | 0 | | | | | | | | 2 | 0 |
| HM-7 | 5 | 1 | 0 | | | | | | | | 6 | 0 |
| LM-1 | 10 | 10 | 9 | 7 | 8 | 8 | 6 | 5 | 5 | 4 | 72 | 5 |
| LM-2 | 9 | 8 | 7 | 9 | 8 | 8 | 8 | 8 | 8 | 5 | 78 | 9 |
| LM-3 | 10 | 9 | 10 | 8 | 5 | 4 | 1 | 3 | 6 | 9 | 65 | 2 |
| LM-4 | 9 | 8 | 6 | 6 | 5 | 3 | 4 | 2 | 2 | 2 | 47 | 3 |
| LM-5 | 9 | 7 | 8 | 6 | 9 | 8 | 10 | 6 | 7 | 5 | 75 | 8 |
| LM-6 | 10 | 9 | 10 | 7 | 4 | 5 | 1 | 1 | 0 | | 47 | 4 |
| LM-7 | 8 | 8 | 8 | 7 | 6 | 5 | 4 | 2 | 2 | 0 | 50 | 6 |
| HF-1 | 7 | 6 | 3 | 1 | 0 | | | | | | 16 | 0 |
| HF-2 | 8 | 8 | 7 | 7 | 5 | 4 | 4 | 5 | 4 | 1 | 53 | 6 |
| HF-3 | 8 | 5 | 5 | 4 | 2 | 2 | 1 | 1 | 2 | 0 | 30 | 1 |
| HF-4 | 7 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | | 18 | 4 |
| HF-5 | 4 | 1 | 1 | 0 | | | | | | | 6 | 1 |
| HF-6 | 2 | 2 | 0 | | | | | | | | 4 | 1 |
| HF-7 | 3 | 3 | 1 | 0 | | | | | | | 7 | 3 |
| LF-1 | 9 | 8 | 7 | 7 | 3 | 2 | 2 | 2 | 2 | 1 | 41 | 5 |
| LF-2 | 7 | 5 | 4 | 1 | 2 | 1 | 10 | 1 | 0 | | 31 | 5 |
| LF-3 | 9 | 10 | 8 | 10 | 8 | 4 | 10 | 8 | 4 | 8 | 83 | 9 |
| LF-4 | 10 | 9 | 7 | 7 | 7 | 5 | 5 | 6 | 1 | 2 | 59 | 2 |
| LF-5 | 9 | 4 | 5 | 5 | 4 | 1 | 1 | 1 | 0 | | 30 | 2 |
| LF-6 | 9 | 9 | 8 | 8 | 7 | 7 | 6 | 5 | 6 | 4 | 69 | 3 |
| LF-7 | 10 | 10 | 7 | 8 | 6 | 6 | 5 | 6 | 6 | 0 | 64 | 7 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 17

RAW DATA FOR GRADE SIX UNDER THE BLACK AND WHITE PHOTO MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 3 | 3 | 1 | 0 | | | | | | | 7 | 0 |
| HM-2 | 7 | 7 | 4 | 0 | | | | | | | 18 | 1 |
| HM-3 | 9 | 3 | 4 | 4 | 1 | 2 | 0 | | | | 23 | 4 |
| HM-4 | 4 | 1 | 0 | | | | | | | | 5 | 0 |
| HM-5 | 6 | 6 | 2 | 0 | | | | | | | 14 | 3 |
| HM-6 | 5 | 1 | 0 | | | | | | | | 6 | 2 |
| HM-7 | 8 | 6 | 3 | 7 | 4 | 2 | 3 | 1 | 0 | | 34 | 4 |
| LM-1 | 3 | 1 | 0 | | | | | | | | 4 | 0 |
| LM-2 | 8 | 10 | 7 | 9 | 10 | 9 | 7 | 10 | 6 | 6 | 82 | 8 |
| LM-3 | 8 | 9 | 5 | 4 | 6 | 6 | 3 | 4 | 2 | 0 | 47 | 5 |
| LM-4 | 9 | 10 | 9 | 6 | 5 | 4 | 3 | 1 | 2 | 0 | 49 | 0 |
| LM-5 | 9 | 8 | 6 | 7 | 6 | 8 | 6 | 5 | 5 | 4 | 64 | 3 |
| LM-6 | 8 | 9 | 7 | 5 | 4 | 2 | 1 | 1 | 0 | | 37 | 0 |
| LM-7 | 8 | 9 | 6 | 5 | 5 | 5 | 3 | 3 | 2 | 1 | 47 | 3 |
| HF-1 | 1 | 0 | | | | | | | | | 1 | 0 |
| HF-2 | 0 | | | | | | | | | | 0 | 0 |
| HF-3 | 4 | 8 | 0 | | | | | | | | 12 | 0 |
| HF-4 | 2 | 2 | 1 | 0 | | | | | | | 5 | 0 |
| HF-5 | 6 | 6 | 5 | 3 | 4 | 3 | 1 | 1 | 0 | | 29 | 4 |
| HF-6 | 4 | 1 | 0 | | | | | | | | 5 | 1 |
| HF-7 | 6 | 5 | 2 | 1 | 0 | | | | | | 14 | 1 |
| LF-1 | 7 | 5 | 2 | 0 | | | | | | | 14 | 7 |
| LF-2 | 8 | 10 | 5 | 7 | 5 | 5 | 6 | 4 | 3 | 3 | 56 | 6 |
| LF-3 | 10 | 8 | 7 | 6 | 5 | 3 | 4 | 2 | 1 | 0 | 46 | 6 |
| LF-4 | 9 | 10 | 9 | 9 | 10 | 4 | 4 | 3 | 3 | 2 | 63 | 10 |
| LF-5 | 9 | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 91 | 9 |
| LF-6 | 9 | 10 | 7 | 9 | 8 | 5 | 7 | 6 | 7 | 6 | 74 | 5 |
| LF-7 | 9 | 9 | 8 | 8 | 7 | 7 | 6 | 5 | 6 | 4 | 69 | 3 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 18

RAW DATA FOR GRADE SIX UNDER THE COLORED LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 9 | 9 | 8 | 5 | 3 | 2 | 1 | 0 | | | 37 | 7 |
| HM-2 | 10 | 8 | 6 | 3 | 2 | 1 | 1 | 1 | 0 | | 32 | 1 |
| HM-3 | 5 | 5 | 3 | 5 | 4 | 4 | 0 | | | | 26 | 4 |
| HM-4 | 2 | 0 | | | | | | | | | 2 | 2 |
| HM-5 | 7 | 7 | 5 | 5 | 3 | 3 | 2 | 1 | 0 | | 33 | 6 |
| HM-6 | 2 | 0 | | | | | | | | | 2 | 1 |
| HM-7 | 5 | 5 | 4 | 3 | 3 | 1 | 0 | | | | 21 | 0 |
| LM-1 | 10 | 10 | 9 | 10 | 10 | 9 | 10 | 10 | 9 | 6 | 93 | 9 |
| LM-2 | 10 | 10 | 10 | 10 | 9 | 10 | 9 | 10 | 10 | 9 | 97 | 9 |
| LM-3 | 10 | 9 | 8 | 7 | 7 | 4 | 4 | 3 | 2 | 1 | 55 | 6 |
| LM-4 | 7 | 7 | 9 | 6 | 7 | 4 | 4 | 2 | 3 | 2 | 51 | 5 |
| LM-5 | 7 | 8 | 7 | 8 | 8 | 7 | 7 | 8 | 7 | 7 | 74 | 10 |
| LM-6 | 8 | 9 | 8 | 7 | 8 | 8 | 8 | 6 | 6 | 6 | 74 | 4 |
| LM-7 | 8 | 7 | 6 | 6 | 5 | 7 | 4 | 2 | 2 | 1 | 48 | 4 |
| HF-1 | 10 | 7 | 7 | 7 | 7 | 3 | 0 | | | | 41 | 7 |
| HF-2 | 9 | 5 | 4 | 3 | 4 | 3 | 2 | 0 | | | 30 | 3 |
| HF-3 | 3 | 7 | 3 | 2 | 1 | 0 | | | | | 16 | 1 |
| HF-4 | 10 | 10 | 7 | 9 | 8 | 9 | 7 | 8 | 3 | 6 | 77 | 6 |
| HF-5 | 5 | 3 | 2 | 2 | 1 | 1 | 0 | | | | 14 | 1 |
| HF-6 | 10 | 10 | 2 | 2 | 0 | | | | | | 24 | 3 |
| HF-7 | 9 | 9 | 8 | 7 | 6 | 3 | 5 | 3 | 3 | 2 | 55 | 3 |
| LF-1 | 7 | 6 | 2 | 3 | 1 | 0 | | | | | 19 | 4 |
| LF-2 | 10 | 6 | 7 | 6 | 3 | 9 | 1 | 1 | 1 | 1 | 45 | 5 |
| LF-3 | 10 | 10 | 10 | 10 | 9 | 7 | 4 | 10 | 3 | 2 | 75 | 6 |
| LF-4 | 10 | 7 | 3 | 5 | 5 | 6 | 2 | 3 | 2 | 1 | 44 | 5 |
| LF-5 | 7 | 6 | 5 | 4 | 4 | 2 | 2 | 4 | 3 | 3 | 40 | 7 |
| LF-6 | 4 | 1 | 2 | 1 | 1 | 1 | 0 | | | | 10 | 3 |
| LF-7 | 10 | 10 | 7 | 6 | 6 | 4 | 4 | 3 | 2 | 1 | 53 | 7 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 19

RAW DATA FOR GRADE SIX UNDER THE COLORED PHOTO MODE

| Pupil no. | Errors per trial number 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 7 | 9 | 8 | 5 | 5 | 2 | 0 | | | | 36 | 4 |
| HM-2 | 10 | 9 | 10 | 9 | 9 | 8 | 8 | 9 | 9 | 7 | 88 | 7 |
| HM-3 | 7 | 8 | 8 | 3 | 4 | 1 | 1 | 0 | | | 32 | 1 |
| HM-4 | 7 | 4 | 3 | 2 | 3 | 0 | | | | | 19 | 3 |
| HM-5 | 10 | 9 | 3 | 2 | 0 | | | | | | 24 | 2 |
| HM-6 | 9 | 1 | 2 | 0 | | | | | | | 12 | 0 |
| HM-7 | 8 | 7 | 5 | 3 | 3 | 2 | 1 | 0 | | | 29 | 1 |
| LM-1 | 7 | 8 | 4 | 1 | 5 | 2 | 2 | 1 | 5 | 6 | 41 | 4 |
| LM-2 | 9 | 6 | 3 | 3 | 2 | 4 | 1 | 3 | 3 | 1 | 35 | 4 |
| LM-3 | 10 | 9 | 9 | 9 | 9 | 8 | 6 | 7 | 6 | 6 | 79 | 7 |
| LM-4 | 10 | 9 | 8 | 7 | 7 | 7 | 6 | 6 | 5 | 7 | 72 | 10 |
| LM-5 | 10 | 9 | 8 | 5 | 3 | 2 | 2 | 3 | 2 | 3 | 47 | 4 |
| LM-6 | 7 | 5 | 4 | 3 | 2 | 2 | 1 | 1 | 0 | | 25 | 3 |
| LM-7 | 10 | 10 | 6 | 4 | 7 | 4 | 3 | 3 | 3 | 1 | 51 | 5 |
| HF-1 | 3 | 0 | | | | | | | | | 3 | 5 |
| HF-2 | 9 | 4 | 6 | 4 | 2 | 2 | 2 | 0 | | | 29 | 0 |
| HF-3 | 5 | 4 | 3 | 0 | | | | | | | 12 | 3 |
| HF-4 | 2 | 0 | | | | | | | | | 2 | 0 |
| HF-5 | 8 | 6 | 5 | 2 | 2 | 4 | 2 | 0 | | | 29 | 2 |
| HF-6 | 3 | 7 | 3 | 2 | 1 | 0 | | | | | 16 | 1 |
| HF-7 | 5 | 5 | 5 | 1 | 1 | 1 | 0 | | | | 18 | 1 |
| LF-1 | 9 | 9 | 9 | 7 | 8 | 9 | 8 | 6 | 7 | 8 | 80 | 8 |
| LF-2 | 9 | 5 | 3 | 3 | 4 | 2 | 1 | 1 | 1 | 1 | 30 | 1 |
| LF-3 | 9 | 7 | 5 | 5 | 6 | 6 | 6 | 4 | 7 | 5 | 60 | 8 |
| LF-4 | 9 | 9 | 7 | 2 | 9 | 9 | 5 | 9 | 8 | 9 | 76 | 10 |
| LF-5 | 8 | 7 | 3 | 4 | 4 | 6 | 4 | 3 | 5 | 5 | 49 | 4 |
| LF-6 | 4 | 1 | 2 | 1 | 1 | 1 | 0 | | | | 10 | 3 |
| LF-7 | 9 | 7 | 5 | 4 | 6 | 6 | 5 | 4 | 5 | 5 | 56 | 6 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 20

RAW DATA FOR GRADE NINE UNDER THE BLACK AND WHITE LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 1 | 10 | 1 | 0 | | | | | | | 12 | 0 |
| HM-2 | 7 | 9 | 2 | 1 | 0 | | | | | | 19 | 1 |
| HM-3 | 1 | 1 | 1 | 0 | | | | | | | 3 | 0 |
| HM-4 | 7 | 7 | 5 | 3 | 2 | 0 | | | | | 24 | 4 |
| HM-5 | 2 | 4 | 0 | | | | | | | | 6 | 0 |
| HM-6 | 9 | 9 | 8 | 6 | 5 | 3 | 3 | 2 | 0 | | 45 | 7 |
| HM-7 | 2 | 3 | 0 | | | | | | | | 5 | 0 |
| LM-1 | 9 | 8 | 5 | 5 | 3 | 2 | 1 | 3 | 1 | 1 | 38 | 2 |
| LM-2 | 4 | 3 | 1 | 0 | | | | | | | 8 | 3 |
| LM-3 | 7 | 10 | 6 | 2 | 2 | 3 | 0 | | | | 30 | 5 |
| LM-4 | 10 | 9 | 9 | 9 | 6 | 9 | 3 | 4 | 3 | 3 | 65 | 4 |
| LM-5 | 6 | 3 | 1 | 3 | 0 | | | | | | 13 | 2 |
| LM-6 | 2 | 2 | 0 | | | | | | | | 4 | 1 |
| LM-7 | 9 | 8 | 6 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 40 | 3 |
| HF-1 | 7 | 6 | 4 | 2 | 2 | 1 | 0 | | | | 22 | 1 |
| HF-2 | 2 | 3 | 2 | 3 | 0 | | | | | | 10 | 0 |
| HF-3 | 3 | 1 | 1 | 0 | | | | | | | 5 | 1 |
| HF-4 | 7 | 7 | 3 | 0 | | | | | | | 17 | 0 |
| HF-5 | 4 | 2 | 1 | 1 | 0 | | | | | | 8 | 0 |
| HF-6 | 4 | 3 | 1 | 0 | | | | | | | 8 | 0 |
| HF-7 | 5 | 3 | 2 | 1 | 0 | | | | | | 11 | 0 |
| LF-1 | 6 | 6 | 1 | 1 | 0 | | | | | | 14 | 1 |
| LF-2 | 10 | 7 | 5 | 4 | 1 | 1 | 0 | | | | 28 | 1 |
| LF-3 | 7 | 6 | 5 | 3 | 2 | 0 | | | | | 23 | 4 |
| LF-4 | 5 | 6 | 3 | 2 | 4 | 2 | 1 | 2 | 1 | 0 | 26 | 4 |
| LF-5 | 7 | 6 | 4 | 3 | 1 | 1 | 0 | | | | 22 | 3 |
| LF-6 | 7 | 6 | 3 | 2 | 2 | 1 | 0 | | | | 21 | 4 |
| LF-7 | 6 | 3 | 1 | 0 | | | | | | | 10 | 0 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 21

RAW DATA FOR GRADE NINE UNDER THE BLACK AND WHITE PHOTO MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 6 | 8 | 6 | 2 | 2 | 0 | | | | | 24 | 2 |
| HM-2 | 7 | 9 | 7 | 5 | 4 | 4 | 4 | 3 | 4 | 2 | 49 | 4 |
| HM-3 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 7 | 7 | 5 | 86 | 5 |
| HM-4 | 9 | 7 | 6 | 5 | 2 | 0 | | | | | 29 | 1 |
| HM-5 | 6 | 8 | 7 | 6 | 9 | 1 | 1 | 0 | | | 38 | 9 |
| HM-6 | 9 | 8 | 7 | 7 | 6 | 6 | 5 | 6 | 5 | 4 | 63 | 3 |
| HM-7 | 7 | 9 | 7 | 5 | 5 | 3 | 2 | 2 | 0 | | 40 | 4 |
| LM-1 | 9 | 7 | 6 | 6 | 6 | 6 | 5 | 10 | 10 | 10 | 75 | 6 |
| LM-2 | 6 | 6 | 6 | 4 | 4 | 3 | 2 | 1 | 1 | 1 | 34 | 6 |
| LM-3 | 8 | 5 | 5 | 4 | 4 | 5 | 2 | 5 | 3 | 1 | 42 | 4 |
| LM-4 | 8 | 7 | 5 | 6 | 4 | 2 | 2 | 1 | 1 | 1 | 37 | 5 |
| LM-5 | 6 | 7 | 3 | 3 | 3 | 1 | 1 | 0 | | | 24 | 0 |
| LM-6 | 9 | 10 | 7 | 6 | 6 | 7 | 5 | 3 | 5 | 3 | 61 | 4 |
| LM-7 | 9 | 5 | 1 | 2 | 1 | 1 | 1 | 0 | | | 20 | 0 |
| HF-1 | 10 | 8 | 7 | 7 | 6 | 4 | 2 | 0 | | | 46 | 6 |
| HF-2 | 10 | 9 | 9 | 7 | 6 | 7 | 7 | 4 | 3 | 2 | 64 | 3 |
| HF-3 | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 8 | 93 | 8 |
| HF-4 | 2 | 3 | 0 | | | | | | | | 5 | 1 |
| HF-5 | 9 | 4 | 4 | 2 | 1 | 0 | | | | | 20 | 4 |
| HF-6 | 3 | 2 | 1 | 0 | | | | | | | 6 | 1 |
| HF-7 | 7 | 6 | 5 | 4 | 3 | 3 | 0 | | | | 28 | 3 |
| LF-1 | 5 | 6 | 5 | 3 | 3 | 3 | 1 | 1 | 0 | | 28 | 4 |
| LF-2 | 3 | 1 | 0 | | | | | | | | 4 | 3 |
| LF-3 | 9 | 9 | 5 | 4 | 3 | 1 | 0 | | | | 31 | 3 |
| LF-4 | 4 | 5 | 2 | 2 | 1 | 3 | 0 | | | | 17 | 3 |
| LF-5 | 6 | 4 | 3 | 1 | 2 | 2 | 1 | 0 | | | 19 | 1 |
| LF-6 | 5 | 6 | 3 | 5 | 5 | 2 | 2 | 1 | 2 | 1 | 32 | 1 |
| LF-7 | 8 | 8 | 7 | 5 | 4 | 4 | 3 | 2 | 2 | 2 | 45 | 1 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 22

RAW DATA FOR GRADE NINE UNDER THE COLORED LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 0 | | | | | | | | | | 0 | 0 |
| HM-2 | 3 | 2 | 0 | | | | | | | | 5 | 2 |
| HM-3 | 1 | 0 | | | | | | | | | 1 | 0 |
| HM-4 | 0 | | | | | | | | | | 0 | 1 |
| HM-5 | 8 | 7 | 7 | 6 | 4 | 3 | 1 | 0 | | | 36 | 0 |
| HM-6 | 2 | 1 | 1 | 0 | | | | | | | 4 | 0 |
| HM-7 | 1 | 0 | | | | | | | | | 1 | 0 |
| LM-1 | 9 | 7 | 5 | 4 | 5 | 4 | 1 | 0 | | | 35 | 5 |
| LM-2 | 8 | 9 | 6 | 6 | 3 | 3 | 0 | | | | 35 | 1 |
| LM-3 | 7 | 5 | 3 | 0 | | | | | | | 15 | 0 |
| LM-4 | 6 | 9 | 5 | 4 | 0 | | | | | | 24 | 0 |
| LM-5 | 7 | 7 | 5 | 3 | 2 | 2 | 1 | 0 | | | 27 | 3 |
| LM-6 | 8 | 7 | 5 | 3 | 3 | 2 | 0 | | | | 28 | 1 |
| LM-7 | 8 | 5 | 5 | 4 | 4 | 5 | 2 | 5 | 3 | 1 | 42 | 4 |
| HF-1 | 4 | 0 | | | | | | | | | 4 | 4 |
| HF-2 | 6 | 7 | 6 | 5 | 3 | 2 | 1 | 0 | | | 30 | 2 |
| HF-3 | 1 | 10 | 0 | | | | | | | | 11 | 0 |
| HF-4 | 1 | 0 | | | | | | | | | 1 | 0 |
| HF-5 | 6 | 6 | 3 | 1 | 2 | 1 | 0 | | | | 19 | 0 |
| HF-6 | 6 | 2 | 2 | 1 | 0 | | | | | | 11 | 0 |
| HF-7 | 2 | 0 | | | | | | | | | 2 | 0 |
| LF-1 | 5 | 5 | 6 | 4 | 1 | 0 | | | | | 21 | 2 |
| LF-2 | 2 | 10 | 3 | 1 | 0 | | | | | | 16 | 0 |
| LF-3 | 10 | 6 | 5 | 4 | 5 | 7 | 5 | 4 | 4 | 0 | 50 | 3 |
| LF-4 | 5 | 2 | 1 | 0 | | | | | | | 8 | 0 |
| LF-5 | 10 | 9 | 7 | 5 | 5 | 4 | 7 | 3 | 4 | 2 | 56 | 7 |
| LF-6 | 4 | 2 | 3 | 0 | | | | | | | 9 | 0 |
| LF-7 | 10 | 9 | 10 | 9 | 9 | 9 | 10 | 9 | 9 | 7 | 91 | 10 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 23

RAW DATA FOR GRADE NINE UNDER THE COLORED PHOTO MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 8 | 8 | 5 | 5 | 2 | 0 | | | | | 28 | 3 |
| HM-2 | 7 | 3 | 3 | 2 | 1 | 0 | | | | | 16 | 0 |
| HM-3 | 1 | 0 | | | | | | | | | 1 | 0 |
| HM-4 | 1 | 1 | 0 | | | | | | | | 2 | 0 |
| HM-5 | 6 | 4 | 3 | 1 | 0 | | | | | | 14 | 0 |
| HM-6 | 8 | 5 | 5 | 2 | 1 | 1 | 0 | | | | 22 | 0 |
| HM-7 | 8 | 4 | 2 | 0 | | | | | | | 14 | 1 |
| LM-1 | 4 | 5 | 5 | 4 | 3 | 1 | 2 | 1 | 3 | 3 | 31 | 3 |
| LM-2 | 9 | 10 | 6 | 5 | 2 | 0 | | | | | 32 | 3 |
| LM-3 | 9 | 6 | 8 | 7 | 4 | 4 | 5 | 5 | 0 | | 48 | 4 |
| LM-4 | 7 | 4 | 3 | 2 | 1 | 0 | | | | | 17 | 2 |
| LM-5 | 10 | 10 | 7 | 4 | 3 | 2 | 2 | 1 | 1 | 1 | 41 | 4 |
| LM-6 | 10 | 10 | 9 | 7 | 9 | 8 | 6 | 6 | 7 | 5 | 77 | 9 |
| LM-7 | 2 | 1 | 0 | | | | | | | | 3 | 0 |
| HF-1 | 4 | 2 | 0 | | | | | | | | 6 | 1 |
| HF-2 | 5 | 0 | | | | | | | | | 5 | 0 |
| HF-3 | 10 | 8 | 6 | 6 | 5 | 2 | 2 | 2 | 2 | 3 | 46 | 1 |
| HF-4 | 10 | 10 | 9 | 7 | 7 | 7 | 10 | 5 | 4 | 8 | 77 | 2 |
| HF-5 | 2 | 0 | | | | | | | | | 2 | 3 |
| HF-6 | 4 | 0 | | | | | | | | | 4 | 2 |
| HF-7 | 3 | 0 | | | | | | | | | 3 | 2 |
| LF-1 | 10 | 7 | 5 | 4 | 2 | 0 | | | | | 28 | 2 |
| LF-2 | 9 | 8 | 5 | 4 | 2 | 1 | 0 | | | | 29 | 0 |
| LF-3 | 4 | 2 | 2 | 0 | | | | | | | 8 | 0 |
| LF-4 | 3 | 3 | 4 | 2 | 1 | 0 | | | | | 13 | 0 |
| LF-5 | 0 | | | | | | | | | | 0 | 1 |
| LF-6 | 3 | 4 | 0 | | | | | | | | 7 | 1 |
| LF-7 | 5 | 3 | 3 | 2 | 1 | 0 | | | | | 14 | 1 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

RAW DATA FOR GRADE TWELVE UNDER THE BLACK AND WHITE LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 1 | 0 | | | | | | | | | 1 | 0 |
| HM-2 | 3 | 3 | 3 | 0 | | | | | | | 9 | 3 |
| HM-3 | 7 | 3 | 0 | | | | | | | | 10 | 2 |
| HM-4 | 0 | | | | | | | | | | 0 | 0 |
| HM-5 | 9 | 9 | 4 | 2 | 0 | | | | | | 24 | 1 |
| HM-6 | 3 | 1 | 3 | 5 | 1 | 0 | | | | | 13 | 5 |
| HM-7 | 1 | 0 | | | | | | | | | 1 | 2 |
| LM-1 | 9 | 10 | 5 | 3 | 3 | 0 | | | | | 30 | 5 |
| LM-2 | 7 | 6 | 4 | 2 | 0 | | | | | | 19 | 0 |
| LM-3 | 7 | 4 | 1 | 1 | 1 | 1 | 1 | 0 | | | 16 | 2 |
| LM-4 | 6 | 4 | 4 | 1 | 10 | 1 | 1 | 0 | | | 27 | 0 |
| LM-5 | 9 | 6 | 6 | 3 | 2 | 3 | 2 | 1 | 0 | | 32 | 0 |
| LM-6 | 7 | 8 | 5 | 5 | 5 | 2 | 3 | 0 | | | 35 | 3 |
| LM-7 | 7 | 6 | 4 | 4 | 4 | 1 | 1 | 0 | | | 27 | 3 |
| HF-1 | 0 | | | | | | | | | | 0 | 0 |
| HF-2 | 4 | 4 | 0 | | | | | | | | 8 | 0 |
| HF-3 | 5 | 2 | 1 | 2 | 1 | 1 | 0 | | | | 12 | 0 |
| HF-4 | 8 | 2 | 0 | | | | | | | | 10 | 0 |
| HF-5 | 1 | 0 | | | | | | | | | 1 | 0 |
| HF-6 | 3 | 1 | 0 | | | | | | | | 4 | 0 |
| HF-7 | 8 | 3 | 8 | 1 | 1 | 1 | 0 | | | | 22 | 1 |
| LF-1 | 7 | 5 | 4 | 4 | 4 | 1 | 1 | 0 | | | 26 | 6 |
| LF-2 | 10 | 9 | 8 | 6 | 9 | 2 | 1 | 1 | 1 | 0 | 47 | 4 |
| LF-3 | 7 | 3 | 2 | 0 | | | | | | | 12 | 1 |
| LF-4 | 8 | 8 | 6 | 6 | 4 | 1 | 1 | 0 | | | 34 | 1 |
| LF-5 | 1 | 1 | 0 | | | | | | | | 2 | 0 |
| LF-6 | 3 | 2 | 0 | | | | | | | | 5 | 1 |
| LF-7 | 2 | 1 | 0 | | | | | | | | 3 | 0 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 25

RAW DATA FOR GRADE TWELVE UNDER THE BLACK AND WHITE PHOTO MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 6 | 9 | 7 | 4 | 4 | 4 | 5 | 2 | 3 | 1 | 45 | 0 |
| HM-2 | 0 | | | | | | | | | | 0 | 0 |
| HM-3 | 2 | 10 | 0 | | | | | | | | 12 | 1 |
| HM-4 | 2 | 2 | 1 | 0 | | | | | | | 5 | 1 |
| HM-5 | 3 | 4 | 1 | 0 | | | | | | | 8 | 0 |
| HM-6 | 2 | 3 | 0 | | | | | | | | 5 | 1 |
| HM-7 | 0 | | | | | | | | | | 0 | 0 |
| LM-1 | 5 | 6 | 3 | 0 | | | | | | | 14 | 2 |
| LM-2 | 4 | 4 | 0 | | | | | | | | 8 | 0 |
| LM-3 | 9 | 10 | 4 | 1 | 4 | 4 | 10 | 1 | 1 | 0 | 44 | 7 |
| LM-4 | 5 | 4 | 5 | 1 | 1 | 0 | | | | | 16 | 1 |
| LM-5 | 1 | 0 | | | | | | | | | 1 | 0 |
| LM-6 | 9 | 6 | 5 | 1 | 2 | 0 | | | | | 23 | 1 |
| LM-7 | 6 | 3 | 4 | 2 | 2 | 0 | | | | | 17 | 1 |
| HF-1 | 3 | 0 | | | | | | | | | 3 | 0 |
| HF-2 | 3 | 2 | 2 | 0 | | | | | | | 7 | 1 |
| HF-3 | 2 | 6 | 0 | | | | | | | | 8 | 3 |
| HF-4 | 0 | | | | | | | | | | 0 | 0 |
| HF-5 | 0 | | | | | | | | | | 0 | 0 |
| HF-6 | 1 | 0 | | | | | | | | | 1 | 0 |
| HF-7 | 4 | 2 | 1 | 0 | | | | | | | 7 | 1 |
| LF-1 | 6 | 6 | 6 | 3 | 2 | 0 | | | | | 23 | 1 |
| LF-2 | 9 | 6 | 3 | 0 | | | | | | | 18 | 0 |
| LF-3 | 2 | 2 | 0 | | | | | | | | 4 | 0 |
| LF-4 | 5 | 2 | 1 | 0 | | | | | | | 8 | 1 |
| LF-5 | 4 | 3 | 0 | | | | | | | | 7 | 2 |
| LF-6 | 2 | 1 | 0 | | | | | | | | 3 | 2 |
| LF-7 | 6 | 5 | 5 | 3 | 1 | 3 | 1 | 2 | 1 | 1 | 28 | 4 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 26

RAW DATA FOR GRADE TWELVE UNDER THE COLORED LINE DRAWING MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 2 | 2 | 0 | | | | | | | | 4 | 1 |
| HM-2 | 1 | 0 | | | | | | | | | 1 | 0 |
| HM-3 | 0 | | | | | | | | | | 0 | 1 |
| HM-4 | 5 | 4 | 6 | 6 | 3 | 1 | 4 | 0 | | | 29 | 4 |
| HM-5 | 0 | | | | | | | | | | 0 | 0 |
| HM-6 | 0 | | | | | | | | | | 0 | 0 |
| HM-7 | 3 | 4 | 0 | | | | | | | | 7 | 1 |
| LM-1 | 4 | 2 | 0 | | | | | | | | 6 | 2 |
| LM-2 | 3 | 1 | 0 | | | | | | | | 4 | 1 |
| LM-3 | 4 | 1 | 3 | 1 | 1 | 0 | | | | | 10 | 1 |
| LM-4 | 9 | 8 | 8 | 4 | 5 | 8 | 6 | 7 | 4 | 4 | 63 | 4 |
| LM-5 | 8 | 10 | 4 | 4 | 1 | 2 | 0 | | | | 29 | 2 |
| LM-6 | 8 | 8 | 6 | 4 | 0 | | | | | | 26 | 0 |
| LM-7 | 6 | 5 | 3 | 2 | 1 | 1 | 1 | 0 | | | 19 | 2 |
| HF-1 | 1 | 0 | | | | | | | | | 1 | 0 |
| HF-2 | 0 | | | | | | | | | | 0 | 0 |
| HF-3 | 1 | 2 | 0 | | | | | | | | 3 | 2 |
| HF-4 | 1 | 0 | | | | | | | | | 1 | 0 |
| HF-5 | 1 | 0 | | | | | | | | | 1 | 1 |
| HF-6 | 1 | 1 | 0 | | | | | | | | 2 | 1 |
| HF-7 | 0 | | | | | | | | | | 0 | 0 |
| LF-1 | 7 | 7 | 3 | 4 | 1 | 0 | | | | | 22 | 4 |
| LF-2 | 6 | 3 | 2 | 1 | 1 | 1 | 0 | | | | 14 | 1 |
| LF-3 | 9 | 9 | 9 | 8 | 7 | 6 | 5 | 3 | 3 | 2 | 61 | 10 |
| LF-4 | 9 | 8 | 8 | 8 | 5 | 4 | 4 | 2 | 2 | 1 | 51 | 6 |
| LF-5 | 3 | 2 | 0 | | | | | | | | 5 | 0 |
| LF-6 | 0 | | | | | | | | | | 0 | 1 |
| LF-7 | 3 | 2 | 2 | 4 | 0 | | | | | | 11 | 1 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

Table 27

RAW DATA FOR GRADE TWELVE UNDER THE COLORED PHOTO MODE

| Pupil no. | Errors per trial no. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Sum of scores | Retention test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HM-1 | 0 | | | | | | | | | | 0 | 0 |
| HM-2 | 0 | | | | | | | | | | 0 | 0 |
| HM-3 | 0 | | | | | | | | | | 0 | 3 |
| HM-4 | 7 | 7 | 4 | 1 | 6 | 2 | 2 | 0 | | | 29 | 7 |
| HM-5 | 1 | 0 | | | | | | | | | 1 | 0 |
| HM-6 | 4 | 3 | 2 | 4 | 1 | 2 | 1 | 0 | | | 17 | 4 |
| HM-7 | 0 | | | | | | | | | | 0 | 2 |
| LM-1 | 3 | 3 | 0 | | | | | | | | 6 | 2 |
| LM-2 | 9 | 6 | 5 | 2 | 0 | | | | | | 22 | 3 |
| LM-3 | 8 | 5 | 5 | 3 | 1 | 0 | | | | | 22 | 0 |
| LM-4 | 0 | | | | | | | | | | 0 | 1 |
| LM-5 | 4 | 4 | 1 | 2 | 0 | | | | | | 11 | 0 |
| LM-6 | 8 | 5 | 4 | 0 | | | | | | | 17 | 1 |
| LM-7 | 2 | 1 | 1 | 0 | | | | | | | 4 | 2 |
| HF-1 | 6 | 4 | 2 | 2 | 1 | 10 | 1 | 0 | | | 26 | 3 |
| HF-2 | 7 | 5 | 2 | 1 | 0 | | | | | | 15 | 2 |
| HF-3 | 1 | 0 | | | | | | | | | 1 | 1 |
| HF-4 | 0 | | | | | | | | | | 0 | 0 |
| HF-5 | 0 | | | | | | | | | | 0 | 0 |
| HF-6 | 4 | 2 | 1 | 0 | | | | | | | 7 | 0 |
| HF-7 | 3 | 1 | 1 | 0 | | | | | | | 5 | 0 |
| LF-1 | 9 | 9 | 6 | 5 | 4 | 3 | 2 | 3 | 2 | 1 | 44 | 5 |
| LF-2 | 10 | 8 | 6 | 7 | 5 | 4 | 4 | 4 | 3 | 4 | 55 | 2 |
| LF-3 | 6 | 2 | 0 | | | | | | | | 8 | 2 |
| LF-4 | 9 | 3 | 4 | 2 | 0 | | | | | | 18 | 0 |
| LF-5 | 4 | 3 | 1 | 0 | | | | | | | 8 | 0 |
| LF-6 | 6 | 3 | 1 | 0 | | | | | | | 10 | 4 |
| LF-7 | 0 | | | | | | | | | | 0 | 1 |

HM = High achieving male
LM = Low achieving male
HF = High achieving female
LF = Low achieving female

# APPENDIX B

| PRESENTATION ORDER OF PAIRS | | | TESTING ORDER OF PAIRS | | |
|---|---|---|---|---|---|
| 1. | ARROW | ZNH | 1. | BANANA | QHS |
| 2. | CANDLE | TBX | 2. | NEEDLE | MKB |
| 3. | HEART | CMG | 3. | LEAF | HLR |
| 4. | NEEDLE | MKB | 4. | CANDLE | TBX |
| 5. | BOARD | SHQ | 5. | BOARD | SHQ |
| 6. | BANANA | QHS | 6. | SKATE | NJR |
| 7. | CARROT | FCR | 7. | KNIFE | KPG |
| 8. | LEAF | HLR | 8. | CARROT | FCR |
| 9. | SKATE | NJR | 9. | ARROW | ZNH |
| 10. | KNIFE | KPG | 10. | HEART | CMG |
| | | | | | |
| 1. | KNIFE | KPG | 1. | SKATE | NJR |
| 2. | ARROW | ZNH | 2. | NEEDLE | MKB |
| 3. | BOARD | SHQ | 3. | KNIFE | KPG |
| 4. | CARROT | FCR | 4. | BANANA | QHS |
| 5. | CANDLE | TBX | 5. | ARROW | ZNH |
| 6. | SKATE | NJR | 6. | CANDLE | TBX |
| 7. | BANANA | QHS | 7. | BOARD | SHQ |
| 8. | NEEDLE | MKB | 8. | CARROT | FCR |
| 9. | LEAF | HLR | 9. | HEART | CMG |
| 10. | HEART | CMG | 10. | LEAF | HLR |
| | | | | | |
| 1. | HEART | CMG | 1. | BOARD | SHQ |
| 2. | BANANA | QHS | 2. | SKATE | NJR |
| 3. | SKATE | NJR | 3. | CARROT | FCR |
| 4. | BOARD | SHQ | 4. | HEART | CMG |
| 5. | CARROT | FCR | 5. | LEAF | HLR |
| 6. | ARROW | ZNH | 6. | CANDLE | TBX |
| 7. | KNIFE | KPG | 7. | NEEDLE | MKB |
| 8. | LEAF | HLR | 8. | ARROW | ZNH |
| 9. | CANDLE | TBX | 9. | BANANA | QHS |
| 10. | NEEDLE | MKB | 10. | KNIFE | KPG |

EXAMPLE:

| | | |
|---|---|---|
| 1. | HAMMER | MQF |

## INSTRUCTIONS GIVEN TO SUBJECTS PRIOR TO CONDUCTION OF THE EXPERIMENT

Good morning. I would like your help in conducting an experiment in how people learn. I think you may find it to be both interesting and fun. How fast you learn the material has nothing to do with how smart you are. You are only asked to do your best. Your teacher or principal will never know your score.

Before we start the experiment, please print your name on the front sheet. Also, fill in what grade you are in and whether you are a boy or girl. Now I would like to show you three slides. You may see words, letters, or numbers in the pictures. If you do, write what you see in the three blanks on your first page. If you see nothing at all, simply put a line through the blank.

Okay, we are now about ready to start the experiment. It is important that you concentrate only on your own work. It is also important not to discuss what you learn with your school-mates because many of them will also be participating in the experiment.

First, you will see slides like this one that have a picture on the left side and three letters on the right side. There are ten of these slides in a set. After you have seen all of the slides, you will be shown slides like this one where the letters are missing. You are then to fill in the blanks on your answer sheets with the letters

that match the picture. The trick is to find some way of remembering what letters go with what picture by associating them together. For example, you might remember the hammer's letters by thinking of a hammer mashing someone's fingers if they were careless. You will notice that both m for mashing and f for fingers are in the three letters that go with the hammer. Now write MQF in the square block on your answer sheet.

At first, you may have difficulty in remembering any of the letters. If you don't remember the letters that go with the picture, mark a line through the box on the answer sheet. Eventually, you will be able to remember all of the letters. When that happens, one of us will hand you a slip of paper. Please do exactly as it says as it is very important that you no longer watch the slides.

Are there any questions?

We are now ready to start. You will see the slides four times before you take the first test. After that, you will be tested after each time you see the slides with the letters. After you finish each test, tear off that answer blank and one of us will pick it up.

STOP SLIP ISSUED AFTER COMPLETION OF PERFECT SET OF RESPONSES

Congratulations. You answered all of the questions right on the last test. Since other students are still being tested, it is important not to disturb them. Please put your head down on the desk and wait until everyone has finished. Do not watch the slides.

## SAMPLE ANSWER BLANKS

TRIAL NO. STUDENT NO. TRIAL R

NAME _____

1. 1.
2. 2.
3. 3.
4. 4.
5. 5.
6. 6.
7. 7.
8. 8.
9. 9.
10. 10.