AN EVALUATION OF THE USE OF COLOR CUES TO FOCUS ATTENTION IN DISCRIMINATION AND PAIRED-ASSOCIATE LEARNING

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ABSTRACT

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A program sequence was developed employing an audio-flashcard reader. The verbal directions of the program sequence remained identical for all subjects while the treatment of color cues varied.

Subjects were pre-tested on their ability to match the figures to form and to match the figures from memory. Upon completion of the program sequence, subjects were post-tested on their ability to match the figures to form, to match the figures from memory, and to associate a low meaningfulness C-V-C trigram with each figure.

Significantly better ($p < .01$ to $.05$) achievement on all three tasks was found for the vanished color treatment over the no-color treatment. From these results it was concluded that: (a) the vanished color treatment enhances the learning of visual discrimination, visual memory, and paired-associate tasks when compared to the no-color treatment, (b) this enhancing effect seems to stem from improved attention to the distinctive feature of a stimulus, and (c) instructional strategies and materials used in teaching these three basic skills should be designed to focus attention on salient features of the stimuli.

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Richard L. Allington

A THESIS

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Dedicated to:

George C. Allington

for his example as a father

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CHAPTER I

INTRODUCTION

Beginning readers must master three basic tasks involving printed letters. The first is that the learner must visually discriminate between the letters of the orthography. A second task is remembering these letters and those features which make each unique. The final and most complex task is that of associating the appropriate verbal response, such as a name or a phoneme, with each symbol.[1]

Many studies have reported that young children have considerable difficulty mastering these tasks with letters which are reversals or up-down rotations of each other.[2]

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[1]Jay Samuels, "Formal Intralist Similarity and the vonRestorff Effect," Journal of Education Psychology, LIX (1968), 432-37.

[2]John Blair and David Ryckman, "Visual Discrimination: Lower Case Letter Confusion" (unpublished paper from the Center for Research on Language and Language Behavior, University of Michigan); Helen Popp, "Visual Discrimination of Alphabet Letters," The Reading Teacher, XVII (1968), 221-26; Joanna Williams, "Reactions to Modes of Word Recognition," Theoretical Models and Processes of Reading, ed. by H. Singer and R. Ruddell (Newark, Del.: International Reading Association, 1970), pp. 38-46; Helen Davidson, "A Study of the Confusing Letters b, d, p, and

While it is valuable to have identified which upper and lower case letters present the most difficulty in learning, it would seem of equal value to develop a teaching technique which reduces the difficulty of learning these letters.

THE PROBLEM

<u>Statement of the problem</u>. This study will evaluate an instructional strategy for teaching children to discriminate and name letter-like figures and the reversal or up-down rotation of these figures. This study will first attempt to determine what effect, if any, adding color highlights to selected features of the figures has on the performance of young children in three separate learning tasks; a paired-associate task, a visual memory task, and a visual discrimination task. The study will also attempt to determine whether a gradual vanishing of these added color cues significantly improves student performance when compared to students receiving continued maximum highlights and students receiving no highlighting on any of the learning trials. Three independent experimental conditions will exist; i.e., (1) figures with no color highlighting in any presentation, (2) figures with

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q," <u>Journal of Genetic Psychology</u>, XLVII (1935), 458-68; and <u>Doreen Asso and Marcia Wyke</u>, "Discrimination of Spatially Confusable Letters by Young Children," <u>Journal of Experimental Psychology</u>, XI (1971), 11-20.

maximum color highlighting throughout all presentations, and (3) figures with color highlighting gradually vanished throughout the presentations. The criterion tasks will present the figures without any color highlights for all groups.

Background to the problem. A prime task facing beginning readers is learning to discriminate and recognize the symbols of English orthography. While researchers have identified which letters present the most difficult learning task for young children, we yet need to know how to most effectively structure the teaching act in order to facilitate this learning.

Williams hypothesized that in developing a strategy for teaching a visual discrimination skill one must consider at least two elements: (1) to what features must the subject attend in order to solve the task, and (2) how can we ensure that the subject attends to these features?[3] Williams also notes that every letter in English orthography differs from every other letter and that these differences are the distinguishing features.

The use of color to highlight these distinguishing features of letters may offer assistance in directing the subjects' attention to the elements necessary to solve the

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[3]Joanna Williams, "Training Kindergarten Children to Discriminate Letter-Like Forms," American Educational Research Journal, VI (1969), 501-13.

task. Dale, in speaking on the use of color in audio-visual materials, stated:

> . . . color may be used to help us see differences, to distinguish and emphasize. We may highlight important parts of a diagram with colored chalk or trace a route on a map with a line of color. Color says to the eye: LOOK HERE![4]

Otto reviewed five studies employing color and concluded:

> . . . the implication of these studies is that . . . learning should be enhanced by the addition of color cues for any or all of the following reasons: aided perception and increased differentiation, the opportunity for cue selection, and greater motivation.[5]

Samuels, however, has reacted to the use of color cues in a different light:

> One strategy for facilitating word recognition is to use color cues . . . While this system may increase rate of initial learning, the critical question is one of transfer. If the learner focuses his attention on color and not letter shape, what happens when the color cues are removed?[6]

To answer his own question, Samuels structured a research project using first graders and college students

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[4]Edgar Dale, Audio-Visual Methods in Teaching (3rd ed.; New York: Holt, Rinehart and Winston, 1969), p. 571.

[5]Wayne Otto, "Color Cues as an Aid to Good and Poor Readers' Paired-Associate Learning," in Perception and Reading, ed. by Helen Smith (Newark, Del.: International Reading Association, 1967), p. 40.

[6]S. Jay Samuels, "Modes of Word Recognition," in Theoretical Models and Process of Reading, ed. by Harry Singer and Robert Ruddell (Newark, Del.: International Reading Association, 1970), p. 28.

in a training sequence in which words were presented either in color or in regular type. He found:

> . . . that the rate of learning the words in color was significantly faster . . . but that on the transfer tests--when the color cues were removed--the tables were turned. In comparing recognition between the words which were always in regular type to the words . . . in color, recognition was superior for the words which had always been in regular type. . . . Apparently, the color cue was so potent they were unable to focus attention on the relevant use of letter shape. . . . In teaching . . . a decision must be made between speed of initial learning and transfer. The decision to foster speed . . . at the expense of transfer may be a false economy.[7]

Samuels' data provide interesting material for analysis. One writer interpreted Samuels' data as providing an empirical base for the following statement:

> Efforts to emphasize distinctive features through the introduction of extraneous cues--coloring the diagonal stroke on R, for example, are of doubtful merit.[8]

However, Samuels did not employ color to emphasize distinctive features; rather he printed the total stimulus in color, thereby emphasizing the stimulus complex. His subjects did not have their attention focused on a singular distinctive feature. His data do provide cautions for the effective use of color. That is, color as applied in the above studies is not necessarily a useful additional

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[7] Ibid., p. 29.

[8] J. K. Hemphill, Teaching Reading as Decoding: Minicourse 18 (Berkeley, Calif.: Far West Laboratory for Educational Research and Development, 1971), p. 11.

cue and color applied inappropriately may be detrimental to learning.

What, then, is the role of color cues in teaching materials or instructional strategies? What cautions must be observed when employing color? Some answers have been provided by a number of researchers in the audio-visual field who offer guidelines for situations in which the use of color might be helpful. Hoban and Van Ormer concluded that color must not be such a potent cue that it draws the learner's attention away from important cues.[9] McGeoch and Irion found that color can be useful in assisting in the discrimination between relevant cues.[10] Miller speculated that color cues would be advantageous if color is one of the most relevant cues or if it can be used to emphasize relevant cues; it would not be advantageous if it distracts or complicates the subject.[11] Black offers a similar finding in the conclusion of a study on relevant and irrelevant pictorial color cues:

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[9] C. F. Hoban and E. B. Van Ormer, Instructional Film Research 1918-1950 (Port Washington, Long Island, N.Y.: Special Devices Center, 1950).

[10] J. A. McGeoch and A. L. Irion, The Psychology of Human Learning (New York: Longman's Green, 1952).

[11] N. E. Miller et al., "Graphic Communication and the Crisis in Education," Audio-Visual Communication Review, V (1957), 3-39.

> Color cues must be relevant, or help differentiate relevant cues, or must emphasize relevant cues but certainly not draw the learner's attention away from important cues.[12]

In a discussion of the use of cues in general, Anderson offered the following cautions:

> It would seem that the prompting stimulus must be of such a nature and related to the discriminative stimulus in such a way that the student cannot help noticing the discriminative stimulus during training. Otherwise, when the prompting stimulus has been withdrawn, it may be found that the student can no longer respond correctly. . . . When the prompting stimulus is of such a nature that it is possible for the subject to ignore the discriminative stimulus during training, transfer of control to the discriminative stimulus may never take place . . .[13]

As Travers points out, we can currently only speculate as to the effectiveness this type of training in visual discrimination, since researchers have

> . . . found no adequate analysis of functions which color might perform in the transmission of information. Research tends to make broad comparisons of color vs. black and white, but no research was located on the use of color for emphasizing the crucial aspects of a visual presentation. Another important use of color of which no mention can be

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[12] Harvey Black, "Relevant and Irrelevant Pictorial Color Cues in Discrimination Learning," from _Final Report: HEW Project 1170_, Indiana University (1967), p. 24.

[13] R. C. Anderson, "Educational Psychology," in _Annual Review of Psychology_, ed. by Paul Farnsworth et al. (Palo Alto, Calif.: Annual Reviews, Inc., 1967), Vol. 18, pp. 103-64.

found in research literature is the separation of one part of a visual display from another.[14]

Otto and Askov summarized the use of color in instructional materials in three points: (1) on the basis of existing research it is not now possible to prescribe use of color cues in instruction; (2) color is presently used not as an additional cue to enhance learning but as a vehicle for carrying basic information; (3) the cue value of color appears to be nebulous, being dependent on the availability of other, more potent cues.[15] Finally, Lumsdaine concluded that:

> . . . no really definite studies have been made on specific ways in which color may contribute to learning from instructional media.[16]

Past research provides us with some guidelines for employing color. Color must be relevant, color must not draw the learners' attention away from relevant information and, if the color cues are not present on the transfer task, the learning environment must be

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[14] Robert Travers, "Research and Theory Related to Audio-Visual Information Transmission" (unpublished paper from the Bureau of Educational Research, University of Utah, July, 1964), p. 4.

[15] Wayne Otto and Eunice Askov, "The Role of Color in Learning and Instruction" (Theoretical paper #12 from the Research and Development Center for Cognitive Learning, University of Wisconsin, March, 1968).

[16] Arthur Lumsdaine, "Instruments and Media of Instruction," in Handbook of Research on Teaching, ed. by N. L. Gage (Chicago: Rand McNally, 1963), p. 635.

structured to include a procedure which will eliminate color cues prior to transfer. While research has provided minimal guidelines for employing color cues, there have been no studies which provide a solid empirical base for decisions on the addition of color cues in discrimination learning.

However, Gibson has summarized research which demonstrates that children learn to search more efficiently for the distinguishing features of letters when verbal instructions were used to focus their attention.[17] Haring has described the role of the teacher as, "ensuring that relevant dimensions of stimuli gain control over the child's responding."[18]

While research is inconclusive regarding the role of color cues in discrimination learning, the importance of attending to distinguishing features has been stressed. It appears no research has been conducted which clearly provides a solution to the second element of the question Williams posed: How can we ensure that the subject attends to appropriate features during training? Or more specifically: Can we effectively use color cues to aid

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[17] Eleanor Gibson et al., "A Developmental Study of the Discrimination of Letter-Like Forms," Journal of Comparative and Physiological Psychology, LV (1962), 897-906.

[18] Norris Haring, Attending and Responding (San Rafael, Calif.: Dimension Publishing Company, 1968), p. 2.

subjects in their search for the distinguishing features of letters? This study, then, will attempt to provide an answer to that question.

SIGNIFICANCE OF THE STUDY

Many research studies have been conducted in an attempt to discover how learning is accomplished and how to facilitate the learning process. Research has also been conducted on the possible application of color to learning situations, but while research is available on the role of color as an aid to learning, it is fragmentary and research on vanishing color cues is minimal and contradictory. This study is intended to provide data regarding the effect of using a single hue vanishing color cue to emphasize or highlight distinguishing features of letter-like forms in an attempt to facilitate visual discrimination and recognition of these forms. These data will provide educators with empirical evidence upon which to base objective decisions regarding the use of color in discrimination learning and paired-associate tasks. The study should also provide insights for further empirical investigations into the applicability of color to other instructional techniques.

DEFINITION OF TERMS

Discrimination: In the presence of two figures, the subject responds appropriately as to whether the presented figures are the same or different.

Highlighting: A form of a prompt. Specifically, the application of color to a distinctive feature of a stimulus, in an attempt to focus visual attention.

Matching from memory: Following a presentation and removal of a stimulus figure the subject selects that figure from a group of four figures.

Match to form: In the presence of a stimulus figure the subject selects that figure from a group of four figures.

Naming: In the presence of a figure, the subject makes the appropriate verbal response.

Prompt: A stimulus added to the terminal stimulus to make a correct response more likely.

Stimulus: In this study, stimulus refers to the letter-like figures; the terminal stimuli are the letter-like figures without color highlights; the prompting stimuli are the color highlights added to the figures.

<u>Vanishing</u>: A method of removing a visual prompt. Specifically, removing the color highlighting by gradually reducing the area of color until no color remains.*

ASSUMPTIONS AND LIMITATIONS

The following assumptions underlie this study: it is assumed that

1. it is important for the subject to be able to match to form;
2. it is important for the subject to be able to match from memory;
3. it is important for the subject to be able to name the figures;
4. naming the figures is equivalent to naming or sounding the letters of the alphabet;
5. the color employed can be generalized to other colors; and
6. learning to discriminate and recognize the letter-like forms is an equivalent task to learning to discriminate and recognize letters of English orthography.

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*Vanishing is a form of the psychological technique of fading. However, while fading is the reduction of the intensity or saturation of a color within a designated area, vanishing is a reduction of the area of color.

The following limitations underlie this study: findings of this study will be limited to

1. the tasks under investigation, or similar tasks;

2. this population or similar populations;

3. situations in which the same or similar materials are employed; and

4. situations in which the same or similar learning environments are employed.

DESIGN OF STUDY

The population of this study consisted of all kindergarten children enrolled at Beach Elementary School, Cedar Springs, Michigan; and all the kindergarten children enrolled at Cody Community School in Flint, Michigan. The schools in these communities were selected to provide subjects from varied geographic, social, economic and cultural backgrounds.

A total of 102 children participated in the training program, 51 children from each elementary school. The children were randomly selected and assigned to one of three treatment groups. Pretests were administered for two tasks; visual discrimination (match to form) and visual memory (match to memory). A training program was developed in which only the visual stimuli varies in three treatments: no color highlights added, maximum color highlights added and continued until transfer, and maximum color highlights added and vanished prior to transfer. Each child, upon completion of the training program, was post-tested for three tasks: naming the figures, visual discrimination, and visual memory.

The results for all treatment groups were tabulated and compared to determine whether the null hypotheses were to be rejected.

HYPOTHESES

The hypotheses, stated as null hypotheses, are as follows:

Hypothesis 1a

Given the task of Matching to Form, there will be no significant difference ($p < .05$) in achievement between groups upon completion of the program sequence.

Hypothesis 1b

Given the task of Matching to Form, there will be no significant difference ($p < .05$) in achievement, upon completion of the program sequence, between the samples drawn from the two school populations.

Hypothesis 1c

There will be no significant interaction effect ($p < .05$) between treatment and school as measured by achievement on the Match to Form task.

Hypothesis 2a

Given the task of Matching from Memory, there will be no significant difference ($p < .05$) in achievement between groups upon completion of the program sequence.

Hypothesis 2b

Given the task of Matching from Memory, there will be no significant difference ($p < .05$) in achievement, upon completion of the program sequence, between the samples drawn from the two school populations.

Hypothesis 2c

There will be no significant interaction effect ($p < .05$) between treatment and school as measured by the Match from Memory task.

Hypothesis 3a

Given the task of Naming, there will be no significant differences ($p < .05$) in achievement between groups upon completion of the program sequence.

Hypothesis 3b

Given the task of Naming, there will be no significant difference ($p < .05$) in achievement, upon completion of the program sequence, between the samples drawn from the two school populations.

Hypothesis 3c

There will be no significant interaction effect ($p < .05$) between treatment and school as measured by the Naming task.

ORGANIZATION OF THE REMAINDER OF THE DISSERTATION

Chapter II is a presentation of the review of pertinent literature. Particular emphasis is on the role of color in learning and specifically in discrimination and paired-associate learning.

Chapter III contains a description of all materials and procedures employed in this study. The design of the study is also presented in detail.

Chapter IV includes presentation of the data collected, treated and analyzed for the study.

Chapter V provides a summary of the study and appropriate conclusions. Implications of this study and suggestions for future research are also included.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction. The purpose of this chapter is to review existing research associated with the function of color in learning and to examine the rationale for the present application of color in this experimental study.

Relevant research on the function of color in learning has roughly been divided into two areas: color as a contextual stimulus to which the response may become indirectly associated, and color as an attentional cue which brings the visual senses into contact with distinguishing features of the stimulus object not previously readily accessible, or of intensifying the stimulation from these features. The relevant studies are reviewed below.

COLOR AS A CONTEXTUAL STIMULUS

The most common use of color has been as a contextual cue and studies of this use have generally incorporated a paired-associate learning model. Color applied as a contextual cue aids the learner in differentiating visual stimuli; that is, when separate colors are paired with each visual stimulus, the learner is provided with an added dimension on which to base his discrimination.

In an early study, Dulsky presented his subjects with pairs of nonsense words presented on two styles of backgrounds.[19] In one style, labeled homogeneous, he presented the nonsense words either with a different color background for each pair or the same color background for each pair. In the second style, labeled heterogeneous, he presented the stimulus half of each card in color and the response half in gray and vice-versa. After learning the nonsense words, subjects were tested for recall under three conditions: repetition of the learning presentation, shifting background color, and changing to words presented on gray backgrounds. Results of this research demonstrated that recall was significantly better when backgrounds on the test trials remained constant with backgrounds presented on the learning trials, regardless of whether stimulus backgrounds in learning were colored or gray. Learning was severely inhibited when the response background colors were changed. The subjects used the color background as an additional cue while learning the

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[19] S. G. Dulsky, "The Effect of a Change of Background on Recall and Relearning," Journal of Experimental Psychology, XVIII (1935), 725-40.

lists. Responses were associated not only with the printed primary stimulus but also with the contextual stimulus, the background color of the card on which the nonsense word was printed.

Dulsky's results seem to support the theory posited by Guthrie and Smith[20] and by Hull[21] that responses can become associated not only with the primary stimuli but also with context stimuli. The nonsense words are primary stimuli and background colors contextual stimuli.

Weiss and Margolius attempted to extend the findings of Dulsky.

> The question now raised is: regardless of the condition under which retention will occur, might there be any advantage for learning if certain context stimuli are presented throughout the lesson?[22]

To answer this question, they presented subjects with pairs of nonsense trigrams and simple word responses on varied color cards. The achievement on the task of associating the correct responses with the appropriate trigrams in terms of mean retention scores was as follows;

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[20] E. R. Guthrie and S. Smith, General Psychology (New York: Appleton-Century-Crofts, 1921).

[21] C. L. Hull, Principles of Behavior (New York: Appleton-Century-Crofts, 1943).

[22] Walter Weiss and Garry Margolius, "The Effect of Context Stimuli on Learning and Retention," Journal of Experimental Psychology, XLVIII, No. 5 (1954), p. 321.

the highest scores were achieved by the group which had no change in stimuli and no change in background. Followed by the group which had a change in stimuli but no change in background, then the group with change in stimuli and change in background color. The lowest scores were recorded by the group which had changes in both stimuli and background color. Commenting on their findings, Weiss and Margolius report that,

> The research confirms the theoretical position that the representation of context stimuli, which has been present consistently while learning was occurring, would aid retention of learned responses. Thus, the findings of Dulsky are confirmed. . . . a possible explanation [of the findings] presumes that distinctly discernible context stimuli may act to reduce intralist generalization [similarity] and thereby facilitate learning.[23]

In an attempt to determine whether subjects are cognizant of added color cues in similar paired-associate tasks, Birnbaum presented subjects with ten consonant-vowel-consonant (CVC) trigrams paired with nonsense syllables, each trigram outlined with a distinctive color during the study trials. The criterion tasks indicated that association between color and primary stimuli had taken place. "S's score significantly better than chance when required to match stimulus words with

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[23]*Ibid.*, p. 321.

the colors which surrounded the words on study trials."[24] After intervening tasks, Birnbaum presented half of the subjects with the same paired-associate task and half with the same stimulus-response pairs but different color outlines. The groups with the same stimulus-response pairs but different color outlines performed at a lower level on this post-test than the same paired-associate group even though the stimulus-response sets remained the same. The color cues then became a function of the stimulus. Responses were associated with the colors as well as the printed stimulus, though to a lesser degree. The color cues were potent enough to produce interference when the color was changed and the printed stimulus remained the same.

Given that color facilitated learning, Saltz attempted to determine if this facilitative effect differed under varied conditions.[25] To accomplish this, subjects were presented with stimuli consisting of trigrams paired with nonsense syllables. The stimuli was varied according to one of four conditions: (1) color on learning trials and color on test trials (C-C), (2) color

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[24]Isabel Birnbaum, "Context Stimuli in Verbal Learning and the Persistence of Associative Factors," Journal of Experimental Psychology, LXXI, No. 4 (1966), p. 485.

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

on learning trials and no color on test trials (C-NC); (3) no color on learning trials and color on test trials, (NC-C); and (4) no color on either learning or test trials (NC-NC). His findings confirmed that color facilitates learning, with the C-C condition providing the most significant results. Both C-NC and NC-C conditions provided more significant gains than the NC-NC condition. This study, like those previously cited, demonstrates that paired-associate learning can be facilitated by the addition of a color cue to the primary stimuli. Beyond this, the Saltz study indicates that color can facilitate learning even when the color cue is not readily accessible as a cue, as in the NC-C and C-NC conditions.

Other researchers have also found that color as a contextual cue can facilitate learning. Otto reported on the first of a series of studies he conducted on the role of color cues in paired-associate learning. This investigation attempted to determine whether the usefulness of color would differ for good and poor readers.[26] Subjects were selected from grades 2, 4, and 6. At each level, half of the subjects learned a list of five geometric forms which had been paired with distinct colors and with a CVC verbal response. The other subjects learned the same list printed in black. In this study, the additional

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[26]Otto, "Color Cues as an Aid."

color had no significant effect on learning. Otto concluded, however, that two factors may have inhibited the usefulness of the color: (1) the geometric figures were dissimilar and previous research has shown that color seems most useful when intralist similarity is high, and (2) the subjects at times seemed unaware of the application of color cues in the task.

In an attempt to control the two weaknesses cited in the first study, Otto designed another study, again using 72 subjects from grades 2, 4, and 6.[27] In this study, the subjects learned a list of six three-letter words written in the Greek alphabet with the Greek letters serving as the stimuli and common English words serving as the responses. These were selected to increase intralist similarity and to provide a task more similar to a reading task. The subjects were informed of the role of the color. Again, half the subjects learned a list with color and half with plain black stimuli. Otto concluded, in this revised study, that color had significantly enhanced learning and that the second graders seemed to utilize the color cues to a greater extent than the others. Otto summarized this research as follows: "With greater stimulus similarity the need for and use of

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[27]Wayne Otto, "Elementary Pupils' Use of Cues in Paired-Associate Learning," <u>Psychology in the Schools</u>, V, No. 2 (1968), 179-82.

further stimulus differentiation on outright cue selection increases . . ."[28]

In a third study, Otto examined the effect of three types of facilitative cues in paired-associate learning.[29] The relative value of color, order of presentation, and intralist similarity were examined. Subjects were asked to learn either a high-similarity or low similarity list of six three-letter words formed with Greek letters. The three-letter words were printed in either black or distinctive colors and the lists were presented in either serial or scrambled order to second graders. Order of presentation and the type of printed stimulus were changed on a post-criterion test in order to measure interaction of the variables. An analysis of these scores suggested that color cues seem less potent than serial order, but that there was evidence of color cue selection. Commenting on the effects reported in this study, Otto states:

> Color cues appear better than no cues at all, and it would be sensible to provide them when stimuli are so similar or so unsystematically presented as to provide little basis for identification . . .

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[28]Wayne Otto and Carin Cooper, "Investigations of the Role of Selected Cues in Children's Paired-Associate Learning" (Technical report #53, Wisconsin Research and Development Center for Cognitive Learning, University of Wisconsin, May, 1968), p. 6.

[29]Wayne Otto, "Intralist Similarity, Order of Presentation and Color in Childrens' Paired-Associate Learning," Psychonomic Science, IX (1967), 531-32.

> One important question that needs a more definitive answer before sound judgments can be made about the pragmatic value of secondary color cues in instruction is whether enhanced learning with color results simply from cue selection or, at least in part, from improved differentiation of primary stimuli. Nevertheless, the essential point seems clear: in every instance the removal of cues resulted in poorer performance, and this was true when color was the only cue removed.[30]

In the studies reported, it has been shown that color cues can effect rate of learning but that other factors may determine the extent of facilitative effect of those color cues.

For instance, Underwood et al. reported that adult subjects could recall meaningful trigrams which had been presented on varied color cards even after the color backgrounds had been removed but the same subjects failed to recall the list of low-meaningfulness trigrams when the color cue was removed. They concluded that color became a functional stimulus when paired with low meaning trigrams but that when the adult subjects learned meaningful trigrams their past experience led them to respond to the words rather than the color.[31] Here Otto's statement that "color cues seem to be better than no cues at

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[30]Otto and Cooper, "Children's Paired-Associate Learning," p. 10.

[31]B. J. Underwood, M. Ham, and B. Ekstrand, "Cue Selection in Paired-Associate Learning," Journal of Experimental Psychology, LXIV (1962), 405-9.

all"[32] seems to be supported. The unanswered question that remains is: When are color cues most effective?

While conducting research to support his reading series, which he calls "a coloured reading" program, Jones had young subjects (ages 3.5--5.1) match letters of English orthography and easily confused words under two conditions: letters and words in color and letters and words in black. Only three colors were used to highlight six letters to eliminate matching on the basis of color alone. Jones concludes, "matching the black letters and black words was at least three times as difficult as the same task in color, even allowing for color matching."[33]

Newman and Taylor concluded that color cues are more effective when primary stimulus intralist similarity is high.[34] Their subjects learned either high or low similarity lists on cards of varied colors and were given either identical color cues or no color cues on criterion trials. The subjects who had been presented with high similarity lists and then had the color cues removed

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[32]Otto, "Intralist Similarity," p. 532.

[33]J. Kenneth Jones, "Colour as an Aid to Visual Perception in Early Reading," British Journal of Educational Psychology, XXXV (1965), 26.

[34]S. E. Newman and R. Taylor, "Context Effects in Paired-Associate Learning as a Function of Element-Sharing Among Stimulus Terms," Journal of Verbal Learning and Verbal Behavior, I (1963), 243-49.

performed at the lowest level of the four groups. These studies appear to support Otto's contention that it seems sensible to provide color cues when intralist similarity is high.

If color cues do facilitate learning in this condition, then there are tasks which beginning readers face where color could be applied. In an attempt to employ color cues in a functional application, Schutz developed a training program for discriminating the letters b and d.[35] However, he reported considerable difficulty in training four-year-olds to discriminate between these letters. The letters were presented in different colors and he found his subjects responding to color rather than the printed figure. Numerous attempts to fade the color from red to black were largely unsuccessful, as were attempts to fade from shades of grey to black. Hall and Caldwell also attempted to teach this b and d discrimination to young subjects and encountered similar difficulty in fading colors from the subjects.[36] Again, their subjects often responded to color rather than the printed

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[35] R. E. Schutz, "Acquisition of Alphabet Letter Discrimination With and Without 'Errors'" (paper read at the American Psychological Association, Los Angeles, 1964).

[36] Vernon Hall and Edward Caldwell, "Analysis of Young S's Performance on a Matching Task" (unpublished research report from Syracuse Center for Research and Development in Early Childhood Education, Syracuse University, April, 1970).

figure and when the two distinctive colors were eliminated the subjects had difficulty in responding correctly.

While attempting to teach children enrolled in a Head Start program the names of four alphabet letters, Washington required the subjects to match stimulus figures. He varied color on the stimulus figure and the matching figure under the following conditions: (1) color on stimulus figure and color on matching figure, (2) color on stimulus figure and no color on matching figure, (3) no color on stimulus figure and color on matching figure, and (4) no color on stimulus figure and no color on matching figure. Groups with color on the stimulus figure and no color on the matching figure achieved at a significantly higher level than the other groups. The results also seem to indicate that subjects in the color-color groups did not attend to the letter stimulus but rather matched colors. Therefore, they could not match the letters in transfer on the basis of form alone.[37]

In the studies reported above, the students often associated their responses with the color cue rather than the printed stimulus. This points out an important

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[37]Ernest David Washington, "Matching and Naming Letters of the Alphabet with and without Redundant Color Cues" (unpublished doctoral dissertation, University of Illinois, 1968).

problem with the use of added cues; that is, how do we force the subject to attend to each of the stimuli, both color and printed form. If the subject uses only the printed stimulus, he is not utilizing maximum information and if he uses only the color he is basing his response on irrelevant information since that color is not present on the transfer task. Further, if he bases his response on the color cue, color becomes the primary stimulus and attempts to fade that cue are unsuccessful. These results were predicted by Sundland and Wickens who advised that precautions must be taken when supplying multiple cues, for subjects may attend only to the most salient stimulus in the stimulus complex. They suggest that when one aspect of the total stimulus becomes more meaningful or more discriminable, subjects are not likely to associate responses with the less meaningful or discriminable components of the total stimulus.[38]

In an attempt to clarify the effects of color cues, Samuels presented 60 first graders with four artificial alphabet words which were paired with common three-letter nouns with the subjects assigned to groups in which the stimulus words were classed as high, medium, or low similarity. Throughout the learning trials, one stimulus in

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[38] D. M. Sunderland and D. D. Wickens, "Context Factors in Paired-Associate Learning and Recall," Journal of Experimental Psychology, LXIII (1962), 302-6.

each list was printed in red and the others in black. Recall was measured after five learning presentations, with each stimulus word printed in black for the recall test. Even though during the learning trials the subjects easily identified the high similarity stimulus in red, during recall there were fewer correct responses for that stimulus than for any other. In each of the other groups (medium similarity, low similarity), there was no significant difference between responses to red or black stimuli. Samuels concludes:

> . . . that in high similarity list 4-L, during learning trials, where discrimination on the basis of letter form was difficult, S's responded to words on the basis of color. On transfer tests the color cue was absent, and S's did poorly with the formerly isolated (red) words. . . . It is conceivable that the S's did not have sufficient experience with the transfer task to realize that color was an irrelevant cue and letter shape the primary cue.[39]

Samuels' study was intended to answer the question: "If the learner focuses his attention on color and not letter shape, what happens when the color cues are removed?"[40] In other words, does color in fact inhibit learning rather than enhance it? In view of the fact that his first grade subjects might possibly have lacked sufficient experience in transfer tasks, he replicated the study using college students. However, on the

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[39] Samuels, "Formal Intralist Similarity," p. 435.

[40] Samuels, "Modes of Word Recognition," p. 29.

transfer tasks the results were again similar to the experiment using young children.

> Samuels found that the rate of learning the words in color was significantly faster than words in regular type. But on transfer tests--when color cues were removed--the subjects had great difficulty in recognizing the words formerly in color. Thus, on transfer tests the tables were turned. In comparing recognition between the words which always were in regular type to the words which had formerly been in color, recognition was always superior for the words which had always been in regular type. What makes these results so surprising is that the college students knew the color cues were to be removed. Apparently, the color cue was so potent that they were unable to focus attention on the relevant cue of letter shape.[41]

Even though Samuels' research findings seem to contradict previously cited research, he has contributed a valuable criteria for employing color in teaching strategies. As Williams points out:

> His warning that children select the easiest cue for recognition, and that the easiest cue is sometimes an "incidental detail" is very well taken. Moreover, one should expect that other, more relevant cues, will also be picked up by the child. One of Samuels' own experiments illustrates this point. Subjects learned to read words printed in color more easily than words printed in regular type; however, when the color cues were removed, they could not recognize the words that had previously appeared in color. In this case, the color cue was so salient that it overrode the relevant cue.[42]

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[41] Ibid., p. 29.

[42] Joanna Williams, "Reactions to Modes of Word Recognition," in Theoretical Models and Processes of Reading, ed. by Helen K. Smith (Newark, Del.: International Reading Association, 1970), p. 38.

In a further study, in which the results were highly similar to those of Samuels, Isaacs added separate colors with high and low discriminability shapes and paired these shapes with a numeral as the verbal response. Reinforcing Samuels' findings, Isaacs reported that

> . . . in the present experiment, the addition of relevant color cues to the shape cues was associated with a significant reduction in the number of trials required to reach the training criterion, but was associated with a relatively greater number of errors on the shape transfer test.[43]

Here, too, color facilitated the initial rate of learning but caused undesirable results at transfer.

A major intent of both the Samuels and the Isaacs studies was to demonstrate that often a decision must be made between a "criterion of speed of initial learning and a criterion in terms of the ability to transfer to new untrained materials."[44] Given that color can facilitate and increase rate of initial learning, can a strategy be developed which eliminates the unwanted loss at transfer? In Williams' opinion, the development of an effective teaching strategy is based on " . . . good answers to two questions: (1) what cues must the child

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[43]Dan Lee Isaacs, "Cue Selection in Paired-Associate Learning as a Function of Relevance of Color Cues and Discriminability of Shape Cues" (unpublished master's thesis, Indiana University, 1966), p. 24.

[44]Williams, "Reactions to Modes of Word Recognition," p. 39.

attend to, in order to solve the criterion task--which we assume to be a transfer task; and (2) how can we ensure that he will attend to those cues?"[45] In an attempt to answ answer the second part of Williams' query, a review of the literature dealing with color as an attentional factor follows.

COLOR AS AN ATTENTIONAL FACTOR

Research on color as an attentional factor is limited. There is, however, a body of research on visual discrimination which is concerned with the search theory, attention, distinctive features, and applications of color in unique instructional settings. In the following sections, a variety of studies in the above areas are reviewed in an attempt to clarify the roles of these factors.

The following studies consider attention as a necessary requisite to discrimination. The role of attention can be viewed from two standpoints: (1) the teacher or experimenter, and (2) the student or subject. Considering these roles, Haring has said:

> Our task as teachers is to insure that relevant dimensions of stimuli gain control over the child's responding. When we are successful in guiding, attending and responding to relevant dimensions of stimuli, appropriate patterns of responding are acquired. When we fail, we have problems like confusion over b and d . . . attending labels of behavior of "looking at" and noticing certain features

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[45] _Ibid._, p. 39.

> which come to be discriminative for the person, thing or condition being attended to.[46]

The importance of the attention factor in visual discrimination has also been pointed out by Wheelock, who notes that in order to make a visual discrimination a subject must attend to the stimuli to be discriminated.[47]

The fact that teachers have often failed to adequately direct attention or adequately teach students to direct attention was reported by McAnnich in an investigation of the visual discrimination abilities of good and poor third grade readers.

> Subjects selected as deficient in reading skills consistently performed less effectively on all discrimination tasks than did subjects selected as demonstrating adequate reading skills . . . In recognizing word or letter groupings in isolation, the findings suggest that the disabled readers attend more to the general configuration of the form, whereas able readers attend to details within the configuration. . . .[48]

Anderson and Samuels drew similar conclusions:

> Good readers were superior to poor readers in Visual Recognition Memory. This superiority . . . was interpreted to stem from the good reader's

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[46] Haring, Attending and Responding, p. 2.

[47] Warren Wheelock, "An Investigation of Visual Discrimination Training for Beginning Readers," in Perception and Reading, ed. by Helen Smith (Newark, Del.: International Reading Association, 1967), pp. 101-4.

[48] Myrene McAnnich, "Investigation of Recognition Variance of Perceptual Stimuli Associated with Reading Proficiency" (paper presented at International Reading Association, Missouri, 1969), p. 4.

> ability to consistently encode distinctive features of the stimuli. Poor readers then . . . have difficulty in attending to or identifying the distinctive features of the stimuli . . .[49]

Williams states that visual discrimination requires that subjects learn to identify the distinguishing features of a stimulus; those features which make it different from other stimuli.[50] This is in keeping with a family of theories in discrimination learning in which the development of the differential response is said to occur in two stages. The first stage involves learning to attend to the distinguishing feature of the stimuli while the second stage is learning to identify and remember that feature. According to search theory, only gross features common to the pair become directly available upon first presentation. The distinctive features are not readily differentiated from stimulus. The subject may respond to the gross features or he may search for a distinctive feature.[51]

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[49] Roger Anderson and S. J. Samuels, "Visual Recall Memory, Paired-Associate Learning, and Reading Achievement" (paper read at American Educational Research Association, Minnesota, March 2, 1970), p. 10.

[50] Joanna Williams, "Effects of Discrimination and Reproductive Training on Ability to Discriminate Letter-Like Forms" (paper presented at American Educational Research Association meeting, February, 1968).

[51] H. M. Jenkins and R. S. Sainsbury, "Discrimination Learning with the Distinctive Feature on Positive and Negative Trials," in <u>ATTENTION: Contemporary Theory and Analysis</u>, ed. by David Nostofsky (New York:

It does not often seem that the inability to pick out these distinctive features is a physical disability. Smith feels that often a child may have adequate visual acuity

> to identify letters as well as an adult . . . [but] what the child does not know is where to look for the distinctive features of letters; he knows how to look, but not what to look for.[52]

In Stott's opinion, the necessary dimension of knowing what to look for may be hindered by lack of attention to the stimulus.

> Nearly all failure to match letters is due to inattention. The child does not give himself time to get sensory information owing to his impulsivity, or else he is not motivated enough to make the effort of attention . . . Once the child becomes conditioned . . . to make the discriminations, the apparent (perceptual) handicap is dissipated.[53]

This inattention itself may be a manifestation of the lack of sufficient information about where to look, as described by Smith.[54]

Appleton-Century-Crofts, 1970), pp. 239-73; Louise Tighe and Thomas Tighe, "Discrimination Learning: Two Views in Historical Perspective," Psychological Bulletin, LXVI, No. 5 (1966), 353-70.

[52]Frank Smith, Understanding Reading: A Psycholinguistic Analysis of Reading and Learning to Read (New York: Holt, Rinehart and Winston, 1971), p. 224.

[53]D. H. Stott, "Some Less Obvious Cognitive Aspects of Learning to Read," The Reading Teacher (January, 1973), 375.

[54]Smith, Understanding Reading, p. 224.

As mentioned previously, it would seem that color could serve the function of bringing the visual senses into contact with distinguishing features of stimulus objects. Color may serve to augment the influx of information from the stimulus, and as reported in Samuels' study, it may unsuitably lead to an exclusion of some features. However, if color cues could be used to attenuate features rather than exclude them, color would help focus attention by highlighting critical features of the stimulus.

OTHER APPLICATIONS OF COLOR

In this section, attention and color again play an important role in two quite different instructional situations. While these studies do not fit neatly into either the contextual or attentional categories presented earlier, they offer insights into the application of color cues.

In the first two studies, color is employed as a literal cue when teaching sight words. Again, problems develop on the transfer task, reinforcing the need to carefully structure the learning environment when adding color cues. In the final study, color is employed as a highlighting device in college textbooks. The attempt is made to focus students' attention on the information highlighted.

In the first category, Taber and Glaser paired specific colors with color words (e.g., the word "red" was printed in black and had red lines of color paired with it) in an instructional program.[55] In this study, first grade children were presented the color words which had been highlighted using lines of the appropriate color radiating from the word. Throughout a series of trials, the radiating lines were removed until on the criterion trial each subject was responding only to the word in black print. The authors concluded that the program was effective in teaching these words and that their simple paradigm was applicable to many instructional situations in the primary grades.

Duell and Anderson attempted to replicate the Taber and Glaser results with kindergarteners. They failed to achieve the same results and commented as follows on their lack of success:

> An important factor in an effective training sequence using prompts is forcing the subject to notice the cue while making the response. An analysis of the observing behavior required of the subject in order for him to respond correctly in the Taber and Glaser study indicates he only had to notice the shapes of the individual letters or overall form of the printed word in order to respond correctly. As a consequence, our children failed to learn to "read" even

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[55]Julian Taber and Robert Glaser, "An Exploratory Evaluation of a Discriminative Transfer Learning Program using Literal Prompts," The Journal of Educational Research, LV, No. 9 (June/July, 1962), 509-12.

> though they completed the training sequence with few errors. Of course, the child could have studied the printed word as well as notice the colors and perhaps voluntarily associate his response with the cue. Second semester first graders do this but kindergarteners don't. This sequence worked for Taber and Glaser because their students were more sophisticated with respect to words and letters.[56]

Again the students seemed unaware of what the task involved, or what to look at. The color did not direct attention to useful information.

However, in the second category, the use of color to cue university students to information in a psychology textbook proved successful in a recent research study.[57] The authors presented three groups of students with textbook material which had principles, explanation of principles or trivial statements underlined. A fourth group had no color added to their texts. Tests given in the course had specific questions directed at each of the three types of knowledge underlined in the texts. An analysis of the test results showed a slight support for the prediction that examination performance would depend on type of material underlined. No evidence of carryover to unhighlighted material was found. This study found a useful application of color, concluding that students'

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[56] Orpha Duell and R. C. Anderson, "A Failure to Teach a Sight Vocabulary by Vanishing Literal Prompts" (paper read at the American Educational Research Association, 1967).

[57] Kenneth Leicht and Valjean Cashen, "Type of Highlighted Material and Examination Performance" (paper read at the American Educational Research Association, 1971).

attention seemed to be focused primarily on learning underlined material which they perceived as important. The color separated certain types of information from the visual array of the page and directed students' attention to that information.

Summary. Each study reviewed in the previous sections of this paper fell generally into one of three broad categories; color as a contextual cue, color as an attentional factor, and other applications of color.

The studies reviewed on color as a contextual cue often demonstrated that color facilitated rate of initial learning but produced undesirable complications on a transfer task. Samuels was especially concerned with this characteristic of color cues and his research provided some necessary cautions for the use of color cues. Otto's research concentrated on the utility of color cues for different subjects under varying conditions. His research demonstrated that color facilitated learning but that other cues, such as order of presentation, could have a more facilitative effect. In sum, the research conducted with color as a contextual cue does appear to demonstrate that color has the potential to become an additional cue on which to base a discriminative response, but that subjects often respond on the basis of color rather than stimulus form.

The research studies focusing on color as an attentional factor attempted to clarify the roles of attention, distinctive features, and color cues in discrimination and paired-associate learning. A number of studies demonstrated that poor readers and children who had difficulty with the task of visual discrimination were inferior in their ability to attend to and identify distinctive features of letters and words. Both Smith and Stott are of the opinion that the inability to pick out distinctive features stems not from a physical disability but, rather, from the fact that the child does not know where to look or how to focus his attention. Williams suggested that, to improve a child's ability to make visual discriminations, it was necessary that the child learn to identify the distinctive features of the stimuli. Such research demonstrates that some children are more successful in identifying distinctive features of stimuli and that this ability seems to be closely related to attention to the stimuli; that is, some children know how and where to focus attention while others apparently do not. The question then raised is: If color can serve as a discriminative cue, might it not also serve as an attentional cue to direct the subject's visual attention to the distinctive feature of a stimulus?

In the final section, studies which did not neatly fall into the previous categories were reported. Taber and Glaser reported the results of a program which used color as a literal cue to teach color words. Their program vanished the color cues and was highly successful in teaching color words to first grade children. Duell and Anderson attempted to replicate that study with kindergarten children and found that their children did not learn because they responded on the basis of color cue rather than word form. These authors then explain that when using color cues, one must exercise caution for if the cue has the ability to become the stimulus on which the response is based, the intended paired-association will not take place. These studies again emphasize the importance of carefully structuring the addition of color cues. Cues must not override the primary stimulus; instead they must direct the learner's attention to useful information.

Two themes seem to emerge from the research studies reported; in order to make a discriminative response, subjects must be able to select the distinctive features of a stimuli and color seems to have the necessary potential to assist the learner in finding that feature.

However, no study attempted to use color solely to emphasize or attentuate distinctive features of a visual display. Such a study would seem to be a logical extension of previous studies for, while it has been shown that color can enhance learning, its potential as a cue which aids in focusing the learner's attention on distinctive features has not been fully realized. By combining the use of a single hue color cue with the concept of the search theory, teachers might assist the learner in his search for the distinctive feature of a stimulus. Instruction, then, could show the learner where to look and maximize the use of his attention by focusing it on the distinctive feature of a stimulus.

The use of multiple hue color cues often allows the learner to focus his attention on the color rather than the salient features of the printed stimulus. Using a single color eliminates the possibility of a learner identifying a stimulus on the basis of an associative hook-up with the color cue. A single hue color cue would serve to highlight the distinctive feature without becoming a discriminator. When color can no longer provide the sole basis for making a discriminative response, vanishing that color cue should be much easier. While it has been shown that color can sometimes enhance learning, the role of color cues in learning is nebulous. This study is designed to clarify the role of color cues and to evaluate an instructional program employing single hue color cues.

CHAPTER III

THE EXPERIMENT

Introduction. The study reported herein was designed to determine experimentally whether adding single hue color cues to distinctive features of low discriminability stimuli during an instructional sequence affects the learning of visual discrimination, visual memory, and paired-associate tasks by young children. In carrying out the study, the experimenter was concerned with the design of the experiment, the materials and procedures involved, the program sequence, the population of the study, and the treatment of the data.

DESIGN OF THE EXPERIMENT

In order to determine the effect of the color hues, this study employed three treatment groups. Group 1 received a program sequence in which the visual stimulus figures were presented in plain black-on-white without any added color cues. The program sequence for the second group employed black stimulus figures with maximum color cues added to all presentations except the final criterion trial. The third treatment group was presented visual stimuli with added color cues which were gradually vanished throughout the presentations. In the criterion trial, the subjects responded to plain black-on-white stimulus. Verbal instructions remained constant between groups in an attempt to evaluate the effect of the treatments of color on the visual stimuli. The only variable in the program sequence was the treatment of color between groups.

Fifty-one children from two schools were randomly assigned to one of the three treatment groups. Each treatment group contained seventeen subjects from each school. Thus, thirty-four children formed each of the three treatment groups and provided a total of 102 subjects for the study.

Pre- and post-program participation measures were collected from each student, and pre- and post-participation means and mean gains were computed from the scores attained.

MATERIALS AND PROCEDURES

<u>Stimuli</u>. The stimulus figures were selected from a group of figures developed and used by Gibson <u>et al</u>.[58] These figures were developed to provide stimuli

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[58]Gibson <u>et al</u>., "Discrimination of Letter-Like Forms," pp. 897-906.

which were similar to letters in English orthography but which would eliminate the influence of previous experience with the stimuli. A description of the process used in development of the figures was provided:

> Construction of Standard Forms. An analysis was made of actual letters (printed capitals, uppercase, of the simple type customarily used in primary texts) in terms of number of strokes, straight vs. curved lines, angles, open vs. closed forms, symmetry, etc. This procedure provided a set of "rules" which describe generally the construction of letters. New forms were generated which follow the same constraints.[59]

Gibson used these figures and their transformations in a study of the development of letter differentiation as it related to those features of letters critical for identification. This study was replicated using real letters. A high correlation (r + .87) was found between the confusions of the same transformations for real letters and the letter-like forms. Gibson concluded: (1) that the effect of a given transformation is not specific to any given form, and (2) the equivalence of the letter-like forms to letters of the English alphabet.[60] While Gibson generated a number of letter-like figures, as well as twelve transformations of each figure, only four of her figures were used in this study.

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[59] Ibid., p. 897.

[60] E. J. Gibson, "Learning to Read," Science, CXLVIII (1965), 1066-72.

Each of the four figures were paired with a single transformation. Two figures were paired with a right to left transformation and two were paired with an up-to-down transformation (see Fig. 1). The right to left and up-down transformations were chosen because numerous research studies have indicated that they are the most difficult for young children to differentiate.[61]

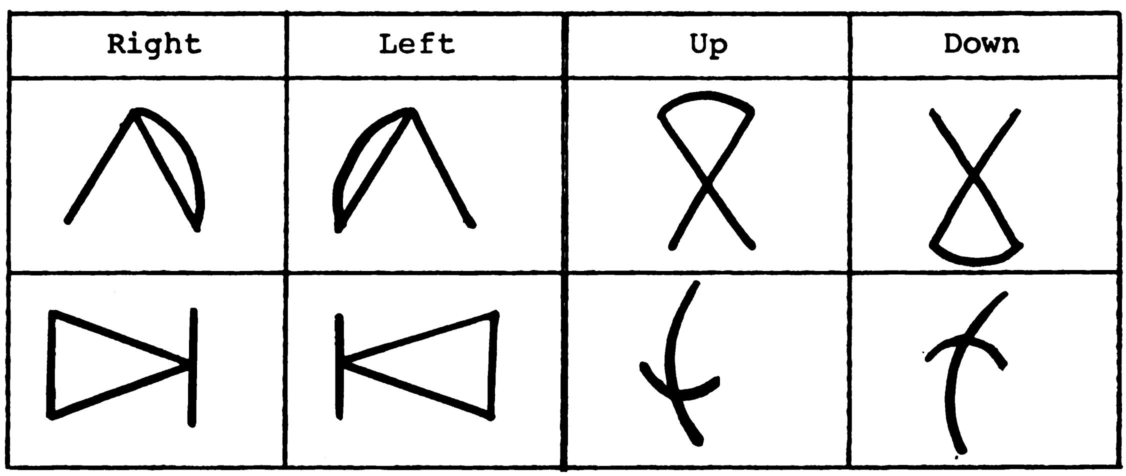

Fig. 1.--The Four Letter-Like Figures and Their Transformations Selected for the Study.

Plastic lettering guides were manufactured for each of the figures to ensure comparability of figures presented in all situations. A black ink medium ball-point pen was used to draw the stimulus figures for all

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[61] Joachim Wohlwill, and Morton Weiner, "Discrimination of Form Orientation in Young Children," Child Development, XXXV, No. 4 (December, 1964), 1113-25; Popp, "Visual Discrimination of Alphabet Letters," pp. 221-26; Blair and Ryckman, "Visual Discrimination: Lower Case Letter Confusion."

tasks. In all cases, the stimulus was in black on a white background. These figures were printed on 2" x 2" cards for the program sequences. The pre-test and post-test sheets were printed on standard white paper with a lithograph. Identical, but separate, sheets were used for both tasks. An orange water base color was used to highlight figures. Orange was selected because of its brightness and transparent qualities which allowed for easy identification of the black stimulus figure after the addition of the color highlighting.

Three sets of seventy-two 2" x 2" cards were prepared for the program sequences. The first set consisted of the cards with the stimulus figures printed in black. The second set of cards consisted of the stimulus figures in black with maximum highlighting on trials 1 through 7, while trial 8 presented plain black figures. The third set consisted of plain black figures in trial 8, with maximum color beginning on trial 1 and subsequently vanished color throughout the remaining trials (2-7). (See Appendix A for illustration of highlighting sequences.) All subjects were presented plain black figures in an introductory trial preceding the beginning of the program sequence to familiarize them with the task required, the responses, the stimuli and the experimental setting.

The consonant-vowel-consonant (CVC) trigrams paired with each figure were selected from a group developed by Archer.[62] Each pair of CVC trigrams was randomly assigned to pairs of stimulus figures (see Fig. 2). The trigram pairs were taken from two lists and matched for percentile of association value as determined by Archer.[63] Only trigrams having an association value of 25 percent or less were used. Appendix B lists the trigrams and their association value.

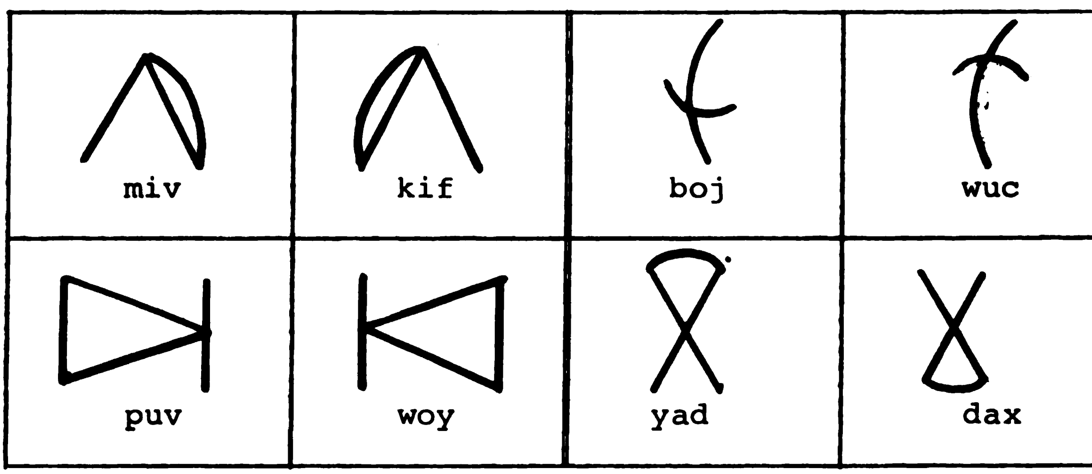

Fig. 2.--The Letter-Like Stimulus Figures and Their Paired CVC Trigram.

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[62] E. J. Archer, "A Re-evaluation of the Meaningfulness of All Possible CVC Trigrams," Psychological Monographs, LXXIV, No. 497 (1960).

[63] Ibid.

Apparatus. In both schools, the experiment took place in small rooms that measured about 8' x 12'. These rooms were separate from the classroom. The experimenter sat at a low table which supported the audio-flashcard reader and supply of pre-tests and post-tests. The subjects sat directly opposite the experimenter with the flashcard reader directly in front of him. The audio flashcards were stacked alongside the flashcard reader and were placed in position by the experimenter.

The flashcard reader employed in this study was a model 101 produced by Electronic Futures Incorporated (see Appendix G for illustration). The audio-flashcards are products of the same firm and were developed for use in the flashcard reader. The flashcards are approximately 11" x 5" and, because a strip of recording tape is affixed to the back of the card, they have audio capabilities. The EFI Audio Flashcard System was chosen for this study because of its simplicity, its capability of ensuring identical verbal instructions, and its novelty for the subjects.

Procedures. In each school, the experimenter spent the first day observing and participating in classroom activities. This was done to familiarize the experimenter with both the classroom activities and the subjects. On the second day, the experimenter again participated in classroom activities and later began pre-testing children in groups of two until ten subjects had been pre-tested on ability to match stimulus figures to form and match stimulus figures from memory. The third day, and subsequent days, were a mixture of presenting the subjects with the program sequence, post-testing, pre-testing additional subjects, and participating in classroom activities.

Pre-tests began with the experimenter engaging each subject in conversation and then presenting the directions (see Appendix C) for the tasks. Pre-tests were administered one day in advance of participation in the program sequence.

Prior to beginning the program sequence, each subject was presented with an introductory trial to familiarize him with the operation of the machine and also to ensure that the subject could enunciate the CVC trigram clearly. Immediately upon completion of this sequence, the subject entered the program sequence. The four pairs of figures, randomly ordered to reduce serial learning, were then presented to the subjects and continued without interruption.

THE PROGRAM SEQUENCE

The total program sequence, including the introductory trial, consisted of seventy-two audio flashcards. While total time for program completion varied, average time from beginning to end was approximately 10-12 minutes. (For a complete transcript of verbal directions on the audio flashcards, see Appendix D.)

The development of the program was influenced by the results of a pilot study which provided pertinent data relevant to the following areas of concern: (1) number of stimulus figures presented, (2) type of stimulus figures presented, (3) number of presentations per figure, (4) length of program, (5) type of highlighting to be employed; and (6) reinforcement procedures. These areas of development are discussed in the following sections.

Number and type of stimulus figures presented. Prior to the pilot study, eight figures and their transformations were selected for the study and a program sequence was developed. This sixteen figure program took nearly 30 minutes to complete and, because of short attention spans of young children, the experimenter decided to shorten the program to twelve figures. These programs incorporated numerous figures in an attempt to reduce the possibility that any student would achieve a maximum score on the pre-tests. During the pilot study, the twelve figure program sequence was used and few problems with this "ceiling effect" developed. However, the program sequence still took nearly 20 minutes to complete. This led to the decision to eliminate two more figures and their transformations, or four figures.

Each time figures were eliminated, one left to right and one up-down transformation was eliminated. Figures which had been most often correctly identified in the pilot study were eliminated. This was done to reduce the "ceiling effect." By using figures which were more difficult to identify, subjects were less likely to achieve high scores on pre-achievement measures.

Number of presentations per figure. The number of presentations per figure was initially chosen on the basis of other similar research. However, an introductory trial was added when the pilot study demonstrated that, either because of the audio capabilities of the machine or the auditory discrimination and memory of the subjects, the subjects often failed to properly enunciate the trigram after several presentations. The introductory trial was designed to control this by presenting the subjects with the unhighlighted stimulus and its paired trigram and asking each subject to repeat the trigram. If they did so incorrectly, they were corrected by the experimenter. This introductory trial also served to present the subjects with the tasks involved prior to program entry.

Each figure was presented eight times following the introductory trial. The pairs of figures were randomly ordered throughout these presentations. The sequence remained the same for all treatment groups. The first trial following the introductory trial was a learning trial. These trials provided the trigram paired with the figure and directed the subject to look at a particular feature of the stimulus figure. These verbal directions also remained constant for all treatment groups.

The second trial following the introductory trial was a test trial. These trials asked the subject if he could recall the "name" of the figure. Each subject was then directed to push another button on the machine to check the correctness of his answer or to find out the "name" of the figure if he had failed to respond with a trigram. A second sound track on the tape affixed to the audio flashcard provided the subject with the appropriate "name" of each figure. Throughout the remainder of the program sequence, learning and test trials were alternated, with the final test trial serving as the post-achievement measure for the naming task. Figure 3 illustrates the sequence.

I	1	2	3	4	5	6	7	8
Introductory	Teaching	Testing	Teaching	Testing	Teaching	Testing	Teaching	Criterion Test

Fig. 3.--Program Sequence: Order of Teaching and Testing Trials.

Length of programs. It was decided that approximately 10-15 minutes was the maximum length of time that young children could maintain interest in the task. One other factor also had to be considered. Each subject was post-tested following completion of the program sequence and this testing took an additional 5-7 minutes. Thus, the young subjects employed in this study were spending approximately 15 minutes away from the classroom.

In summary, the program was shortened based on data collected in a pilot study. This was done in an attempt to make the program length appropriate to the attention span of the young subjects. After initial development of the program sequence employing eight presentations per figure, the only change was to add the introductory trial for the reason given above. In all other ways, the eight presentations were satisfactory.

Type of highlighting. Three styles of vanishing highlighting were employed in the pilot study. In each style, the features selected as distinctive remained constant but the method of highlighting differed. Figure 4 presents the three styles of highlighting compared in the pilot study. One letter-like figure is presented as an example of each style. On the basis of the results of the pilot study, style 3 was chosen for use in this study. Figure 5 presents the treatment of color for each treatment group throughout the complete

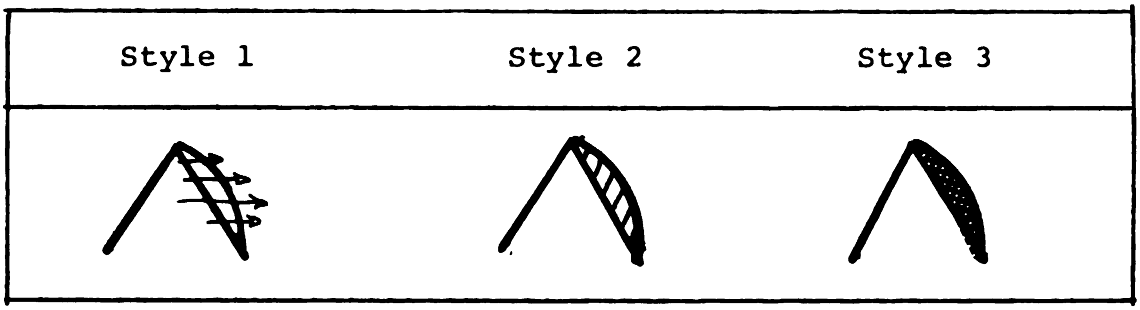

Fig. 4.--Styles of Color Highlighting Employed in the Pilot Study.

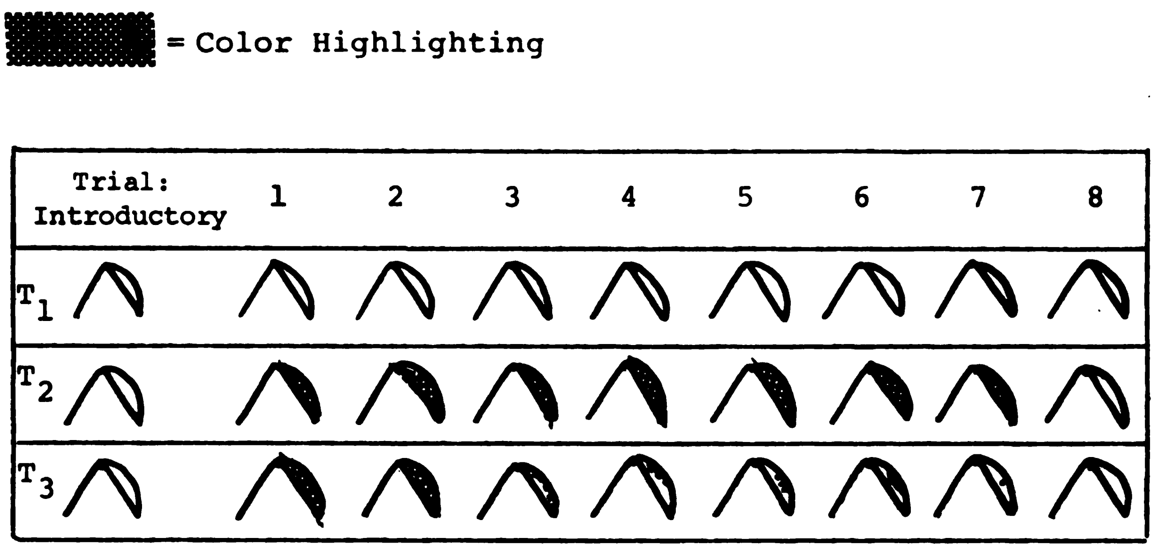

Fig. 5.--Style of Color Highlighting Used for Each Treatment Group.

Notes: T_1 = no color

T_2 = maximum color

T_3 = vanished color.

program sequence. Again, one letter-like figure is presented as an example (see Appendix A for complete highlighting sequence).

Three sets of 2" x 2" stimulus figure cards were prepared, one set for each treatment of color. When all subjects from any treatment group had finished the program sequence, the 2" x 2" stimulus figure cards for the next treatment group were placed on the audio flash cards. To facilitate changing the visual stimuli, the 2" x 2" stimulus figure cards were attached to the audio flashcard with a small paper clip. Thus, changing the stimulus figure cards was a relatively simple task while having the additional advantage of insuring that each subject, regardless of treatment group, received identical verbal instructions throughout the program sequence. As each subject began the final trial, his verbal responses to the visual stimuli were recorded on a separate score sheet by the experimenter. Upon completion of the program sequence, each subject was post-tested on ability to match the stimulus figures to form and to match the stimulus figures from memory. The final trial of the program sequence served as the criterion test for ability to name the figures. Upon completion of the program sequence and post-tests, subjects returned to scheduled classroom activities.

<u>Reinforcement procedures</u>. Throughout the experiment reinforcement procedures were constant for all

participants. Small candies served as reinforcers. Each subject was presented with two candies for each correct verbal response on test trials throughout the program. In addition, each subject received one small candy on the third card of each learning trial, together with the comment, "You're really working hard." This method was developed as a result of a pilot study which demonstrated that some subjects tended to become disinterested and discouraged when they were unable to correctly respond to any figure. Including reinforcement for only maintaining attention to the task eliminated the problem of disinterest.

Test forms. Identical forms were used in administering the pre-test and the post-test. These forms were constructed following a model proposed by Smith. He suggested that

> . . . foils be selected so that recognition of the unit must be based upon unique characteristics. Thus, other members of its class are used. They have some features in common (class features), thus are maximally confusable, and they differ from the unit in other characteristics (unique features).[64]

Each form then contained the correct figure, its transformation, an incomplete figure and/or a figure with an added feature and/or a transformation of the figure other than one used in the program sequence. Position of

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[64] Donald E. P. Smith, "On Discrimination Programming" (unpublished paper from the School of Education, Bureau of Psychological Services, and Center for Research on Language and Language of Behavior, University of Michigan), p. 21.

correct answer was randomly determined. The pre- and post-tests used in this study can be found in Appendix E.

POPULATION OF THE STUDY

Subjects. The subjects were 102 children enrolled in kindergarten. Samples were randomly drawn from the kindergarten populations of the Beach Elementary School in the Cedar Springs Public Schools District, Cedar Springs, Michigan and the Cody Community School in the Flint Public Schools Districts, Flint, Michigan. These subjects were randomly assigned to one of three treatment groups and no subject was disqualified.

Subjects in the study ranged in age from 5 years 3 months to 6 years 1 month. Fifty-four males and forty-eight females participated in the experiment, as illustrated in Figure 6.

School	Males	Females	Total N
Flint	31	20	51
Cedar Springs	23	28	51
Total n =	54	48	102

Fig. 6.--Subjects Participating in Study: By Sex and School Location.

The schools. The Beach Elementary School in Cedar Springs, Michigan houses the primary grades (K-4) for the

Cedar Springs School District. Three kindergarten classrooms are housed in the building. The student population of Beach Elementary School is drawn from the town of Cedar Springs, and from the surrounding rural areas. The Cody Community School in Flint, Michigan houses students in all elementary grades (K-6). Cody Community School has two kindergarten classrooms and draws its students from an urban working class population in Flint.

THE TREATMENT OF THE DATA

Experimental design. A two-way multivariate and three univariate analyses of covariance were employed as the primary statistical procedure. The analysis of covariance was used because:

> Simply stated, the analysis of covariance is a statistical technique which tests the significant differences between two or more groups after initial differences between the groups are statistically eliminated. The advantage of the analysis of covariance is that . . . should there be any initial random error between groups, this can be eliminated statistically.[65]

Thus by reducing the error variance, this procedure provides a more sensitive test of the between-group differences.

The design, shown in Table 1, included two independent variables: the treatments of color used in

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[65]Gilbert Sax, Empirical Foundations of Educational Research (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968), p. 35.

the program sequence, and the school location. The covariates were the achievement scores on the Match to Form and the Match from Memory pre-tests. The dependent variables were the achievement scores on the three post-test measures: Match to Form, Match from Memory, and Naming.

TABLE 1.--Experimental Design.

	1	2	3
F	FNC	FMC	FVC
CS	CSNC	CSMC	CSVC

Notes:

School

Flint (F) = sample drawn from all kindergarten children enrolled at Cody Community School.

Cedar Springs (CS) = sample drawn from all kindergarten children enrolled at Beach Elementary School.

Treatment of Color

No Color (NC) = figures receive no added color.

Maximum Color (MC) = figures receive maximum added color throughout program sequence.

Vanished Color (VC) = figures receive maximum added color, which is gradually vanished throughout the program sequence.

Statistical procedures. For each main effect factor (treatment and school) and for the interaction effect (treatment X school), a multivariate analysis of covariance provided an over-all test based on all three dependent variables (see Figures 7, 8 and 9). If a source of variation was found to be significant in the multivariate analysis of covariance, univariate analyses of covariance were then applied to the data to identify on which dependent variables the significant effect occurred. This procedure was then followed, when appropriate, by a post hoc analysis employing the Scheffé technique.

The Match to Form and the Match from Memory pre-tests were used as the covariates in an attempt to gain greater statistical precision in the analysis. While random assignment of subjects statistically equates groups, the use of the covariate allows for reduction of the mean square within (MS error) by eliminating that portion of the post-test variance which is predicted by the covariates.

<u>Summary</u>. This study was conducted to evaluate the effect of added color cues in discrimination and paired-associate learning. To this end, the study utilized 102 children enrolled in kindergarten classrooms in two public school districts in Michigan.

Subjects were randomly selected and assigned to one of three treatment groups, no color added, maximum color added, and vanished color. After the administration of two pre-test instruments, each subject completed an audio-visual program sequence designed to train him to visually discriminate and name four pairs of high

T_1	T_2	T_3
n = 34	n = 34	n = 34

Fig. 7.--Number of Subjects per Cell for the Treatment Effect.

Flint	n = 51
Cedar Springs	n = 51

Fig. 8.--Number of Subjects per Cell for the School Effect.

	T_1	T_2	T_3
Flint	n = 17	n = 17	n = 17
Cedar Springs	n = 17	n = 17	n = 17

Fig. 9.--Number of Subjects per Cell for the Treatment X School Interaction Effect.

similarity letter-like figures. Upon completion of the program, each subject was tested on the ability to perform three tasks; name each figure, select each figure from memory, and match each figure to form.

Multivariate and univariate analyses of covariance were used to determine whether significant differences existed between treatment groups. In an attempt to eliminate the possibility of differences between treatment groups prior to exposure to the program sequence, the pre-achievement measures were employed as the covariates. The results of these analyses are reported in Chapter IV.

CHAPTER IV

RESULTS

Introduction. This study was designed to evaluate the effects of adding color highlighting to distinctive features of high similarity letter-like figures. To this end, an audio-visual program sequence was developed. This program sequence was employed to measure the effect of the color highlighting in three treatment conditions. These conditions were: (1) no color added to the visual stimuli, (2) maximum color added to the visual stimuli, and (3) maximum color added to the visual stimuli and subsequently vanished through the program sequence.

The subjects for this study were 102 randomly selected and assigned students from the kindergarten populations of the Beach Elementary School, Cedar Springs, Michigan and the Cody Community School, Flint, Michigan.

Each subject was administered a Match to Form and a Match from Memory pre-test prior to entry into the program sequence. These measures served as covariates in the analysis. Three post-tests served as the dependent variables and were administered upon completion of the program sequence. These were: (1) the Match to Form post-test, (2) the Match from Memory post-test, and (3) the Naming task. For all measures a score of one was given for each correct choice, with a maximum score of 8 for each measure.

Specifically this study was designed to test the following hypotheses:

Hypothesis 1a

Given the task of Matching to Form, there will be no significant difference in achievement between groups upon completion of the program sequence.

Hypothesis 1b

Given the task of Matching to Form, there will be no significant difference in achievement upon completion of the program sequence, between the samples drawn from the two school populations.

Hypothesis 1c

There will be no significant interaction effect between treatment and school as measured by achievement on the Match to Form task.

Hypothesis 2a

Given the task of Matching from Memory, there will be no significant difference in achievement between groups upon completion of the program sequence.

Hypothesis 2b

Given the task of Matching from Memory, there will be no significant difference in achievement upon completion of the program sequence, between the samples drawn from the two school populations.

Hypothesis 2c

There will be no significant interaction effect between treatment and school as measured by the Match from Memory task.

Hypothesis 3a

Given the task of Naming, there will be no significant differences in achievement between groups upon completion of the program sequence.

Hypothesis 3b

Given the task of Naming, there will be no significant difference in achievement upon completion of the program sequence, between the samples drawn from the two school populations.

Hypothesis 3c

There will be no significant interaction effect between treatment and school as measured by the Naming task.

DETERMINING WHETHER SIGNIFICANT DIFFERENCES EXIST

Rationale. The multivariate and univariate analyses of covariance are statistical techniques for testing whether or not two or more population means for an effect differ at a specified significance level.[66] Thus, the first step in this analysis was to conduct a two-way multivariate analysis of covariance in order to test the above hypotheses. The results of the multivariate analysis of covariance identified a significant main effect for the treatment variable. However, while this analysis indicated a significant treatment effect, it does not identify on which of the three dependent variables that significant effect occurred. Therefore, in order to identify on which dependent variables a significant treatment effect existed, a two-way univariate analysis of covariance was conducted on each dependent variable.

The univariate analysis of covariance identified on which of the three dependent variables significant treatment effects occurred.

Having obtained a significant treatment effect for each univariate analysis of covariance, it was necessary to identify between which treatment groups the significant difference occurred. To this end, the post hoc Scheffé was then applied.

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[66] Linda Glendenning, "Posthoc: A Fortran IV Program for Generating Confidence Intervals Using Either Tukey or Scheffé Multiple Comparison Procedures" (unpublished occasional paper #20, from the Office of Research Consultation, School for Advanced Studies, College of Education, Michigan State University, January, 1973).

The following sections report the results of the multivariate analysis of covariance, the univariate analyses of covariance, and the post-hoc analyses.

Results of the multivariate analysis of covariance. The first statistical analysis applied to the data was a two-way multivariate analysis of covariance. In this analysis, the two independent variables were treatment and school. There were two covariates: (1) the Match to Form, and (2) the Match from Memory pre-tests. Three dependent variables existed: (1) the Match to Form post-test, (2) the Match from Memory post-test, and (3) the Naming task. Table 2 reports the results of the multivariate analysis of covariance as applied to the treatment and school variables.

TABLE 2.--A Multivariate Analysis of Covariance on Three Dependent Variables: (1) the Match to Form Post-test, (2) the Match from Memory Post-test, and (3) the Naming Task.

Source of Variation	df	F
Treatment	6,184	8.4561*
School	3,92	1.7031
Treatment X School	6,184	1.3561

*p < .0001.

For the treatment effect, the table illustrates an F-ratio of 8.4561 was attained which, with 6 and 184 degrees of freedom, had a significance level of p less than .0001. This provides strong evidence that significant differences exist between groups as the result of the treatment. Thus, on the basis of this multivariate analysis of covariance test, hypotheses 1a, 2a, and 3a were rejected.

In contrast, for the school variable, an F-ratio of 1.7031, with 3 and 92 degrees of freedom, had a significance level of p less than .1719, indicating no main effect for school. Thus hypotheses 1b, 2b, and 3b were not rejected; that is, no significant differences in achievement existed between the samples drawn from the two school populations on any of the three dependent variables.

When considering the interaction between treatment and school, an F-ratio of 1.3561 was obtained which, with 6 and 184 degrees of freedom, had a significance level of p less than .2347. Thus, hypotheses 1c, 2c, and 3c were not rejected; that is, there was no significant interaction effect between the variables treatment and school on any of the three dependent variables.

In summary, the multivariate analysis of covariance provided strong evidence that significant differences did exist and that these differences were not attributable to the differences in school populations. Rather, the differences were attributable to the effects of the treatments.

IDENTIFYING WHERE SIGNIFICANT DIFFERENCES EXIST

Rationale. In order to determine whether the significance noted above was in Match to Form, Match from Memory, or Naming, it was necessary to apply a two-way univariate analysis of covariance to each dependent variable. In each univariate analysis of covariance, the independent variables were treatment and school.

In the multivariate analysis of covariance, group means are adjusted statistically in order to provide precision. These means are adjusted from the original means of the raw scores in relation to the amount of variance accounted for by the covariates. The adjusted means are used as a basis for comparing groups. Table 3 presents

TABLE 3.--Adjusted Group Means for Each Treatment Group on the Three Dependent Variables: (1) Match to Form Post-Test, (2) Match from Memory Post-Test, and (3) Naming Task.

Variable	Treatment		
	1*	2**	3***
Match to Form	4.9949	5.6083	6.4621
Match from Memory	3.6438	3.9049	5.2817
Naming	0.6942	1.0218	1.4159

*No color. **Maximum color. ***Vanished color.

the adjusted group means on each dependent variable. (Group means and raw scores for each subject on all tasks can be found in Appendix F.)

Multiple correlation coefficients. Table 4 presents the coefficients of determination between the two covariates and each dependent variable. The coefficients of determination is that proportion of the variance of a dependent variable which may be predicted or accounted for by another variable or variables.[67]

TABLE 4.--Multiple Correlation Coefficients and Coefficients of Determination for Both Covariates with Each Dependent Variable.

Variable	df	R	R^2	F
Match to Form	2,94	0.6933	0.4807	43.5071*
Match from Memory	2,94	0.6011	0.3614	26.5956**
Naming	2,94	0.3435	0.1180	6.2868***

*p < .0001 **p < .0001 ***p < .0028

As indicated by Table 4, the multiple correlation coefficients for the two covariates with each of the three dependent variables were statistically significant. As the R^2 coefficients indicate, the two covariates

[67] John T. Roscoe, Fundamental Research Statistics for the Behavioral Sciences (New York: Holt, Rinehart & Winston, Inc., 1969), p. 80.

account for 48 percent, 36 percent, and 11 percent of the variances on the dependent variables (Match to Form, Match from Memory, and Naming, respectively).

The results for the univariate analyses of covariance and post hoc comparisons are reported separately for each dependent variable in the sections that follow.

Analysis on the Match to Form variable. This section reports the results of the two-way univariate analysis of covariance and the Scheffé post hoc analysis as applied to the Match to Form dependent variable. Both the Match to Form and the Match from Memory pre-tests were employed as covariates. Table 5 presents the results of the univariate analysis of covariance on the dependent variable Match to Form.

TABLE 5.--Univariate Analysis of Covariance on the Dependent Variable Match to Form.

Sources of Variation	df	MS	F
Treatment	2	22.7561	16.2927*
School	1	0.9262	0.6631
Treatment X School	2	4.4859	3.2117
Within Cell	94		

*p < .0001

This table illustrates that the main effect for treatment had an F-ratio of 16.2927 which, with 2 degrees of freedom, had a significance level of p less than .0001. Since this was less than .05 (the p value specified), hypothesis 1a for the Match to Form was rejected. This means that significant differences exist between treatment groups on the Match to Form variable.

Given a significant F-ratio for the treatment effect in the univariate analysis of covariance, it was necessary to conduct a post hoc analysis in order to determine where significant differences between treatment groups occurred.

The Scheffé post hoc technique was applied to test for differences between the adjusted means ($\bar{Y}'$) of the three treatment groups: (1) no color ($\bar{Y}_1'$), (2) maximum color ($\bar{Y}_2'$), and (3) vanished color ($\bar{Y}_3'$). Table 6 reports the results of that analysis.

TABLE 6.--Scheffé Post Hoc Comparisons of Treatment Group Adjusted Means on the Dependent Variable Match to Form.

Comparisons	99% Confidence Interval	95% Confidence Interval
$\bar{Y}_3' - \bar{Y}_2' = .8538$	± .8976	± .7176*
$\bar{Y}_3' - \bar{Y}_1' = 1.4672$	± .8923**	--
$\bar{Y}_2' - \bar{Y}_1' = .6134$	±1.1159	±1.0387

*Significant at $p < .05$ **Significant at $p < .01$

An inspection of Table 6 reveals that there was a significant difference at the .01 level between the treatment group receiving vanished color highlighting and the group receiving no color highlighting. This difference favored the vanished color treatment. A comparison of the vanished color treatment with the maximum color treatment yielded another significant difference at the .05 level, again favoring the vanished color treatment. No significant difference was found between the maximum color treatment group and the no color treatment group on the Match to Form variable.

Analyses on the Match from Memory variable. This section reports the results of the univariate analysis of covariance and the Scheffé post hoc analysis, applied to the Match from Memory dependent variable. The Match to Form and the Match from Memory pre-tests were employed as covariates.

Table 7 presents the relevant data for the univariate analysis of covariance on the dependent variable Match from Memory.

Table 7 illustrates that the main effect for the variable treatment yielded an F-ratio of 4.5445 which, with 2 degrees of freedom, had a significance level of $p < .0001$. Since this was less than .05 (the p value specified), hypothesis 2 for the Match from Memory dependent variable was rejected. This means that significant differences exist between treatments on the Match to Form variable.

TABLE 7.--Univariate Analysis of Covariance on the Dependent Variable Match from Memory.

Sources of Variation	df	MS	F
Treatment	2	24.6935	4.5445*
School	1	3.5706	2.9352
Treatment X School	2	1.0330	.8492
Within Cell	94		

*p < .0001

Given a significant F-ratio for the treatment effect in the univariate analysis of covariance, it was necessary to conduct a post hoc analysis in order to determine where significant differences between treatment groups occurred.

The Scheffé post hoc technique was applied to test for differences between the adjusted group means. Table 8 presents the results of this analysis for the three treatment groups: ($\overline{Y}_1'$) no color, ($\overline{Y}_2'$) maximum color, ($\overline{Y}_3'$) vanished color.

An inspection of Table 8 reveals that there were significant differences at the .01 level between the treatment group receiving vanished color and the groups receiving maximum color and no color highlighting. In both comparisons, the difference favored the vanished color group. No significant difference was found between the maximum color treatment group and the no color treatment group on the Match from Memory variable.

TABLE 8.--Scheffé Post Hoc Comparisons of Treatment Group Adjusted Means on the Dependent Variable Match from Memory.

Comparison	99% Confidence Interval	95% Confidence Interval
$\bar{Y}'_3 - \bar{Y}'_2 = 1.3768$	± .8378*	--
$\bar{Y}'_3 - \bar{Y}'_1 = 1.6379$	± .8325*	--
$\bar{Y}'_2 - \bar{Y}'_1 = .2611$	±1.0411	±.8324

*Significant at $p < .01$

Analyses on the Naming variable. This section reports the results of the two-way univariate analysis of covariance and the Scheffé post hoc analysis, as applied to the Naming dependent variable. Both the Match to Form and the Match from Memory pre-tests were employed as covariates.

Table 9 presents the results for the univariate analysis of covariance on the Naming dependent variable.

Table 9 illustrates that the main effect for the variable treatment had an F-ratio of 4.5445 which, with 2 degrees of freedom, was significant at the .0131 level.

Since this was less than .05 (the p level specified), hypothesis 3 for the Naming dependent variable was rejected. This means that significant differences exist between treatments on the Naming variable.

TABLE 9.--Univariate Analysis of Covariance on the Dependent Variable Naming.

Sources of Variation	df	MS	F
Treatment	2	4.8009	4.5445*
School	1	.0657	.06222
Treatment X School	2	1.3926	1.3182
Within Cell	94		

*$p < .0131$

Given a significant F-ratio for the treatment effect in the univariate analysis of covariance, it was necessary to conduct a post hoc analysis in order to determine where significant differences between treatment groups occurred.

The Scheffé post hoc technique was applied to test for differences between the adjusted group means. Table 10 presents the results of this analysis for the three treatment groups: ($\bar{Y}'_1$) no color, ($\bar{Y}'_2$) maximum color, and ($\bar{Y}'_3$) vanished color.

TABLE 10.--Scheffé Post Hoc Comparisons of Treatment Group Adjusted Means on the Dependent Variable Naming.

Comparison	95% Confidence Interval
$\bar{Y}_3' - \bar{Y}_2' = .3841$	±.6242
$\bar{Y}_3' - \bar{Y}_1' = .7217$	±.6202*
$\bar{Y}_2' - \bar{Y}_1' = .3276$	±.7759

*Significant at $p < .05$

An inspection of Table 10 reveals that there was a significant difference at the .05 level between the treatment group receiving vanished color and the treatment group receiving no color highlighting. This difference favored the vanished color treatment. No significant differences were found between the vanished color and the maximum color treatments nor between the maximum color and the no color treatments on the Naming variable.

Summary. Having found a significant main effect for the treatment variable in the multivariate analysis of covariance, a univariate analysis of covariance was then applied to each dependent variable.

The univariate analysis of covariance on the dependent variable Match to Form indicated a significant treatment effect at the $p < .0001$ level. The Scheffé post hoc comparisons identified significant difference

($p < .01$) between the vanished color and the no color treatments, favoring the vanished color treatment. A significant difference ($p < .05$) was also found between the vanished color and maximum color treatments, again favoring the vanished color treatment.

The univariate analysis of covariance on the dependent variable Match from Memory indicated a significant treatment effect at the $p < .0001$ level. The Scheffe post hoc comparisons identified a significant difference ($p < .01$) between the vanished color and the no color treatment and between the vanished color and the maximum color treatment. Both significant differences favored the vanished color treatment.

The univariate analysis of covariance on the dependent variable Naming indicated a significant treatment effect at the $p < .0131$ level. The Scheffe post hoc comparisons identified a significant difference ($p < .05$) between the vanished color and the no color treatments, favoring the vanished color treatment.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Introduction. This study was designed to experimentally evaluate whether adding single hue color cues effects the learning of visual discrimination, visual memory, and paired-associate tasks.

A review of the research concerned with adding color cues found that color can have a facilitative effect upon the rate of initial learning. However, eliminating the color cues presented difficulty. Often the color cue became the primary stimulus upon which the discrimination was based. In other words, the color cue was often so potent that it overrode the relevant cue of stimulus form. In these research studies, two or more colors were used, with separate colors being paired with each stimulus figure. The study reported in this paper was designed to test the effect of employing a single color as a cue for a variety of stimuli. It was felt that the use of a single color might eliminate the problems previously associated with the use of multiple color cues while still focusing subjects' attention on the distinctive features of the stimuli.

SUMMARY

<u>The study</u>. To evaluate the usefulness of a single hue color cue, a program sequence was developed. This program was prepared for use with an audio flashcard reader. An audio track was developed and these verbal directions remained constant for all treatment groups. Four letter-like figures and their transformations were selected as visual stimuli. The transformations of left to right and up to down, were chosen because of their difficulty. Each letter-like figure was randomly assigned a low meaningfulness CVC trigram as its name.

Three sets of the figures were prepared for use in the program sequence. The first set had no color cues added to the stimulis figures, the second set had maximum color cues added to the stimulus figures, and the third set had maximum color cues added and subsequently vanished from the stimulus figures.

This program sequence was used with 102 children enrolled in the kindergarten classrooms of two Michigan school districts. Each subject was pre-tested on the ability to match the letter-like figures to form, and the ability to match the letter-like figures from memory.

Following the administration of the pre-tests, subjects participated individually in the program sequence. Immediately following completion of the program sequence, each subject was post-tested on the ability to name the letter-like figures, to match the letter-like figures from memory, and to match the letter-like figures to form.

In order to determine whether significant differences existed between the three treatment groups, a multivariate and three univariate analyses of covariance were applied to the data. The Match to Form and the Match from Memory pre-tests were employed as covariates in these analyses.

The results. On the basis of the results of the multivariate analysis of covariance, no significant differences in achievement between school populations were found on the three variables: Match to Form, Match from Memory, and Naming. Similarly, no significant interaction effect existed for the treatment X school variable. This means that the treatments of color had similar effects for subjects in both schools.

The results of the multivariate analysis of covariance did, however, reveal significant differences for the treatment effect. A univariate analysis of covariance was then applied to each dependent variable in order to identify where the significant differences occurred.

For the Match to Form variable, significant differences ($p < .0001$) were found in the univariate analysis of covariance. Given these differences, a Scheffé post hoc comparison was applied in order to identify between which treatment groups these significant differences existed on the Match to Form variable. The results of the Scheffé analysis revealed that the vanished color treatment was significantly better ($p < .01$) than the no color treatment. The vanished color treatment was also found to be significantly better ($p < .05$) than the maximum color treatment on the Match to Form measure.

For the Match from Memory variable, significant differences ($p < .0001$) were found in the univariate analysis of covariance. Given these differences, a Scheffé post hoc analysis was applied in order to identify between which treatment groups the significant differences existed on the Match from Memory variable. The results of the Scheffé analysis revealed that the vanished color treatment was significantly better ($p < .01$) than either the no color or the maximum color treatment.

For the Naming variable significant differences ($p < .0131$) were also found in the univariate analysis of covariance. Given these differences, a Scheffé post hoc comparison was again applied in order to identify between which treatment groups the significant differences occurred on the Naming variable. The results of the Scheffé analysis revealed that the vanished color treatment was significantly better ($p < .05$) than the no color treatment.

The results of the post hoc analyses indicate that the vanished color treatment was superior to the no color treatment on each of the three learning tasks. Further, the vanished color treatment was superior to the maximum color treatment on the Match to Form and the Match from Memory tasks.

CONCLUSIONS

The major conclusion of this study is that children who receive instruction which utilizes vanished color cues learn the tasks of visual discrimination, visual memory, and association of a verbal response at a significantly higher level of achievement than children who receive instruction without vanished color cues. Further, it is concluded that the vanished color cues serve to focus attention on the distinctive feature of the figure to be learned without producing interference at transfer.

IMPLICATIONS

The results of this study indicate that attending to appropriate features of visual stimuli improves performance on visual discrimination, visual memory, and paired-associate tasks.

More specifically, this study demonstrates that vanished color cues facilitate attention in learning these three basic tasks. In contrast to previous studies using multiple hue color cues, a single hue color cue which is vanished seems to facilitate attention to the distinctive features of letter-like figures without producing interference on a transfer task. These color cues were useful because they directed the learner's attention to salient information. A single hue eliminates the tendency to respond on the basis of the color cue alone. By employing a bright transparent color, attention can be focused on the distinctive feature of the letter-like figure while allowing the printed form of that figure to remain visible.

Gradually vanishing the color cue in subsequent presentations increases the effectiveness of the cue by forcing the subject to attend more to the distinctive feature of the stimulus and less to the color cue. The vanished color cues have the ability, when combined with verbal directions, to increase stimulus differentiation by directing attention to the salient features of the stimulus rather than to the color itself.

The crucial point is that even after a limited amount of training at an early age (i.e., kindergarten), there occurred significant differences in achievement favoring the vanished color treatment over the no color treatment. These data indicate that the effectiveness of visual discrimination training depends upon the technique employed. While visual discrimination training is often provided in kindergarten classrooms, it is not unusual for a number of children to experience difficulty with these tasks, especially with discriminations involving reversals or rotations of letters. The systematic use of vanishing single hue color cues, however, should assist these young children in mastering the discrimination tasks more efficiently. Hence, the use of vanishing color cues to focus attention on distinctive features of visual stimuli should help minimize many of the relatively common perceptual confusions currently found in many elementary classrooms.

RECOMMENDATIONS

The recommendations offered here fall into two separate categories: recommendations for teachers of reading and recommendations for further research.

<u>Recommendations for teachers of reading</u>. Teachers of reading should use vanished color cues to assist children in

1. learning to visually discriminate between letters; and in

2. learning to recognize easily confused letters.

Recommendations for further research. Further study is needed regarding the application of vanished color cues to other instructional tasks and the refinement of the technique developed in this study. The effect of vanished color cues need to be examined under the following conditions:

1. Present only two conditions, vanished color and no color. For each treatment develop a set of limited verbal directions (i.e., "This is a puv.") and compare the treatments under these conditions.

2. Compare the vanished color and the no color treatments employing limited verbal directions and expanded verbal directions (i.e., as used in this study). This would provide needed information on the relative potency of the vanished color cues.

3. Present the vanished color and the no color treatments to subjects identified as making the common error of letter reversals. Highlight the confused letters in the same manner as described in this study.

4. Present the vanished color and the no color treatments to subjects identified as making common word reversal errors or confusing similar words.

Again use the color to highlight the distinctive features of the words.

5. Test the applicability of vanished color cues to learning situations outside the area of reading skills.

6. Test the effect of the use of vanished color cues over an extended period when compared with instruction without color cues.

7. Editors for publishing houses may do well to employ the technique developed herein when designing texts and materials for teaching or practicing discrimination or association skills.

In summary, while this study has demonstrated that vanished color cues can enhance the learning of three basic tasks, still more research is needed into the relative effectiveness of employing similar techniques in other learning environs and for other learning tasks. It has been demonstrated that attention can be appropriately focused with the use of vanished color cues but further research is needed to provide an empirical base for extending the use of color as an attentional device.

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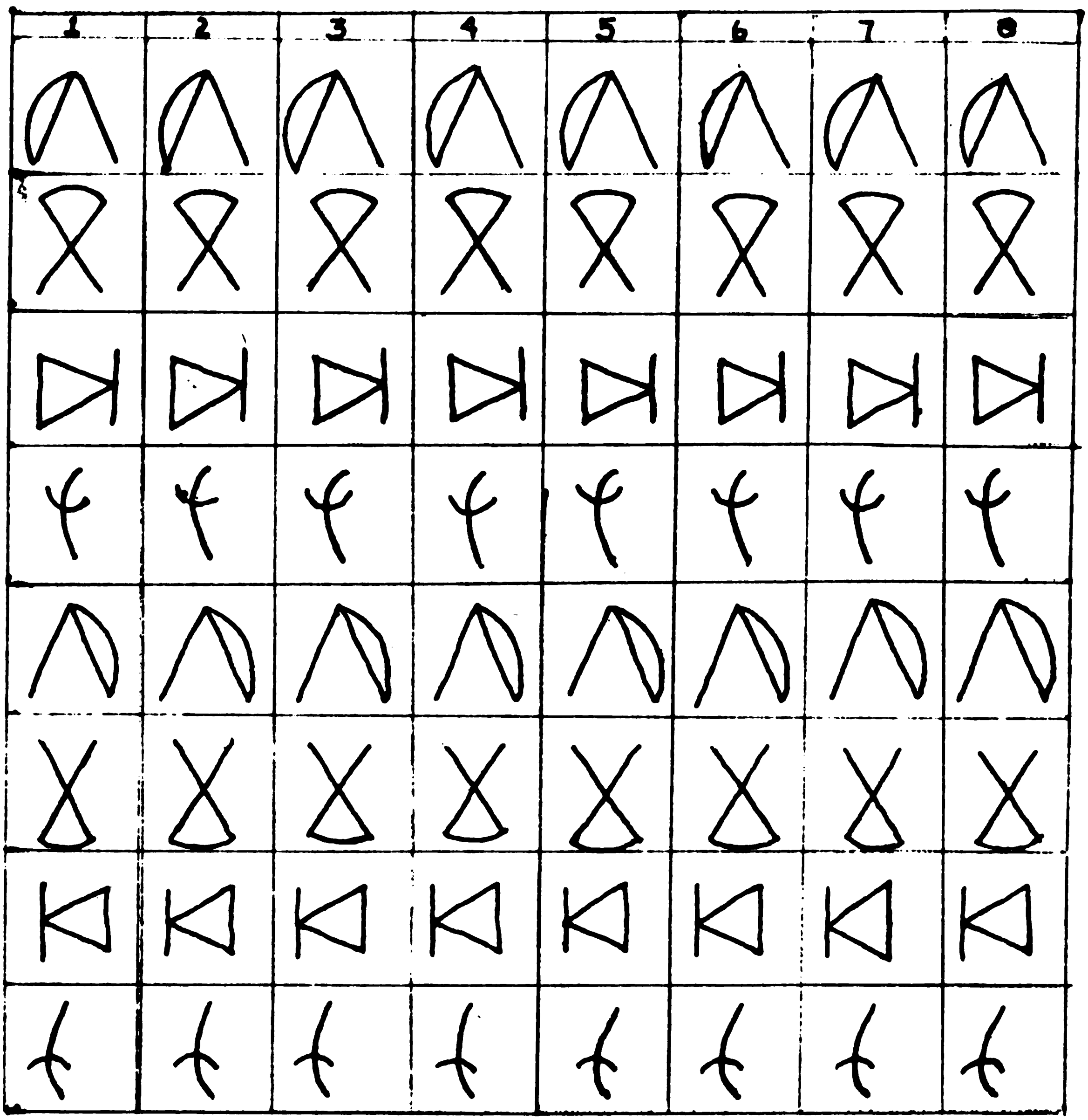
APPENDICES

APPENDIX A

METHOD OF COLOR HIGHLIGHTING FOR ALL TREATMENTS

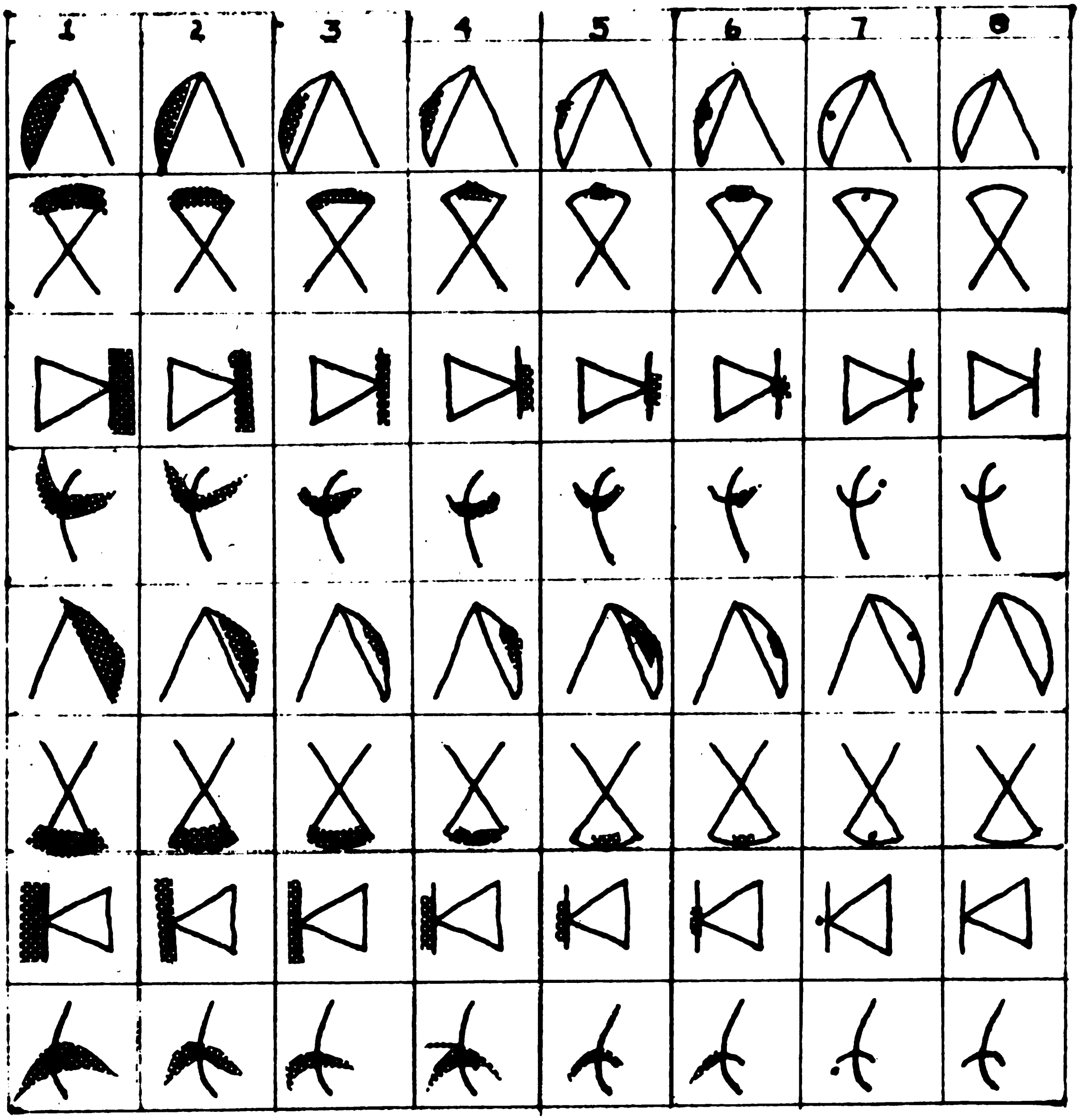
APPENDIX A

NO COLOR



VANISHED COLOR TREATMENT FOR LETTER-LIKE FIGURES BY TRIAL

= ORANGE HIGHLIGHTING



APPENDIX B

TRIGRAMS AND ASSOCIATION VALUE

APPENDIX B

TRIGRAMS AND ASSOCIATION VALUE

List 1	Percentile Association Value	List 2
yad	25	dax
puv	22	woy
miv	17	kif
boj	16	wuc

APPENDIX C

DIRECTIONS FOR PRE-TESTS AND POST-TESTS

APPENDIX C

DIRECTIONS FOR THE MATCH TO FORM PRE-TEST

Instructions to Subjects:

"Look carefully at the figure I'm pointing to. Can you find this figure on your paper? Put your finger on it. (Check to make sure finger is on correct figure.) Now, look carefully at each of the other four figures in the row. Does this one look just exactly like the first figure? Or this one? Or this one? Or this one? Only one of these figures is just exactly the same as the first one, put a mark on it."

"Good. Now look at this figure (point to key figure in second row). Look carefully at each of the other figures in the row and mark the one that looks just exactly like the first one. Remember only one is exactly the same."

"Good. Now put your finger on the first figure in the next row and find the other figure that looks just exactly like the first one."

"Good. Do the rest of the rows just like that. Look at the first figure and then mark the one that looks just exactly like it."

If necessary continue repeating instructions. If subject marks more than one figure say, "Remember only one figure looks just exactly like the first one." If subjects asks, "Is this right?", or something similar, reply, "Good, mark it."

DIRECTIONS FOR THE MATCH FROM MEMORY PRE-TEST

Instructions to subjects:

Provide subject with test sheet and cover properly aligned over first row of figures.

"This sheet is different from the other one. This time I will show you a figure on a card like this (hold up card). You must look carefully at the figure on this card and try to remember what it looks like. After you have seen the figure slide the cover down like this and look carefully at each figure, then put a mark on the figure that looks just like the one you saw on the card. You can't look back because I'm going to put the card down after you've looked at it. This is tricky, so look carefully at the figure when I show it to you."

"Ready? Here is the first figure. Look carefully at it. Now, slide the cover down and look at all the figures, then mark the one that looks just like the one that was on the card. Remember only one is just exactly like the one on the card."

"Good. Now look carefully at th is figure. Now slide the cover down, look at all four figures and mark the one just exactly like the one on the card."

"Good. Now here's the next one. Look carefully and mark the figure that looks exactly like it."

"Good. Now here's the next figure." (Continue through cards.) If subject marks more than one figure say, "Remember, only one figure looks just exactly like the one on the card." If subject asks, "Is this right?", or something similar reply, "Good, mark it."

DIRECTIONS FOR THE MATCH TO FORM POST-TEST

Instructions to Subjects:

"Remember how we did this paper before? You put your finger on this figure (demonstrate) and look carefully at each of the other figures, then you put a mark on the figure that is just exactly like this first one. Remember that only one figure looks just exactly like the first one."

Again if any questions arise concerning correctness of subject's choice reply, "Good, mark it."

DIRECTIONS FOR THE MATCH FROM MEMORY POST-TEST

Instructions to Subjects:

"Do you remember how we did this paper? I'll hold up a card like this, you look carefully at the figure on the card, then slide the cover down and find the one that looks just exactly like the figure on the card I held up. Remember only one figure is just exactly like the one on the card."

"O.K., now look carefully at this figure." (Hold up card.) "Slide the cover down and mark the figure just exactly like the one that was on the card."

"Good, now look at this figure." (Continue through cards.)

If questions arise concerning correctness of subject's choice reply, "Good, mark it."

APPENDIX D

INTRODUCTION TO AND VERBAL DIRECTIONS

FOR THE PROGRAM SEQUENCE

APPENDIX D

INTRODUCTION TO PROGRAM

Instructions to Subjects:

"I'm trying to find out how kids learn. So what I've done is put some figures on these cards. I want to see if you can learn the names of these figures. This is really hard because no one has ever learned all the names. But every time you do remember even one name you'll get some of these candies. OK? Let me show you how this (the Audio Flashcard Reader) works. I'll put the card in and then push this button. Listen (to audiotrack of card). When you push the button that voice will tell you the name of the figure. Later the voice will ask if you remember the figure's name. If you do, say it, then push this button to see if you were right. If you don't remember the name push this button and it will tell you."

Verbal Directions	Trial	Figure	Card Sequence Number	Audio Track
"This is a miv. Say miv."	I	Miv	1	1.
"This is a kif. Say kif."	I	Kif	2	1.
"This is a yad. Say yad."	I	yad	3	1.
"This is a dax. Say dax."	I	dax	4	1.
"This is a boj. Say boj."	I	boj	5	1.
"This is a wvc. Say wuc."	I	wuc	6	1.
"This is a puv. Say puv."	I	puv	7	1.
"This is a woy. Say woy."	I	woy	8	1.
"This is a yad. Look at the top of the yad. Say yad."	1	yad	9	1.
"This is a dax. Look at the bottom of the dax. Say dax."	1	dax	10	1.
"This is a puv. See which its' pointing? Say puv."	1	puv	11	1.
"This is the woy. See which way its pointing? Say woy."	1	woy	12	1.
"This is a miv. Which side is the hump on? Say miv."	1	miv	13	1.
"This is the kif. See which side its hump is on? Say kif."	1	kif	14	1.
"This is a boj. See how the lines point down? Say boj."	1	boj	15	1.
"This is a wuc. See how the lines point up? Say wuc."	1	wuc	16	1.
Can you remember the name of this figure? Say its name and then push button three to see if you were right.	2	boj	17	1.
That is a boj. Did you say boj?				2.
"Can you remember the name of this figure? Say it and then push button three to see if you were right."	2	wuc	18	1.
"This is a wuc. Did you say wuc or did I trick you?"				2.
"Can you remember the name of this one? If you can say the name and then push button three to see if you're right."	2	miv	19	1.
"This is a miv. Did I fool you?"				2.

Verbal Directions	Trial	Figure	Card Sequence Number	Audio Track
"Let's see if you remember the name of this one. Say it's name and then push button three to see if you're right."	2	kif	20	1.
"Kif. This is kif. Did you remember that?"				2.
"If you remember the name of this one, say it. Then push button three to see if you're right."	2	puv	21	1.
"Did you say puv. That's right."				2.
"Here's another hard one. If you remember its name say it and then push button three to see if you're right."	2	woy	22	1.
"I'll bet I tricked you didn't I. Did you say woy?"				2.
"Do you remember the name of this one? If you do, say it and then push button three to see if you're right."	2	yad	23	1.
"This is a yad. Can you say yad? Did you get it right?"				2.
"Try this one. Do you remember its name. If you do say it and then push button three to see if you're right."	2	dax	24	1.
"This is a miv. See which side the hump is on? Say miv."	3	miv	25	1.
"This is a kif. See which side the hump is on now? Say kif."	3	kif	26	1.
"This is a puv. See which way it's pointing? Say puv."	3	puv	27	1.
"This is a woy. See which way its pointing? Say woy."	3	woy	28	1.
"This is a boj. See which way the arms are pointing? Say boj."	3	boj	29	1.
"This is a wuc. See which way his arms are pointing? Say wuc."	3	wuc	30	1.

Verbal Directions	Trial	Figure	Card Sequence Number	Audio Track
"This is a yad. See the top of the yad? Say yad."	5	yad	31	1.
"This is a dax. See the botton of the dax? Say dax."	3	dax	32	1.
"Can you remember the name of this figure? If you can say it. Then push button three to see if you're right."	4	miv	33	1.
"Did you say miv? If you di you are right.				2.
"Do you remember the name of this figure, it's a hard one. If you can say it, then push button three."	4	kif	34	1.
"Kif. That's a kif. Did you get it right? I hope so."				2.
"How about this one. Do you remember its name? Say it, then push button three."	4	boj	35	1.
"If you said boj, you're absolutely right."				2.
"They're really getting tricky. If you remember this one, say its name and then push button three."	4	wuc	36	1.
"Wuc. Did you say wuc. That's the right answer."				2.
"Can you remember the name of this figure. Say it and then push button three."	4	yad	37	1.
"Yad. If you said yad, you're absolutely right."				2.
"Do you remember this tricky one? If you do, say its name, then push button three."	4	dax	38	1.
"That is the dax. Did you get it?"				2.
"Here's another hard one. If you remember it's name, say it. Then push button three."	4	puv	39	1.
"Did you say puv. If you did, congratulations."				2.
"Do you remember the name for this figure? If you do say it, then push button three."	4	woy	40	1.
"Did you say, woy? If you did you're absolutely right."				2.

Verbal Directions	Trial	Figure	Card Sequence Number	Audio Track
"This is a puv. See which side the bar is on? Say puv."	5	puv	41	1.
"This is a woy. See which way it is pointing? Say woy."	5	woy	42	1.
"This is a miv. See which side the hump is on? Say miv."	5	miv	43	1.
"Kif. This is a kif. The hump is on the other side. Say kif."	5	kif	44	1.
"This is a boj. See which way the arms are pointing? Say boj."	5	boj	45	1.
"This is a wuc. See how the arms point up? Say wuc."	5	wuc	46	1.
"This is a yad. See how the top of the yad has a line across it? Say yad."	5	yad	47	1.
"This is a dax. See the line across the bottom of the dax? Say dax."	5	dax	48	1.
"What's the name of this figure? If you remember, say it. Then push button three."	6	boj	49	1.
"Did you say boj? If you did, you're right."				2.
"Can you remember the name of this figure? Say its name, then push button three."	6	wuc	50	1.
"Wuc. Did you say wuc."				2.
"Can you name this figure. If you can, say it, then push button three."	6	miv	51	1.
"That's a miv. Did you say miv?"				2.
"Do you remember what we call this one? If you do, say it, then push button three."	6	kif	52	1.
"Kif. Did you say kif?"				2.
"Do you remember this one from before? Say its name, then push button three."	6	yad	53	1.
"That is a yad. If you said, yad, you're right."				2.

Verbal Directions	Trial	Figure	Card Sequence Number	Audio Track
"I'll bet you've forgotten this one. If you haven't say its name. Then push button three."	6	dax	54	1.
"Did you remember we call this one dax?				2.
"Can I trick you again? Do you remember the name of this one? Say it's name and then push button three."	6	puv	55	1.
"That is a puv. Did you say puv?"				2.
"Here's another hard one. Say its name and then push button three."	6	woy	56	1.
"Woy. That's a woy. Did you get it right?"				2.
"Puv. That is puv. See which side the bar is on? Say puv."	7	puv	57	1.
"That's a woy. See which way it's pointing" Say woy."	7	woy	58	1.
"Boj. That's a boj. See which way the arms are pointing? Say boj."	7	boj	59	1.
"This is a wuc. See which way the arms are pointing? Say wuc."	7	wuc	60	1.
"Miv. This is a miv. Point to the hump. Say miv."	7	miv	61	1.
"This is a kif. Point to the hump. Say kif."	7	kif	62	1.
"Yad. This is a yad. Point to the top of the yad. Say yad."	7	yad	63	1.
"This is a dax. Point to the bottom of the dax. Say dax."	7	dax	64	1.
"Can you remember the name of this one. If you do, say it real loud, then push button three."	8	puv	65	1.
"Did you say puv? That's right."				2.
"Say the name of this one and then push button three."	8	woy	66	1.
"This figure is woy. Did you remember it?"				2.

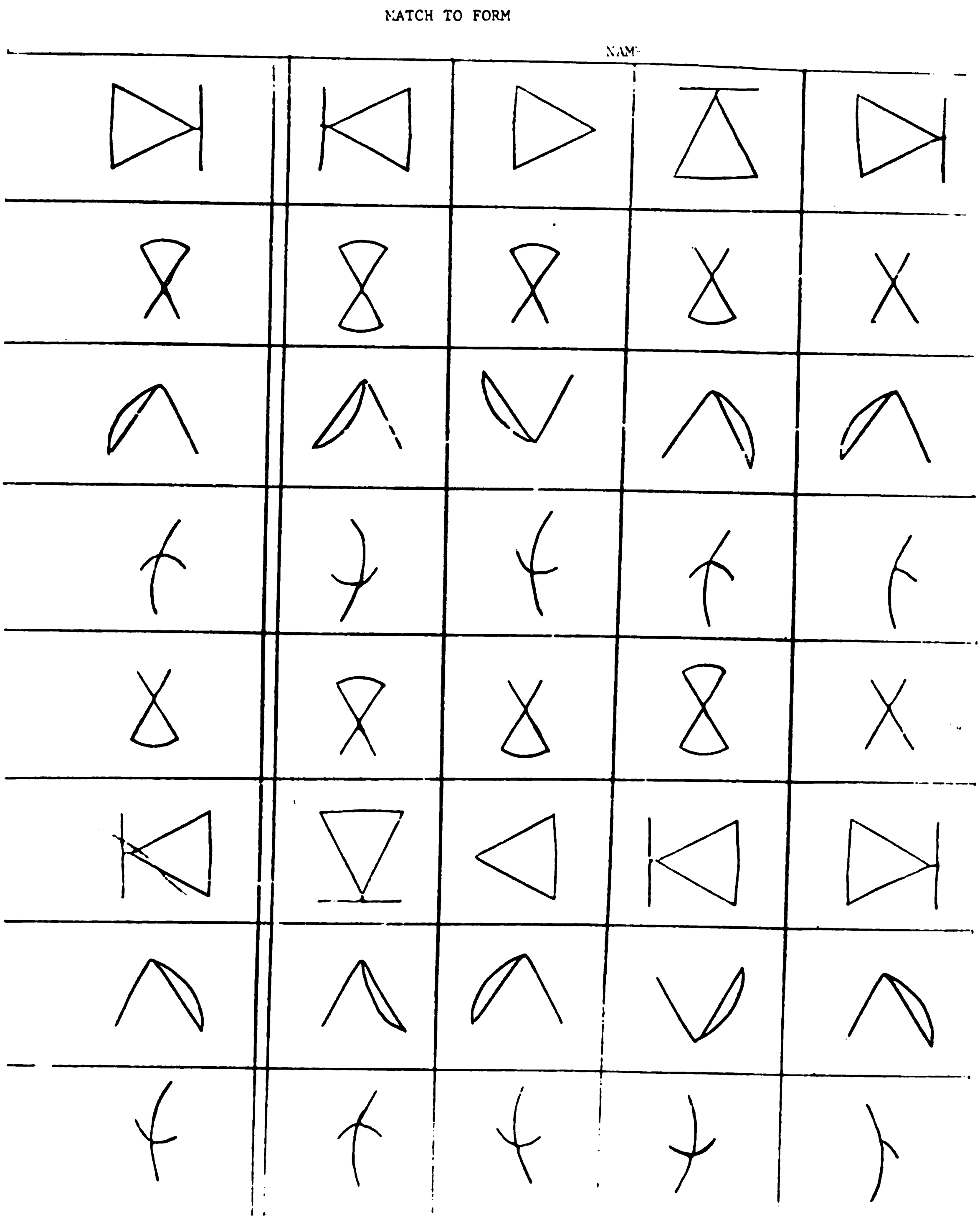
Verbal Directions	Trial	Figure	Card Sequence Number	Audio Track
"Do you remember this one? If you do say it's name. Then push button three."	8	miv	67	1.
"Did you say miv? That's right."				2.
"Try this hard one. Say its name, then push button three."	8	kif	68	1.
"That's a kif. If you said kif, you're absolutely right."				2.
"Do you remember this one? Say its name, then push button three."	8	yad	69	1.
"Yad. Did you say yad?"				2.
"Do you remember the name of this figure. If you do, say it, then push button three."	8	dax	70	1.
"Dax. Did you get it right?"				2.
"Say the name of this figure. Then push button three."	8	boj	71	1.
"This one is boj. Did you say boj?"				2.
"Say the name of this figure. Then push button three."	8	wuc	72	1.
"Wuc. If you said wuc you're absolutely right.				2.

APPENDIX E

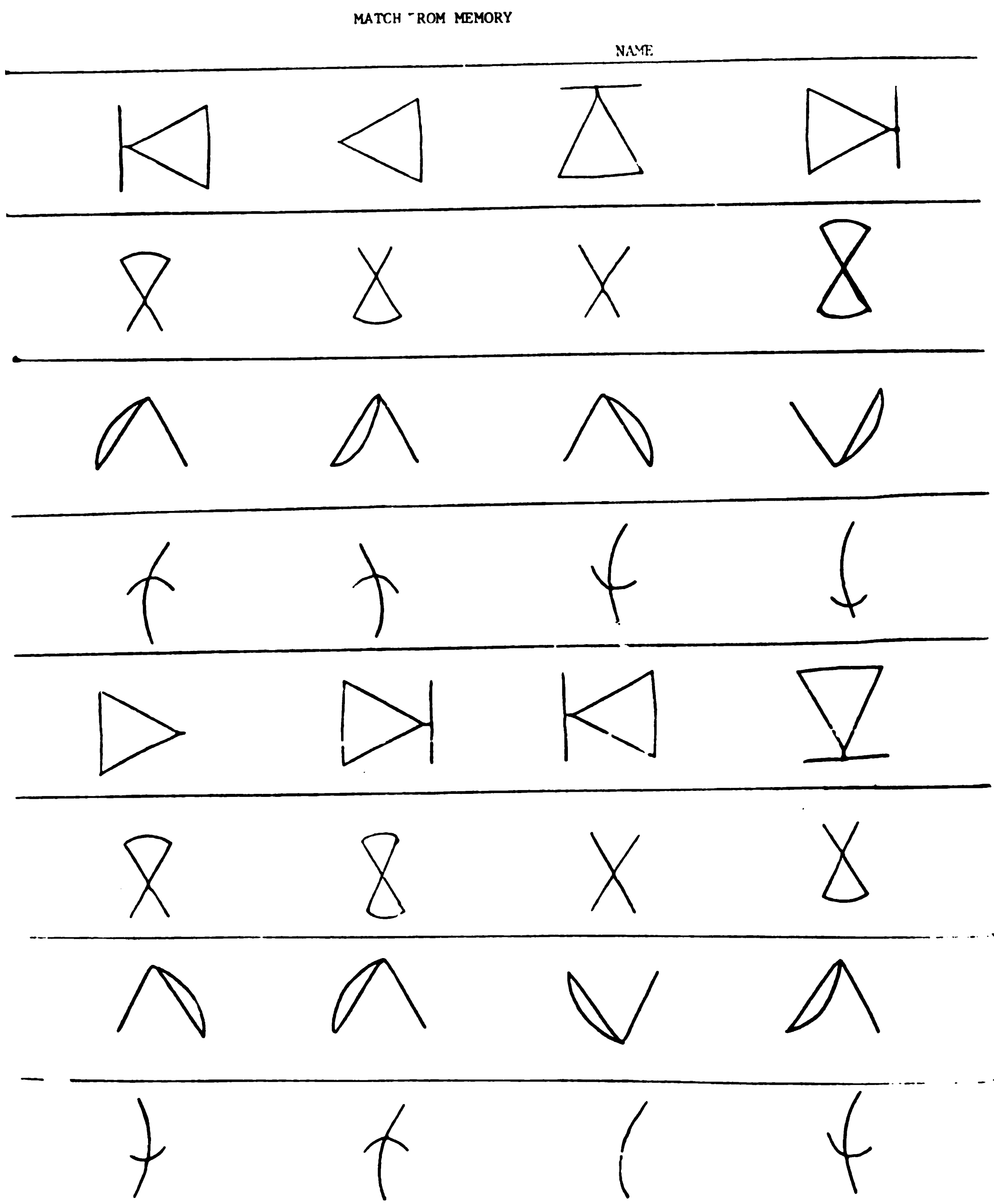
POST-TEST SHEETS AND PRE-TEST SHEETS

APPENDIX E

MATCH TO FORM PRE-TEST AND POST-TEST SHEET



MATCH FROM MEMORY PRE-TEST AND POST-TEST SHEET



APPENDIX F

GROUP MEANS OF RAW SCORES, RAW SCORES, AND WITHIN-GROUP SAMPLE CORRELATION MATRIX

APPENDIX F

GROUP MEANS OF RAW SCORES, RAW SCORES, AND WITHIN-GROUP SAMPLE CORRELATION MATRIX

Raw Group Means

	T_1	T_2	T_3	Total $\bar{X}$	Variance
$\bar{X}$ VM Pre-test	3.5000	3.2647	3.5588	3.4411	2.0353
$\bar{X}$ VM Post-test	3.7941	3.8823	5.3529	4.3431	1.8874
$\bar{X}$ MTF Pre-test	4.1176	4.3235	4.0588	4.1666	3.5641
$\bar{X}$ MTF Post-test	4.9705	5.5294	6.5294	5.6764	2.6253
$\bar{X}$ Naming	0.7058	1.0588	1.4411	1.0686	1.1648

Within-Group Sample Correlation Matrix on the Two Covariates and the Three Dependent Variables

	1 Naming	2 VM Pre	3 VM Post	4 MTF Pre	5 MTF Post
1 Naming	1.000	--	--	--	--
2 VM Pre-test	0.103	1.000	--	--	--
3 VM Post-test	0.345	0.535	1.000	--	--
4 MTF Pre-test	0.343	0.357	0.446	1.000	--
5 MTF Post-test	0.370	0.287	0.502	0.692	1.000

PARTICIPANT TEST DATA

No Color

Treatment	Location	Student's number	Naming	MFM Pretest	MFM Post-Test	MFM Gain	MTF Pretest	MTF Post-Test	MTF Gain
1	F	0 1	0	5	4	1	4	4	0
1	F	0 2	0	4	3	1	2	5	3
1	F	0 3	0	6	6	0	5	6	1
1	F	0 4	0	4	4	0	5	6	1
1	F	0 5	1	3	4	1	6	7	1
1	F	0 6	1	4	6	2	7	7	0
1	F	0 7	0	3	2	-1	4	4	0
1	F	0 8	1	2	3	1	4	4	0
1	F	0 9	1	2	2	0	3	5	2
1	F	1 0	0	4	4	0	5	4	-1
1	F	1 1	2	4	3	-1	3	3	0
1	F	1 2	0	4	3	-1	3	5	2
1	F	1 3	1	2	2	0	3	5	2
1	F	1 4	0	5	3	2	0	0	0
1	F	1 5	1	2	3	1	3	5	2
1	F	1 6	0	6	4	-2	5	4	-1
1	F	1 7	0	4	3	-1	4	3	-1
1	C	1 8	2	1	6	5	5	6	1
1	C	1 9	2	2	4	2	5	5	0

No Color (continued)

Treatment	Location	Student's number	Naming	MFM Pretest	MFM Post-test	MFM Gain	MTF Pretest	MTF Post-test	MTF Gain
1	C	2 0	1	4	3	-1	6	6	0
1	C	2 1	0	5	4	-1	6	6	0
1	C	2 2	0	2	2	0	3	4	1
1	C	2 3	2	6	8	2	3	7	4
1	C	2 4	0	2	3	1	4	4	0
1	C	2 5	0	3	4	1	5	8	3
1	C	2 6	0	4	4	0	6	5	-1
1	C	2 7	2	1	2	1	4	8	4
1	C	2 8	1	4	5	1	4	5	1
1	C	2 9	2	2	5	3	4	5	1
1	C	3 0	1	4	4	0	4	8	4
1	C	3 1	0	5	4	-1	3	4	1
1	C	3 2	1	4	4	0	3	3	0
1	C	3 3	0	3	3	0	2	1	-1
1	C	3 4	2	3	5	2	7	7	0
Maximum Color									
2	F	0 1	1	4	4	0	6	7	1
2	F	0 2	0	4	4	0	4	6	2
2	F	0 3	1	5	3	-2	4	5	1
2	F	0 4	0	4	3	-1	4	4	0
2	F	0 5	3	3	2	-1	3	6	3

Maximum Color (continued)

Treatment	Location	Student's Number	Naming	MFM Pretest	MFM Post-test	MFM Gain	MTF Pretest	MTF Post-test	MTF Gain
2	F	0 6	1	5	6	1	8	8	1
2	F	0 7	0	3	3	0	2	4	2
2	F	0 8	4	4	4	0	5	7	2
2	F	0 9	0	3	2	-1	2	6	4
2	F	1 0	0	2	3	1	3	4	1
2	F	1 1	1	2	4	2	3	5	2
2	F	1 2	1	5	5	0	6	6	0
2	F	1 3	2	2	4	2	2	4	2
2	F	1 4	0	1	3	2	0	5	5
2	F	1 5	2	4	6	2	6	7	1
2	F	1 6	1	5	4	-1	5	5	0
2	F	1 7	0	5	6	1	3	7	4
2	C	1 8	0	4	5	1	3	4	1
2	C	1 9	2	2	5	3	2	4	2
2	C	2 0	0	0	1	1	2	3	1
2	C	2 1	1	2	5	3	5	8	3
2	C	2 2	2	2	4	2	6	6	0
2	C	2 3	0	2	3	1	2	3	1
2	C	2 4	2	5	4	-1	4	5	1
2	C	2 5	1	5	6	1	7	8	1
2	C	2 6	3	6	6	0	6	7	1
2	C	2 7	1	4	4	0	6	6	0

Maximum Color (continued)

Treatment	Location	Student's Number	Naming	MFM Pretest	MFM Post-test	MFM Gain	MTF Pretest	MTF Post-test	MTF Gain
2	C	2 8	2	1	4	3	4	4	0
2	C	2 9	0	4	3	-1	4	5	1
2	C	3 0	2	2	6	4	8	8	0
2	C	3 1	0	2	1	-1	5	3	-2
2	C	3 2	0	2	2	0	3	4	1
2	C	3 3	3	4	4	0	8	8	0
2	C	3 4	0	3	3	0	6	6	0
Vanished Color									
3	F	0 1	1	2	5	3	4	6	2
3	F	0 2	1	5	6	1	4	6	2
3	F	0 3	3	4	7	3	3	7	4
3	F	0 4	1	2	5	3	7	8	1
3	F	0 5	1	4	4	0	4	8	4
3	F	0 6	2	3	4	1	7	8	1
3	F	0 7	0	3	5	2	1	4	3
3	F	0 8	1	4	5	1	3	8	5
3	F	0 9	2	6	7	1	8	8	0
3	F	1 0	1	3	3	0	2	6	4
3	F	1 1	0	2	4	2	0	5	5
3	F	1 2	2	4	5	1	3	6	3
3	F	1 3	2	3	5	2	3	4	1

Vanished Color (continued)

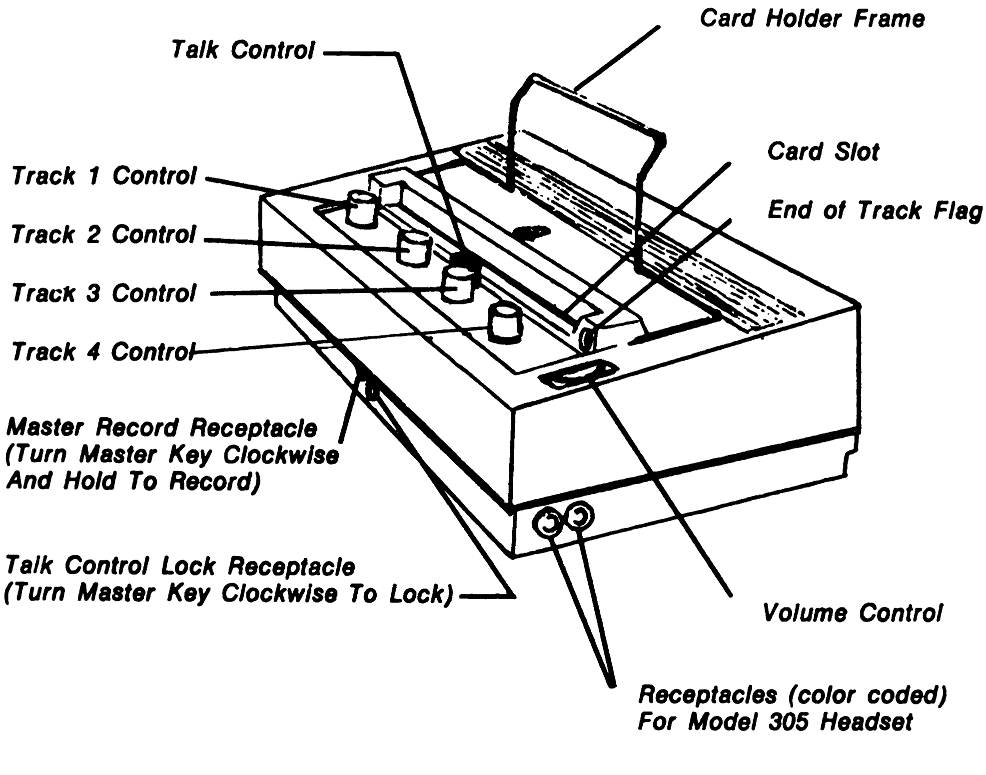
Treatment	Location	Student's Number	Naming	MFM Pretest	MFM Post-test	MFM Gain	MTF Pretest	MTF Post-test	MTF Gain
3	F	1 4	1	2	5	3	2	6	4
3	F	1 5	4	4	6	2	4	8	4
3	F	1 6	5	4	6	2	4	7	3
3	F	1 7	0	1	3	2	3	6	3
3	C	1 8	1	4	6	2	2	6	4
3	C	1 9	0	6	8	2	6	8	2
3	C	2 0	0	5	7	2	4	7	3
3	C	2 1	3	3	5	2	8	8	0
3	C	2 2	2	6	7	1	6	8	2
3	C	2 3	0	4	4	0	2	6	4
3	C	2 4	2	5	7	2	7	8	1
3	C	2 5	1	6	5	-1	5	7	2
3	C	2 6	4	5	7	2	7	7	0
3	C	2 7	2	5	6	1	5	7	2
3	C	2 8	1	2	5	3	2	5	3
3	C	2 9	0	3	4	1	5	6	1
3	C	3 0	0	1	5	4	5	5	0
3	C	3 1	2	3	6	3	5	8	3
3	C	3 2	1	2	2	0	0	2	2
3	C	3 3	2	2	6	4	4	7	3
3	C	3 4	1	3	7	4	3	6	3

APPENDIX G

ILLUSTRATION OF AUDIO FLASHCARD READER

APPENDIX G

ILLUSTRATION OF AUDIO FLASHCARD READER



Model 101M Audio Flashcard Reader