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ABSTRACT

This study was designed to determine whether subjects who received one of three treatments of color cues in an instructional program differed significantly on three learning tasks. Subjects were randomly selected from the kindergarten populations of two Michigan public schools and were assigned to one of three treatment groups. Eight letter-like figures were presented to the 102 subjects in one of the three treatments: no color, maximum color, and maximum color added and then vanished. Subjects were pretested on the ability to match the figures to form and to match the figures from memory. Following the completion of a teaching sequence, subjects were posttested on the ability to match the figures to form, to match the figures from memory, and to associate a meaningless trigram with each figure. The results indicated that the vanished color treatment was significantly better than the no-color treatment. From the results it was concluded that the vanished color treatment enhanced the learning of visual discrimination, visual memory, and paired-associate tasks when compared to the no-color treatment and that this enhancing effect seemed to result from improved attention to the distinctive feature of a stimulus. (WR)

The use of color cues to focus attention in discrimination and paired-associate learning.

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SUMMARY

This study was designed to determine whether subjects who received one of three treatments of color cues in an instructional program differed significantly on three learning tasks. 102 randomly selected subjects from the kindergarten populations of two Michigan public schools were assigned to one of three treatment groups. Four letter-like figures and their left-to-right or up-to-down transformations were selected for use in the study. These eight figures were presented to the subjects in one of three treatments: (1) no color added to letter-like figures, (2) maximum color added to the letter-like figures, and (3) maximum color added and then vanished from the letter-like figures.

Subjects were pre-tested on the ability to match the figures to form and to match the figures from memory. Upon completion of a teaching sequence, subjects were post-tested on the 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 basic skills should be designed to focus attention on salient features of the stimuli.

INTRODUCTION

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

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 (Blair & Ryckman; Popp, 1968; Gibson, et.al, 1962; Davidson, 1935; Asso and Wyke, 1971).

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.

STATEMENT OF THE PROBLEM

This study was designed to provide data regarding the effect of adding a single hue vanishing color cue to emphasize or highlight distinctive features of letter-like figures in an attempt to facilitate visual discrimination and recognition of these figures. Specifically, the attempt was made to determine what effect, if any, adding color highlights to selected features of the figures had on the performance of young children in three separate learning tasks; a paired-associate task, a visual memory task, and a visual discrimination task. Of further interest was whether a gradual vanishing of these added color cues significantly improved student performance when compared to students receiving continued color cues, and students receiving no color cues.

BACKGROUND TO THE PROBLEM

Williams (1970) 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? 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 task.

Color previously has been used in a variety of ways, but the most common use of color has been as a contextual cue within 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.

The results of early research on the use of color as a contextual cue (Dulsky, 1935) seemed to support the theory posited by Guthrie and Smith (1921) and by Hull (1943), that responses can become associated not only with the primary stimuli but also with the context stimuli. Weiss and Margolius (1954) confirmed the position that context stimuli aids retention of learned responses and offered the explanation that context stimuli becomes a distinguishing feature upon which to base discriminative responses and color also acts to reduce intralist similarity. In attempting to define the use of color cues, Otto (1967, 1968, Otto and Cooper, 1968) designed a series of research studies employing color cues in varying c ons. Commenting on the effect of the use of multiple hue color cues Otto concluded that, "they appear better than no cues at all...". Color cues seemed most potent when the stimuli presented had high intralist similarity but other cues were of equal or greater potency; e.g. order of presentation and meaningfulness (Otto, 1967; Newman and Taylor, 1963; Underwood, et. al. 1962).

If color cues do facilitate learning, color might be applicable in beginning reading. Attempts to employ color cues in functional applications by a number of researchers, however, have generally failed to support this hypothesis. Schutz (1964) and Hall and Caldwell (1970) developed training programs for discriminating between the letters b and d. They presented the letters in separate colors and attempted to fade these cues. The subjects responded on the basis of the color rather than the printed form and attempts to fade the colors were largely unsuccessful. Washington (1968) had similar problems while attempting to teach Head Start children to name alphabet letters highlighted in a variety of colors. While Taber and Glaser (1962) reported the development of a successful program using color cues in teaching the color words to second graders, a replication of this study by Duell and Anderson (1967) was unsuccessful with younger subjects. Duell and Anderson concluded that the older children are perhaps more "word-wise" but, nevertheless, children could successfully complete the program with few errors without learning the ultimate task intended.

In the studies reported the students often associated their responses with the color cue rather than the printed stimulus. This points out an important problem with the use of added cues; that is, how do we force the subject to attend to each of the stimuli? If the subject uses only the printed stimulus, he is not utilizing maximum information and if he uses only the color, the response is based on irrelevant information since color is not present on the transfer task. Further, if the response is based on the color cue, color then becomes the primary stimulus and attempts to fade that cue will be unsuccessful. These results were predicted by Sunderland and Wickens (1962) who advised that precautions 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. In this regard, Samuels (1968) designed a study to answer the question: "If the learner focuses his attention on color and not letter shape, what happens when the color cues are removed?" Subjects were presented with four artificial alphabet words which were paired with common three-letter nouns. The subjects were assigned to groups in which the stimulus words were classed as high, medium, or low similarity. Throughout the learning trials, one stimulus in 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, at 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' data provide interesting material for analysis. One writer interpreted it 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. (Hemphill, 1971)

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 cue and color applied inappropriately may be detrimental to learning. The problem is determining when color is appropriate.

Some answers have been provided by researchers in the audio-visual field who offer guidelines for the use of color. Hoban and Van Ormer (1950) concluded that color must not be so potent as to draw the learner's attention away from important cues. Miller (1957) 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. Black (1967) concluded that color cues must not only be relevant or emphasize relevant cues but, that they must also not distract the learners attention from important cues. Anderson (1967) offers a similar conclusion and further states that if the prompting stimulus is of such a nature that it allows the subject to ignore the primary stimulus during learning, transfer may never take place.

Past research provides us with some guidelines for employing color. Color must be relevant, it 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 structured to include a procedure which will eliminate color cues prior to transfer.

Related research has attempted to clarify the roles of attention, distinctive features, and color cues in discrimination and paired-associate learning. It has been demonstrated that poor readers and children who had difficulty with the tasks of visual discrimination were inferior in their ability to attend to and identify distinctive features of letters and words. (McAnnich, 1969; Anderson and Samuels, 1970). Both Smith (1971) and Stott (1973) are of the opinion that this 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 (1968) suggested that, to improve a child's ability to make visual discriminations, it is necessary that the child learn to identify the distinctive features of the stimuli. Such research has demonstrated that some children are more successful in identifying distinctive features of stimuli and that some children know how and where to focus attention while others apparently do not. The question now 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?

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. The single color could perhaps assist the student in his visual search for the distinctive feature of a stimulus. A single hue color cue would serve to highlight the distinctive feature without becoming a discriminator. When color can no longer provide a sole basis for making discriminative responses, vanishing that color should be much easier. While it has been shown that color can sometimes enhance learning, the role of color cues is nebulous. This study was designed to clarify that role and to evaluate an instructional program employing single hue color cues.

DEFINITION OF TERMS

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.

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

*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 reudction of the area of color.

PROCEDURES

In an attempt to determine the effect of the color cues, this study employed three treatment groups. The first group entered a program sequence in which the visual stimulus figures were presented black-on-white without added color cues. The program sequence for the second group employed black stimulus figures with continued 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 black-on-white stimuli. Verbal instructions remained constant between groups in an attempt to evaluate the effect of the treatments of color.

Fifty-one kindergarten children from a rural elementary school and a like number from an urban elementary school 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.

Stimuli. The stimulus figures were selected from a group of figures developed and used by Gibson et al. (1962). These figures were developed to provide stimuli which were similar to letters in English orthography but which would eliminate the influence of previous experience with the stimuli. While Gibson generated a number of letter-like figures, as well as twelve transformations of each figure, only four figures were employed in this study. Each of the four figures was 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. These transformations were chosen since research indicates these are the most difficult for young children to differentiate. Figure 1 presents each stimulus figure with the selected transformation.

Insert Figure 1 about here

The stimuli were printed in black on white 2" X 2" cards for the program sequences. The pre-test and post-test sheets were printed in black on standard white paper. 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.

The consonant-vowel-consonant (CVC) trigrams paired with each figure were selected from a group developed by Archer (1960). Each pair of CVC trigrams was randomly assigned to pairs of stimulus figures. The trigram pairs were taken from two lists and matched for percentile of association value as determined by Archer. Only trigrams having an association value of 25 percent or less were used.

Apparatus. The flashcard reader employed in this study was model 101 produced by Electronic Futures Incorporated. 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". A strip of recording tape is affixed to the back of the card providing 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.

The Program Sequence. The total program sequence, including the introductory trial, consisted of 72 audio-flashcards. While total time for program completion varied, average time from beginning to end was approximately 10-12 minutes. 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 throughout the program sequence. Appendix A presents a single stimulus figure illustrating the condition for each treatment group.

Each subject was presented with an introductory sequence. This was provided to familiarize subjects with the operation of the machine and procedures to be followed during the experiment. Unhighlighted figures were presented to all subjects with the appropriate trigrams. Subjects were asked to repeat the trigram. If the pronounciation was incorrect, they were corrected by the experimenter.

Each figure was presented eight times following the introductory trial. The pairs of figures were randomly ordered throughout these presentations but with the sequence remaining constant for all groups. Random ordering was effected to negate the effects of serial learning.

The first sequence of trials following the introductory sequence was a learning trial. Learning trials presented the trigrams associated with the figures, directed the subject to attend to a particular feature of the stimulus figure and to repeat the name on that figure.

The seoncd sequence of trials was a test trial. The subjects were asked to recall the names of the figures. Subjects were then directed to push a second button to check whether the 'name' supplied was correct or to find out the 'name' if no response occurred. Throughout the remainder of the program sequence, learning and test trials were alternated, with the final trial serving as the post-achievement measure for the Naming task.

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.

Identical forms were used in administering the pre-test and the post-test. These forms were constructed following a model proposed by Smith (1967). He suggested that, "foils be selected so that recognition of the unit must be based upon unique characteristics." Thus, each form contained the correct figure, the 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 the correct answer was randomly determined.

STATISTICAL PROCEDURES

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

RESULTS

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

Insert Table 2 About Here

For the treatment effect, 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.

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. 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. That is, there was no significant interaction effect between the variables treatment and school on any of the three dependent variables.

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. Thus, 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 analysis 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 basic tasks. In contrast to previous studies using multiple hue color cues, a vanished single hue color cue 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 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 minimal 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 elementary classrooms, it is not unusual for a number of children to experience difficulty, 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.

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

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APPENDIX A

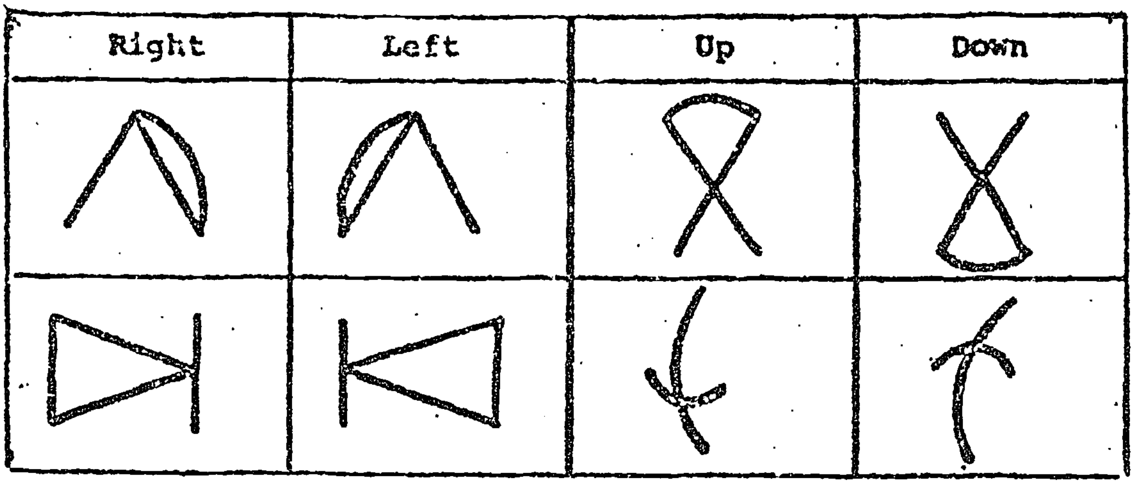


Fig. 1.--The Four Letter-Like Figures and Their Transformations Selected for the Study.

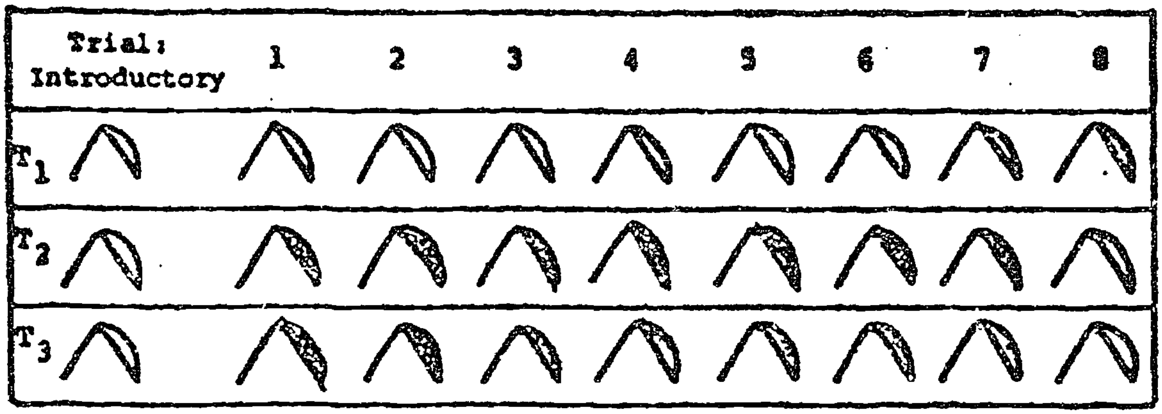
TABLE 2.--A Multivariate Analysis of Covariance on Three Dependent Variables: (1) the Match to Form Post-test, (2) the Match from Memory Post-test, and (3) the Naming Task.

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

*$p < .0001$.

APPENDIX A

= Color Highlighting



Style of Color Highlighting Used for Each Treatment Group.

Notes: T_1 = no color

T_2 = maximum color

T_3 = vanished color.

APPENDIX B

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 Cogy Community School.

Cedar Springs (CA) = 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.

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

Fig. 2.--Number of Subjects per Cell for the Treatment Effect.

Flint	n = 51
Cedar Springs	n = 51

Fig. 3.--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. 4.--Number of Subjects per Cell for the Treatment X School Interaction Effect.