1-1-1971

Eye movement preferences as individual differences in learning from color and non-color pictures.

Juan Pedro Cabán
University of Massachusetts Amherst

EYE MOVEMENT PREFERENCES AS INDIVIDUAL DIFFERENCES IN LEARNING FROM COLOR AND NON-COLOR PICTURES

A Dissertation Presented

By

JUAN PEDRO CABÁN

In partial fulfillment of the requirements
of the Graduate School of the University of Massachusetts
for the degree of

DOCTOR OF EDUCATION

December 1971

Major Subject: Educational Communications:
Media and Technology

EYE MOVEMENT PREFERENCES AS INDIVIDUAL

DIFFERENCES IN LEARNING

FROM COLOR AND NON-COLOR PICTURES

A Dissertation

By

Juan P. Caban

Approved as to style and content by:

(Chairman of Committee)

(Head of Department)

(Member)

(Member)

(Member)

December 1971

A mis padres Ana María y Juan Pedro

A mi esposa Braulia

Y a nuestros hijos

Juan Federico y Ana Isabel

En agradecimiento a su inspiración

ACKNOWLEDGEMENTS

This study was made possible by the assistance and cooperation of many people. Deep and lasting appreciation is extended to Dr. David G. Coffing for serving as Chairman of my doctoral committee, and for his encouragement and aid during the most difficult stages of the study. Special appreciation is expressed to Dr. Thomas E. Hutchinson for his critical reading, and helpful suggestions on the manuscript. A sincere note of gratitude is extended to Dr. Daniel C. Jordan for his cheerful and efficient service as Chairman of the Guidance and Comprehensive Committees, and for his constant support and assurance throughout the doctoral program. To Dr. Raymond Wyman, my sincere appreciation for his support and counsel.

In addition, I am indebted to Mr. Kenneth McKown. Without his dedication and skillful contribution to the design and construction of the eye movement apparatus, there would not have been any data to analyze.

The sustained patience and support of my wife, Braulia, and our children, John Frederick and Anne Elizabeth, are acknowledged deeply. Without their understanding, sacrifice and love, this study would not have been possible.

Finally, a humble thanks to those who wished me well and who had confidence in the outcome of my efforts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Individual Differences and Aptitude-Treatment Interaction. A growing awareness exists among educational experimenters that an educational outcome must be viewed as some combination of individual differences or aptitudes and instructional programs. It has been suggested by Gagné (1964) that individual aptitudes must be ranked among the most important independent variables in the study of complex learning. One of the first to suggest a methodology to deal with individual differences and instructional programs was Cronbach (1957) who in his American Psychological Association presidential address encouraged psychologists in experimental and correlational disciplines to combine their interests and methods, to observe experimental effects for subjects of different characteristics, and to conduct investigations to find aptitude-treatment interactions (ATI). The goal of research on ATI is to find significant disordinal interactions between alternative treatments and individual variables, i.e., to develop alternative instructional programs so that optimal educational payoff is achieved when students are assigned on the basis of their characteristics to different alternative programs. The individual variables in ATI research are defined as any measure of individual characteristics, e.g. attitudes, psychological and

physiological measures, abilities, preferences, skills, attributes, etc.

Given a common set of desired outcomes, some students will be more successful with one instructional program and other students will be more successful with another instructional program. Consequently, a greater proportion of students will attain the instructional objectives when instruction is differentiated for different types of students. An idealized model is represented in Figure 1.

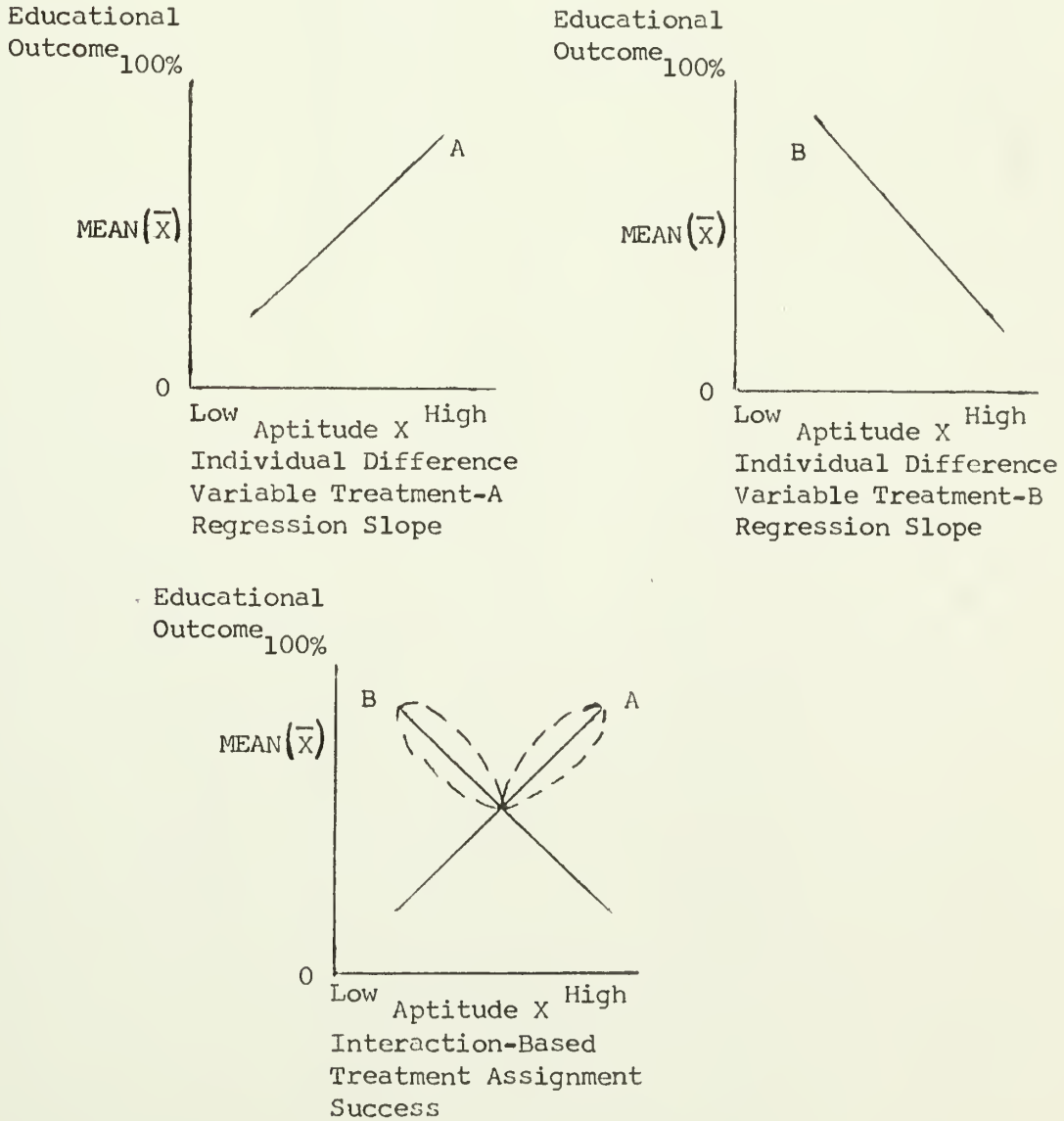


Figure 1 Model of Aptitude-Treatment Interaction

Purpose of the Study

One of the important tasks in education is to create conditions that produce efficient learning for individuals alone and in groups. There are numerous possible ways of increasing the efficiency of individual learning, one of which may be that of presenting the visual part of audio-visual materials pictorially rather than in print in a learning situation. Alternate ways of presenting the visual component may be related to individual differences in learners according to the way they process incoming information. To explore the above question, this study was designed to examine the effectiveness of color and non-color (black-and-white) pictures in a paired-associate (PA) efficiency of learning audio-visual presentation by subject characteristics. It, furthermore, explored the use of eye movement technology as one component of the examination of subject characteristics.

In general, studies on the effectiveness of color in instructional settings have rarely looked at individual student preferences for color visual presentations. This study used individual preferences as expressed by eye movement fixations when subjects were given a choice between color and non-color presentation as one important set of predictors of learning efficiency. Specifically, eye movement fixation patterns were used as indices of preference between simultaneously presented color and non-color visual displays of objects accompanied by an object labeling and relating audio channel.

This study assumed that eye movement analysis would provide the basis for differentiation of subjects in terms of developed preference for color and non-color visual presentations by quantifying the

behavioral resultant of sensory control over visual intake of information to be learned and that these quantifications could then be used to predict differential success based on learner characteristics with either presentation mode in the standard PA learning situation used.

Survey of Literature: Intake and Processing of Information

Studies by Norman H. Mackworth (1968) and A. L. Yarbus (1967) have demonstrated the effectiveness of eye movement technology for obtaining information on visual strategies reflecting subject attention. Jane F. Mackworth (1970) with regard to attention, states:

> The concept of attention has recently returned to favour in psychological and physiological research. It is acquiring not only a qualitative but even a quantitative aspect, with the borrowing of the idea of capacity from information theory, biology and physics. The animal or human is more than a stimulus-response machine; he actively searches for and selects those stimuli that are important to him and he increases their impact by a whole range of physiological and psychological processes. (J. F. Mackworth, 1970, p. 13)

Treisman (1966) has reviewed the research which lead to the integration of information theory, expectancy, and attention in the Broadbent (1958) filter model, for selective attention. Broadbent's theory posits a receptors stage, a short-term storage bank, a filter for information selection, and a limited capacity single channel for serial information transfer into long-term storage. Travers (1966) further adapted the Broadbent model for the purpose of designing audio-visual materials. A representation of this information-processing model is shown in Figure 2.

The model is an attempt to represent the operations which appear

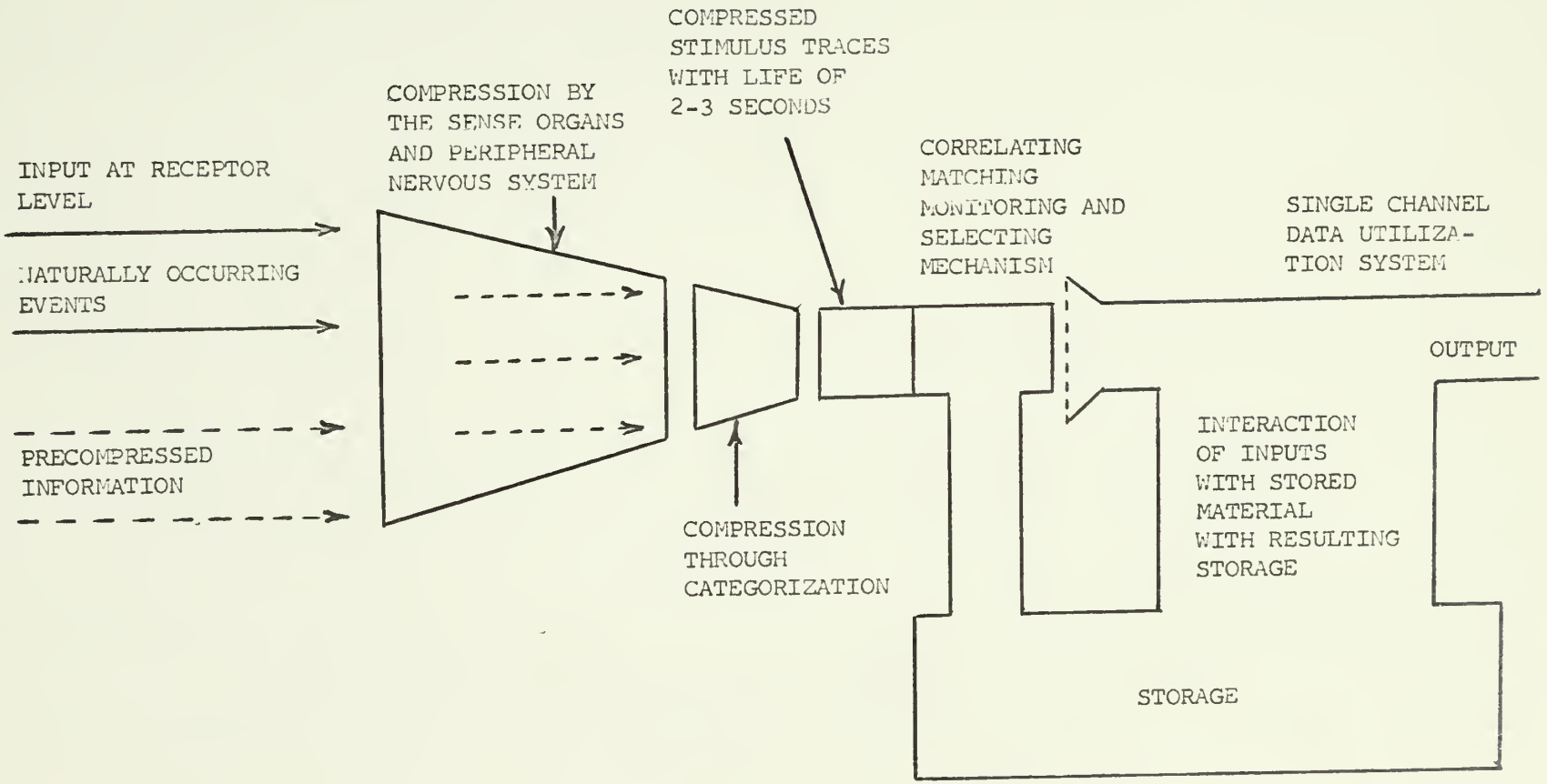


Figure 2 Travers' (1966) information processing model derived from a model developed by Broadbent (1958).

to be performed on incoming information from the time of entry through the receptor organs to the time when the information fades from the system, or is used to make a decision relative to action, or is relegated to storage.

Concerning the compression or filter process, Travers outlines the situation as follows:

> The compression process involves the retention of that information which is the more critical to the receiver and the discarding of the less critical information: it is exemplified by the use of black-and-white line drawings representing full-colored natural phenomena which have a wealth of detail which the line drawing omits. Very little is known about the effect of precompressing information either on the learning process itself or upon the ability to transfer what is learned to subsequent situations which involve a larger number of irrelevant cues. (Travers, 1966, p. 4)

Another way of looking at the filter process is that of Miller, Galanter and Pribram (1960). In their model, derived from neuropsychology, the organism creates and stores for future use neural models or "plans" of the world as perceived. These models or plans in the organism are recalled upon receipt of new stimuli. The new perceptions are compared to the stored model or plan "templates" and perceptions are altered in reference to the quality of fit expectation of the organism.

J. Mackworth (1971) has developed a model for the reading process which is derivative of the Broadbent and Miller et al. models which integrates auditory, visual stimulus and eye movement. (See Figure 3.) The model assumes that there must be precise "models," "traces" or records corresponding to a vast number of incoming patterns of neural changes, and a retrieval system so efficient that it can match an event

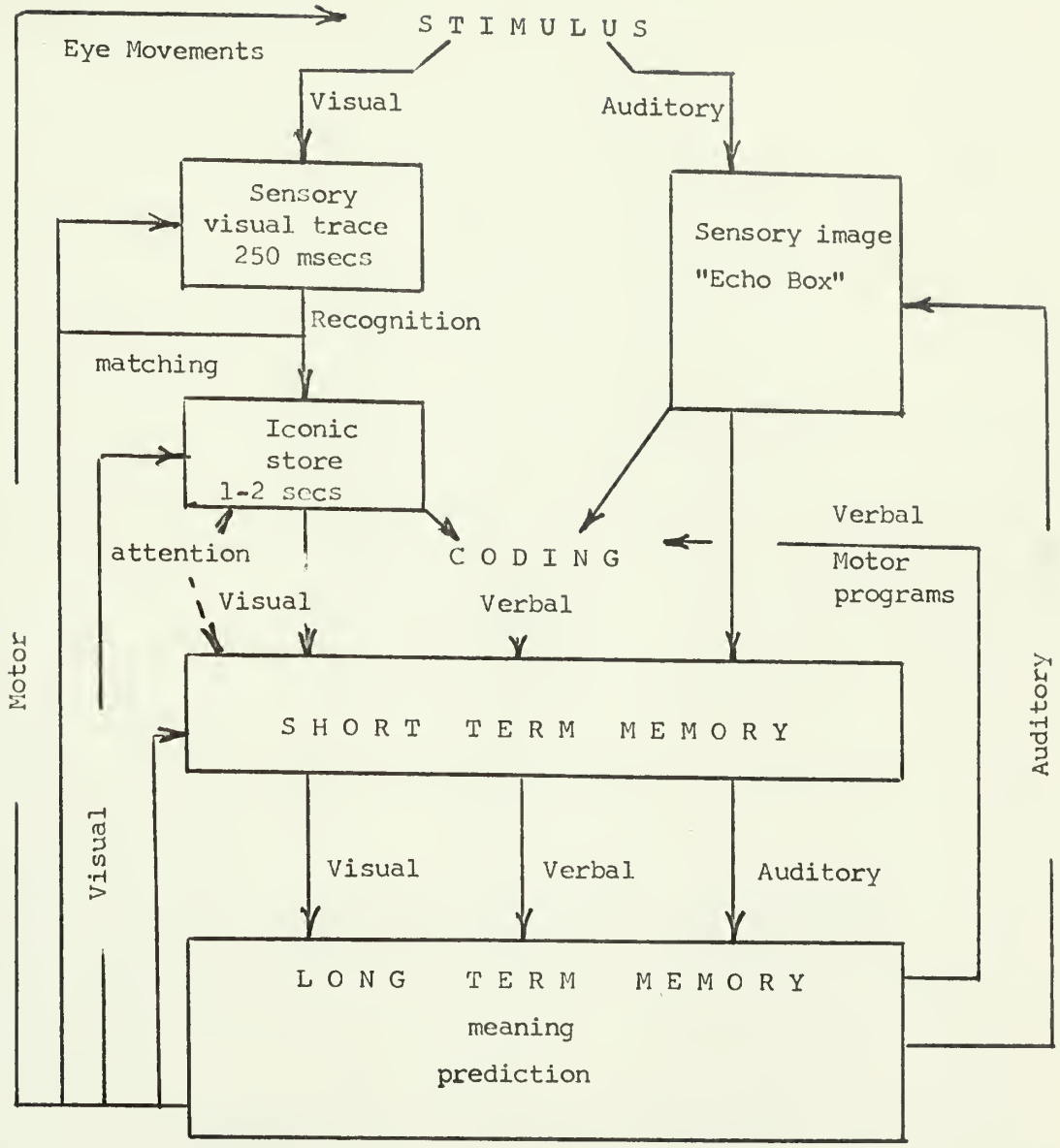


Figure 3 J. Mackworth's model of reading process

to its record quickly. "All this may occur within a tenth of a second, so that the final neural responses to a particular event are damped or augmented while messages travel throughout the body to bring about a state of alertness, if necessary." (J. Mackworth, 1970, p. 184)

Increasingly the psychological models and flow diagrams are being linked with the underlying physiology of the nervous system, thereby clarifying the process of gaining and controlling attention. Gagné (1969), focusing on the process as it refers to learning, states:

> Whatever stimulus objects are to form part of the learning event, whether they be actual objects, pictures, symbols, or words, they must have an initial registration effect in order for learning to occur. Essentially this means that they must be perceived, or coded, in some way that makes it possible for them to mediate the neural events necessary for learning. (p. 101)

Yarbus (1967) points out how the process of registration can be monitored with regard to visual displays.

> Records of eye movements show that the observer's attention is usually held only by certain elements of the picture. As already noted, the study of these elements show that they give information allowing the meaning of the picture to be obtained. Eye movements reflect the human thought processes; so that the observer's thought may be followed to some extent from records of eye movements (the thought accompanying the examination of the particular object). It is easy to determine from these records which elements attract the observer's eye (and, consequently, his thought), in what order, and how often. (p. 190)

Survey of Literature: Color vs. Non-Color

Experimental results in the use of color in visual presentations are confusing. Long (1945), using fifth, sixth, eleventh and twelfth grade students, found color film to be superior in "acquisition and retention" in the fifth, sixth and twelfth grades. In the eleventh grade black-and-white film was superior in "acquisition," but color film superior in retention."

Vandermeer (1952), using high school students, found no differences between color and black-and-white films in an immediate test of student learning after viewing films but did find a difference in a retention test in favor of color film.

Zuckerman (1954), using Air Force pilots, found no significant differences in learning from color film and black-and-white filmstrips made up of pictures from the same film.

Kanner (1960), using Army Signal Corps trainees, investigated color and black-and-white television in eleven different subject matter areas and found no significant differences in learning between the two versions in 10 out of 11 comparisons.

Link (1961), using three groups of ninth-grade students, found no significant differences in learning between color film projected and black-and-white films via television. The third group that saw both versions did learn significantly more than the other groups.

May and Lumsdaine (1958) reported a study in which fifth-grade pupils learned as much from a crude black-and-white film based on a story board as they did from the finished color film.

Utz (1968) stated that, although color may have an effect when it interacts with other variables, color alone does not increase the rated perception of reality.

Dwyer (1967), using an identification test, found that shaded color drawings were more effective than realistic color drawings or color photographs.

Chan et al. (1965) found that more was learned via the visual channel with "color embellished" condition, although the overall amount

learned did not differ significantly from the amount learned under the black-and-white condition.

McLean (1965) reported that legibility was found to increase as contrast value increased, suggesting color should be considered in its application as a coding technique in complex system displays.

Child (1968) found a consistent preference by males for cool hues and high saturation, whereas females preferred lighter colors, and for both, increasing age was related to a decreasing preference for high saturation. Chen and Wang (1965) found that preschool children were more uniform in their ranking of color preference than university students, the order of preference being red, blue, green, and yellow. Tampieri (1968) reported that there is an increasing preference for form over color, especially after four years of age. Interestingly, Parson (1968) found that in a paired-associate learning experiment undergraduate slow learners consistently ignored the random shape to which instruction specifically directed them and selected instead the context color as the functional cue.

A review of the literature by Otto and Askov (1968) related the function of color in learning, examined the rationale for the present application of color in instructional materials, and considered the implications of the use of color as an aid to learning. They made the following three points:

> (1) It is not possible to prescribe the use of color cues in instruction, until the interaction among a variety of cues with diverse populations is clarified.
> (2) Color is presently being used in instructional materials as a vehicle for carrying basic information although there have been no real attempts to apply research results regarding the cue value of color learning to instructional

materials.
(3) The cue value of color appears to be nebulous, being dependent upon the availability of a variety of other more potent cues. (p. 162)

In summary, the implications of the use of color vs. non-color materials in instruction have not been clearly established.

Origin of This Study

In part, this study replicated Coffing's (1971) methodology and procedure. Coffing used the PA learning materials developed by Rohwer (1967) and obtained stronger results than Rohwer's in the same direction. Both studies showed that the presentation of pictures of objects was significantly more effective than the presentation of printed names of the objects for subjects in the learning situation.

Rohwer's experiment was designed to assess the effectiveness of different audio-visual presentations in a paired-associate efficiency of learning paradigm with 96 third- and 96 sixth-grade children. The visual stimuli were either pictures of objects or the printed names of the objects and were simultaneously presented with a redundant sound track labeling the objects in a sentence structure such as "the bat strikes the ball."

The amount learned was measured in terms of the total numbers of correct responses given. The mean numbers of correct responses were presented in a four-way analysis of variance table. Here the main effect for grades was not significant nor was the expected interaction of grades with materials. Clearly, however, learning was more efficient with pictorial than with printed materials in both grades ($p < .01$), so much so that more than 32 percent of the total variance was associated

with this factor.

Coffing, using Rohwer's visuals, with 40 high school students, presented via an eye movement apparatus, found a significant main effect for picture vs. print presentations ($p < .001$). Effects were examined by a two-way analysis of variance with repeated measures using order and mode of presentation as the two independent variables. Thus, Coffing confirmed Rohwer's argument that pictorial supported audio-visual associative learning is superior to printed word supported audio-visual associative learning. He attributed his stronger results to increased control of extraneous variables.

The present study, taking success with pictures found by the above studies as its point of departure, is a further investigation of the possibility of differential efficiency of learning rates from color vs. non-color visuals.

Hypotheses of the Study

Hypothesis I: In a synchronous audio-visual presentation, learning will be facilitated more by color picture than by non-color picture.

This hypothesis follows from studies that indicate that color aids in ordering and differentiating visual presentations, thus providing more visual cues and thereby facilitating learning.

Hypothesis II: The interaction of presentation mode preferences, as expressed by eye fixation variables, and presentation mode conditions on learning scores should be significant. That is, the pictorial preference as defined by fixation time should be positively related to performance under color pictorial treatment and negatively related to

performance under non-color pictorial treatment. The reverse is predicted for non-color pictorial preference.

This hypothesis follows from the previous argument that eye movement fixations are indicators of presentation mode preferences that developed from past experience with such modes. This hypothesis implies non-parallel regression slopes although, considered with the first major hypothesis, not necessarily disordinal slopes within the scale range of the measurement instruments.

Hypothesis III: a) Prediction of learning success will be facilitated by the addition of eye movement variables to more conventional ability predictors; and b) Prediction of learning success will be facilitated by the addition of color card preference choices to other ability predictors.

This follows from the general strategy of prediction improvement by inclusion of new variables not related to other predictors yet related to criteria. As an exploratory hypothesis, it will test the value of eye movement instrumentation, analysis of picture variables, and color card preferences for learning under color and non-color presentations.

General Research Strategy: This study uses a theory modification approach as a reference for the hypotheses. That is, the hypotheses cannot be proven true; they can only be proven false or not be proven false. If the hypothesis is not proven false, under the theory modification approach, knowledge is generated on the basis of replicability; if the same thing happens every time a statement is tested, it is shown not falsifiable and becomes knowledge (to date) through replicability

confirmation. However, one contrary instance is enough to disprove the hypothesis; consequently, if the hypothesis is proven false, modification of the theory is necessary to deal with the instance when the hypothesis is proven false. The modified hypothesis is then submitted to test. This logic is common to the physical sciences and is now being applied to the behavioral sciences.

Definition of Terms

Efficiency of Learning. The performance of subjects on tasks that principally demand immediate PA recall rather than the recall of what has been learned in the past is termed efficiency of learning. The strength of the efficiency of learning alternative paradigm is that the assumption of equivalent previous opportunity for learning is unnecessary. Its weakness is that any single learning task must necessarily be quite specific and not representative of the wide range of learning activities demanded in school. (Rohwer, 1966, p. 10) The present experiment used 32 paired-associated (PA) visual presentations in the study-trial format from which were derived efficiency of learning scores.

Conventional Tests (paper and pencil). Standardized tests sampling a broad range of the kinds of demands made by school learning tasks are generally administered in a written form requiring a written response. In this experiment seven tests from the Educational Testing Service, French, et al., Kit of Reference Tests for Cognitive Factors (1962) were used.

Eye Movement. "The human eyes voluntarily and involuntarily fixate on those elements of an object which carry or may carry essential and

useful information. The more information is contained in an element, the longer the eyes stay on it. The distribution of points of fixation on the objects changes depending on the purpose of the observer, i.e., depending on the information which he must obtain, for different information can usually be obtained from different elements of an object." (Yarbus, 1967, p. 211) In this experiment seven measures of eye movements were used.

Color Card Preference. When requested, subjects will normally indicate which colors they prefer. Such choices differ according to the subject's experience with and relation to individual colors. In this experiment eight color cards from the Lüscher Color Test Set (short form) (1969) were used from which subjects selected their preferences.

Individual Differences. "Individual differences can be interpreted as initial states which must enter into a description of behavioral change." (Glaser, 1967, p. 13) Individual differences have ". . . been defined as any characteristic of the individual that increases (or impairs) his probability of success in any given treatment." (Cronbach and Snow, 1969, p. 7)

C H A P T E R I I

EYE CAMERA TECHNOLOGY

Underlying eye movement technology are some basic properties of vision. The greatest resolution of the eye is in the fovea centralis, an area on the retina of about 0.4mm in size i.e., about 1.3^{o}. Within the fovea centralis are located about 7 million color sensitive cones varying in diameter from .002 to .007mm. The retina also contains about 130 million rods mainly associated with the mechanism of twilight vision. It is the rods and cones of the eye that convert the visual stimulus for transmission to the cortex.

The nature of vision requires that the eye stay in motion, otherwise visual perception cannot take place.

> In man under natural conditions the retinal image is never stationary relative to the retina, and if a strictly stationary and unchanging retinal image is created artificially, the eye ceases to see. In other words, within any object of perception remaining strictly stationary relative to the retina and unchanging in time, after about 1-3 sec. all visual contours disappear (the resolving power of the eye rapidly falls to zero). (Yarbus, 1967, p. 1)

Eye motion is maintained by micro and macro movements, voluntary and involuntary. Among the involuntary, imperceptible to the individual organism, are drifts, tremors, and small saccades (sometimes resembling spasms of the eyes). These movements are not of interest to this study. Among the voluntary movements are macro eye movements that relate

directly to the perception of objects--identical and simultaneous rapid rotation of the eyes, termed "saccades." "The saccades of the eyes are of high velocity (the duration of a saccade is measured in hundredths of a second) and uniform amplitude, and both eyes move simultaneously." (Yarbus, 1967, p. 103) For the purpose of this study "fixations" are defined as the process of perception taking place between any two adjacent saccades when the object of perception is stationary relative to the observer's head.

Lamansky (1869) first studied the velocity and duration of saccades. Subsequently, they have been studied, according to Yarbus, by Dodge, 1907; and by Yarbus, 1956; Westheimer, 1958; and Gurevich, 1961, among others.

The main function of saccades is to change the point of fixation, to direct the most sensitive region of the retina (the fovea) to a particular element of the object of perception. The high velocity and correspondingly short duration of the saccades usually permit the eye to remain in a state of fixation for about 95 percent of the total time. The nature of saccades is responsible for much of the refinement of perception.

> Under normal conditions, the duration of equal saccades in different observers is approximately the same; it cannot be varied at will by the observer and is determined almost entirely by the amplitude of the saccade. (Yarbus, 1967, p. 146)

Eye camera data show the number, duration, and location of eye fixations, and these data provide good indicators of attention. (Gould and Shaffer, 1967)

Thus it can be seen that by recording eye fixations and movement

patterns a measure of an observer's visual attention can be determined.

Eye Movement Instrumentation

Recording eye movement by motion pictures (Ling, 1942; Fitts, Jones, and Milton, 1949) was followed by recording the reflection of the scene in the eye to indicate visual choice. (Fantz, 1965; Zinchenko, 1963). Then Mackworth (1962) developed the basic design for an eye camera apparatus that allows the experimenter to determine the eye fixation of the subject within one-degree accuracy out of a 20° by 20° field.

Mackworth and Morandi (1967) developed an eye camera which recorded the reflection of a light off the surface of the cornea superimposed on a photographic plate on an image of the visual display being examined by the subject. Subsequently, Mackworth (1968) has developed a reflection eye movement apparatus which recorded on film eye movements and the reflection of the visual display simultaneously by a direct filming process. Figure 4 presents a Mackworth photograph.

Instrumentation. The basic eye movement apparatus of the present experiment was based upon Mackworth's reflection apparatus as refined by Coffing (1971). The present apparatus makes use of a Lecina Super 8mm camera to record the eye movements and stimuli reflections on High Speed Ektachrome film. It departs from Coffing's (1971) use of a television camera and video tape to record through a two-way mirror the eye movement. The use of direct recording with color film in this experiment reduced costs and allowed for increased discrimination of dark eyes among subjects who because of the brown component in their irises were difficult to record on black-and-white television, which is not

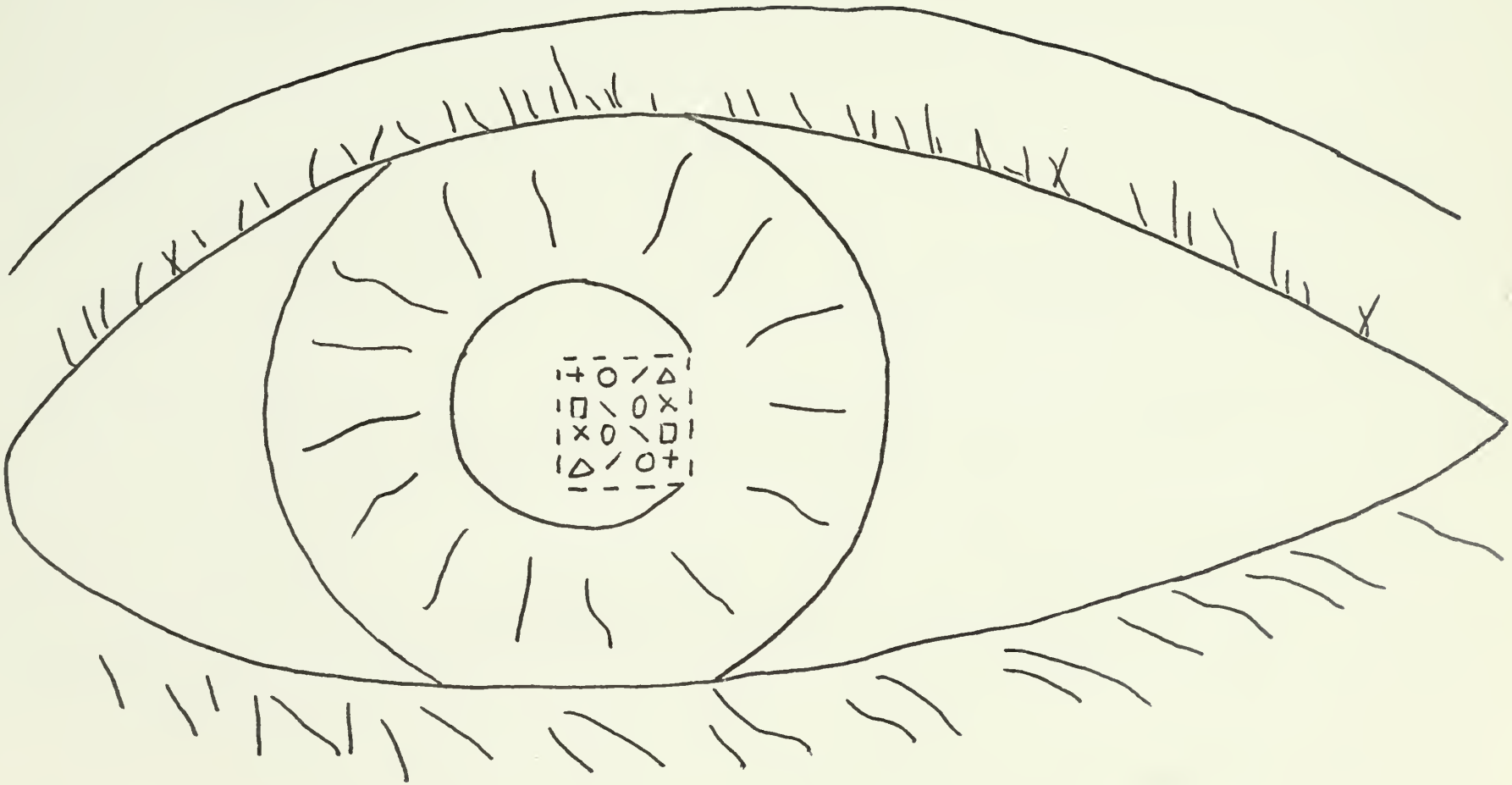


Figure 4 Drawing from photograph taken from Mackworth's Reflection Eye Movement Camera. Subject is Fixating a Square in the Visual Field.

sensitive to this color. The audio experimental presentation and the real time subject responses were recorded on a Wollensack AV tape recorder.

Fixation time was based upon frame counts of the film which was exposed at five frames per second. The various statistics for data were derived from this basic quantification. The basic categories of enumeration were as follows: the four quadrants in the visual display area, a center area equivalent to a quadrant which includes the central one-fourth of each of the four quadrants, fixation occurring outside of the visual field and frames not readable due to blinking of the eyelid.

The visual information was presented by a Kodak Carousel projector using 87 slides. The slide changing signal was derived from the second track of the stereo tape and was not dependent upon the timing mechanism of the Carousel projector. The cue track, originally prepared by Coffing, was derived from 16mm magnetic film edited to provide a precise synchronous excitation pulse through to the projector every five seconds. Accuracy in slide change intervals was better than $\pm$ .02 seconds over the five-second period. The slide change excitation pulse also advanced a counter that was superimposed (by way of a small mirror placed at the edge of the camera lens) along the left vertical edge of the visual field photographed, thus accurately defining the visual presentation then available to the subject. An additional cue for rating was made possible by the recorded visual reflection from the cornea surface of the subject's eye.

The experimental apparatus consisted then of a slide projector that projected by way of a reflection front surface mirror onto an

8 X 10 inch Eastman Kodak High Gain Screen. The subject sat looking through a binocular 30/70 two-way transmission mirror arrangement at the reflection of the screen. The Super 8mm camera photographed the right eye reflecting in the 30/70 mirror. Neither the camera and its associated apparatus nor the microphone hidden in the immediate proximity of the subject's mouth was visible to the subject. (See Figure 5.)

The audio presentation was provided by two speakers mounted on either side of the subject's head within two inches of the ears. The accoustical arrangement was similar to the open type telephone booth. This construction and the proximity of the speakers to the ears tended to mask any extraneous noises in the greater accoustical environment.

The eyes of the subject were evenly illuminated with two especially constructed 40-watt lights that included filtration of the light to reduce heat discomfort. Both eyes were illuminated, even though only one eye was being photographed, to balance the lighting and make the visible environment comfortable to the subject. The area of fixation was determined by a comparison of the relationship of the pupil-iris interface with the reflected image of the visual display from the cornea--the center of the pupil coinciding with the area fixated.

Because of the extreme magnification used on the film camera and the narrow angle of view, restriction of head movement was essential. This was accomplished by a headrest and a headstrap which held the head comfortable snug in the forehead locating headrest, thus restricting forward and back, up and down and sideways movement. No bite bar was deemed necessary, and no subjects were lost because of excessive head movement that the camera could not follow.

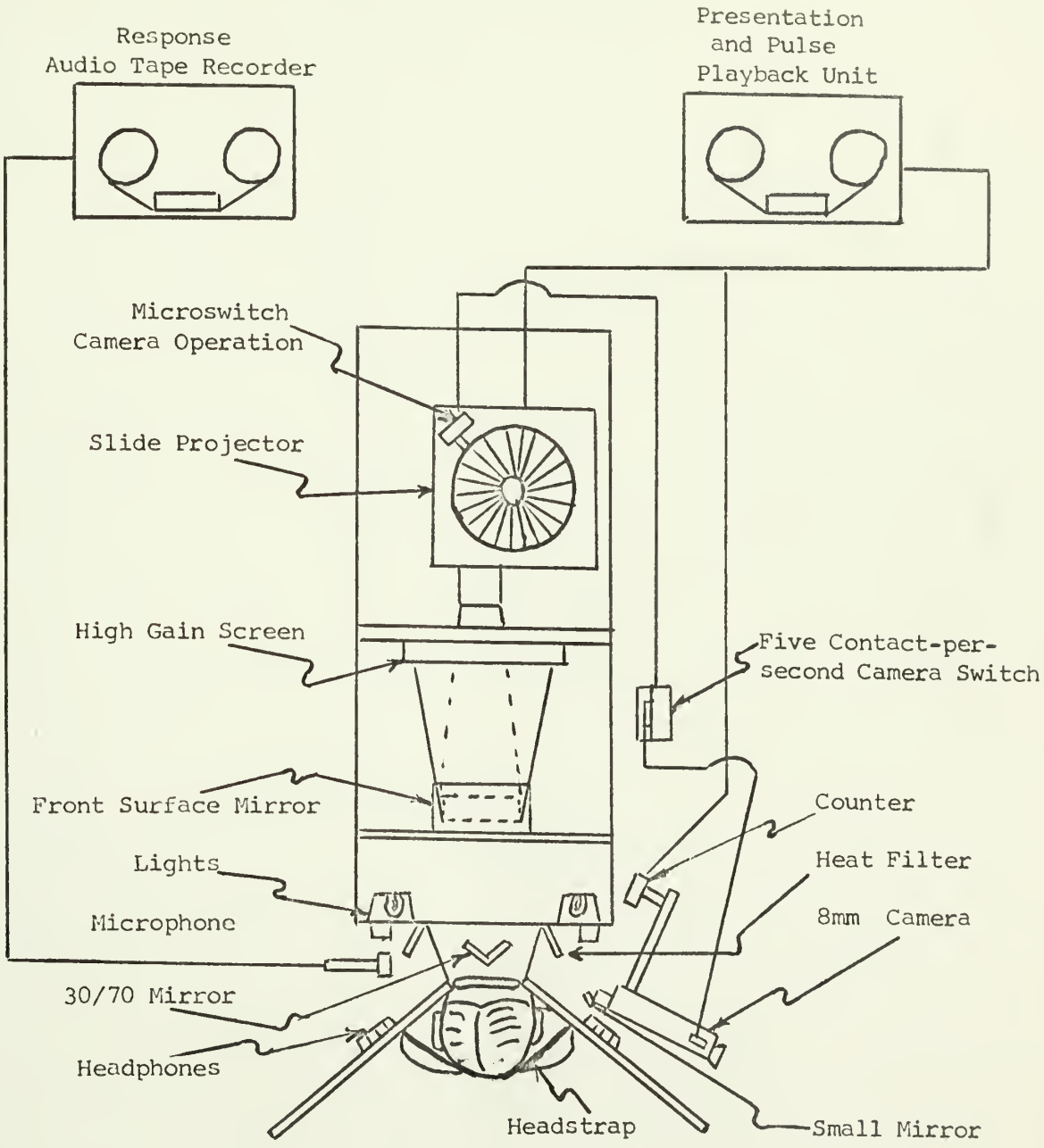


Figure 5 Eye Movement Recording Apparatus Used in this Study (Top view).

All electronics equipment was created from integrated circuits and proved completely reliable within the experimental situation. The Lecina Super 8mm camera was manufactured by Leitz. Since each procedure was seven minutes long, eight subjects were recorded on each 50-foot cartridge of High Speed Ektachrome film and ten subject presentation and oral response on each side of an 1800-foot audio tape. The film was processed by Eastman Kodak. Analysis of the data from the motion picture film was by means of a Kodak MFS 8 stop Super 8mm motion picture projector. Each frame was in turn displayed on an 11 X 14 screen and the location of the fixation area determined by the experimenter. The location of fixation was recorded on a tape recorder which was later used as the information source for paper and pencil recording onto a special form. Data recording, translation and reduction took six days to be accomplished. Several checks of rater accuracy were made, and the rater was consistent in each check.

The current apparatus was an outgrowth of Coffing's eye movement apparatus. Basic to this design was the use of two-way transmission mirrors that allowed simultaneous subject's viewing of stimuli and motion picture recording of his eye movements. Once the 30/70 mirror placement and angle were determined, and camera positioned, the necessary support features were built. The following special units were constructed: 1) a five contact per second hysteresis synchronous camera triggering unit, 2) a microswitch addition to a Carousel 800 slide projector to start camera when Pre- and Post-Learning Presentation Preference slides were projected, and then to turn off camera. Slide trays were modified to actuate a micro-switch, and 3) a pulse actuated

counter attachment for the camera. The audio tape recorders used were a Stereo Sony 630 for the experimental program and control pulses, and a Wollensak AV model for subject response recording.

CHAPTER III

PROCEDURE

Experimental Design. The experimental design is displayed in Figure 6. Each subject was presented with four paired-associate (PA) learning situations developed from materials used by Rohwer (1967) and Coffing (1971). The materials were taken directly from the list supplied by Rohwer from his Experiment 8 on sentence elaboration with verbal and pictorial materials. Rohwer based his construction on the following:

> First, a large number of high-frequency nouns was selected, subject to the principal restriction that each should be the name of an object either small enough itself to be easily accommodated in a 4 x 4 x 4 foot photographic set, or capable of being represented by a model of restricted size. Out of the entire set of nouns 24 subsets of two nouns each were formed by a process that was random except for the requirement that a meaningful, grammatical sentence of the form article-noun-verb-article-noun could be constructed for every pair of nouns. These sentences constituted the [verbal level of the presentation]. (p. 61)

A complete list of the verbal materials used appears in Appendix I.

The use of the Rohwer and Coffing materials and the Coffing procedure in this experiment facilitate comparison between the present study and the aforementioned studies.

On the screen in front of the subject were projected four groups of visual stimuli of six, twelve, twelve, and six slides each. The first and fourth sets of slides (Pre-Learning and Post-Learning

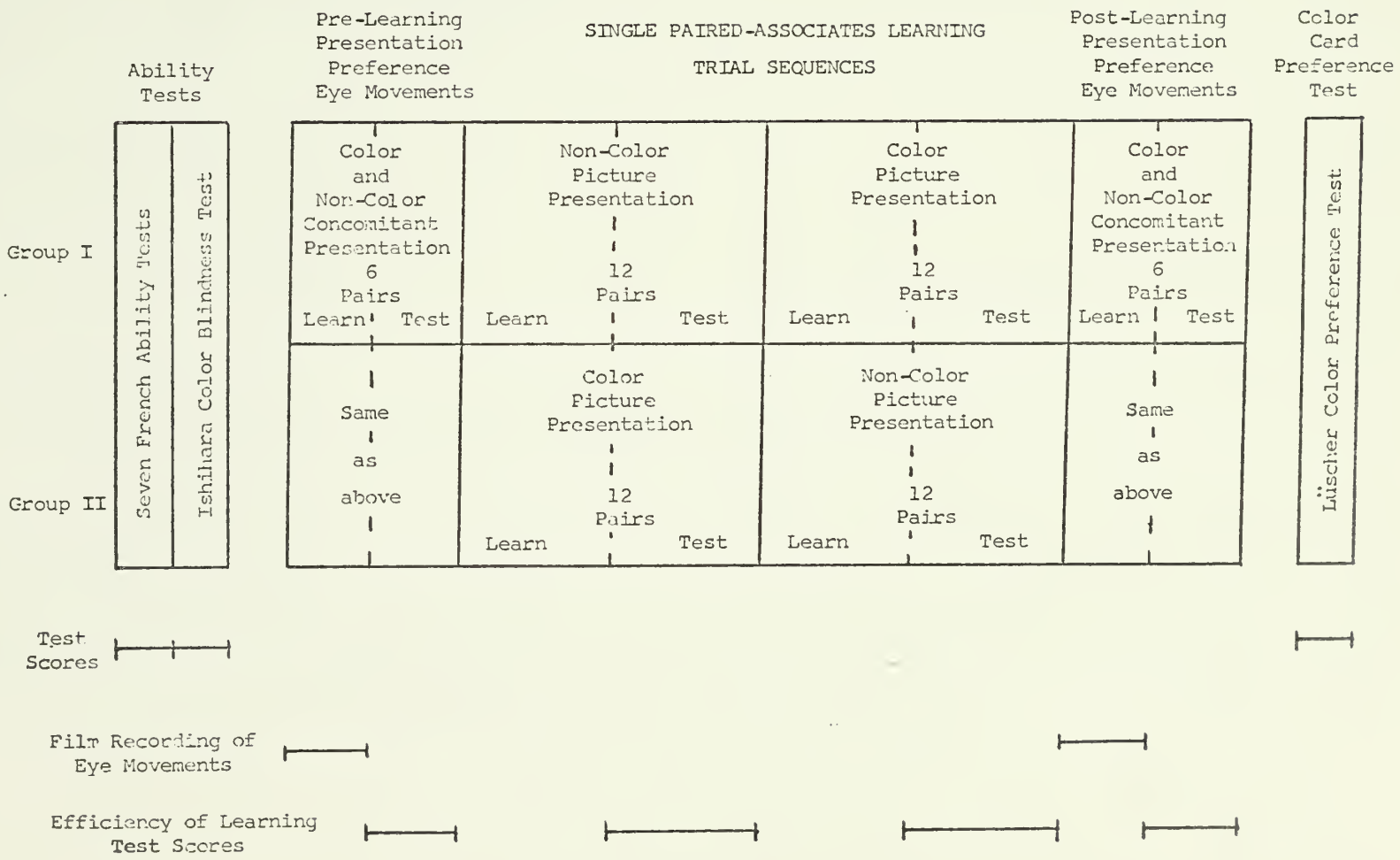


Figure 6 Experimental Design

Presentation Preference) were four way concomitant Color and Non-Color presentation preference stimuli and learning treatments (see Figure 7); the second and third sets of twelve slides (Single Paired-Associates Learning Trial Sequence) were either Color or Non-Color learning treatments. (See Figures 8 and 9.)

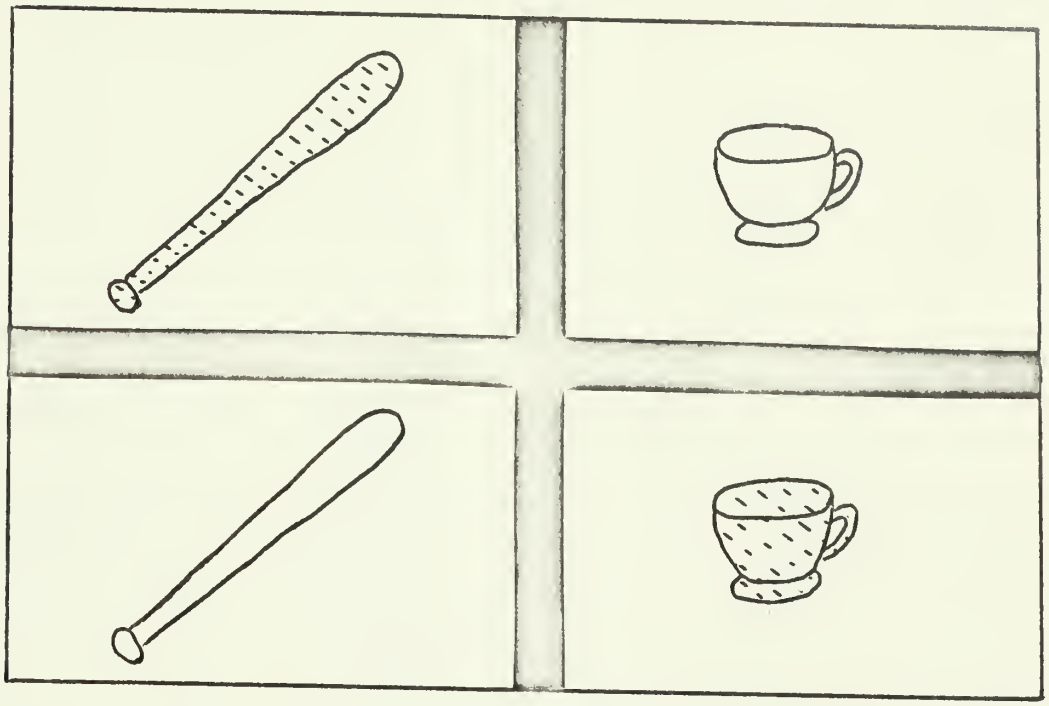
The film recording by the eye camera of the subject's eye fixations during the Pre-Learning and Post-Learning Presentation Preference Treatment served as the data source for indicators of the subject's preference for Color or Non-Color pictures of objects.

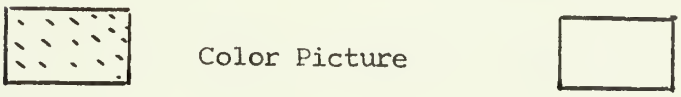
The diagonal placement of the pictures in the Pre- and Post-Learning Presentation Preference slide sets was introduced to balance the effect of the left-to-right reading tendency among American subjects. (See Figure 7 for an example.)

The visual frames for the Color and Non-Color slides were structured as in Figures 8 and 9.

In these examples the visual presentation was accompanied by an audio presentation saying, "The bat strikes the cup." In the Color picture condition the subject viewed color representations of the objects, (see Figure 8), and in the Non-Color condition a black and white representationsof the objects.(see Figure 9) At the end of each learning treatment the subject was given a randomized audio-visual test of the first object or left hand member of the pair and his oral responses as to his recall of the second or right hand member of the pair were recorded. In this example a bat and cup are used for both Color and Non-Color picture presentations; actually, in the experiment

Figure 7 Visual Frame Construction Used in Both Pre-and Post-Learning Presentation Preference Slides





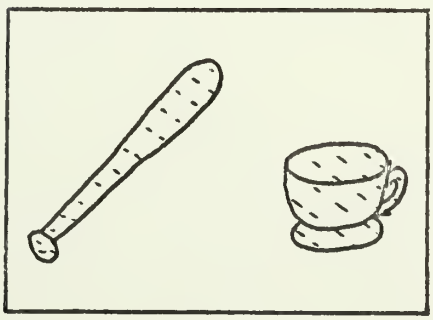


Figure 8

Paired-Associate Learning

Visual Frame: Color

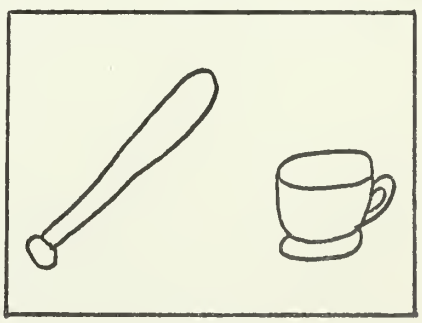


Figure 9

Paired-Associate Learning

Visual Frame: Non-Color

no visuals were used more than once. The order of presentation of the Color and Non-Color sets was counterbalanced in nested presentations to which subjects were randomly assigned.

Color and Non-Color Paired Associate Slides. The PA object pairs were photographed against a gray background with a 35mm Pentax Spotmatic camera on Kodachrome Type "A" film using Colortran Quartz Iodine lamps as illumination. Object size was maximized. Film was processed by Eastman Kodak. The pairs of slides that were to be used as Non-Color stimuli were copied using Panatomic X film which was then processed by the experimenter to produce black-and-white slides.

Pre- and Post-Learning Slides. The Pre-Learning and Post-Learning slides were prepared through special technology photography. This was required because of the need for the simultaneous presentation of both Color and Non-Color stimuli. The slides were made subject to the same four-way conditions as Coffing's. Each slide had, in its center, one of the PA objects against a gray background.

The following procedure was followed in preparing the concomitant four-way slides:

1. 35mm randomly selected sets of Kodachrome color PA slides were converted to non-color (black-and-white) slides using reversal Panatomic X film.
2. The Color and Non-Color slides were then trimmed along their long axis and the matching pairs placed on an illuminated copy table. The PA color slides of one set were placed on one diagonal in the First and third quadrants and the non-color (reversal Panatomic X) slides of the same set on the

other diagonal, second and fourth quadrants. Therefore representations in the diagonals were PA slide combinations.

3. These combinations were then photographed with a Pentax Spotmatic camera and a Macro Takumar F/4 50mm lens using High Speed Ektachrome color film to produce the final slide. (See Figure 7.)

It should be noted that much color filtration experimentation and density balancing was undertaken in order to obtain slides that contained black-and-white and color images of the proper value side by side. The range of light transmission among the presentation slides varied by less than half an F/stop.

Evaluation of Eye Fixation Preference. In order to rate the eye fixation variables, a time sampling of the recorded process was devised. This was accomplished by obtaining five Super 8mm motion picture frames per second. Since each slide was presented for four seconds a total of 20 frames per slide were available for rating. Each frame contained a photograph of the reflection of the stimulus material on the surface of the cornea of the eye and the position of the pupil in relation to the reflection. Thus, each frame permitted the accurate locating of the line of sight or fixation of the subject and the stimulus in use at that time by simply observing what portion of the reflection was over the center of the pupil. Identification across frames gave duration of each fixation, sequence of fixations, cumulative fixation totals, and ratio of Color to Non-Color picture fixation, etc. The current technology exposed the film for 1/50th of a second and resulted in sharp and precise recordings. This represents a change from Coffing's (1971)

procedure where each exposure to film was 1/3 of a second long, which required more interpretation due to within frame eye movements. In Coffing's (1971) study, film image blurring occurred when exposure of the eye took place during a "saccade." The resulting exposure necessitated a close study of the image density to determine where fixation took place. The shorter exposure of 1/50th of a second in the present study reduced blurring to such a degree that the few cases that did exist were easily decided.

Experimental Procedure. All subjects were presented with the following four learning treatments, (see Appendix I for actual slides used): 1) a presentation preference Pre-Learning treatment with six concomitant Color and Non-Color object pair visuals followed by a learning test with the six left hand side object visuals randomly presented as stimuli; 2) a Non-Color picture treatment, 12 object pairs to learn plus the 12 left hand side objects as test stimuli; 3) a Color picture treatment, 12 object pairs to learn plus the 12 left hand side objects as test stimuli; and 4) a presentation preference Post-Learning treatment with six concomitant Color and Non-Color object pair visuals followed by a learning test with the six left hand side object visuals randomly presented as stimuli. The test evaluated the efficiency of learning under these particular conditions.

During each treatment all pictures were projected accompanied by simultaneous audio labeling of the objects in each learning presentation. The oral test responses as to the subjects recall of the second or right hand member of the pair were recorded by an audio tape recorder. Thus the criterion tests for efficiency of learning with Non-Color and

Color pictorial presentations were administered within the experimental procedure itself. The Color and Non-Color picture treatments were counterbalanced to check possible presentation order effect.

The timing of the presentation was identical with the Coffing experiment (a copy of Coffing's audio presentation and timing tape was used). The visual was displayed for four seconds with a one-second change interval between each presentation. The audio channel was identical in all presentations except for the order of presentation transposition between the Color and Non-Color picture treatments.

Instructions to the subjects used during the experimental treatments were tape recorded to eliminate possible experimental bias. Thus, all subjects received the same audio presentations. The experimenter welcomed the subjects into the room as follows:

> "Hello. You are going to see a slide show.
> Please be seated and look into the opening."

The chair height was adjusted for each subject and his head strapped. He was asked if he was comfortable; in all cases the answer was "Yes." The criterion response tape recorder was then turned on, and the subject asked to give his name and grade. The stereo tape with instructions, labeling and relating audio first channel and timed pulse second channel, was then started. From this point on, the experiment was under the control of the pulse track at the audio playback stereo tape recorder. The two treatment groups, Color picture treatment first and Non-Color picture treatment first, had separate Carousel trays and stereo audio tapes. The control audio track was identical for both treatments. Audio presentation was recorded by a professional announcer. (See

Appendix I.)

The experiment proceeded automatically for seven minutes. At the end of the experiment, the experimenter thanked the subject and removed the headstrap.

The experimental treatment was administered over a six-day period. Ten subjects were run through in a two-and-one half hour morning period. The subjects were available for the experiment from 9 a.m. to 11:30 a.m. during the normal class schedule with the exception of the recreation period.

The eye movement apparatus was located in the School of Education of the University of Massachusetts.

Subjects. The subjects were drawn from the roster of fifth- and and sixth-grade students in the Mark's Meadow Elementary School in Amherst, Massachusetts, during the spring semester of 1971. This elementary school was chosen because of its proximity to the University of Massachusetts' School of Education, thus facilitating scheduling. The general research strategy of this study requires that the sample chosen make possible the chance of failure of the hypothesis. Since the sample was not chosen specifically because it would support the hypothesis as not proven false, it was felt that it was an appropriate sample. Choice of the fifth and sixth grades was based on the fact that Rohwer (1967) used sixth grade children in his experiments. Sixty subjects were randomly selected and assigned to the experimental treatments. However, through clerical error and non-attendance of subjects, improper assignment to ability tests and treatments occurred, and 12 subjects were dropped. A total of 48 subjects from the 93 available

in the fifth and sixth grades served in the experiment. Of these, 46 were white, one black and one Philippine/American.

Ability and Preference Tests. All subjects were administered seven aptitude tests taken from the E.T.S. test kit (French, Ekstrom, and Price, 1963). The E.T.S. tests used were the following: S-2, Cube Comparisons Test; Cf-1, Hidden Figures Test; P-3, Identical Pictures Test; Ss-1, Maze Tracing Speed Test; Vz-3, Surface Development Test; V-3, Extended Range Vocabulary Test; and Ms-3, Letter Span-Auditory Test; five two-part and two single tests. The tests in the E.T.S. kit are suggested for use in factorial studies where representation is desired for any of the above mentioned aptitude or achievement factors. It is intended that the use of the test kits for this purpose will facilitate interpretation and the confident comparison of one factor study with another. The usual reliability, norming, validity, or other information ordinarily expected in a test manual have not been included because these tests are suggested for the single purpose of factorial research.

The E.T.S. kit aptitude tests were administered prior to the experiment,presented in two test periods: S-2, Cf-1, P-3 and Ss-1 in the first session and Vz-3, V-3 and Ms-3 in the second session. Each session lasted approximately forty-five minutes and the tests were administered to the total student body (93) of these two grades. The tests were monitored and timed. The large number of students taking the tests presented a control problem which resulted in some distractive behavior. This might have influenced subject performance on some tests. Since testing was administered before the experimental treatment, it

could be argued that it potentially influenced the experimental results; however, dissimilarity of content and procedure minimizes this possibility.

The Lüscher Color Preference Test (1969) and the Ishihara Color Blindness Tests (1936) were individually administered. The Lüscher color cards were obtained from Random House, New York. Personal data was also collected on each subject. The Color Blindness test was administered and the personal data collected immediately prior to the experimental treatment. The Color Card Preference Test was administered in the subject's classroom a week after the completion of the experiment.

Variables. Five classifications of variables were involved in the experiment: Ability, Color Card Preference, Personal Data, Eye Movement Fixation, and Associative Learning Measures. These variables were used in an attempt to determine whether they had any explanation of variance ability with regard to the subjects' success with Color and Non-Color PA learning tasks. Coffing (1971) made use of many of the same variables in his study.

Ability Measures. The abilities chosen from the kit of Reference Tests (French et al., 1963) were as follows:

1. S-2, Cube Comparison Test. This test is part of a group thought to define the ability to perceive spatial patterns or to maintain orientation with respect to objects in space. It was adapted from Thurstone's Cubes.
2. Cf-1, Hidden Figures Test. This test involves the ability to keep one or more definite configurations in mind so as to make identification in spite of perceptual distractions.

3. P-3, Identical Pictures Test. This test involves the speed of finding figures, making comparisons and carrying out other very simple tasks involving visual perception. It was adapted from a test originated by Thurstone. It is especially concerned with evaluating speed of novel form discriminations.

4. Ss-1, Maze Tracing Speed Test. This test involves speed of visual exploration of a wide and complicated spatial field.

5. V-3, Wide Range Vocabulary Test. This test involves the ability to understand the English language with reference to the size of vocabulary comprehended.

6. Vz-3, Surface Development Test. This test involves the ability to manipulate or transform the image of spatial patterns into other visual arrangements.

7. Ms-3, Letter Span-Auditory Test. This test involves the ability to recall perfectly for immediate reproduction a series of items, in this case, letters, after only one presentation of the series.

The first five tests are made up of two parts. For the purpose of this experiment, each part was considered separately. Thus, there were a total of twelve ability measures derived from the Kit of Preference Tests for Cognitive Factors.

Personal Data. This set of variables included ten measures: Grade; Age; Sex; Race (white vs. non-white); Color Blindness; User of Eye Glasses; Eye Color; Test Behavior; Reading Grade; and Reading Level.

Color Card Preference Measures. The following eight colors were

ranked according to preference from 1 through 8: Blue, Green, Red, Yellow, Violet, Brown, Black and Gray. The colors were selected by subjects from the set of Lüscher Color Cards (1969).

Eye Movement Fixation Measures. Seven measures were derived from the rating of the still frames of the film recording of the subject's eye movements during the Pre-Learning and Post-Learning treatments of the experiment. Since there were six slides in each of these two phases and each slide was on for four seconds, with five frames photographed during each second, a total of 120 frames were obtained for each learning phase per subject with a grand total of rated frames of 240 per subject for the entire experiment. Given 48 subjects, a total of 11,520 fixation ratings was accomplished.

The eye movement variables evaluated in this experiment from rated frames were as follows:

1. Color Picture Stimulus Fixation Time. This measure gives for each subject the total number of fixations located in the quadrant identified as the Color Picture stimulus location. For half of the slides it was the upper left quadrant; for the other half it was the lower left quadrant.
2. Non-Color Picture Stimulus Fixation Time. This measure gives for each subject the total number of fixations located in the quadrant identified as the Non-Color picture stimulus location. For half of the slides it was the lower left quadrant, for the other half it was the upper left quadrant.
3. Center Viewing Fixation Time. This measure gives fixation totals for the number located in a phantom central rectangle

equal in size to a quadrant of the slide.

4. Non-Color Picture Response Fixation Time. This measure gives for each subject the total number of fixations located in the quadrant identified as the location of the Non-Color picture. It was located diagonally opposite the Color picture stimulus location.

5. Color Response Fixation Time. This measure gives for each subject the total number of fixations located in the quadrant identified as Color picture response. It was located diagonally opposite the Color picture stimulus location.

6. Eye Blink Time. This measure gives for each subject the number of frames showing the eyelid in a blinking position, thereby obscuring the direction of looking at the moment.

7. Off-Display Fixation Time. This measure gives for each subject the total number of frames, if any, of fixations located off the display in any direction.

Associative Learning Measures

1. Pre-Learning Efficiency of Learning Score. The number of paired-associates correctly supplied in the Pre-Learning test of the six possible.

2, 3. Criterion Measures. There were two dependent variables involved in the present experiment. The first was the associative learning score for the Color picture criterion test. The second was the associated learning score for the Non-Color picture criterion test.

4. Post Learning Efficiency of Learning Score. The number of

paired-associates correctly supplied in the Post-Learning test of the six possible.

Summary of Main Variables

		Part
1.	Grade	
2.	Age	
3.	Sex	
4.	Race	
5.	Color Blindness	
6.	Glasses	
7.	Eye Color	
8.	Test Behavior	
9.	Reading Grade	
10.	Reading Level	
11.	Cube Rotation	I
12.	Cube Rotation	II
13.	Hidden Figures	I
14.	Hidden Figures	II
15.	Identical Pictures	I
16.	Identical Pictures	II
17.	Maze Tracing	I
18.	Maze Tracing	II
19.	Wide Range Vocabulary	I
20.	Wide Range Vocabulary	II
21.	Surface Development	
22.	Letter Span-Auditory	
23.	Blue Preference	
24.	Green Preference	
25.	Red Preference	
26.	Yellow Preference	
27.	Violet Preference	
28.	Brown Preference	
29.	Black Preference	
30.	Gray Preference	

Pre-Learning Presentation Preference I

31. Color Stimulus Fixation Time
32. Non-Color Stimulus Fixation Time
33. Center Viewing Fixation Time
34. Non-Color Response Fixation Time
35. Color Response Fixation Time
36. Eye Blink Time
37. Off-Display Fixation Time

Post-Learning Presentation Preference II

38. Color Stimulus Fixation Time
39. Non-Color Stimulus Fixation Time
40. Center Viewing Fixation Time
41. Non-Color Response Fixation Time
42. Color Response Fixation Time
43. Eye Blink Time
44. Off-Display Fixation Time
45. Pre-Learning Efficiency of Learning Score
46. Post-Learning Efficiency of Learning Score

Criterion Tests

47. Dependent Variable: Non-Color Efficiency of Learning Score
48. Dependent Variable: Color Efficiency of Learning Score

C H A P T E R I V

RESULTS

Total Population Analysis: Major Hypothesis I

This hypothesis states that learning will be facilitated more by Color pictures than by Non-Color pictures in a synchronous audio-visual presentation. Effects on all subjects were examined by a two-way analysis of variance with repeated measures using presentation order and mode as the two independent variables. Raw scores show that 71 percent of the subjects scored higher on Color than on Non-Color, 12 percent scored higher on Non-Color, and 17 percent scored the same on Color and Non-Color. See Table 1.

TABLE 1.--Number of Subjects Who Obtained Higher Criterion Score with Color or Non-Color Picture and the Score Range for Each Category for the Total Population, N = 48

Higher Score Category	Number of Subjects	Score Range
Color Picture	34 (71%)	6 - 12 *
Non-Color Picture	6 (12%)	3 - 11
Equal on Color and Non-Color picture	8 (17%)	8 - 11

*Two subjects obtained the maximum score of 12

Table 2 presents the analysis of variance summary using efficiency of learning as criteria. The analysis shows no significant main effect for order of presentation but shows a significant main effect for Color vs. Non-Color presentation ($p < .001$), and a significant interaction effect of order with presentation mode ($p < .05$). Thus Hypothesis I is not proven false for the total population.

The tests of significance used in this study were based on the premise that it is reasonable to ask and answer the following question: Can chance be ruled out as a plausible explainer of the differences or relationships found in these data? Given that statistical significance is obtained, chance must be excluded from the set of hypotheses that may explain the results, and some explanation based on a systematic difference of relationship must be maintained. Given that statistical significance is obtained, the interpretation must still be limited to the very small population from which the sample was randomly drawn. (Roe and Hutchinson, 1969, p. 392.)

An examination of the main effect between the two criterion treatment score means, Table 2 indicates, that the difference resulted more from the Non-Color treatment mean difference $Xa_1 - Xa_2 = 1.04$ than from the Color treatment mean difference $Xa_2 - Xa_1 = .33$. In terms of the order of presentation difference, Group I received the Non-Color treatment first and had a mean difference Color minus Non-Color of 1.08, while Group II received the Color treatment first and had a mean difference Color minus Non-Color of 2.29. The small significant interaction effect seems due both to the reduced scores within each criterion category when that category was experienced second and the greater score

TABLE 2.--Analysis of Variance Summary Using Efficiency of Learning as Criteria for Order of Presentation Effects (A) by Non-Color vs. Color Presentation Mode Success (B), N = 48

		df	Mean Square	F Ratio
Between Subjects		47		
A	Order of Presentation (Two levels)	1	3.01	.95
S/A	Subjects Within Groups	46	3.08	
Within Subjects		48		
B	Non-Color vs. Color Picture (Repeated)	1	61.76	34.11***
AB	Interaction of Color vs. Non-Color By Order of Presentation	1	11.34	6.25*
SA/B	Subjects Within Groups	46	1.81	

* = $p < .05 = 4.05$
** = $p < .01 = 7.21$
*** = $p < .001 = 12.29$

Winer (1962) p. 303

Cell Means and (Standard Deviations)

		B: Non-Color Picture		B: Color Picture		
A	1. Non-Color Picture	8.58	(1.69)	9.5	(1.38)	= 1.08
	2. Color Picture	7.54	(1.93)	9.8	(1.13)	= 2.29
		1.04		.33		

reduction effect on the Non-Color criterion scores when that category was experienced second.

The interaction effect difference was not very large and was considerably less of an explainer of variance than is the main effect Non-Color vs. Color. Therefore, since the interaction effect was not hypothesized by this study, it will not be dealt with in subsequent analysis. However, it is noted that there is now some empirical support for maintaining a hypothesis relative to this interaction for subsequent study.

Total Population Analysis: Major Hypothesis II

This hypothesis states that preference expressed by eye fixation variables for several visual presentation modes should be differentially related to efficiency of learning using those modes.

Hypothesis II is proven false for the total subject population. Although this hypothesis dealt with eye fixation variables only, the regression slopes obtained between the criterion measures and each of the predictor variables under each treatment were tested by a parallelism of regression test (Parlreg--statistical reference--Dixon and Massey, 1957, p. 218, Equation 2,A) created at the Stanford Center for Research and Development of Teaching and converted and improved at the University of Massachusetts by David Coffing to determine the extent to which each treatment differed. Table 3 presents the obtained F/ratios. In none of the individual Pre- and Post-Learning Eye Fixation variables (V31 - V44) were there significant non-parallel regression slopes in relationship to the two criterion variables (V47 and V48). These results across

the total subject population do not support the hypothesis of interaction between the eye fixation preferences and performance on the criterion measures where Color pictures and Non-Color pictures are offered as alternative modes of audio-visual presentation.

TABLE 3.--Test of Parallelism of Regression Results between Standardized Main Variables and the Two Learning Criterion Measures for the Total Population, Df = 92 N = 48

			Parallelism I Ratio	Non-Color beta′	Color beta′
	Personal Data Measures				
1.	Grade		.10	-.02	.08
2.	Age		.50	-.36	-.13
3.	Sex		.09	.06	-.04
4.	Race		1.46	.22	-.18
5.	Color Blindness		.23	-.29	-.53
6.	Glasses		.01	-.13	-.07
7.	Color Eyes		.09	-.09	-.19
8.	Test Behavior		.35	.08	-.11
9.	Reading Grade		.20	.02	.17
10.	Reading Level		.46	-.02	-.25
	Ability Measures				
11.	Cube Rotation	I	.27	.02	.19
12.	"	II	.10	-.08	.03
13.	Hidden Figures	I	.04	.07	.13
14.	"	II	1.67	-.20	.23
15.	Identical Pictures	I	1.09	-.40	.06
16.	"	II	.31	.10	.28
17.	Maze Tracing	I	.02	.16	.20
18.	"	II	1.05	.32	-.01
19.	Wide Range Vocabulary	I	.22	.17	.32
20.	"	II	1.46	-.08	.32
21.	Surface Development		.25	-.40	-.23
22.	Letter Span Auditory		3.25	-.62	-.05
	Color Card Preference Measures				
23.	Blue		.00	.28	.27
24.	Green		.81	-.02	.28

TABLE 3.--Continued.

			Parallelism F Ratio	Non-Color beta′	Color beta′
	Color Card Preference Measures				
25.	Red		.02	-.27	-.22
26.	Yellow		.92	.00	-.31
27.	Violet		.54	-.28	-.04
28.	Brown		1.71	.39	-.04
29.	Black		.88	-.09	.22
30.	Gray		.03	-.02	-.09
	Eye Fixation Measures				
31.	EF Color Stimulus	Pre-Lrng.	.03	-.03	-.09
32.	" Non-Color Stimulus	"	.05	-.05	.02
33.	" Center Viewing	"	.82	-.21	.09
34.	" Non-Color Response	"	.38	.40	.20
35.	" Color Response	"	.11	-.26	-.15
36.	" Eye Blink	"	.00	.02	.04
37.	" Off-Display	"	.39	.13	-.08
38.	" Color Stimulus	Post-Lrng.	.00	.06	.05
39.	" Non-Color Stimulus	"	1.56	-.52	-.12
40.	" Center Viewing	"	2.68	-.56	-.03
41.	" Non-Color Response	"	1.84	.68	.25
42.	" Color Response	"	.00	-.15	-.12
43.	" Eye Blink	"	1.90	.38	-.07
44.	" Off-Display	"	.12	-.18	-.07
45.	Pre-Learning Lrng. Score		.54	.26	.02
46.	Post-Learning "		.01	.14	.12

*$p < .05 = 3.95$
**$p < .01 = 6.98$

Total Population Analysis: Major Hypothesis III

This hypothesis states that prediction of learning success would be enhanced by the addition of eye fixation and Color Card Preference variables to more conventional paper and pencil ability tests. Before examining multiple correlation analyses, however, it will be useful to

summarize the general trends within the simple correlation matrix.

Zero Order Correlation Analysis: Total Population

Table 4 shows the full correlation matrix and gives overall means and standard deviations for the major variables developed and used in the present experiment. Table 5 simplifies the matrix by showing only the significant predictor variable correlations ($p < .05$ and better).

Personal Data variables (V1-V10) show 6 significant or 13 percent correlation out of the total possible correlations within this classification. Furthermore, Personal Data variables (V1-V10) significantly correlated with the Color Non-Color Criterion once or 5 percent of the 20 possible correlations. Color Blindness (V5) was negatively correlated with the Color Criterion (V48). Personal Data variables (V1-V10) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
French Ability Tests (V11-V22)	14 out of 120 possible	11%
Color Card Preference Tests (V23-V30)	16 " 80 "	20%
Pre-Learning Eye Fixation (V31-V37)	6 " 70 "	9%
Post-Learning Eye Fixation (V38-V44)	7 " 70 "	10%
Pre- & Post-Learning Learning Scores (V45 & V46)	2 " 20 "	10%

French Ability Test variables (paper and pencil) (V11-V22) show 29 significant or 54 percent correlations out of the possible correlations

		Personal Data								French Ability Test										Color Preference							Eye Fixation Variables																P&P Lrng.	Crt. V's		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	MEAN	SD
1	GRADE	1	63	13	00	09	31	04	-05	07	-16	22	26	11	13	01	-01	31	24	13	11	05	13	-10	-02	24	-23	29	-10	-02	-13	16	-15	04	15	-19	04	-21	21	-10	07	07	-20	-05	-13	16	09	01	07	5.5	.5
2	AGE	•	1	16	-31	13	34	15	05	01	-08	15	33	02	06	11	-06	23	14	-03	05	03	01	-29	13	15	-16	37	-13	00	-13	16	-24	19	12	-08	-05	-25	20	-04	-21	-07	-13	-04	-28	-02	-09	-19	-11	1.0	.7
3	SEX	•	•	1	-18	23	-04	-14	-16	-04	-21	11	09	-20	00	-07	34	34	17	19	07	-10	34	-12	-18	26	19	01	-14	-14	03	-08	14	06	-13	14	-23	04	-39	16	07	-22	39	-05	-03	21	-06	03	-03	.6	.5
4	RACE	•	•	•	1	05	06	15	11	06	02	22	08	16	01	-10	-13	06	11	-14	-03	-03	-04	12	-24	-12	00	-22	-06	-11	39	-12	13	-42	-08	17	05	06	00	07	-27	09	-10	-08	10	17	15	12	-14	1.0	.2
5	CLR BLD	•	•	•	•	1	-08	-01	-23	-07	06	09	17	-08	-17	-16	-02	-01	-05	02	-09	-05	18	-24	12	11	05	30	-18	-44	10	-12	-15	09	-06	28	-08	-07	00	12	32	-20	03	-08	-04	-15	-08	-10	-28	.1	.2
6	GLASSES	•	•	•	•	•	1	-07	01	17	-16	24	38	-02	11	08	-17	22	16	-16	24	-31	-13	-19	09	17	-24	-05	12	11	00	-03	-08	02	-09	03	37	-09	05	11	15	-18	-18	29	14	08	-22	-05	-04	.1	.3
7	EYE CLR	•	•	•	•	•	•	1	16	01	-10	04	-01	-15	-16	01	-09	-17	-20	08	-08	-04	-09	04	-16	-12	24	-05	-30	17	26	-09	26	-06	-11	03	-05	-14	09	-05	07	-12	-01	13	-09	-36	-15	-05	-15	.4	.5
8	TEST BEHV	•	•	•	•	•	•	•	•	1	-31	00	-12	14	10	09	-14	21	03	04	-16	-16	-11	-13	-10	20	-31	09	-20	03	26	13	-11	07	08	-03	04	04	17	-04	20	-03	00	-16	18	-02	13	02	05	09	1.7	.4
9	READ GRD	•	•	•	•	•	•	•	•	•	1	31	08	15	00	-03	42	-08	06	14	29	44	09	35	22	-24	16	00	05	-01	-12	02	-09	11	-01	03	00	-09	-08	03	16	14	-15	-05	02	-14	-05	13	01	13	2.1	.6
10	READ LVL	•	•	•	•	•	•	•	•	•	•	1	-11	-09	02	-11	23	-03	01	25	01	06	05	04	19	00	-26	03	00	22	-16	08	07	-14	00	08	04	-13	-09	25	-10	-18	00	-03	-17	-22	-24	-11	-01	-19	2.5	.5
11	CUBE I											1	50	27	24	19	10	38	41	13	24	11	02	12	-11	07	-23	02	-03	-06	27	02	-11	01	-15	15	14	-03	01	11	11	-10	-06	-07	04	-08	-04	01	15	8.2	4.1
12	CUBE II											•	1	23	35	24	15	21	20	08	22	07	-16	04	26	-01	-37	01	09	-08	08	10	-14	05	-11	12	-07	16	01	21	22	-23	-14	11	01	03	06	-04	02	6.6	3.1
13	HID FIG I											•	•	1	41	08	37	32	41	21	15	19	09	28	00	-19	-39	-24	30	26	11	-12	24	10	-08	-03	-05	03	05	05	-06	-29	25	25	-13	38	13	04	11	2.6	2.1
14	HID FIG II											•	•	•	1	28	31	22	31	24	35	32	10	24	18	-12	-33	14	-18	30	-18	20	-06	-08	-06	-15	22	19	02	05	05	-13	-03	-01	25	13	12	-11	18	2.6	1.9
15	IDEN PIC I											•	•	•	•	1	-24	24	22	36	24	23	25	09	-16	14	05	-05	-11	13	-10	-04	19	-07	-22	14	-03	-13	-06	15	06	-29	20	-06	-08	-15	17	-21	-05	29.2	7.9
16	IDEN PIC II											•	•	•	•	•	1	22	24	17	20	21	10	12	20	-30	-29	-01	18	09	10	00	-08	36	11	-22	15	20	-10	-02	13	02	01	08	07	12	23	05	23	22.5	9.9
17	MAZE I											•	•	•	•	•	•	1	76	11	20	03	17	21	-03	-17	-29	05	-01	09	25	-07	-02	12	-14	10	20	05	-24	18	-15	-18	21	02	05	10	19	08	16	8.8	2.8
18	MAZE II											•	•	•	•	•	•	•	1	18	26	08	16	24	-05	-16	-18	-03	06	-05	19	13	-05	-10	-03	-08	13	01	06	00	-17	-09	00	05	-13	16	13	17	-01	11.5	2.8
19	VOCAB I											•	•	•	•	•	•	•	•	1	41	07	55	40	04	03	-09	00	-17	02	-21	03	19	-08	-07	-13	06	01	00	-02	17	-16	13	-03	-03	-01	08	09	26	6.1	2.7
20	VOCAB II											•	•	•	•	•	•	•	•	•	1	05	29	38	10	-18	-11	10	-18	08	-17	01	00	-06	-06	04	06	07	-02	13	05	-18	-04	11	10	19	-05	-04	25	4.6	2.7
21	SURF DEV											•	•	•	•	•	•	•	•	•	•	1	09	11	-18	-01	-03	31	-24	11	-07	20	-04	-15	05	-19	09	04	-06	04	-03	03	13	-29	03	03	22	-21	-19	7.8	4.6
22	LTR SPAN											•	•	•	•	•	•	•	•	•	•	•	1	08	-20	29	19	06	-33	-16	-07	-24	22	14	-09	06	04	-06	-24	19	30	-24	16	03	14	-03	12	-33	-04	5.4	2.8
23	BLUE																							1	-13	-46	-29	-23	07	-28	-06	01	29	-17	-25	07	-14	26	-03	00	-32	-04	08	01	13	09	14	15	21	3.5	1.7
24	GREEN																							•	1	-24	-23	27	-17	-24	-33	18	-42	-01	14	-07	27	16	29	-17	27	15	-43	18	15	-12	-19	-01	22	3.5	1.8
25	RED																							•	•	1	09	01	-21	-30	-09	11	-09	08	02	-09	01	-12	-09	-05	28	-08	14	-09	04	-10	-17	-14	-17	3.4	1.9
26	YELLOW																							•	•	•	1	11	-37	-20	-05	-34	23	-09	09	19	-21	-33	-17	22	05	-03	06	03	-23	-16	06	00	25	4.0	1.9
27	VIOLET																							•	•	•	•	1	-44	-29	-39	-39	-52	-18	29	-31	30	07	17	-29	10	29	-28	-06	19	-14	-19	-15	-03	2.5	1.9
28	BROWN																							•	•	•	•	•	1	08	18	-08	15	23	-02	00	-25	03	10	-05	-15	03	06	-04	-27	32	16	21	-03	5.5	1.8
29	BLACK																							•	•	•	•	•	•	1	-08	-06	36	-05	-20	-06	10	16	-16	12	-19	-15	23	04	18	29	21	-05	17	6.7	1.4
30	GREY																							•	•	•	•	•	•	•	1	-26	10	21	-19	32	-08	-19	-13	29	-15	24	21	-48	-15	12	05	-01	-06	6.8	1.5
31	EP CS I																															1	-56	-38	21	-58	03	22	44	42	-06	30	-34	-32	10	07	-06	-01	-07	34.7	6.7
32	EP NCS I																															•	1	10	-55	28	-23	-08	-26	15	-11	-26	37	11	-10	25	21	-03	01	19.8	6.1
33	EP CTR I																															•	•	1	-10	09	-03	-17	-11	09	33	-25	19	05	-11	-09	16	-11	07	5.6	2.2
34	EP NCR I																															•	•	•	1	-64	-03	-18	42	-23	05	39	-38	-06	-35	-14	01	22	16	35.0	6.9
35	EP CR I																															•	•	•	•	1	-21	-08	-51	51	-03	-39	36	07	10	-05	-10	-14	-11	22.5	7.0
36	EP BLK I																															•	•	•	•	•	1	18	-12	-10	06	06	-09	39	53	-16	-18	01	03	2.3	2.9
37	EP OFF I																															•	•	•	•	•	•	1	-31	05	-03	02	-06	36	54	03	-06	07	-07	.2	.6
38	EP CS II																																						1	-53	10	33	-63	-26	-42	03	00	03	04	33.9	7.8
39	EP NCS II																																						•	1	-02	-61	35	03	-01	-06	03	-28	-09	17.4	7.2
40	EP CTR II																																						•	•	1	-29	-19	06	08	-22	12	-30	-03	6.3	2.5
41	EP NCR II																																						•	•	•	1	-61	02	-04	09	09	36	20	33.0	8.2
42	EP CR II																																						•	•	•	•	1	-24	00	05	-10	-07	-10	22.2	8.4
43	EP BLK II																																						•	•	•	•	•	1	39	-12	-09	20	-06	3.7	3.2
44	EP OFF II																																						•	•	•	•	•	•	1	-04	-09	-10	-05	1.0	2.1
45	PRE-LEARNING																																												1	34	14	01	4.1	1.4
46	POST-LEARNING																																												•	1	08	10	4.4	1.2
47	NC CRITERION																																														1	23	8.1	1.9
48	C CRITERION																																														•	1	9.7	1.3

TABLE 4.--Correlation Matrix with Means and Standard Deviations for the Variables and the Criteria. Total Population (N=48).

		Personal Data									French Ability Test																Color Preference								Eye Fixation Variables														P&P Lang.	Crt. V's		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	MEAN	SD
1	GRADE	1	63	.	.	.	31	.	.	.	.	.	26	.	.	.	.	31	24	.	.	.	.	.	.	24	.	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.5	.5
2	AGE	.	1	.	-31	.	34	.	.	.	.	.	33	.	.	.	.	.	.	.	.	.	.	.	.	.	37	.	.	.	-24	.	.	.	-25	.	.	.	.	.	-28	.	.	.	.	.	.	.	.	.	1.0	.7
3	SEX	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	34	34	.	.	.	.	34	.	.	26	.	.	.	.	.	.	.	.	.	.	.	.	-39	.	.	.	39	.	.	.	.	.	.	.	.	.6	.5
4	RACE	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-24	.	.	.	.	.	.	39	.	.	-42	.	.	.	.	.	.	.	.	.	-27	.	.	.	.	.	.	.	.	.	.	.	1.0	.2
5	CLR BLD	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	-24	.	.	.	.	.	30	.	-44	.	.	.	.	.	28	.	.	.	32	.	.	.	.	.	.	.	.	.	.	.	.	-28	.1	.2
6	GLASSES	.	.	.	.	.	1	.	.	.	.	24	38	.	.	.	.	.	.	24	-31	.	.	.	.	-24	.	.	.	.	.	.	.	37	.	.	.	.	.	29	.	.	.	.	.	.	.	.	.	.	.	.1	.3
7	EYE CLR	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	24	.	.	26	.	26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-36	.	.	.	.	.4	.5
8	TEST BEHV	.	.	.	.	.	.	.	1	-31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-31	.	.	26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.7	.4
9	READ GRD	.	.	.	.	.	.	.	.	1	31	.	.	.	42	.	.	.	.	29	44	.	35	.	-24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.1	.4
10	READ LVL	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	25	.	.	.	.	.	.	-26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	.	.	.	.	.	-24	.	.	.	.	2.5	.5
11	CUBE I											1	50	27	24	.	.	38	41	.	24	.	.	.	.	-23	.	.	.	27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.2	4.1
12	CUBE II											.	1	.	35	24	.	.	.	.	.	.	.	.	26	.	-27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6.6	3.1
13	HID FIG I											.	.	1	41	.	37	32	41	.	.	.	.	28	.	.	-39	-24	30	26	.	.	24	.	.	.	.	.	.	.	.	.	-29	25	.	.	38	.	.	.	2.6	2.1
14	HID FIG II											.	.	.	1	28	31	.	31	24	35	32	.	24	.	.	-33	.	.	30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	.	.	.	.	.	2.6	1.9
15	IDEN PIC I											.	.	.	.	1	24	24	.	36	24	.	25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-29	.	.	.	.	.	.	.	29.2	7.9
16	IDEN PIC II											.	.	.	.	.	1	.	24	.	.	.	.	.	-30	-29	.	.	.	.	.	36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22.5	9.9
17	MAZE I											.	.	.	.	.	.	1	76	.	.	.	.	.	.	-29	.	.	.	25	.	.	.	.	.	.	-24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8.8	2.8
18	MAZE II											.	.	.	.	.	.	.	1	.	26	.	24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11.5	2.8
19	VOCAB I											.	.	.	.	.	.	.	.	1	41	.	55	40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	26	6.1	2.7
20	VOCAB II											.	.	.	.	.	.	.	.	.	1	.	29	38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	4.6	2.7
21	SURF DEV											.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	31	-24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-29	.	.	.	.	.	7.8	4.6
22	LTR SPAN											.	.	.	.	.	.	.	.	.	.	.	1	.	.	29	.	.	-33	.	.	-24	.	.	.	.	.	-24	.	.	.	.	-24	.	.	.	.	.	-33	.	5.4	2.8
23	BLUE																							1	.	-46	-29	.	.	-28	.	.	29	.	-25	.	.	26	.	.	-32	.	.	.	.	.	.	.	.	.	.	3.5	1.7
24	GREEN																							.	1	-24	.	27	.	-24	-33	.	-42	.	.	.	27	.	29	.	27	.	-43	.	.	.	.	.	.	.	3.5	1.8
25	RED																							.	.	1	.	.	.	-30	.	.	.	.	.	.	.	.	.	.	28	.	.	.	.	.	.	.	.	.	3.4	1.9
26	YELLOW																							.	.	.	.	.	-37	.	.	-34	.	.	.	.	-33	.	.	.	.	.	.	.	.	.	.	.	.	25	4.0	1.9
27	VIOLET																							.	.	.	.	1	-44	-29	-39	-39	-52	.	29	-31	30	.	.	-29	.	29	-28	.	.	.	.	.	.	.	2.5	1.9
28	BROWN																							.	.	.	.	.	1	.	.	.	.	.	.	.	-25	.	.	.	.	.	.	.	.	-27	32	.	.	5.5	1.8
29	BLACK																							.	.	.	.	.	.	1	.	.	36	.	.	.	.	.	.	.	.	.	.	.	.	.	29	.	.	6.7	1.4
30	GREY																							.	.	.	.	.	.	.	1	-26	.	.	.	32	.	.	.	29	.	24	.	.	.	.	.	.	.	6.8	1.5
31	EF CS I																															1	-56	-38	.	-58	.	.	44	42	.	30	-34	-32	.	.	.	.	.	34.7	6.7
32	EF NCS I																															.	1	.	-55	28	.	.	-26	.	.	-26	37	.	.	25	.	.	.	19.8	6.1
33	EF CTR I																															.	.	1	.	.	.	.	.	33	-25	.	.	.	.	.	.	.	5.6	2.2
34	EF NCR I																															.	.	.	1	-64	.	.	42	.	.	39	-38	.	-35	.	.	.	.	35.0	6.9
35	EF CR I																															.	.	.	.	1	.	.	-51	51	.	-39	36	.	.	.	.	.	.	22.5	7.0
36	EF BLK I																															.	.	.	.	.	1	.	.	.	.	.	39	53	.	.	.	.	2.3	2.9
37	EF OFF I																															.	.	.	.	.	.	1	-31	.	.	.	.	36	54	.	.	.	.	.2	.6
38	EF CS II																																						1	-53	.	33	-63	-26	-42	.	.	.	.	33.9	7.8
39	EF NCS II																																						.	1	.	-61	35	.	.	.	.	-28	.	17.4	7.2
40	EF CTR II																																						.	.	1	-29	.	.	.	.	.	-30	.	6.3	2.5
41	EF NCR II																																						.	.	.	1	-61	.	.	.	.	36	.	33.0	8.2
42	EF CR II																																						.	.	.	.	1	-24	.	.	.	.	.	22.2	8.4
43	EF BLK II																																						.	.	.	.	.	1	39	.	.	.	.	3.7	3.2
44	EF OFF II																																						.	.	.	.	.	.	1	.	.	.	.	1.0	2.1
45	PRE-LEARNING																																												1	34	.	.	4.1	1.4
46	POST-LEARNING																																												.	1	.	.	4.4	1.2
47	NC CRITERION																																													.	1	.	8.1	1.9
48	C CRITERION																																														.	1	9.7	1.3

TABLE 5.--Correlation Matrix with Means and Standard Deviations and Significant Correlation for the Variables and the Criteria. Total Population (N=38)

within this classification. Furthermore, French Ability Test variables (V11-V22) significantly correlated with the Color and Non-Color Criterion 3 or 13 percent of the 24 possible correlations. Wide Range Vocabulary variables I and II (V17 and V18) were positively correlated with Color Criterion (V48) and Letter Span Auditory variable (V22) was negatively correlated with Non-Color Criterion (V47). French Ability Test variables (V11-V22) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	14 out of 120 possible	11%
Color Card Preference Tests (V23-V30)	23 " 96 "	23%
Pre-Learning Eye Fixation (V31-V37)	3 " 84 "	4%
Post-Learning Eye Fixation (V38-V44)	8 " 84 "	9%
Pre- & Post-Learning Learning Scores (V34 & V46)	1 " 24 "	4%

Color Card Preference Test variables (V23-V30) show 12 significant or 53 percent correlation out of the possible correlations within this classification. Furthermore, Color Card Preference variables significantly correlated with the Color and Non-Color Criterion once or 6 percent of the 16 possible correlations. Yellow (V26) was positively correlated with Color Criterion (V48). Color Card Preference Test variables (V23-V30) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	16 out of 64 possible	20%
French Ability Tests (V11-V22)	23 " 96 "	23%
Pre-Learning Eye Fixation (V31-V37)	16 " 56 "	29%
Post-Learning Eye Fixation (V38-V44)	11 " 56 "	21%
Pre- & Post-Learning Learning Scores (V45 & V46)	2 " 12 "	12%

Pre-Learning Eye Fixation variables (V31-37) show 5 significant or 24 percent correlation out of the possible correlations within this classification. There were no correlations with either criterion variables (V47 and V48). Pre-Learning Eye Fixation variables (V31-V37) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	6 out of 70 possible	9%
French Ability Tests (V11-V22)	3 " 84 "	4%
Color Card Preference Tests (V23-V30)	16 " 56 "	29%
Post-Learning Eye Fixation (V38-V44)	23 " 49 "	48%
Pre- & Post-Learning Learning Scores (V45 & V-46)	1 " 14 "	7%

Post-Learning Eye Fixation variables (V38-V44) show 11 significant or 52 percent correlation out of the possible correlations within this classification. Furthermore, Post-Learning Eye Fixation variables significantly correlated with Color and Non-Color Criterion 3 or 21 percent of the 14 possible correlations. Eye Fixation Non-Color Picture Stimulus variable (V39) and Eye Fixation Center Picture variable (V40) were both negatively correlated with Color Criterion (V48) and Eye Fixation Non-Color Picture Response (V41) was positively correlated with Non-Color Criterion (V47). The Post-Learning Eye Fixation variables (V38-V44) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	7 out of 70 possible	10%
French Ability Tests (V11-V22)	8 " 84 "	9%
Color Card Preference Tests (V23-V30)	11 " 56 "	21%
Pre-Learning Eye Fixation (V31-V37)	23 " 49 "	48%
Pre- & Post-Learning Learning Scores (V45 and V46)	None	0

Pre- and Post-Learning Learning Score variables (V45 and V46) were significantly correlated with each other. There were no correlations with either of the Criterion variables (V47 and V48). Pre- and Post-Learning Learning Score variables (V45 and V46) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	2 out of 20 possible	10%
French Ability Tests (V11-V22)	1 " 24 "	4%
Color Card Preference Tests (V23-V30)	2 " 16 "	12%
Pre-Learning Eye Fixation (V31-V37)	1 " 14 "	7%
Post-Learning Eye Fixation (V38-V44)	None	0

Multiple Regression Analysis: Total Population

To examine the relationship between the predictor variables (V1-V46) and the two criterion variables (V47 and V48), the analysis used a Stepwise Regression Analysis (Biomedical Program, 02R) and MUREG: a program derived from the Biomedical program that provides in addition standardized Beta weights for the regression analysis.

The results of the Stepwise regression analysis for each of the two criterion variables (V47 and V48) are displayed in Tables 6 through 13.

The general strategy of analysis involves first the presentation of the Stepwise regressions constructed from all major variables for Non-Color Picture Criterion Success (V47), Table 6, and Color Picture Criterion Success (V48), Table 7; next, the effects of first forcing Race (V4), Color Blindness (V5), and Reading Level (V10) for Non-Color, Table 8, and for Color, Table 9; then forcing Hidden Figures II (V14), Identical Pictures I (v15), and Maze Tracing II (V18) for Non-Color,

Table 10, and for Color, Table 11. Each Variable Classification, Personal Data (V1-V10), French Ability Tests (V11-V22), Color Card Preference Test (V23-V30) and Eye Fixation variables (V31-V44), was then run independently in a multiple-regression analysis to see its own unique capability of predicting the dependent variables (V47 and V48). See Tables 12 and 13.

The results of forcing three of the Personal Data variables: Race (V4), Color Blindness (V5), and Reading Level (V10) for both Non-Color and Color Criterion variables contributed little towards the explanation of variance (see Tables 8 and 9). Only Color Blindness gave indications of approaching a significant F/value. Neither did results of forcing the three French Ability variables, Hidden Figures II, Identical Pictures I, and Maze Tracing II (Tables 10 and 11), produce much explanation of variance for the Non-Color and Color Criterion variables. It is clear that forcing these variables was unproductive of a significant explanation of variance with the Non-Color and Color Criterion variables; therefore, further analysis along these lines in future studies appears unwarranted.

Hypothesis III is not proven false by these analyses. The conventional paper and pencil tests represented by French Ability Test variables (V11-V22) contributed 33 percent, Eye Fixation variables (V31-V44) contributed 22 percent, and Color Card Preference variables (V23-V30) contributed 4 percent of the variance explained for Non-Color Picture Criterion variable (V47) (see Table 12); whereas French Ability Test variables (V11-V22) contributed 15 percent, Eye Fixation variables (V31-V44) contributed 4 percent and Color Card Preference variables

(V23-V30) contributed 13 percent of the variance explained for Color Picture Criterion variable (V48). See Table 13.

However, when both Eye Fixation variables (V31-V44) and Color Card Preference variables (V23-V30) were combined with French Ability Test variables (V11-V22), (Tables 6 and 7), the explanation of variance reached nearly 65 percent for Non-Color Picture Criterion variable (V47) and 60 percent for Color Picture Criterion (V48).

Exploratory Analysis: Total Population

Given these data the researcher decided to do a number of exploratory analyses and to examine the results as they relate to the state of knowledge of the field. Results of the analyses could also serve to generate hypotheses for which there appears to be some empirical support and that might be followed up in subsequent investigations.

Table 14 presents the fixation preferences for Non-Color vs. Color presentations for all subjects in terms of stimulus and response quadrant viewing in the Pre-Learning and Post-Learning Eye Fixation tests (V31-V44). In the main, between the Pre-Learning and Post-Learning Eye Fixation tests (V31-V44), 32 of the 48 subjects did not change their stimulus-response fixation preference but the remaining 16 of the 48 subjects did change fixation preference. Thirty of the 32 Non-Changers were Color Stimulus and Non-Color Response fixators and 2 were Color Stimulus and Color Response fixators. Sixteen of the 48 subjects changed their fixation preference in the Post-Learning Eye Fixation Test (V31-V44) as follows:

TABLE 6.--Stepwise Regression Analysis With Non-Color as the Criterion Variable, N = 48

Non-Color							
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	beta	beta′	Label of Variable
1.	41	.13	.13	6.91*	.11	.49	EF Non-Color Resp. II
2.	27	.20	.07	3.97	-.17	-.17	Violet
3.	22	.24	.04	2.75	-.48	-.72	Letter Span-Auditory
4.	19	.35	.11	7.16*	.33	.48	Extended Vocabulary I
5.	3	.40	.05	2.99	.68	.18	Sex
6.	43	.44	.04	3.36	.06	.11	EF Eye Blink II
7.	18	.47	.03	2.11	.19	.28	Maze Tracing I
8.	31	.50	.03	2.46	-.06	-.24	EF Color Stimulus I
9.	34	.53	.03	2.10	.23	.06	EF Non-Color Resp. I
10.	44	.55	.02	2.13	.07	.11	EF Off-Display II
11.	9	.58	.03	1.99	.84	.27	Reading Grade
12.	15	.61	.03	2.55	-.56	-.24	Identical Pictures I
13.	42	.63	.02	2.12	.05	.25	EF Color Resp. II

Note: Betas used in this table are those that correspond to each variable at step 13, and are not the Betas when the variables first entered the regression formula.

$$Y = .86 + .49\,(V41) - .17\,(V27) - .72\,(V22) + .48\,(V19) + .18\,(V3) + .11\,(V43) + .28\,(V18) - .24\,(V31) + .06\,(V34) + .11\,(V44) + .27\,(V9) - .24\,(V15) + .25\,(V42)$$

*$p < .05$
**$p < .01$

TABLE 7.--Stepwise Regression Analysis With Color as the Criterion Variable, N = 48

		Color					
Step Number +++	Variable Number	R SQ.	RSQ Increase	F in/out	beta	beta′	Label of Variable
1.	5	.08	.08	3.79	-2.02	-.44	Color Blindness
2.	19	.14	.06	3.62	.14	.07	Extended Vocabulary I
3.	24	.21	.05	3.38	.11	.16	Green
4.	8	.24	.03	1.87	-.65	-.23	Test Behavior
5.	31	.28	.04	2.51	-.08	-.46	EF Color Stimulus I
6.	26	.32	.04	2.46	-.24	-.37	Yellow
7.	43	.36	.04	2.63	-.15	-.39	EF Eye Blink II
8.	41	.41	.05	3.23	.04	.26	EF Non-Color Resp. I
9.	10	.45	.04	2.70	-.25	-.10	Reading Level
10.	21	.49	.04	2.54	-.11	-.39	Surface Development
11.	28	.53	.04	3.38	-.26	-.37	Black
12.	16	.58	.05	4.15	.03	.27	Identical Pictures II

Note: Betas used in this table are those that correspond to each variable at Step 12, and are not the Betas when the variables first entered the regression formula.

$$Y = 15.37 - .44\,(V5) + .07\,(V19) + .16\,(V24) - .23\,(V8) - .46\,(V31) - .37\,(V26) - .39\,(V43) + .26\,(V41) - .10\,(V10) - .39\,(V21) - .37\,(V28) + .27\,(V16)$$

*$p < .05$
**$p < .01$

TABLE 8.--Stepwise Regression Analysis With Non-Color as the Criterion Variable With Selected Personal Data Variables Forced, N = 48

Non-Color					
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Race Forced					
1.	4	.01	.01	.67	Race
2.	41	.14	.13	6.48*	EF Non-Color Resp. II
3.	27	.20	.06	3.49	Violet
4.	22	.25	.05	2.70	Letter Span Auditory
5.	19	.36	.11	7.39**	Vocabulary I
6.	3	.41	.05	3.45	Sex
7.	43	.45	.04	3.19	EF Eye Blink II
Color Blindness Forced					
1.	5	.01	.01	.48	Color Blindness
2.	41	.13	.12	6.28*	EF Non-Color Resp. II
3.	27	.21	.08	4.20*	Violet
4.	22	.26	.05	2.93	Letter Span Auditory
5.	19	.37	.12	7.68**	Vocabulary I
6.	17	.42	.05	3.28	Maze Tracing I
7.	43	.46	.04	3.17	EF Eye Blink II
Reading Level Forced					
1.	10	.00	.00	.00	Reading Level
2.	41	.13	.13	6.77*	EF Non-Color Resp. II
3.	27	.20	.07	3.88	Violet
4.	18	.25	.05	2.68	Maze Tracing II
5.	22	.31	.06	3.76	Letter Span Auditory
6.	19	.40	.09	6.12*	Vocabulary I
7.	31	.45	.06	3.95	EF Color Stimulus I

*$p < .05$
**$p < .01$

TABLE 9.--Stepwise Regression Analysis with Color as the Criterion Variable With Selected Personal Data Variables Forced, N = 48

Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
			Color		
Race Forced					
1.	4	.02	.02	.91	Race
2.	5	.09	.07	3.58	Color Blindness
3.	19	.15	.06	3.16	Vocabulary I
4.	24	.21	.05	2.94	Green
5.	11	.24	.04	1.97	Cube I
6.	15	.28	.04	2.32	Identical Pictures I
7.	31	.32	.04	2.26	EF Color Stimulus I
Color Blindness Forced					
1.	5	.07	.07	3.79	Color Blindness
2.	19	.14	.07	3.62	Vocabulary I
3.	24	.21	.06	3.38	Green
4.	8	.24	.03	1.87	Test Behavior
5.	31	.28	.04	2.51	EF Color Stimulus I
6.	26	.32	.04	2.46	Yellow
7.	43	.36	.05	2.64	EF Blink II
Reading Level Forced					
1.	10	.04	.04	1.85	Reading Level
2.	5	.11	.07	3.54	Color Blindness
3.	19	.18	.07	3.69	Vocabulary I
4.	24	.24	.06	3.41	Green
5.	8	.27	.04	1.82	Test Behavior
6.	31	.31	.04	2.20	EF Color Stimulus I
7.	43	.36	.05	3.01	EF Blink II

*$p < .05$
**$p < .01$

TABLE 10.--Stepwise Regression Analysis with Non-Color as the Criterion Variable with Selected French Ability Test Variables Forced N = 48

Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
			Non-Color		
Hidden Figures II Forced					
1.	14	.01	.01	.52	Hidden Figures II
2.	41	.13	.12	6.40*	EF Non-Color Resp. II
3.	27	.20	.07	3.69	Violet
4.	18	.25	.05	2.78	Maze II
5.	22	.31	.06	3.76	Letter Span Auditory
6.	19	.41	.11	7.41**	Vocabulary I
7.	31	.46	.05	3.57	EF Color Stimulus I
Identical Pictures I Forced					
1.	15	.05	.05	2.20	Identical Pictures I
2.	41	.14	.10	5.15*	EF Non-Color Resp. II
3.	27	.21	.07	3.82	Violet
4.	18	.27	.05	3.16	Maze II
5.	22	.32	.05	3.19	Letter Span Auditory
6.	19	.44	.12	8.52**	Vocabulary I
7.	31	.49	.05	4.30	EF Color Stimulus I
Maze II Forced					
1.	18	.03	.03	1.40	Maze II
2.	41	.17	.14	7.84**	EF Non-Color Resp. II
3.	22	.25	.08	4.75*	Letter Span Auditory
4.	19	.35	.10	6.30*	Vocabulary I
5.	31	.48	.04	3.07	EF Color Stimulus I
6.	15	.52	.04	3.13	Identical Pictures I

*$p < .05$
**$p < .01$

TABLE 11.--Stepwise Regression Analysis with Color as the Criterion Variable with Selected French Ability Variables Forced, N = 48

Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
			Color		
Hidden Figures II Forced					
1.	14	.03	.03	1.55	Hidden Figures II
2.	21	.10	.07	3.30	Surface Development
3.	5	.16	.06	3.20	Color Blindness
4.	19	.21	.05	2.96	Vocabulary I
5.	41	.26	.05	2.74	EF Non-Color Resp. II
6.	16	.30	.03	1.90	Identical Pictures II
7.	8	.34	.04	2.54	Test Behavior
Identical Pictures I Forced					
1.	15	.00	.00	.00	Identical Pictures I
2.	19	.09	.09	4.22*	Vocabulary I
3.	5	.19	.10	5.26	Color Blindness
4.	24	.23	.05	2.63	Green
5.	11	.27	.04	2.44	Cube I
6.	8	.31	.04	2.23	Test Behavior
7.	31	.36	.05	3.34	EF Color Stimulus
Maze II Forced					
1.	18	.00	.00	.00	Maze Tracing II
2.	5	.08	.08	3.74	Color Blindness
3.	17	.15	.08	3.91	Maze Tracing I
4.	19	.23	.08	4.48*	Vocabulary I
5.	24	.29	.06	3.41	Green
6.	15	.33	.04	2.31	Identical Pictures I
7.	11	.37	.04	2.78	Cube I

*$p < .05$
**$p < .01$

TABLE 12.--Stepwise Regression Analysis with Non-Color Card as the Criterion Variable for the Following Classification Variables: Personal Data, French Ability, Color Preference, and Eye Fixation, Taken Separately, N = 48

		Non-Color			
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Personal Data					
1.	2	.04	.04	1.80	Age
Ability					
1.	22	.11	.11	5.70*	Letter Span Auditory
2.	19	.22	.11	6.12*	Vocabulary I
3.	15	.27	.05	3.30	Identical Picture I
4.	18	.33	.05	3.47	Maze II
Color Card Preference					
1.	28	.04	.04	2.07	Brown
Eye Fixation					
1.	41	.13	.13	6.92*	EF Non-Color Resp. II
2.	40	.17	.04	2.29	EF Center Viewing II
3.	43	.22	.04	2.40	EF Blink II

*p $<$.05
**p $<$.01

TABLE 13.--Stepwise Regression Analysis With Color Card as the Criterion Variable for the Following Classification Variables: Personal Data, French Ability, Color Preference and Eye Fixation, Taken Separately, N = 48

		Color			
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Personal Data					
1.	5	.08	.08	3.79	Color Blindness
2.	10	.11	.03	1.64	Reading Level
3.	9	.14	.03	1.61	Reading Grade
Ability					
1.	19	.07	.07	3.26	Vocabulary I
2.	22	.11	.05	2.29	Letter Span Auditory
3.	21	.15	.04	1.83	Surface Development
Color Card Preference					
1.	26	.06	.06	3.09	Yellow
2.	24	.09	.03	1.40	Green
3.	23	.13	.04	1.77	Blue
Eye Fixation					
1.	41	.04	.04	1.87	EF Non-Color Resp. II

*p $<$ .05
**p $<$ .01

TABLE 14.--Subject Preferences Expressed by the Larger of the Two Representation Mode Sums in Pre-Learning and Post-Learning Stimulus and Response Eye Fixation Conditions.

Post-Learning	Pre-Learning: Color Stimulus Color Response	Color Stimulus Non-Color Response	Non-Color Stimulus Non-Color Response	Non-Color Stimulus Color Response
Color Stimulus Color Response	2	5	1	1
Color Stimulus Non-Color Response	2	30	1	
Non-Color Stimulus Non-Color Response	1	3		1
Non-Color Stimulus Color Response	1			

5 moved from Color Stimulus and Non-Color Response to Color Stimulus and Color Response fixating;

3 moved from Color Stimulus and Non-Color Response to Non-Color Stimulus and Non-Color Response fixating;

2 moved from Color stimulus and Color Response to Color Stimulus and Non-Color Response fixating;

1 moved from Color Stimulus and Color Response to Non-Color Stimulus and Color Response fixating;

1 moved from Non-Color Stimulus and Non-Color Response to Color Stimulus and Non-Color Response fixating;

1 moved from Color Stimulus and Color Response to Non-Color Stimulus and Non-Color Response fixating;

1 moved from Non-Color Stimulus and Color Response to Color Stimulus and Color Response fixating;

1 moved from Non-Color Stimulus and Color Response to Non-Color Stimulus and Non-Color Response fixating; and

1 moved from Non-Color Stimulus and Non-Color Response to Color Stimulus and Color Response fixating.

Of the 16 Change subjects, 9 (56 percent) moved from Pre-Learning to Post-Learning Eye Fixation picture preference in the direction of the Picture treatment in which they had the higher Color or Non-Color Criterion learning score: 7 moved toward fixating more on Color pictures, and 2 moved toward fixating more on Non-Color pictures. Of the remaining 7 subjects, 4 (25 percent) moved from Pre-Learning to Post-Learning Eye Fixation picture preference away from the picture treatment in which they had the higher Color Criterion learning score and 3

(19 percent) could not be determined because they had the same learning score for both Color and Non-Color picture treatments. If the 9 whose eye fixating preference moved toward the picture treatment where they had the higher criterion learning score were added to the 3 for whom it was not possible to determine fixating preference change because of the tied score, the total would be 74 percent of the subjects moving toward fixating on picture where they had the higher criterion learning score. Taking the above eye fixation preference movement into consideration it seems reasonable to hypothesize for future study that the change in fixating preference from Pre-Learning to Post-Learning will be in the direction of the picture treatment where the subject achieved the higher learning score.

Stimulus Representation Mode Fixation Preference. In the Pre-Learning Eye Fixation Preference Test (V31-V37), 44 of the 48 subjects exhibited Color Stimulus picture viewing preference, that is, fixated more on the Color Stimulus pictures than on the Non-Color Stimulus pictures. When these 44 subjects reached the Post-Learning Eye Fixation Preference Test (V38-V44), 4 changed their preference to Non-Color picture fixating. Of the 4 subjects who preferred the Non-Color picture stimulus in the Pre-Learning Eye Fixation Preference Test (V31-V37), 3 changed in the Post-Learning Eye Fixation Preference Test (V38-V44), in the direction of Color picture stimulus fixating.

Response Representation Mode Fixation Preference. In the Pre-Learning Eye Fixation Preference Test (V31-V37) 40 of the 48 subjects showed fixation preference for Non-Color picture response, that is, fixated more on the Non-Color picture response than on the Color picture

response. When these 40 subjects reached the Post-Learning Eye Fixation Test (V38-V44) 38 continued to fixate more on the Non-Color picture response. The other 8 of the 48 subjects not already mentioned preferred to fixate on the Color picture response in the Pre-Learning Eye Fixation Preference Test (V31-V37) while 10 subjects preferred Color picture response in the Post-Learning Eye Fixation Preference Test (V38-V44).

Eye Fixations and Learning Consistency. A comparison of the Pre-Learning and Post-Learning Eye Fixation data (V31-V44) provides an index of consistency of Eye Fixation Preference during the experimental procedure. See Table 15. The fixation categories examined are: Color Picture Stimulus (V31 and V38), Color Picture Response (V35 and V42), Non-Color Picture Stimulus (V32 and V39), Non-Color Picture Response (V34 and V41), Center Viewing (V33 and V40), Off-Display (V37 and V44), and Eye Blinks (V36 and V43). An examination of the analysis of variance tables shows changes for Eye Fixation Preference from the Pre- to Post-Learning as follows: a reduction in Non-Color Picture Stimulus fixation, and an increase in Eye Blinks and Off-Display fixations.

The other test of consistency compares the Pre- and Post-Learning Presentation Preference Scores (V45 and V46). See Table 16 for the analysis of variance. The analysis showed no significant difference between these two tests.

Exploratory Analysis: Sub-Population

Sub-Population analysis in this study is based upon fixation preference differences among subjects similar to differences suggested by Coffing's (1971) study. Some subjects did not change their fixation

TABLE 15.--Analysis of Variance Summary of Criterion Variables' Order of Presentation Effects (A) by Seven Eye Fixation Variables Pre-Learning vs. Post-Learning Scores (B)

	df	Mean Square	F		Cell Means and (Standard Deviations)	
					Pre-Learning	Post-Learning
Frames: Color Stimulus						
Between Subjects						
"	47					
A	1	213.01	2.94			B
SA	46	72.43			1	2
				1	35.54 (7.59)	35.96 (8.15)
Within Subjects						
"	48			A		
B	1	15.84	.53			
AB	1	36.26	1.23	2	33.79 (5.59)	31.75 (7.00)
SB/A	46	29.81				
Frames: Color Response						
Between Subjects						
"	47					
A	1	108.38	1.34			B
SA	46	80.55			1	2
				1	21.70 (8.04)	20.91 (8.89)
Within Subjects						
"	48			A		
B	1	2.04	.05			
AB	1	6.00	.17	2	23.33 (5.89)	23.54 (7.80)
SB/A	46	36.06				
Frames: Non-Color Stimulus						
Between Subjects						
"	47					
A	1	145.04	3.05			B
SA	46	47.52			1	2
				1	19.00 (6.43)	15.25 (5.81)
Within Subjects						
"	48			A		
B	1	187.04	5.34*			
AB	1	22.04	.63	2	20.50 (6.47)	18.67 (6.96)
SB/A	46	35.22				

TABLE 15.--Continued.

	df	Mean Square	F		Cell Means and (Standard Deviations) Pre-Learning	Post-Learning
Frames: Non-Color Response						
Between Subjects						
"	47					
A	1	18.38	.23		B	
SA	46	80.80			1	2
				1	35.58	36.33
Within Subjects					(7.87)	(9.13)
"	48			A		
B	1	22.04	.60			
AB	1	1.04	.03	2	34.50	35.67
SB/A	46	36.39			(5.90)	(7.33)
Frames: Center Display						
Between Subjects						
"	47					
A	1	3.38	.45		B	
SA	46	7.52			1	2
				1	5.46	6.75
Within Subjects					(2.55)	(2.35)
"	48			A		
B	1	10.67	2.88			
AB	1	9.38	2.54	2	5.71	5.75
SB/A	46	3.69			(1.83)	(2.66)
Frames: Eye Blinks						
Between Subjects						
"	47					
A	1	8.76	.68		B	
SA	46	12.88			1	2
				1	2.58	3.96
Within Subjects					(2.95)	(3.67)
"	48			A		
B	1	49.59	8.59**			
AB	1	.09		2	1.92	3.42
SB/A	46	5.82			(2.89)	(2.64)

TABLE 15.--Continued.

	df	Mean Square	F		Cell Means and (Standard Deviations)	
					Pre-Learning	Post-Learning
Frames: Off Display						
Between Subjects						
"	47					
A	1	.84	.54			
SA	46	3.10				
					B	
					1	2
				1	.17	.83
Within Subjects					(.64)	(1.58)
"	48					
			A			
B	1	17.51	10.20**			
AB	1	.84	.39	2	.17	1.21
SB/A	46	1.72			(.56)	(2.54)

*p < .05 = 4.05
**p < .01 = 7.21

TABLE 16.--Analysis of Variance Summary Using Efficiency of Learning as Criteria for Order of Presentation Effects (A) by Pre-Learning vs. Post-Learning Success (B), N = 48

		df	Mean Square	F Ratio
Between Subjects		47		
A	Order of Presentation	1	.26	.11
S/A	Subjects Within Groups	46	2.21	
Within Subjects		48		
B	Pre-Learning I vs. Post-Learning II	1	1.26	1.19
AB	Interaction of Pre-Learning vs. Post-Learning by Order of Presentation	1	1.26	1.19
SB/A	Subjects Within Groups	46	1.06	

* = $p < .05 = 4.05$
** = $p < .01 = 7.21$
*** = $p < .001 = 12.29$

Winer (1962) p. 303

Cell Means and (Standard Deviations)

		B	
		Pre-Learning (I)	Post-Learning (II)
A	1	3.96 (1.46)	4.42 (1.32) = .46
	2	4.29 (1.27)	4.29 (1.04) = 00
		.33	.13

preference strategy between the Pre-Learning and the Post-Learning Eye Fixation Test, but some did. It is this distinction between Changers and Non-Changers that constitutes the basis for the sub-population analysis. In this study two thirds of the subjects did not change their eye fixation preferences while one third did.

An analysis of the subjects who fit the Non-Change category discloses two kinds: one, Color Stimulus, Non-Color Response fixators (N=30), and the other, Color Stimulus, Color Response fixators (N=2). Because of the greater number of the group of Color Stimulus, Non-Color Response fixators (N=30), it was decided to look at them as a group to be compared with all other subjects. The Color Stimulus, Non-Color Response group will subsequently be called Group A (N=30). All other subjects will be called Group B (N=18). It should be noted that Group B (N=18) actually contained two Non-Change subjects (Color Stimulus, Color Response fixators) and 16 subjects who did change their fixation preferences. If these two subjects had not been included in the Sub-Population Group B (N=18), these populations could actually have been classified on the basis of Change and Non-Change fixation preference subjects. Since there were only two Non-Change subjects included in Group B (N=18) it was felt that their effect on the Change sub-population was not great and that the results of this exploratory analysis could be used as a basis for future hypothesis with regard to actual Change and Non-Change fixation preference populations.

Although there were no hypotheses related to the sub-populations, it was decided to explore these sub-populations to see whether the Major Hypothesis I, II and III might receive support for subsequent study

with similar population groupings.

Exploratory Analysis: Major
Hypothesis I—Sub-Population

This hypothesis states that learning will be facilitated more by Color pictures than by Non-Color pictures in a synchronous audio-visual presentation.

The mean and standard deviation for the total population and the two sub-populations are shown on Table 17.

Group A (N=30)

Table 18 presents the analysis of variance summary using efficiency of learning as the criterion. The analysis shows a significant main effect for Color vs. Non-Color presentation ($p < .001$).

Group B (N=18)

Table 19 presents the analysis of variance summary using efficiency of learning as the criterion. The analysis shows a significant main effect for Color vs. Non-Color presentation ($p < .001$).

By these exploratory analyses, Hypothesis I is empirically supported for future study using similar sub-population groupings.

Exploratory Analysis: Major
Hypothesis II—Sub-Population

This hypothesis states that preference expressed by eye fixation variables for several visual presentation modes should be differentially related to efficiency of learning using those modes.

Group A (N=30)

Hypothesis II is not empirically supported for future study using similar Group A (N=30) sub-populations. Although Hypothesis II dealt

TABLE 17.--Summary of Non-Color and Color Criteria Means and Standard Deviations for the Total Population and Sub-Populations (N=48), (N=30) and (N=18)

		Non-Color	Color
Total Population (N=48)			
	Mean	8.1	9.7
	S.D.	1.9	1.3
Group A Sub-Population (N=30)			
	Mean	8.33	9.73
	S.D.	1.73	1.39
Group B Sub-Population (N=18)			
	Mean	7.61	9.56
	S.D.	2.06	1.04

TABLE 18.--Analysis of Variance Summary Using Efficiency of Learning as the Criterion, Non-Color vs. Color Presentation Mode Success (N=30)

	Sum of Squares	DF	Mean Square	F Ratio
Between Group	722	1	722	30***
Within Group	347	28	12	
Total	1069	29		

*p $<$ .05 = 4.20
**p $<$ .01 = 7.64
***p $<$ .001 = 13.50

TABLE 19.--Analysis of Variance Summary Using Efficiency of Learning as the Criterion, Non-Color vs. Color Presentation Mode Success (N=18)

	Sum of Squares	DF	Mean Square	F Ratio
Between Group	2444	1	2444	94***
Within Group	468	16	33	
Total	2912	17		

*p $<$ .05 = 4.49
**p $<$ .01 = 8.53
***p $<$ .001 = 16.12

with only Eye Fixation variables, the regression slopes obtained between the criterion measures and each of the predictor variables under each treatment were tested by a parallelism of regression test for the extent to which they differed. Table 20 presents the obtained F/ratios. These results across Group A do not support the hypothesis of interaction between eye fixation strategies used and performance on the criterion measure where Color picture and Non-Color picture are offered as alternative modes of audio visual presentations.

TABLE 20.--Test of Parallelism of Regression Results between Standardized Main Variables and the Two Learning Criterion Measures for the Eye Fixation Group A Subjects Df = 56, N = 30

			Parallelism F Ratio	Non-Color beta′	Color beta′
	Personal Data Measures				
1.	Grade		.07	-.05	.15
2.	Age		.01	-.17	-.21
3.	Sex		.03	-.14	-.07
4.	Race		1.43	.48	-.06
5.	Color Blindness		.08	-.90	-.66
6.	Glasses		1.32	.44	-.17
7.	Color Eyes		.48	.05	-.24
8.	Test Behavior		.37	.00	-.24
9.	Reading Grade		.00	.25	.25
10.	Reading Level		.31	-.02	-.27
	Ability Measures				
11.	Cube Rotation	I	.22	.09	.26
12.	"	II	.61	.40	.06
13.	Hidden Figures	I	.08	.28	.14
14.	"	II	.00	.31	.29
15.	Identical Pictures	I	.49	.47	.10
16.	"	II	.26	-.17	.07
17.	Maze Tracing	I	.01	.05	.09
18.	"	II	1.78	.37	.32
19.	Wide Range Vocabulary	I	.15	.56	.39

TABLE 20.--Continued.

			Parallelism F Ratio	Non-Color beta′	Color beta′
	Ability Measures				
20.	Wide Range Vocabulary	II	.03	.29	.36
21.	Surface Development		.16	-.27	-.12
22.	Letter Span Auditory		3.25	-.91	-.09
	Color Card Preference Measures				
23.	Blue		.45	.34	.07
24.	Green		.62	-.11	.19
25.	Red		.04	-.05	.03
26.	Yellow		.06	-.18	-.28
27.	Violet		2.44	-.52	.05
28.	Brown		2.59	.39	-.25
29.	Black		.03	.34	.27
30.	Gray		.01	-.05	-.09
	Eye Fixation Measures				
31.	EF Color Stimulus	Pre-Lrng.	.88	.31	-.13
32.	EF Non-Color Stimulus	"	.06	-.01	-.10
33.	EF Center Viewing	"	1.94	-.64	-.04
34.	EF Non-Color Response	"	.27	-.01	.27
35.	EF Color Response	"	.06	-.06	.06
36.	EF Eye Blink	"	.00	.00	.02
37.	EF Off-Display	"	.30	.10	-.08
38.	EF Color Stimulus	Post-Lrng.	.00	-.01	-.02
39.	EF Non-Color Stimulus	"	.17	-.33	-.08
40.	EF Center Viewing	"	1.51	-.50	.00
41.	EF Non-Color Response	"	.02	.10	.18
42.	EF Color Response	"	.11	.25	.08
43.	EF Eye Blink	"	1.30	.21	-.23
44.	EF Off-Display	"	.01	-.07	-.03
45.	Pre-Learning Lrng. Score		.22	.08	-.13
46.	Post-Learning "		.00	.02	.03

*$p < .05 = 4.01$
**$p < .01 = 7.10$

Group B (N=18)

Hypothesis II is empirically supported for future study using similar Group B (N=18) sub-populations. Although Hypothesis II dealt with only Eye Fixation variables, the regression slopes obtained between the criterion measures and each of the predictor variables under each treatment were tested by a parallelism of regression for the extent to which they differed. Table 21 presents the obtained F/ratios. These results across Group B (N=18) population support the hypothesis of interaction between the eye fixation strategies used and performance on the criterion measure where Color pictures and Non-Color pictures are offered as alternative modes of audio-visual presentations.

TABLE 21.--Test of Parallelism of Regression Results between Standardized Main Variables and the Two Learning Measures for the Eye Fixation Group B Subjects Df = 32, N = 18

			Parallelism F Ratio	Non-Color beta′	Color beta′
	Personal Data Measures				
1.	Grade		.08	-.21	-.05
2.	Age		1.02	-.52	-.06
3.	Sex		.88	.63	.05
4.	Race		.21	.08	-.31
5.	Color Blindness		.85	.16	-.44
6.	Glasses		6.37*	-1.91	.18
7.	Color Eyes		.08	-.26	-.10
8.	Test Behavior		.09	.35	.18
9.	Reading Grade		.36	-.20	.10
10.	Reading Level		.17	-.01	-.22
	Ability Measures				
11.	Cube Rotation	I	.19	-.46	-.12
12.	"	II	1.68	-.64	.00
13.	Hidden Figures	I	.15	-.03	.14

TABLE 21.--Continued.

			Parallelism F Ratio	Non-Color beta′	Color beta′
	Ability Measures				
14.	Hidden Figures	II	9.25**	-1.62	.06
15.	Identical Pictures	I	3.15	-.90	-.13
16.	"	II	.09	.39	.53
17.	Maze Tracing	I	.08	.56	.46
18.	"	II	.12	.35	.20
19.	Wide Range Vocabulary	I	.99	-.23	.26
20.	"	II	2.44	-.54	.27
21.	Surface Development		.06	-.74	-.57
22.	Letter Span Auditory		.42	-.29	.01
	Color Card Preference Measures				
23.	Blue		.68	.18	.65
24.	Green		.40	.07	.48
25.	Red		.02	-.87	-.80
26.	Yellow		2.88	.65	-.38
27.	Violet		.79	.20	-.49
28.	Brown		.01	.27	.31
29.	Black		3.74	-1.03	.14
30.	Gray		1.98	2.48	.20
	Exe Fixation Measures				
31.	EF Color Stimulus	Pre-Lrng.	4.43*	-1.59	-.33
32.	EF Non-Color Stimulus	"	.20	.08	.35
33.	EF Center Viewing	"	.12	.49	.31
34.	EF Non-Color Response	"	1.15	.62	.12
35.	EF Color Response	"	.27	-.11	-.45
36.	EF Eye Blink	"	.05	-.13	.10
37.	EF Off-Display	"	.00	-.39	-.35
38.	EF Color Stimulus	Post-Lrng.	1.49	-1.01	.21
39.	EF Non-Color Stimulus	"	.76	-.63	-.12
40.	EF Center Viewing	"	1.65	-.82	-.12
41.	EF Non-Color Response	"	3.95	1.40	.41
42.	EF Color Response	"	.07	-.18	.35
43.	EF Eye Blink	"	1.05	1.02	.39
44.	EF Off-Display	"	.38	-.65	-.22
45.	Pre-Learning Lrng. Scores		.13	.33	.15
46.	Post-Learning "		.01	.51	.45

*p .05 = 4.15
**p .01 = 7.50

Group A (N=30) vs. Group B (N=18)

Table 22 presents the test of parallelism of regression slopes between standardized main variables (V1-V46) and the Non-Color Learning Measures for the 18 Eye Fixation Group B subjects vs. the 30 Eye Fixation Group A subjects. Glasses (V6), Hidden Figures II (V14), Identical Pictures I (V15), Black (V29), Eye Fixation Color Picture Stimulus (V31), Eye Fixation Center Viewing (V33), and Eye Fixation Non-Color Picture Response (V41) achieved significant F/ratio slope differences.

TABLE 22.--Test of Parallelism of Regression Results between Standardized Main Variables and the Non-Color Learning Measures for the 18 Eye Fixation Group B Subjects vs. the 30 Eye Fixation Group A Subjects, Df = 44

			Parallelism F Ratio	Group B (N=18) Subjects beta′	Group A (N=30) Subjects beta′
	Personal Data Measures				
1.	Grade		.21	-.21	.05
2.	Age		.43	-.52	-.17
3.	Sex		1.55	.63	-.14
4.	Race		1.10	-.08	.48
5.	Color Blindness		1.47	.16	-.90
6.	Glasses		8.31**	-1.91	.44
7.	Color Eyes		.29	-.26	.05
8.	Test Behavior		.36	.35	.00
9.	Reading Grade		.65	-.20	.25
10.	Reading Level		.00	-.01	-.02
	Ability Measures				
11.	Cube Rotation	I	.62	-.46	.09
12.	"	II	3.74	-.64	.40
13.	Hidden Figures	I	.32	-.03	.28
14.	"	II	11.93**	-1.62	.31
15.	Identical Pictures	I	6.11*	-.90	.47
16.	"	II	1.01	.39	-.17

TABLE 22.--Continued.

			Parallelism F Ratio	Group B (N=18) Subjects beta′	Group A (N=30) Subjects beta′
17.	Maze Tracing	I	.79	.56	.05
18.	"	II	.00	.35	.37
19.	Wide Range Vocabulary	I	2.18	-.23	.56
20.	"	II	2.27	-.54	.29
21.	Surface Development		.54	-.74	-.27
22.	Letter Span-Auditory		1.38	-.29	-.91
	Color Card Preference Measures				
23.	Blue		.08	.18	.34
24.	Green		.08	.07	-.11
25.	Red		1.93	-.87	-.05
26.	Yellow		1.95	.65	-.18
27.	Violet		1.11	.20	-.52
28.	Brown		.05	.27	.39
29.	Black		5.50*	-1.03	.34
30.	Gray		3.37	2.48	-.05
	Eye Fixation Measures				
31.	EF Color Stimulus	Pre-Lrng.	9.06**	-1.59	.31
32.	EF Non-Color Stimulus	"	.02	.08	-.01
33.	EF Center Viewing	"	4.30*	.49	-.64
34.	EF Non-Color Response	"	1.20	.62	.01
35.	EF Color Response	"	.00	-.11	-.06
36.	EF Eye Blink	"	.02	-.13	.00
37.	EF Off-Display	"	.17	-.39	.10
38.	EF Color Stimulus	Post-Lrng.	1.28	-1.01	-.01
39.	EF Non-Color Stimulus	"	.19	-.63	-.33
40.	EF Center Viewing	"	.34	-.82	-.50
41.	EF Non-Color Response	"	4.67*	1.40	.10
42.	EF Color Response	"	.42	-.18	.25
43.	EF Eye Blink	"	1.85	1.02	.21
44.	EF Off-Display	"	.81	-.65	-.07
45.	Pre-Learning Lrng. Score		.20	.33	.08
46.	Post-Learning "		.53	.51	.02

*$p < .05 = 4.06$
**$p < .01 = 7.24$

Table 23 presents the test of parallelism of regression slopes between standardized main variables (V1-V46) and the Color Learning Measures for the 18 Eye Fixation Group B subjects vs. the 30 Eye Fixation Group A subjects. Red (V25) achieved significant F/ratio slope differences.

TABLE 23.--Test of Parallelism of Regression Results Between Standardized Main Variables and the Color Learning Measures for the 18 Eye Fixation Group B Subjects vs. the 30 Eye Fixation Group A Subjects, Df = 44

			Parallelism F Ratio	Group B (N=18) Subjects beta′	Group A (N=30) Subjects beta′
	Personal Data Measures				
1.	Grade		.27	-.05	.15
2.	Age		.16	-.06	-.21
3.	Sex		.07	.05	-.07
4.	Race		.46	-.31	-.06
5.	Color Blindness		.15	-.44	-.66
6.	Glasses		.35	.18	-.17
7.	Color Eyes		.10	-.10	-.24
8.	Test Behavior		1.11	.18	-.24
9.	Reading Grade		.16	.10	.25
10.	Reading Level		.02	-.22	-.27
	Ability Measures				
11.	Cube Rotation	I	.67	-.12	.26
12.	"	II	.02	.00	.06
13.	Hidden Figures	I	.00	.14	.14
14.	"	II	.31	.06	.29
15.	Identical Pictures	I	.32	-.13	.10
16.	"	II	1.62	.53	.07
17.	Maze Tracing	I	.77	.43	.09
18.	"	II	1.84	.20	.32
19.	Wide Range Vocabulary	I	.14	.26	.39
20.	"	II	.06	.27	.36
21.	Surface Development		1.08	-.57	-.12
22.	Letter Span Auditory		2.29	.01	-.09

TABLE 23.--Continued.

			Parallelism F Ratio	Group B (N=18) Subjects beta′	Group A (N=30) Subjects beta′
	Color Card Preference Measures				
23.	Blue		2.29	.65	.07
24.	Green		.49	.48	.19
25.	Red		4.48*	-.80	.03
26.	Yellow		.05	-.38	-.28
27.	Violet		1.32	-.48	.05
28.	Brown		2.13	.31	-.25
29.	Black		.11	.14	.27
30.	Gray		.09	.20	-.09
	Eye Fixation Measures				
31.	EF Color Stimulus	Pre-Lrng.	.18	-.33	-.13
32.	EF Non-Color Stimulus	"	1.24	.35	-.10
33.	EF Center Viewing	"	.79	.31	-.04
34.	EF Non-Color Response	"	.14	.12	.27
35.	EF Color Response	"	1.22	-.45	.06
36.	EF Eye Blink	"	.02	.10	.02
37.	EF Off-Display	"	.11	-.35	-.08
38.	EF Color Stimulus	Post-Lrng.	.15	.21	-.02
39.	EF Non-Color Stimulus	"	.01	-.12	-.08
40.	EF Center Viewing	"	.10	-.12	.00
41.	EF Non-Color Response	"	.27	.41	.18
42.	EF Color Response	"	.92	.35	.08
43.	EF Eye Blink	"	2.18	.39	-.23
44.	EF Off-Display	"	.17	-.22	-.03
45.	Pre-Learning Lrng. Score		.53	.15	-.13
46.	Post-Learning "		.85	.45	.03

*$p < .05 = 4.06$
**$p < .01 = 7.24$

Tables 24 and 25 present a summary of the test of parallelism of regression derived from Tables 22 and 23 showing significant results for population of 18 Group B vs. 30 Group A fixation pattern subjects between standardized main variables and Non-Color Criterion (V47) and Color Criterion (V48), respectively.

Hypothesis II is empirically supported for future study between similar Group A and Group B sub-populations.

TABLE 24.--Summary Presentation of Test of Parallelism of Regression Showing Significant Results for Population of 18 Group B vs. 30 Group A Fixation Pattern Subjects with Standardized Main Variables and Non-Color Criterion from Table 22

			F Ratio	Group B N=18 beta′	Group A N=30 beta′
	Personal Data Measures				
6.	Glasses		8.31**	-1.91	.44
	Ability Measures				
14.	Hidden Figures	II	11.93**	-1.62	.31
15.	Identical Pictures	I	6.11*	-.90	.47
	Color Card Preference				
29.	Black		5.50*	-1.03	.34
	Eye Fixation Measures				
31.	Color Stimulus	I	9.06**	-1.59	.31
33.	Center Viewing	I	4.30*	.49	-.64
41.	Non-Color Response	II	4.67*	1.40	.10

*p < .05 = 4.06
**p < .01 = 7.24

TABLE 25.--Summary Presentation of Test of Parallelism of Regression Showing Significant Results for Population of 18 Group B vs. 30 Group A Fixation Pattern Subjects with Standardized Main Variables and Color Criterion from Table 23

		F Ratio	Group B N=18 beta′	Group A N=30 beta′
	Color Card Preference			
25.	Red	4.78*	-.80	.03

*p < .05 = 4.06
**p < .01 = 7.24

Exploratory Analysis: Major Hypothesis III—Sub-Population

This hypothesis states that prediction of learning success would be enhanced by the addition of eye fixation variables and Color Card Preference to more conventional paper and pencil ability tests. Before examining multiple correlation analyses, it will be useful to summarize the general trends for simple correlations.

Zero Order Correlation Analysis: Group A (N=30)

Table 26 shows the correlation matrix and gives overall means and standard deviations for the major variables developed and used in the present experiment. It shows only the significant predictor variable correlations ($p < .05$ and better).

Personal Data variables (V1-V10) showed 5 significant or 11 percent correlation out of the possible correlations within this classification. There were no correlations with either criterion variables (V47-V48).

Personal Data variables (V1-V10) were intercorrelated with the

		Personal Data									French Ability Test										Color Preference										Eye Fixation Variables										P&P Lrng.	Crt. Vis		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	MEAN	SD
1	GRADE	1	61	.	.	.	31	.	.	.	.	.	.	31	.	.	.	32	.	31	.	.	.	.	.	.	32	.	-31	.	.	.	.	-34	.	-35	37	-33	.	.	.	.	.	.	.	.	.	.	5.53	.51
2	AGE	.	1	.	.	32	39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-38	40	.	.	40	.	.	.	.	-38	.	41	.	.	-37	44	-30	.	.	.	.	-83	.	-45	.	.	.97	.62
3	SEX	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	41	.	.	.	.	.	.	.	.	.	.	.	-32	.	.	.	34	.	.	.	.	.	.	.	.50	.51
4	RACE	.	.	.	1	.	.	.	.	.	.	31	36	.	.	.	.	.	.	.	.	.	.	.	.	42	.	-38	.	32	47	.	32	.	-38	31	.	.	.	.	.	.	.	.	.	.	.	48	.	.	.97	.18
5	CLR BLD	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	39	.	.	.	38	.	-69	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-36	.	.	.	.03	.18
6	GLASSES	.	.	.	.	.	1	.	.	.	.	.	.	.	.	-41	34	.	.	-43	.	.	.	.	.	.	.	.	.	.	.	.	44	.	.	.	.	.	.	45	.	.	-36	.	.	.10	.31
7	EYE CLR	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.33	.48
8	TEST BEHV	.	.	.	.	.	.	.	1-48	.	.	.	.	.	.	.	33	.	.	.	.	.	.	.	.	.	36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.70	.47
9	READ GRD	.	.	.	.	.	.	.	1	.	.	.	32	.	.	.	.	.	47	.	.	.	.	.	.	.	.	.	.	.	.	-33	36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.17	.53
10	READ LVL	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	40	.	.	.	.	.	57	.	.	.	.	-31	.	.	.	.	45	.	-32	.	-34	.	-31	.	.	.	.	.	.	.	.	.	2.53	.51
11	CUBE I											1	46	35	.	34	.	43	44	.	.	.	.	.	.	.	36	.	.	.	.	.	.	.	.	.	.	.	.	.	-37	.	.	.	.	.	.	.	8.57	4.64
12	CUBE II											.	1	42	35	.	.	.	.	.	.	.	.	.	-54	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38	.	.	.	.	.	.	.	6.57	2.96
13	HID FIG I											.	.	1	33	.	39	.	.	38	.	37	.	34	.	.	-40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	31	.	.	2.50	1.76
14	HID FIG II											.	.	.	1	32	37	32	44	34	37	40	.	.	.	.	.	-33	.	.	.	.	.	-31	.	.	.	.	.	.	.	30	.	.	.	.	.	.	.	2.53	2.08
15	IDEN PIC I											.	.	.	.	1	.	.	.	.	34	.	.	.	.	.	.	.	.	.	-36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27.13	6.15
16	IDEN PIC II											.	.	.	.	.	1	.	.	.	.	55	.	.	.	-39	.	.	.	.	.	.	-31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22.63	9.13
17	MAZE I											.	.	.	.	.	.	1	63	.	.	.	.	.	.	33	.	.	.	.	.	.	46	.	.	.	.	.	.	30	.	.	.	.	.	.	.	.	8.00	2.35
18	MAZE II											.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	35	.	-32	.	.	.	.	.	.	-35	.	.	.	.	.	.	.	.	.	.	.	.	.	11.30	2.23
19	VOCAB I											.	.	.	.	.	.	.	.	1	44	.	39	49	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	30	.	6.10	2.48
20	VOCAB II											.	.	.	.	.	.	.	.	.	1	.	.	50	.	.	.	-39	.	-31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.47	2.60
21	SURF DEV											.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	35	-35	.	.	.	.	-32	.	.	.	.	.	.	.	.	36	.	.	7.73	5.07
22	LTR SPAN											.	.	.	.	.	.	.	.	.	.	.	1	.	.	32	.	.	-35	-32	.	-37	.	38	.	.	.	.	.	40	.	.	.	.	.	.	-45	.	5.10	2.38
23	BLUE																							1	.	-53	.	.	.	35	.	.	.	-36	.	.	.	33	.	.	-36	.	.	.	.	.	.	.	.	3.47	1.70
24	GREEN																							.	1	.	.	.	.	.	-32	.	-55	.	36	.	.	.	30	-45	.	.	-53	30	.	-35	.	.	3.67	1.90
25	RED																							.	.	1	.	.	.	-40	.	.	.	38	.	.	.	.	.	.	34	.	.	.	.	.	.	.	.	3.60	1.98
26	YELLOW																							.	.	.	1	.	.	.	-30	31	.	.	.	.	-38	.	.	.	.	.	-31	.	.	.	.	.	3.67	1.97
27	VIOLET																							.	.	.	.	1	-62	-35	-42	39	-58	.	36	-35	39	.	.	-31	.	36	-38	.	.	-38	.	-33	.	2.83	2.07
28	BROWN																							.	.	.	.	.	1	.	31	.	.	.	-32	41	-38	.	.	.	.	.	.	.	35	.	.	.	5.70	1.81
29	BLACK																							.	.	.	.	.	.	1	.	.	38	.	.	.	.	.	.	.	.	.	.	.	47	.	.	.	6.60	1.52
30	GREY																							.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6.64	1.78
31	EF CS I																										1	-60	-38	41	-69	.	.	35	-31	-34	32	.	.	.	.	.	.	.	.	.	.	.	.	.	37.30	6.00
32	EF NCS I																										.	1	.	-67	36	.	.	-32	33	.	.	40	.	.	56	39	.	.	.	.	.	.	.	18.83	6.30
33	EF CTR I																										.	.	1	.	.	.	.	.	.	.	55	-37	.	.	.	.	.	-34	.	.	.	.	5.23	2.05
34	EF NCR I																										.	.	.	1	-55	.	.	48	-39	.	32	-35	-33	-38	-40	.	.	.	.	.	.	.	.	36.33	5.85
35	EF CR I																										.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19.47	5.72
36	EF BLK I																										.	.	.	.	.	1	.	.	.	.	.	.	.	40	66	-31	.	.	.	.	.	.	2.50	3.44
37	EF OFF I																										.	.	.	.	.	.	1	.	.	.	.	.	.	40	65	.	.	.	.	.	.	.	.23	.73
38	EF CS II																																	1	-61	.	.	-61	.	-55	.	.	.	.	.	.	.	.	36.93	7.85
39	EF NCS II																																	.	1	.	-60	62	.	.	.	.	.	.	.	.	.	.	13.90	4.85
40	EF CTR II																																	.	.	1	-30	.	.	.	-30	.	.	.	.	.	.	.	6.50	2.54
41	EF NCR II																																	.	.	.	1	-56	.	.	.	.	.	.	.	.	.	.	39.43	6.48
42	EF CR II																																	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	18.73	6.77
43	EF BLK II																																	.	.	.	.	.	1	58	.	.	.	.	.	.	.	.	3.40	3.43
44	EF OFF II																																	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1.10	2.34
45	PRE-LEARNING																																								1	44	.	.	.	.	.	.	.	4.33	1.24
46	POST-LEARNING																																								.	1	.	.	.	.	.	.	4.40	1.33
47	NC CRITERION																																								.	.	1	.	.	.	.	8.33	1.73
48	C CRITERION																																								.	.	.	1	.	.	.	9.73	1.39

TABLE 26.--Correlation Matrix with Means and Standard Deviations for Significant Correlations for the Variables and the Criteria. Group A (N=30)

other classification as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
French Ability Tests (V11-V22)	13 out of 120 possible	11%
Color Card Preference Tests (V23-V30)	14 " 80 "	18%
Pre-Learning Eye Fixation (V31-V37)	12 " 70 "	17%
Post-Learning Eye Fixation (V38-V44)	12 " 70 "	17%
Pre- & Post-Learning Learning Scores (V45 & V46)	4 " 20 "	20%

French Ability Test variables (paper and pencil) V11-V22 showed 23 significant or 34 percent correlation out of the possible correlations within this classification. Furthermore, the French Ability Test variables significantly correlated with the Color and Non-Color Criterion twice or 4 percent of the 24 possible correlations. Wide Range Vocabulary I (V19) positively correlated with Non-Color Criterion (V47) while Letter Span Auditory negatively correlated with Non-Color Criterion (V47). The French Ability Test variables (V11-V22) were intercorrelated with other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Date (V1-V10)	13 out of 120 possible	11%
Color Card Preference Test (V23-V30)	16 " 96 "	17%

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Pre-Learning Eye Fixation (V31-V37)	9 out of 84 possible	11%
Post-Learning Eye Fixation (V38-44)	5 " 84 "	6%
Pre- & Post-Learning Learning Scores (V45 & V46)	4 " 20 "	20%

Color Card Preference Test variables (V23-V30) showed 8 significant or 32 percent correlation out of the possible correlations within this classification. Furthermore, the Color Card Preference variables significantly correlated with the Color and Non-Color Criterion once or 6 percent of the 16 possible correlations. Yellow was negatively correlated with Non-Color Criterion (V47). Color Card Preference Test variables (V23-V30) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	14 out of 80 possible	18%
French Ability Tests (V11-V22)	16 " 96 "	17%
Pre-Learning Eye Fixation (V31-V44)	17 " 56 "	18%
Post-Learning Eye Fixation (V38-V44)	10 " 56 "	18%
Pre- & Post-Learning Learning Scores (V45 & V46)	4 " 16 "	25%

Pre-Learning Eye Fixation variables (V31-V37) showed 7 significant or 33 percent correlation out of the possible correlations within this classification. Furthermore, the Pre-Learning Eye Fixation variables significantly correlated with the Color and Non-Color Criterion once or 8 percent of the 14 possible correlations. Eye Fixation Center Viewing (V33) was negatively correlated with the Non-Color Criterion (V47). Pre-Learning Eye Fixation variables (V31-V37) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	12 out of 70 possible	17%
French Ability Tests (V11-V22)	9 " 84 "	11%
Color Card Preference Tests (V23-V30)	17 " 56 "	30%
Post-Learning Eye Fixation (V38-V44)	19 " 49 "	39%
Pre- & Post-Learning Learning Scores (V45 & V46)	4 " 14 "	28%

Post-Learning Eye Fixation variables (V38-V44) showed 8 significant or 33 percent correlations out of the possible correlations within this classification. There were no correlations with either criterion variable (V47 and V48). Post-Learning Eye Fixation variables (V38-V44) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	12 out of 70 possible	17%
French Ability Tests (V11-V22)	5 " 84 "	6%
Color Card Preference Test (V23-V30)	10 " 56 "	18%
Pre-Learning Eye Fixation (V31-V37)	19 " 49 "	39%
Pre- & Post-Learning Learning Scores (V45 & V46)	1 " 14 "	8%

Pre- and Post-Learning Learning Score variables (V45 and V46) showed one significant or 100 percent correlation within classifications. There were no correlations with either criterion variables (V47 and V48). Pre- and Post-Learning Learning Score variables (V45 and V46) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	4 out of 20 possible	20%
French Ability Tests (V11-V22)	3 " 24 "	12%
Color Card Preference Tests (V23-V30)	4 " 16 "	25%
Pre-Learning Eye Fixation (V31-V37)	4 " 14 "	28%
Post-Learning Eye Fixation (V38-V44)	1 " 14 "	8%

Zero Order Correlation Analysis: Group B (N=18)

Table 27 shows the correlation matrix and gives overall means and standard deviations for the major variables developed and used in the present experiment. It shows only the significant predictor variable correlations ($p < .05$ and better).

Personal Data variables (V1-V10) showed 1 significant or 2 percent correlation out of the possible correlations within this classification. Furthermore, the Personal Data variables significantly correlated with the Color and Non-Color Criterion once or 5 percent of the 20 possible correlations. Glasses (V6) was negatively correlated with the Non-Color Criterion (V47). Personal Data variables (V1-V10) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
French Ability Tests (V11-V22)	17 out of 120 possible	14%
Color Card Preference Test (V23-V30)	9 " 80 "	11%
Pre-Learning Eye Fixation (V31-V37)	5 " 70 "	7%
Post-Learning Eye Fixation (V38-V44)	10 " 70 "	14%
Pre- and Post-Learning Learning Scores (V45 and V46)	7 " 20 "	35%

		Personal Data									French Ability Test										Color Preference								Eye Fixation Variables												P&P Lrng.	Crt. V's		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	MEAN	SD
1	GRADE	1	68	.	.	.	.	.	.	.	.	44	.	.	.	.	.	44	.	.	.	.	.	.	.	.	.	.	.	.	45	.	.	.	.	.	.	.	.	.	.	.	.	.	.	49	.	.	5.4	.51
2	AGE	.	1	.	.	.	.	.	.	.	.	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40	.	44	.	41	.	.	.	.	.	.	.	.	.	.	.	.	.	55	.	.	1.0	.84
3	SEX	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	42	.	44	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-52	.	.	.	40	.	.	61	.	.	.67	.49
4	RACE	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	-39	.	.	.	.	.	.	.	.	.	.	.	.	.	56	.	-82	.	.	.	.	.	.	.	.	.	.	.	.	-48	.	.	.84	.24
5	CLR BLD	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-46	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	53	.	.	.	.	.	.	.11	.33
6	GLASSES	.	.	.	.	.	1	.	.	.	52	74	.	67	.	.	.	.	.	45	.	.	.	.	.	.	.	.	.	.	41	.	.	.	.	.	.	65	41	-46	-46	.	.	.	-56	.	.	.06	.24
7	EYE CLR	.	.	.	.	.	.	1	.	.	.	.	-45	.	.	-46	.	-38	.	.	.	.	.	.	.	.	.	-47	.	.	43	.	.	.	.	.	.	.	.	.	.	.	.	.	-49	.	.	.39	.50
8	TEST BEHV	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-43	40	.	.	.	.	-38	.	.	.	.	.	.	.	42	.	.	-55	39	.	.	.	.	.	1.78	.43
9	READ GRD	.	.	.	.	.	.	.	.	1	-45	.	.	.	39	.	.	.	38	42	.	55	.	.	.	.	.	.	.	.	.	.	.	-42	.	.	.	.	.	.	.	.	-43	.	39	.	.	2.17	.71
10	READ LVL	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-43	.	.	2.55	.62
11	CUBE I											1	66	.	42	.	.	55	51	.	.	.	.	.	.	.	.	.	.	.	38	.	.	-40	41	.	.	44	.	.	-38	.	46	.	.	7.67	3.03
12	CUBE II											.	1	.	.	.	.	.	.	.	40	.	.	.	.	.	.	.	.	.	51	.	.	.	.	.	.	56	50	-51	.	-39	.	.	38	.	.	6.78	3.46
13	HID FIG I											.	.	1	58	.	.	43	54	.	.	.	.	.	.	.	-48	.	41	.	.	.	.	.	.	.	.	.	.	.	37	.	.	.	.	.	.	2.89	2.65
14	HID FIG II											.	.	.	1	.	.	.	.	.	.	.	.	42	.	-55	.	.	51	.	42	.	.	.	.	.	.	.	.	.	.	-52	.	.	.	.	-66	.	2.87	1.61
15	IDEN PIC I											.	.	.	.	1	.	.	.	45	.	38	.	.	.	.	.	.	-45	46	.	.	.	.	.	.	38	.	.	-47	.	-47	.	.	-51	.	32.72	9.37
16	IDEN PIC II											.	.	.	.	.	1	39	.	.	51	-41	.	.	39	-61	-50	.	65	.	.	.	57	.	.	.	.	.	.	.	.	.	.	.	40	.	58	22.39	11.25
17	MAZE I											.	.	.	.	.	.	1	90	.	.	.	48	.	.	-42	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	56	.	46	10.00	3.16
18	MAZE II											.	.	.	.	.	.	.	1	.	.	.	41	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-39	.	45	.	.	11.83	3.63
19	VOCAB I											.	.	.	.	.	.	.	.	1	.	.	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6.22	3.14
20	VOCAB II											.	.	.	.	.	.	.	.	.	1	.	42	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	45	.	.	.	.	.	.	.	.	4.89	2.85
21	SURF DEV											.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-45	8.1	3.70
22	LTR SPAN											.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6.0	3.34
23	BLUE																							.	1	.	.	-42	-69	.	.	.	45	.	.	.	.	.	.	.	.	.	.	.	.	.	.	61	3.56	1.62
24	GREEN																							.	1	-38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40	3.22	1.52
25	RED																							.	.	1	.	.	-43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-39	-70	3.11	1.78
26	YELLOW																							.	.	.	1	.	-64	-66	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4.50	1.72
27	VIOLET																							.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2.06	1.39
28	BROWN																							.	.	.	.	.	1	.	.	.	48	.	-46	.	.	.	.	.	.	.	.	-39	.	.	.	.	5.28	1.74
29	BLACK																							.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-44	.	6.94	1.26
30	GREY																							.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40	.	7.33	.59
31	EF CS I																															1	43	.	.	.	.	.	.	.	-45	.	-45	.	.	.	-62	.	30.28	5.33
32	EF NCS I																															.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	21.28	5.69
33	EF CTR I																															.	.	1	.	.	.	.	.	.	.	.	.	.	.	52	.	.	6.17	2.38
34	EF NCR I																															.	.	.	1	-72	.	.	.	.	.	.	.	43	.	.	.	.	32.89	8.13
35	EF CR I																															.	.	.	.	1	.	.	.	.	.	.	.	55	.	.	.	.	27.61	6.05
36	EF BLK I																															.	.	.	.	.	1	47	.	.	.	.	.	44	.	.	.	.	1.83	1.69
37	EF OFF I																															.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.06	.24
38	EF CS II																																						1	.	.	.	.	-41	.	.	.	.	28.72	4.36
49	EF NCS II																																						.	1	.	.	-66	.	.	.	.	.	23.17	6.82
40	EF CTR II																																						.	.	1-61	.	.	.	39-40	.	5.83	2.53
41	EF NCR II																																						.	.	.	1	.	44	.	.	64	.	30.28	7.67
42	EF CR II																																						.	.	.	.	1-50	.	.	.	.	28.06	7.63
43	EF BLK II																																						.	.	.	.	.	1	.	.	42	.	4.17	2.70
44	EF OFF II																																						.	.	.	.	.	.	1	.	-41	.	.89	1.68
45	PRE-LEARNING																																						1	.	.	.	.	.	.	.	.	.	3.78	1.52
46	POST-LEARNING																																						.	1	.	.	.	.	.	.	.	.	4.23	.89
47	NC CRITERION																																						.	.	1	.	.	.	.	.	.	.	7.61	2.06
48	C CRITERION																																						.	.	.	1	.	.	.	.	.	.	9.56	1.04

TABLE 27.--Correlation Matrix with Means and Standard Deviations for Significant Correlations for the Variables and the Criteria. Group B (N=18)

French Ability Test variables (paper and pencil) (V11-V22) showed 16 significant or 24 percent correlation out of the possible correlations within this classification. Furthermore, the French Ability Test variables significantly correlated with the Color and Non-Color Criterion 5 times or 21 percent of the 24 possible correlations. Hidden Figures II (V13) and Identical Pictures I (V15) were negatively correlated with the Non-Color Criterion (V47). Identical Pictures II and Maze Tracing I were positively correlated with the Color Criterion (V48) and Surface Development (V21) was negatively correlated with the Color Criterion (V48). The French Ability Test variables (V11-V22) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	17 out of 120 possible	14%
Color Card Preference Test (V23-V30)	13 " 96 "	13%
Pre-Learning Eye Fixation (V31-V37)	7 " 84 "	8%
Post-Learning Eye Fixation (V38-V44)	13 " 84 "	16%
Pre- & Post-Learning Learning Scores (V45 & V46)	5 " 24 "	20%

Color Card Preference Test variables (V23-V30) showed 6 significant or 21 percent correlation out of the possible correlations within this classification. Furthermore, the Color Card Preference variables significantly correlated with the Color and Non-Color Criterion 6 times or

38 percent of the 16 possible correlations. Red (V25) and Black (V29) were negatively correlated, while Gray (V30) was positively correlated with the Non-Color Criterion (V47). Blue (V23) and Green (V24) were positively correlated, while Red (V25) was negatively correlated with the Color Criterion (V48). Color Card Preference Test variables (V23-V30) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	9 out of 80 possible	11%
French Ability Tests (V11-V22)	13 " 96 "	13%
Pre-Learning Eye Fixation (V31-V37)	3 " 56 "	5%
Post-Learning Eye Fixation (V38-V44)	3 " 56 "	5%
Pre- & Post-Learning Learning Scores (V45 & V46)	None	0

Pre-Learning Eye Fixation variables (V38-V44) showed 3 significant or 14 percent correlation within classifications. Furthermore, the Pre-Learning variables significantly correlated with the Color and Non-Color Criterion once or 8 percent of the 16 possible correlations. Eye Fixation Color Picture Stimulus (V31) was negatively correlated with the Non-Color Criterion (V47). Pre-Learning Eye Fixation variables (V38-V44) were intercorrelated with the other classifications as follows:

Variance Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	5 out of 70 possible	7%
French Ability Tests (V11-V22)	7 " 84 "	8%
Color Card Preference Test (V23-V30)	3 " 56 "	5%
Post-Learning Eye Fixation (V38-V44)	5 " 49 "	10%
Pre- & Post-Learning Learning Scores (V45 & V46)	1 " 14 "	7%

Post-Learning Eye Fixation variables (V38-V44) showed 5 significant or 24 percent correlation out of the possible correlations within this classification. Furthermore, the Post-Learning Eye Fixation variables significantly correlated with the Color and Non-Color Criterion 3 times or 21 percent of the 14 possible correlations. Eye Fixation Center Viewing (V40) negatively correlated with the Non-Color Criterion (V47), while Eye Fixation Non-Color Response II (V41) and Eye Fixation Blink II (V42) were positively correlated with the Non-Color Criterion (V47). Post-Learning Eye Fixation variables (V39-V44) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	10 out of 70 possible	14%
French Ability Tests (V11-V22)	13 " 84 "	16%

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Color Card Preference Test (V23-V30)	3 out of 56 possible	5%
Pre-Learning Eye Fixation (V31-V37)	5 " 49 "	10%
Pre- & Post-Learning Learning Scores (V45 & V46)	2 " 14 "	14%

Pre- and Post-Learning Learning Score variables (V45 and V46) showed no significant correlations within classification. Pre- and Post-Learning Score variables (V45 and V46) were intercorrelated with the other classifications as follows:

Variable Classification	Number of Significant Intercorrelations	Percentage of Total Possible Correlations
Personal Data (V1-V10)	7 out of 20 possible	35%
French Ability Tests (V11-V22)	5 " 24 "	20%
Color Card Preference Test (V23-V30)	None	0
Pre-Learning Eye Fixation (V31-V37)	1 " 14 "	7%
Post-Learning Eye Fixation (V38-V44)	2 " 14 "	14%

Summary Comparison of Group A (N=30) and Group B (N=18)

Dividing the Total Population into two sub-populations on the basis of subjects' change in Eye Movement Preference from Pre-Learning to Post-Learning tests (see p. 54) resulted in some interesting findings. The analysis of Group B (N=18) and Group A (N=30) variables indicates that

the zero correlation matrix produced a number of significant correlations with the Color and Non-Color Criterion. Comparing the two Sub-populations with the Total Population it is observed that the Total Population had 7, Group A (N=30) had 4, and Group B (N=18) had 16 significant correlations.

Color Criterion Correlations. The Total Population (N=48) produced 3 significant correlations; Group B (N=18) produced 6 significant correlations, and Group A (N=30) produced no significant correlations with the Color Criterion. (See Table 28.)

TABLE 28.--Summary of the Significant Correlations (Tables 5, 26 and 27) for Color Criterion from the Zero Order Correlation Matrix for the Total Population (N=48) and the Sub-Populations, Group A (N=30) and Group B (N=18)

	Color		
Classification	Total Population (N=48)	Group A (N=30)	Group B (N=18)
Personal Data	Color Blindness (-)		
French Ability Tests	Vocab. I (+) Vocab. II (+)		Iden. Pic. II (+) Maze Tr. I (+) Surf. Dev. (-)
Color Card Preference			Blue (+) Green (+) Red (-)

(+) Positive significant correlation
(-) Negative significant correlation

It is evident that for the Total Population and Group B (N=18) different variables seem to have different predictive ability with regard to

the Color Picture Criterion. In the Total Population (N=48), the Personal Data variable classification Color Blindness was negatively correlated with the Color Picture Criterion, while in the French Ability Test variable classification, both Wide Range Vocabulary I and II were significantly positively correlated with the Color Picture Criterion.

In Group B (N=18), the French Ability Test variable classifications, Identical Pictures II and Maze Tracing I were positively correlated, and Surface Development was negatively significantly correlated with Color Picture Criterion, while in the Color Card Preference variable classification, Blue and Green were positively correlated and Red negatively significantly correlated with the Color Criterion. With these two populations, the Total Population (N=48) and Sub-Population Group B (N=18), the predictor variables are non-overlapping and there are different variables operating for Color Picture Criterion within the Total Population or individual sub-populations.

Non-Color Criterion Correlations. Total Population (N=48) produced 4, Group A (N=30) produced 4, and Group B (N=18) produced 10 significant correlations with the Non-Color Criterion. (See Table 29.) As with the Color Criterion correlations the significant variables were different for the various groups: the Total Population or individual sub-populations.

For the Total Population (N=48), one Color Card Preference variable classification, Yellow, showed a negative significant correlation with the Non-Color Criterion, while in the Eye Fixation variable classification (Post-Learning) Non-Color Stimulus, Center and Non-Color Response were significantly correlated with the Non-Color Criterion.

In Group A (N=30), French Ability Test variables classification

TABLE 29.--Summary of Significant Correlations for the Non-Color Criterion from the Zero Order Correlation Matrix (Tables 5, 26 and 27) for the Total Population (N=48) and the Sub-Populations, Group A (N=30) and Group B (N=18)

	Non-Color		
Classification	Total Population (N=48)	Group A (N=30)	Group B (N=18)
Personal Data			Glasses (+)
French Ability Tests		Vocab. I (+) Ltr. Span (-)	Hid. Fig. II (-) Ident. Pic. I (-)
Color Card Preference	Yellow (-)	Violet (-)	Red (-) Black (-) Gray (+)
Eye Fixation	EF NCS II (-) EF Center II (-) EF NCR II (+)	EF Center I (-)	EF Color Stim. I (-) EF Center II (-) EF NCR II (+) EF Eye Blink II (-)

(+) Positive Significant Correlation
(-) Negative Significant Correlation

Vocabulary I (positively) and Letter Span-Auditory (negatively) were significantly correlated with the Non-Color Criterion, while in the Color Card Preference variables classification, Violet showed a negative significant correlation with the Non-Color Criterion. Eye Fixation classification Pre-Learning Center Fixating also showed a negative significant correlation with the Non-Color Criterion.

In Group B (N=18), Personal Data variable classification Glasses was significantly correlated with Non-Color Criterion Success; the French Ability Test variable classifications Hidden Figures II and Identical Pictures I showed a negative significant correlation with Non-Color Criterion Success. With the Color Card Preference variable classification, Red and Black showed a negative and Gray showed a positive significant correlation with the Non-Color Criterion, while with the Eye Fixation variable classification Pre-Learning, Color Stimulus showed a negative significant correlation, and Post-Learning, Non-Color Response and Eye Blink showed positive significant correlations with the Non-Color Criterion.

Multiple Regression Analysis: Sub-Population

To examine the relationship between the predictor variables (V1-V46) and the two criterion variables (V47 and V48) the analysis used a Stepwise Regression Analysis (Biomedical program, 02R) and MUREG: a program derived from the Biomedical program that provides in addition standardized Beta weights for the regression analysis.

Group A (N=30)

The results of the Stepwise regression analysis for each of the two criterion variables (V47 and V48) are displayed in Tables 30 through 33.

The general strategy of analysis involves first the presentation of the Stepwise regressions constructed from all major variables for Non-Color Picture Criterion Success (V47), Table 30, and Color Picture Criterion Success (V48), Table 31; each variable classification, Personal Data (V1-V10), French Ability Tests (V11-V22), and Eye Fixation variables (V31-V44), was then run independently in a multiple-regression analysis to see its own unique contribution to the explanation of variance regarding the dependent variables (V47 and V48). See Tables 32 and 33.

Hypothesis III is empirically supported for future study using similar Group A (N=30) sub-populations. The conventional paper and pencil tests represented here by the French Ability Tests contributed 57 percent to the variance explained with the Non-Color Picture Criterion variable (V47) and 28 percent to the variance explained with the Color Picture Criterion variable (V48). As can be seen in Tables 30 and 31, the contribution of Eye Fixation and Color Card Preference variables were important in the regression formula. When taken by themselves, (Tables 32 and 33), the Eye Fixation variables produced 12 percent explanation of variance for Non-Color Picture Criterion (V47). Eye Fixations did not, however, produce an explanation of variance at the F level = 1 or greater with the Color Picture Criterion (V48).

Color Card Preference contribution to the regression was also important; taken by itself (Tables 32 and 33) it contributed 14 percent explanation of variance for the Non-Color Picture Criterion (V47) and an explanation of variance of 15 percent for the Color Picture Criterion (V48).

However, when both Eye Fixation and Color Card Preference were

combined with French Ability Tests (V11-V22), Tables 30 and 31, the explanation of variance reached 90 percent for the Non-Color Picture Criterion (V47) and 71 percent for the Color Picture Criterion (V48).

TABLE 30.--Stepwise Regression Analysis with Non-Color as the Criterion Variable for the Sub-Population Group A (N=30)

Non-Color

Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	beta	beta′	Label of Variable
1.	22	.20	.20	7.19*	-.37	-.52	Letter Span-Auditory
2.	19	.47	.27	13.38**	.52	.74	Wide Range Voc.
3.	27	.53	.06	3.16	-.55	-.66	Violet
4.	7	.59	.06	3.69	-1.49	-.41	Color Eyes
5.	6	.63	.04	2.89	4.19	.74	Glasses
6.	14	.67	.04	3.03	.32	.40	Hidden Figures II
7.	26	.73	.06	4.23	.46	.53	Yellow
8.	45	.76	.03	3.30	-.56	-.40	Pre-Learning
9.	21	.79	.03	2.56	.11	.32	Surface Development
10.	31	.81	.02	1.98	.23	.79	EF Color Stimulus I
11.	4	.84	.03	3.75	3.03	.32	Race
12.	18	.87	.03	4.06	-.26	-.33	Maze Tracing II
13.	35	.90	.03	3.92	.08	.29	EF Color Resp. I

Note: Betas used in this table are those that correspond to each variable at step 13, and are not Betas when the variable first entered the regression formula.

$$Y = -2.42 - .52\,(V22) + .74\,(V19) - .66\,(V27)$$
$$- .41\,(V7) + .74\,(V6) + .40\,(V14) + .53\,(V26)$$
$$- .40\,(V45) + .32\,(V21) + .79\,(V31) + .32\,(V4)$$
$$- .33\,(V18) + .29\,(V35)$$

*$p < .05$
**$p < .01$

TABLE 31.--Stepwise Regression Analysis with Color as the Criterion Variable for the Sub-Population Group A (N=30)

		Color					
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	beta	beta'	Label of Variable
1.	19	.07	.07	2.00	.05	.09	Wide Range Voc. I
2.	5	.14	.07	2.40	-2.55	-.34	Color Blindness
3.	7	.20	.06	2.01	-1.87	-.64	Color Eyes
4.	45	.27	.07	2.22	-.56	-.50	Pre-Learning
5.	18	.32	.05	1.77	-.59	-.94	Maze Tracing II
6.	11	.41	.09	3.49	.18	.62	Cube Rotation
7.	38	.51	.10	4.72*	.10	.54	EF Color Stimulus II
8.	29	.59	.08	4.07	.32	.35	Black
9.	40	.64	.05	2.53	-.20	-.36	EF Center Viewing II
10.	14	.71	.07	4.47*	.24	.35	Hidden Figures II

Note: Betas used in this table are those that correspond to each variable at step 10 and are not the Betas when the variable first entered in the regression formula.

$$Y = 12.59 + .09\,(V19) - .34\,(V5) - .64\,(V7) - .50\,(V45)$$
$$- .94\,(V18) + .62\,(V11) + .54\,(V38) + .35\,(V29)$$
$$- .36\,(V40) + .35\,(V14)$$

*p < .05
**p < .01

TABLE 32.--Stepwise Regression Analysis with Non-Color as the Criterion Variable for the Following Classification Variables: Personal Data, French Ability, Color Card Preference and Eye Fixation for the Sub-Population, Taken Separately, Group A, (N=30)

		Non-Color			
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Personal Data					
1.	5	.07	.07	1.95	Color Blindness
2.	4	.13	.06	2.17	Race
Ability					
1.	22	.20	.20	7.19**	Letter Span Auditory
2.	19	.47	.26	13.38**	Vocabulary I
3.	14	.50	.03	1.38	Hidden Figures II
Color Card Preference					
1.	27	.11	.11	3.44	Violet
2.	23	.14	.04	1.09	Blue
Eye Fixation					
1.	33	.12	.12	3.77	EF Center Viewing I

*$p < .05$
**$p < .01$

TABLE 33.--Stepwise Regression Analysis With Color as the Criterion Variable for the Following Classification Variables: Personal Data, French Ability, Color Card Preference and Eye Fixation for the Sub-Population, Taken Separately, Group A (N=30)

Color					
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Personal Data					
1.	5	.06	.06	1.65	Color Blindness
2.	8	.12	.07	2.06	Test Behavior
Ability					
1.	19	.07	.07	2.00	Vocabulary I
2.	18	.11	.04	1.29	Maze Tracing II
3.	14	.18	.07	2.30	Hidden Figures
Color Card Preference					
1.	26	.04	.04	1.29	Yellow
2.	28	.10	.06	1.69	Brown
3.	27	.15	.05	1.49	Violet
Eye Fixation					
NONE					

*$p < .05$
**$p < .01$

Group B (N=18)

The results of the Stepwise regression analysis for each of the two Criterion variables (V47 and V48) are displayed in Tables 34 through 37.

The general strategy of analysis involved the presentation of the Stepwise regression constructed from all major variables for Non-Color Picture Criterion Success (V47), Table 34, and Color Picture Criterion Success (V48), Table 35. Each variable classification, Personal Data (V1-V10), French Ability Tests (V11-V22), Color Card Preference Test (V23-V30), and Eye Fixation variables (V31-V44), was then run independently in a multiple-regression analysis to see its own unique capability of contributing to the variance explained of the dependent variables (V47 and V48). See Tables 36 and 37.

Hypothesis III is empirically supported for future study using the Group B (N=18) sub-population. The conventional paper and pencil tests represented here by the French Ability Tests contributed 63 percent to the variance explained with the Non-Color Picture Criterion variable (V47) and 4 percent to variance explained with the Color Picture Criterion variable (V48) and as can be seen in the Tables 34 and 35, the contribution of Eye Fixation and Color Card Preference variables were important in the regression formula. When taken by themselves (Tables 36 and 37), the Eye Fixation variables explained 60 percent of the variance for the Non-Color Picture Criterion (V47) and 40 percent of the variance for the Color Picture Criterion (V48).

Color Card Preference contribution to the Stepwise regression was also important; taken by themselves (Tables 36 and 37), they contributed 41 percent to the explanation of variance of Non-Color Picture Criterion

(V47) and 69 percent to the explanation of variance for Color Picture Criterion (V48).

However, when both Eye Fixation and Color Card Preference were combined with French Ability Tests (V11-V22), Tables 34 and 35, the variance explained reached 99 percent for the Non-Color Picture Criterion (V47) and 96 percent for the Color Picture Criterion (V48).

It should, nevertheless, be noted that, in the case of the Color Picture Criterion explanation of variance, the third step variable in Table 35 is the Post-Learning, Learning Score, which is an artifact variable of the completed experiment, and is available only after administering the Post-Learning treatment. Its appearance in the third step may very well be influencing the contribution of all variables after this step and therefore a conservative reading of 77 percent explanation of variance for this table is assumed by the experimentor.

In Table 30 the Pre-Learning, Learning Score variable makes its appearance at the 8th step of the regression analysis when 76 percent explanation of variance is reached. Since the Pre-Learning, Learning Score is not an artifact of the completed experiment one could very well maintain that its influence is in keeping with its proper function in the analysis; therefore, 90 percent explanation of variance could be considered in this table. A similar conclusion can be reached with regard to Tables 31 and 34, and the explanation of variance for which they account are 71 percent and 99 percent respectively.

Notwithstanding what has been expressed, consideration must be given to the small size of the sub-population as well as the large number of variables. A multiple regression with a large number of variables and a

small number of subjects is more likely to give an inflated multiple R than would be true with larger sample sizes because of approaching near unique solutions to the equation inherent in the process of multiple regression. Therefore, the high explanation of variance percentages should be examined and a more conservative position maintained with regard to the interpretation of these tables. In this light, an explanation of variance of 70 percent is a more realistic figure to consider with regard to the two criterion variables.

TABLE 34.--Stepwise Regression Analysis with Non-Color as the Criterion Variable for the Sub-Population Group B (N=18)

		Non-Color					
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	beta	beta′	Label of Variable
1.	14	.44	.44	12.48**	-1.00	-.78	Hidden Figures II
2.	25	.65	.21	9.32**	-.33	-.29	Red
3.	13	.79	.14	9.51**	.27	.35	Hidden Figures I
4.	24	.87	.08	7.15**	.35	.25	Green
5.	41	.92	.05	7.30**	.10	.36	EF Non-Color Resp. II
6.	18	.94	.02	4.27	.21	.37	Maze Tracing II
7.	20	.97	.03	13.04**	-.16	-.22	Wide Range Voc. II
8.	23	.99	.02	11.46**	-.21	-.16	Blue

Note: Betas used in this table are those that correspond to each variable at Step 8 and are not the Betas when the variables first entered the regression formula.

$$Y = 5.54 - .78\,(V14) - .29\,(V25) + .35\,(V13) + .25\,(V24) + .36\,(V41) + .37\,(V18) - .22\,(V20) - .16\,(V23)$$

*p < .05
**p < .01

TABLE 35.--Stepwise Regression Analysis with Color as the Criterion Variable for the Sub-Population Group B (N=18)

Color

Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	beta	beta′	Label of Variable
1.	25	.49	.49	15.55**	-.26	-.44	Red
2.	23	.66	.17	7.57*	.48	.74	Blue
3.	46	.77	.11	6.80*	.45	.39	Post-Learning
4.	37	.87	.10	8.92*	-.21	-.47	EF Off-Display I
5.	36	.91	.04	5.65*	.15	.24	EF Eye Blinks I
6.	18	.93	.02	2.84	-.07	-.26	Maze Tracing II
7.	44	.94	.01	3.14	-.13	-.20	EF Off-Display II
8.	15	.96	.02	3.15	-.02	-.14	Identical Pictures I

Note: Betas used in this table are those that correspond to each variable at Step 8 and are not the Betas when the variables first entered the regression formula.

$$Y = 8.08 - .44\,(V25) + .74\,(V23) + 39\,(V46) - .47\,(V37)$$
$$+ .24\,(V36) - .26\,(V18) - .20\,(V44) - .14\,(V15)$$

*$p < .05$
**$p < .01$

TABLE 36.--Stepwise Regression Analysis with Non-Color as the Criterion Variable for the Following Classification Variables: Personal Data, French Ability, Color Card Preference and Eye Fixation for the Sub-population, Taken Separately, Group B (N=18)

		Non-Color			
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Personal Data					
1.	6	.31	.31	7.24*	Glasses
2.	7	.37	.06	1.40	Color Eyes
3.	8	.45	.08	2.09	Test Behavior
Ability					
1.	14	.44	.44	12.48**	Hidden Figures II
2.	13	.64	.20	8.56*	Hidden Figures I
3.	22	.72	.07	3.60	Letter Span Auditory
4.	21	.77	.05	2.73	Surface Development
Color Card Preference					
1.	29	.19	.19	3.83	Black
2.	25	.36	.17	3.97	Red
3.	24	.41	.05	1.08	Green
Eye Fixation					
1.	41	.40	.40	10.87**	EF Non-Color Resp. II
2.	44	.50	.15	4.67*	EF Off Display II
3.	31	.60	.05	1.94	EF Color Stimulus I

*$p < .05$
**$p < .01$

TABLE 37.--Stepwise Regression Analysis with Color as the Criterion Variable for the Following Classification Variables: Personal Data, French Ability, Color Card Preference and Eye Fixation for the Sub-Population, Taken Separately, Group B, (N=18

Color					
Step Number	Variable Number	R SQ.	RSQ Increase	F in/out	Label of Variable
Personal Data					
1.	5	.14	.14	2.52	Color Blindness
2.	4	.24	.10	1.95	Race
3.	10	.33	.09	1.98	Reading Level
Ability					
1.	16	.33	.33	8.02*	Identical Pictures II
2.	17	.40	.07	1.67	Maze Tracing I
3.	11	.54	.14	4.17	Cube I
Color Card Preference					
1.	25	.49	.49	15.55**	Red
2.	23	.66	.17	7.57*	Blue
3.	24	.69	.02	1.30	Green
Eye Fixation					
1.	35	.14	.14	2.60	EF Color Response I
2.	41	.27	.13	2.62	EF Non-Color Resp. II
3.	34	.40	.13	e.10	EF Non-Color Resp. I

*p < .05
**p < .01

Standardization of Z Score in Parallelism of Regression Formula (Parlreg). A computer program was developed to convert the independent variable scores to Z scores. The use of Z scores allowed for a common X axis base for the regression slopes, thereby facilitating visual comparison. This procedure allowed uncovering interactions that might have otherwise not been immediately apparent, for it makes the angle and crossing more comparable across independent variables.

The discussion to follow on Aptitude-Treatment Interaction relationships found in the study makes use of Parallelism of Regression slopes derived from the Parlreg program (see page 48) using Z scores for the independent variables and raw scores for the two criterion variables in order to compare directly the individual variable contribution while maintaining relative effects on the two criterion variables, since non-parallelism between treatment slopes on a single variable needs the additional ordinal-disordinal dimension analysis. In terms of multiple regression, variables with strong slopes tend to be useful in terms of differentiating portions of the population. In addition to looking for interactions across a single variable, what happens across groups or families of variables in terms of slopes could indicate ways to use several variables to complete ATI's.

Correlation, Regression Slopes and Tests for Parallelism of Regression Tables

An attempt has been made to present the pertinent information concerning the correlations, regression slopes and tests for parallelism of regression in a tabular form which will indicate trends and facilitate visual comparison. The variables presented are all those that were

significant or important. Each grouping and the Total Population columns represent the data of that group and the two treatments: Color and Non-Color. In the case of Group A vs. Group B, these two have a common treatment. Only the significant slopes or interactions have been entered in each box in order to simplify the presentation. The slopes have been drawn accurately. In a few instances low order correlations for Color or Non-Color were entered because they were part of a significant Aptitude-Treatment Interaction. The dotted slope line represents Color, while the solid line represents Non-Color. The left hand box number is the correlation for Color and the right hand box is for the Non-Color correlation. The F level of significant non-parallelisms from tests for parallelism of regression is located in the lower portion of the relevant boxes.

Personal Data (ATI's). An examination of Table 38 shows that there was a single significant ATI among the Personal Data variables. It was between the Glasses variable and the Non-Color Criterion. Glasses had a significant correlation with Non-Color in Group B (N=18) and an opposite although not significant correlation in Group A (N=30). When examined for parallelism between these two groups, these opposite slopes prove significantly different at the .01 level. However, the results are an artifact of one glasses-wearing person's extreme score and the non-parametric statistic--wears glasses/does not wear glasses--which distorted the relationship; therefore, no generalization can be made from this data and further study is needed to see if the variable has any merit.

The same might be said with regard to the color-blind subjects in Group A (N=30) and Group B (N=18). There were three subjects in this category, one in Group A and two in Group B. The results suggest,

TABLE 38.--Personal Data Variables and Significant or Important Correlation, Regression Slopes and Tests for Parallelism of Regression for the Color and Non-Color Criteria with the Total Population (N=48), the Sub-Populations, Group A (N=30), Group B (N=18) and Group A vs. Group B

Variable	Total Population (N=48)	Group A (N=30)	Group A vs. Group B ATI	Group B (N=18)
Age				-.31
Sex				.27
Glasses		.20	F = **	.11 -.56** F = *
Color-blindness	-.28	-.24 -.26		

Non-Color: r = Right No., Slope = (————)
Color: r = Left No., Slope = (- - - - - - -)
For significant values of r and F see Appendix II

* .05
** .01

however, that this category might produce significant results in future studies involving larger numbers of subjects classifiable as color blind.

French Ability Variables (ATI's). An examination of Table 39 shows that there was a number of significant correlations for the French Ability variables between the total and the two sub-population groups and the Color and Non-Color Criterion variables. The two Vocabulary II significant regression slopes are disordinal relationships between the Color and Non-Color Criterion treatment for Group B (N=18). These were not significantly non-parallel but approached that level. The ATI produced by this variable seems to indicate that Group B subjects who did poorly with Vocabulary II would profit from the Non-Color Picture treatment, while those who did well with Vocabulary II would do better with the Color Picture treatment under these learning conditions.

As can be seen, the addition of the positive non-parallel Color slopes for Groups A and B with regard to Vocabulary II produced a .05 significant positive slope for the Color Criterion with the Total Population (N=48).

Strong significant ATI's (.01) are found for the Non-Color Criterion by Hidden Figures II and Identical Pictures I by the two sub-populations. Even though for Identical Pictures I there is no significant regression in the Group A column, the difference is enough to make this disordinal intersection differentiating, such that Group B people who are low in Hidden Figures II and Identical Pictures I and Group A people high on Hidden Figures II and Identical Pictures I might, if assigned to Non-Color materials, produce maximum learning outcomes. The Group A correlations are significant or approach significance for five of these

TABLE 39.--French Ability Test Variables and Significant or Important Correlation, Regression Slopes and Tests for Parallelism of Regression for the Non-Color and Color Criteria with the Total Population (N=48), the Sub-Populations, Group A (N=30), Group B (N=18) and Group A vs. Group B

Variable	Total Population (N=48)	Group A (N=30)	Group A vs. Group B ATI	Group B (N=18)
Hid. Fig. II		.23 .20	F = **	.05 -.66** F = *
Iden. Pic. I	-.21	.21	F = **	-.51*
Iden. Pic. II	.23			.58** .21
Maze Tracing I				.46* .31
Vocab. I	.26*	.26 .30		.28
Vocab. II	.26*	.26		.28 -.28
Surf Dev.	-.21			-.44* -.29
Letter Span Auditory	-.33*	-.45*		

Non-Color: r = Right No., Slope = (————)
Color: r = Left No., Slope = (- - - - - - -)
For significant values of r and F see Appendix II

* .05
** .01

paper and pencil variables, while Group B has 7 out of 8. These relationships can be looked at in terms of these fifth- and sixth-grade students as possibly developmental, hence transitory for some, while, depending on motivation effects and learning to learn rate curves, etc., other scores could be relatively stable. Cross validation and longitudinal analysis is needed to give us more confidence in the predictive possibility of these tests.

Color Card Preference (ATI's). An examination of Table 40 shows that there was a large number of significant correlations for the Color Card Preference variables with the two sub-population groups and the Color and Non-Color Criteria. Group B (N=18) had ten significant relationships between Color Preference and success with the Non-Color and Color Criteria, and Group A (N=30) had five significant relationships. For the Total Population, Yellow is the only Color Card Preference variable that is significant, correlated with the criteria. In Group B an interaction with Yellow is almost a significant ATI in terms of the two treatments.

Two significant ATI's appear between the two sub-populations. One, Red, is related to the Color Criterion Success and the other, Black, is related to Non-Color Criterion Success. In both cases, the B Group is strongly significant and negatively related in terms of variable by outcome while the A group is not significantly related and thus predictable to the relationships. In any event, for Group B individuals, the less they prefer Red, the better they do with the Color Criterion, and the less they prefer Black, the better they do with the Non-Color Criterion. How a subject would fair with either or both criterion treatments if he

TABLE 40.--Color Card Preference Variables and Significant or Important Correlation, Regression Slopes and Tests for Parallelism of Regression for the Color and Non-Color Criteria with the Total Population (N=48), the Sub-Populations, Group A (N=30), Group B (N=18) and Group A vs. Group B

Variable	Total Population (N=48)	Group A (N=30)	Group A vs. Group B ATI	Group B (N=18)
Blue	.22			.61**
Green	.22			.40*
Red		.02	F = *	-.70 *** -.39
Yellow	-.25*	-.21		-.33 .29
Violet		-.33*		-.35
Brown	.21	.23		.30
Black		.21 .21		-.44*
Gray				.40*

Non-Color: r = Right No., Slope = (————)
Color: r = Left No., Slope = (- - - - - - - -)
For significant values of r and F see Appendix II
* .05
** .01
*** .001

has low (or for that matter, high) preference for both remains to be analyzed.

In all fairness, it must be indicated that this is the first known application of this Color Card Preference test in a prediction relationship of learning outcomes from different treatments. As such, these results can only be judged as exploratory and must await replication on other populations before the usefulness of this test for differential prediction can be evaluated. However, these initial results are encouraging.

Eye Fixation Variables (ATI's): Pre-Learning

Group A (N=30) had only one significant correlation, that of Center Viewing which was negatively related to Non-Color. On the other hand, a pattern of significant and near significant correlations between Group B (N=18) and Eye Fixation Preferences in Pre-Learning involved all the categories except Eye Blink and Off-Display (four with Color and three with Non-Color). Concerning the Center Viewing variable, Group B was related by a positive slope to Non-Color. See Table 41.

When looking at each criterion by Eye Fixation variable by the subpopulations, one significant ATI appears between Non-Color and Center Viewing. Center Viewing can be taken as quickness of response since almost universally this quantification occurs immediately after a slide change--following a slide change the eyes strongly tend to fixate in the center of the dark screen--and thus Eye Center fixation counts would be indicative of slow responding to the new visual with the reverse true for low Center Viewing counts. It may be said, in following this logic,

TABLE 41.--Pre-Learning Eye Fixation Variables and Significant or Important Correlation, Regression Slopes and Tests for Parallelism of Regression for the Color and Non-Color Criteria with the Total Population (N=48), the Sub-Populations, Group A (N=30), Group B (N=18) and Group A vs. Group B

Variable	Total Population (N=48)	Group A (N=30)	Group A vs. Group B ATI	Group B (N=18)
Color Stimulus		.16	F = **	-.25 -.62** F = *
Non-Color Stimulus				.31
Center Viewing		-.35*	F = *	.32 .25
Non-Color Response	.22			.36
Color Response				-.37*
Eye Blink				
Off-Display				

Non-Color: r = Right No., Slope = (————————)
Color: r = Left No., Slope = (- - - - - - - -)
For significant values of r and F see Appendix II

* .05
** .01

that slow Group B and fast Group A responsers do well with Non-Color visual stimuli in terms of the pretest.

Color stimulus displayed a significant ATI at almost a .001 level which also appears to be washed out by the combining of the two groups into the Total Population analysis. Here the strong negative Group B regression slope accounts for the non-parallelism between the two groups with regard to Non-Color. Weak Group B Color stimuli lookers do very well with Non-Color, whereas Group A shows little relationship in terms of this variable.

Eye Fixation Variables (ATI's): Post-Learning

The eye fixations under this condition are accomplished after the several criterion tests and so it could be said, in contrast to the Pre-Learning situation, that the Subjects now know what the learning tasks are about; how well they do differentially with each presentation mode and therefore some effect on information intake consequent to this in interaction with rate of learning to learn (or adjustment to learning environment) could be expected. Group B does reflect such artifactual changes since this group was chosen because most did in fact alter either or both their stimulus and response visual viewing preferences from Pre- to Post-Learning. (See Table 42.) The significant correlations for the Post-Learning are all with the Non-Color Criterion and show negative in Center Viewing (opposite of the Pretest positive Center Viewing regression slope) and positive correlations with Non-Color Response Fixating and Eye Blinks. The Group B Non-Color Response regression slope relationship is strong enough (almost .001) to create a significant ATI between the two sub-populations in spite of the zero correlation

TABLE 42.--Post-Learning Eye Fixation Variables and Significant or Important Correlation, Regression Slopes and Tests for Parallelism of Regression for the Color and Non-Color Criteria with the Total Population (N=48), the Sub-Populations, Group A (N=30), Group B (N=18) and Group A vs. Group B

Variable	Total Population (N=48)	Group A (N=30)	Group A vs. Group B ATI	Group B (N=18)
Color Stimulus				-.27
Non-Color Stimulus	-.28*			-.29
Center Viewing	-.30*	-.29		-.40*
Non-Color Response	.36**	.01	F = *	.37 .64**
Color Response				-.31
Eye Blink				.32 .42*
Off-Display				-.25

Non-Color: r = Right No., Slope = (————)
Color: r = Left No., Slope = (- - - - - - - -)
For significant values of r and F see Appendix II
* .05
** .01

relationship of Group A and this variable. The Group B Correlation is strong enough to survive the diluting combination and remains a significant slope for the total group. It appears that subject's willingness to alter information intake as reflected by Eye Movement Fixation style is related to performance with Non-Color materials. For example, slow movement, i.e., Center Fixating,was almost significantly positively related to success with Non-Color in the Pretest, but after the criterion test experiences success with Non-Color is now related positively to fast movement.

In summary, it looks as if there are alternations in Eye Movements related to learning as demonstrated by change in Center Viewing. Future examination of this phenomenon may produce additional information.

One point of interest derived from the sub-population exploration is what happens to variable scores that are differentially related to sub-population groupings when they are combined and examined from the total group perspective. Although regression analysis is not linearly additive, the opposite group relationships tend to cancel each other out when the two groups are combined as a total population. In consequence, for example, although Hypothesis II was not supported for the total population, empirical support exists from the analysis of these two subject populations in support of future study of Hypothesis II using these two kinds of subjects as the basis for hypothesizing.

A recent study of Coffing's (1971) data (Private Communication) in terms of what he defined as Eye Fixation Change and Non-Change groupings indicates that his data are analyzable into similar categories and with the same kinds of results. This finding from an antecedent study lends

further support for the additional investigation of these two kinds of subjects in terms of Hypothesis II.

Summary:

Hypothesis I was not proven false for the Total Population (N=48). The results of the exploratory analysis with Group A (N=30) and Group B (N=18) were empirically significant and therefore they support the future study of this hypothesis using these sub-populations.

Hypothesis II was proven false for the Total Population (N=48). The results of the exploratory analysis with Group A (N=30) were not empirically significant, and therefore they do not support the further study of this hypothesis using this sub-population whereas with Group B (N=18) the results were empirically significant and they do support the future study of this hypothesis using this sub-population.

Hypothesis III was not proven false for the Total Population (N=48). The results of the exploratory analysis with Group A (N=30) and Group B (N=18) were empirically significant and therefore they support the future study of this hypothesis using these sub-populations.

C H A P T E R V

DISCUSSION AND CONCLUSIONS

This study aimed at examining the comparative effectiveness of color and non-color (black-and-white) pictures in a paired-associate learning task. The study also used individual eye movement quantifications as a predictor of preference for color or non-color pictures. Eye movement analyses are assumed to be indicators of the information intake and processing styles of individuals that may be related to their differential efficiency of PA learning from different kinds of visual presentations or treatments. Specifically,eye movement fixation patterns were used as indices of preference for color and non-color visual displays. Color preference in the Lüscher Color Test along with E.T.S. French Ability Tests, Personal Data and Eye Movement Fixation patterns were also examined as explainers of variance of learning efficiency with the color and non-color pictures.

An exploratory examination of the results of individual eye fixation preference in the experiment suggested that the total subject population could be subdivided into two groups. Group A consisted of subjects who looked at Color Stimulus, Non-Color Response and did not change fixating preference from Pre-Learning to Post-Learning Test. Group B consisted of all other subjects. The resulting sub-populations of Group A (N=30) and Group B (N=18) subjects were then treated as independent populations

and analyzed with regard to the three major hypotheses to determine whether future study is warranted using these sub-populations and these hypotheses. The results for each group, N=48, N=30, and N=18, are given under the individual hypotheses.

Major Hypothesis I

In a synchronous audio-visual presentation, learning will be facilitated more by Color pictures than by Non-Color pictures.

For the Total Population, the analysis showed no significant main effect for order of presentation but did show a significant main effect for Color vs. Non-Color presentation.

With regard to the Exploratory Sub-Populations Group A (N=30) and Group B (N=18), the analysis showed a significant main effect for Color vs. Non-Color presentation for both groups. Therefore, Hypothesis I is <u>not</u> proven false for the Total Population (N=48) and, by the exploratory analysis, is empirically supported for future study using similar sub-population groupings.

Major Hypothesis II

The interaction of presentation mode preferences, as expressed by Eye Fixation variables, and presentation mode condition on Learning Scores should be significant. That is, the pictorial preference as defined by fixation time should be positively related to performance under Color pictorial treatment and negatively related to performance under Non-Color pictorial treatment. The reverse is predicted for Non-Color pictorial preference.

The relationship in the predicted direction was not found

significant for Total Population (N=48). The Hypothesis is proven false. The preference expressed by Eye Fixation variables for the two visual presentation modes was not shown to differentially relate to efficiency of learning. The predicted positive relationships were not significant. The tests for parallelism did not support the hypothesis of interaction between eye fixation preference used and Color and Non-Color picture presentation modes using learning performance as criteria.

With regard to the sub-populations, for Group A (N=30) the results did not support the hypothesis of interaction between Eye Fixation preference used and performance on the criterion measures. The exploratory analysis is not empirically supportive of picture studies using a similar sub-population grouping.

However, with regard to Group B (N=18) the results do support the hypothesis of interaction between Eye Fixation preference used and performance on the criterion measures where Color pictures and Non-Color pictures are offered as alternative modes of audio-visual presentations. The exploratory analysis is empirically supportive of future study using a similar sub-population grouping.

Major Hypothesis III

a) Prediction of learning success will be facilitated by the addition of eye movement variables to more conventional ability predictors; and b) Prediction of learning success will be facilitated by the addition of Color Card Preference choices to other ability predictors.

For the Total Population, 48 variables were examined in relation to the two criterion variables using zero order correlation and multiple

stepwise regression. In general, the following in the zero order correlation were involved significantly in the prediction of the criteria: 1 out of 10 Personal Data variables--Color Blindness; 1 out of 12 cognitive ability tests--Wide Range Vocabulary; 1 out of 8 Color Card Preference Test variables--Yellow; and 3 out of 14 Eye Fixation variables--(Post-Learning) Non-Color Stimulus, Center Viewing, and Non-Color Response.

These analyses support the acceptance of Hypothesis III as not proven false. Eye Fixation variables showed little correlation with either the Personal Data, Ability, or Color Card Preference variables, yet their inclusion in the multiple regression prediction increased the amount of variance accounted for. With the Non-Color Criterion (Table 6) Eye Fixation entered at steps 1, 6, 8, 9, 10 and 13, while with the Color Criterion (Table 7) it entered at steps 5, 7 and 8. The Color Card Preference variables, although they intercorrelated higher with other variable classifications, did contribute to the explanation of variance. With Non-Color Criterion (Table 6), Color Card Preference entered at step 2, while with Color Criterion (Table 7) it entered at step 3, 6 and 11.

Stepwise Regression Analysis explained 63 percent of Non-Color Picture Criterion Variance and 58 percent of Color Picture Criterion Variance.

In terms of Personal Data variables, little contribution to the Explanation of Variance was found except for the negative correlation of Color Blindness with the Color Picture Criterion. This finding supports Prater's (1968) results in which color-blind children in the Prater study suggested that instruction materials which utilize color " . . . may

produce confusion and negative emotional reaction in color-deficient individuals."

The high intercorrelation among the cognitive ability tests used interfered with interpretation. Of all the ability tests used in this study, Maze Tracing, Part II, for the Total Population (Table 4) presented the only suggestion of differentiation, although not significant, strongly positive with the Non-Color Picture and mildly negative with the Color Picture Criterion.

Center Viewing fixation's negative contribution appeared as an important index. As in Coffing's (1971) study, during each slide change there was a strong tendency for each subject's fixation direction to return to the center of the visual display. As the slide flashed on, fixations were accumulated for this index until the subject looked to one of the active areas, off-display or blinked. Since the slide flashing on this was in effect a starting signal, this index may be best understood as a measure of reaction time if the assumption is valid that in a stimulus field there is a tendency to fixate on areas of relevance. Since the center of the screen was always without visual interest, this index quantifies this tendency. In the correlation matrix under discussion the performance of subjects with short center looking (i.e. fast reaction time) correlated highly with success in Non-Color Picture treatment. It may be said that active looking produced good results with Non-Color pictures.

In general the following were involved significantly in the explanation of variance for Group A (N=30): none of the Personal Data variables; 2 out of 12 Cognitive Ability tests--Wide Range Vocabulary I and Letter

Span Auditory; 1 out of 8 Color Card Preference variables--Violet; and 1 out of 14 Eye Fixation variables--(Pre-Learning) Center Viewing.

On the other hand, the following were involved significantly in the explanation of variance for the Group B (N=18): 1 out of 10 Personal Data variables--Glasses; 4 out of 12 Cognitive Ability Tests--Hidden Figures II, Identical Pictures I, Maze Tracing I, and Surface Development; 5 out of 8 Color Card Preference variables--Blue, Green, Red, Black, Gray; and 4 out of 14 Eye Fixation variables--(Pre-Learning) Color Stimulus I, (Post-Learning) Center Viewing Non-Color Response, and Eye Blink.

Stepwise regression analysis for Group A (N=30) explained 90 percent of Non-Color Picture Criterion variance and 71 percent of Color Picture Criterion variance, while for Group B (N=18) the stepwise regression analysis explained 99 percent of the Non-Color and 96 percent of the Color Picture Criterion variance. It should be realized that, because of the small sub-population size and the large number of variables, a conservative reading of these tables is warranted. (See page 106 for further discussion on this topic.)

The contribution of the Eye Fixation variables to multiple regression entered as follows: for Group A (N=30) Table 30, with Non-Color Criterion at steps 7 and 9; and with Group B (N=18), Table 34, with the Non-Color Criterion at step 5; Table 35, with the Color Criterion at steps 4, 5, and 7. (See Tables 43 and 44.)

The contribution of Color Card Preference variables to the multiple regression was also important, entering as follows: for Group A (N=30) Table 28, with the Non-Color Criterion at steps 3 and 7; Table 31 with

Color Criterion at step 8; and with Group B (N=18) Table 32, with Non-Color Criterion at steps 2, 4, and 8; Table 33, with Color Criterion at steps 1 and 2. (See Summary Tables 43 and 44.)

Color and Non-Color Pictures. Color and Non-Color pictures in a paired-associate learning trial sequence using an audio-visual presentation produced learning results in favor of the Color Picture at a $P(F) < .001$. This F/level in favor of the Color Picture was maintained for the total population (N=48) as well as the sub-populations, Group A (N=30) and Group B (N=18). The magnitude of performance with Color pictures over Non-Color pictures in this study tends to support the following: to the extent that the paired-associate learning trial sequence used in this study is related to the learning situation on Long's (1945) experiment, it supports his conclusion that color films are generally superior to black-and-white films (Non-Color) for subjects in an "acquisition" (learning) situation. However, the results of VanderMeer (1952), Zuckerman (1954), and Kanner et al. (1959), that black-and-white film, filmstrip, and television are superior to the color version of the same, is not supported to the extent that the PA learning trial sequence used in this study relates to the learning task in these three earlier studies.

With regard to the use of Color and Non-Color pictures in various tasks the following might be operative: 1) when color is clearly essential to the differentiation to be made, Color pictures are superior to Non-Color; 2) when color is not important to the differentiation to be made, Non-Color is as good or superior; however, 3) when the subject does not know whether or not color is important, he will tend to use the

TABLE 43.--Summary of Entering Step Number From Stepwise Regression Analysis Tables for Eye Fixation and Color Card Preference Variables and Non-Color Criterion for the Total Population (N=48), Group A (N=30), and Group B (N=18)

Non-Color

Subject	Table No.	Variable	Entering Step
Total Population (N=48)	6	Eye Fixation	1,6,8,9,10,13
		Color Card Pref.	2
Group A (N=30)	28	Eye Fixation	10,13
		Color Card Pref.	3,7
Group B (N=18)	32	Eye Fixation	5
		Color Card Pref.	2,4,8

TABLE 44.--Summary of Entering Step Number From Stepwise Regression Analysis Tables for Eye Fixation and Color Card Preference Variables and Color Criterion for the Total Population (N=48), Group A (N=30), and Group B (N=18)

Color

Subject	Table No.	Variable	Entering Step
Total Population (N=48)	7	Eye Fixation	5,7,8
		Color Card Pref.	3,6,11
Group A (N=30)	29	Eye Fixation	7,9
		Color Card Pref.	8
Group B (N=18)	33	Eye Fixation	4,5,7
		Color Card Pref.	1,2

Color and do better with Color because it provides additional cues. That is, the subject cannot really do worse with Color except in the situation where Color is irrelevant to the task. Therefore, there may be some situations where Non-Color is better.

Color, however, may also be benign--may not have any positive or negative effect; if it is not a distractor on the task, it simply does not contribute to the task. In some cases Color may be a distractor from the task; in other cases Color may be the whole task. These factors may help to explain the results in earlier studies.

The effect of color on learning in this study might be the result of the following:

1. Color provided more cues than Non-Color during the 4-second exposure of the test materials.
2. Color better meets the expectations of subjects for an audio-visual presentation under the experimental conditions.
3. Color enhances the three dimensional perception of the test materials.
4. Color may be generally more pleasing for a subject to work with in a test condition.
5. Shadows in the Color test materials were less confusing than shadows in the Non-Color test materials.
6. There may be less fatigue working with Color than Non-Color.

It is suggested that, in terms of learning from film where the learning is not pre-defined, color related learning is part of the learning process. Not to use color, that is, to use black-and-white, withholds the possibility of learning in that area and therefore

may have a negative effect upon the total amount of learning accomplished by any individual.

Eye Fixation Patterns

Subject Eye Fixation patterns in this study present interesting new areas of investigation, that is, working with populations in terms of their willingness or capacity or flexibility to change perceptual style consequent to their understanding of the situation or as a function of their participation in the situation. Although not hypothesized directly in terms of Group A and B subjects, the Eye Movement variables do indicate potentially important relationships to these sub-populations; thus it could be said that Hypothesis II would be not proven false if examined using these sub-populations. However, because of the reduction due to washout of the effect when looking at the total population, the hypothesis is not supported. This results from combining two different kinds of people which then cancel each other's uniqueness, leaving us a normalization of results which denies confirmation of the hypothesis. In effect, however, the hypothesis is supported and relevant when applied to either group separately, and this means that the hypothesis is still functional and useful. This sub-population partition needs to be investigated further to find out what happens in terms of individual differences among people; we need to look at the partitions within sub-populations.

Instrumentation. In general, the apparatus performed to expectations. The use of the Lecina Super 8mm camera allowed a 1/50th of a second exposure that resulted in sharp and precise recordings (See p. 33). There are, however, several features that would improve the operation

of the apparatus.

1. Development of a stand that would allow the quick adjustment of apparatus height to subjects' comfort.
2. Development of a pivoting frame for the right hand 30/70 mirror which would allow compensation for varying subject eye width, thereby enabling the experimentor to center stimulus slide exactly in center of the subject's pupil.
3. Development of an accurate variable camera switch with range up to 10 contacts-per-second to allow for increasing the fixation recordings and thereby increasing the possible data derived from these.

In summary, the apparatus as herein developed has been demonstrated to be easy to operate and reliable in use. Future use depends upon educational needs and the ingenuity of researchers.

Color-blind Subjects. There were 3 color-blind subjects in this study and, although the number is small, several interesting trends are evident in the analysis. With regard to the Total Population (N=48) Color Blindness was the only variable that correlated significantly and negatively with Color Picture Learning Success (Table 5). In neither of the sub-populations, Group A (N=30) nor Group B (N=18), did this Color Blindness have a significant correlation. There was 1 color-blind subject in Group A and 2 in Group B.

Taking the 3 color-blind subjects as a group and comparing them with the 7 (not including color-blind subjects) whose criterion scores were below the Total Population mean (N=48), the following results were obtained:

	Total (N=48)	Color-blind (N=3)	Below Mean Score Group (N=7)
$\bar{X}$ Color Criterion	9.7	8.33	8.71
$\bar{X}$ Non-Color Criterion	8.1	7.33	6.00

The color-blind subjects did better with Non-Color than the Below Mean Score Group. The color-blind subjects also did better with the Color Criterion than with the Non-Color Criterion but did not do as well as the Below Mean Score Group with the Color Criterion. These findings support the hypothesis that a learning task involving Color may raise color-blind subjects' anxiety and that this anxiety interferes with learning. As already noted, the results support Prater's (1968) conclusion that " . . . color may produce confusion and negative emotional reaction in color-deficient individuals."

Stimulus Materials. The treatment materials for Color and Non-Color PA Learning Trial Sequences were carefully prepared. An examination with a Mackbeth TD 203 A and M color densitometer showed that the background of the color visuals varied the equivalent of 10 color correction filter units of cyan (equivalent of Green & Blue) from neutral gray. Color was saturated and the fine grain of the Kodachrome film resulted in maximum quality slides. The reversal Non-Color (black-and-white) slides had full contrast range with rich blacks and clean highlights. The black-and-white slides had a gray scale which was visually the equivalent of the color gray scale. One possible limitation that could be attributed to the Color and Non-Color PA Learning Trial Slides is the fact that they were not photographed in a light tent. The result was that the object cast shadows which in the

case of the Non-Color slides could introduce distracting details which might interfere with the subjects' visual perception. In the case of Color the contrast of the color object with the shadows left no doubt as to which was which.

The objects used in the PA Learning Trial Sequences were taken from materials used by Coffing (1971), who was not involved with color as an aspect of his research. An effort was made to make the objects colorful, as in the case of the camera and tripod which were decorated with colored tape (green, yellow, and blue). It must be pointed out, however, that certain objects did not lend themselves to this treatment, i.e., the film and reel and the key and lock. Furthermore, even though objects were colorful or successfully colored, when converted into black-and-white slides they occasionally lost contrast because the colors did not have good separation on the gray scale.

The Pre- and Post-Learning slides presented difficult problems because of the complicated requirements of having both pure black-and-white and color materials simultaneously on the screen, which necessitated that the presentation slides be color slides. The final slides used did not achieve the ideal pure black-and-white but ended up with a slight green cast equivalent to a green color correction filter of .05 density. This occurred after six attempts to correct for all the variables. (See page 29 for details of procedures.)

The preparation of the Pre- and Post-Learning slides required the use of a black mask that served as a frame for the four individual color and black-and-white slides that were copied for the simultaneous presentation. This deviated from Coffing's (1971) procedure that used

a very light white line between the four objects. Some of the results in this study might have been affected as a consequence of having this thick black line interfering with the movements of the eyes or interfering with the apparent connection of the color vs. black-and-white stimulus display areas. This may have resulted in a horizontal fixation strategy similar to viewing a comic strip rather than the diagonal choice pattern between stimulus materials which this eye movement preference test required.

Suggestions for the modifications to the stimulus materials:

1. Increasing the number of Pre- and Post-Learning concomitant slides to provide more fixation information.
2. Use of light tent to eliminate shadows from PA slide objects.
3. Photographying PA objects such that for concomitant slides original color and black-and-white transparencies could be used.
4. Developing masking system that would allow flashing of dark masked area to lighten to neutral gray the center black strips.

Color Card Preference. Color Card Preference variables had a high number of significant correlations with the various subject groupings and the Color and Non-Color Criterions. Interestingly, the individual colors were different in predicting success for the various populations and with Non-Color. (see Tables 28 and 29) For the Total Population (N=48), Yellow had a significant negative correlation with Non-Color Success; for Group A (N=30), Violet had a significant negative correlation with Non-Color Success; and for Group B (N=18), Red and Black had

significant negative correlations and Gray had a significant positive correlation with Non-Color Success.

In the case of Color Criterion Success, only Group B (N=18) had Color Card Preference correlations; Blue and Green had significant positive correlations and Red has a significant negative correlation.

It is clear that Color Card Preference choices may function as important predictors with regard to Color and Non-Color Picture Criterion Success and is empirically supported for further study.

Individual Differences. This study found two kinds of individuals based upon each person's changing or not changing his eye fixation (EF) preference between the Pre-Learning and the Post-Learning tests. No ATI's were found for the non-changers. However, the changers were involved in ten ATI's regarding Color vs. Non-Color treatment outcomes. Strong individual differences seem to be reflected in several of the variables. The following ATI's in reference to Color vs. Non-Color success were significant: glasses, positive with Color, negative with Non-Color; Hidden figures II, positive with Color, negative with Non-Color; and EF Color Stimulus I, weakly negative with Color, strongly negative with Non-Color. Almost significant were Vocabulary II, positive with Color, and negative with Non-Color; and Yellow, negative with Color, positive with Non-Color.

In terms of outcome success across the two groups, changers who were non-glasses wearers, or who had low scores on Hidden Figures II, low Identical Pictures I, low EF Color Stimulus I, high Center Viewing I or high Non-Color Response II did well with the Non-Color Picture presentation. Changers low on Red Color Card Preference did well with

Color Picture presentation. Tables 33-42 show that variables important to one group and not important to the other group disappear in significance when combined in the Total Population.

These ATI's that were uncovered need tests of replication as predictors of differential success of style changes in terms of Color and Non-Color presentations and as potential identifiers, in supplement to or exclusive of EF preference change information, of the two kinds of learners in terms of interaction facilitation of the two visual presentation treatment outcomes of interest here.

What seems to be important is that if analysis is made within the population it may be possible to find groupings of individuals who react differently to the presentation forms than would seem to be the case in terms of the total population. The problem is finding ways of subdividing the population to get maximum kinds of information. The use of individual differences as a sorting strategy, in this case in terms of eye movement behaviors, seems to have been a useful way of organizing the analysis. Its value can only be determined by subsequent replication.

Summary of the Conclusions and Suggestion for Further Study

Hypothesis I: In a synchronous audio-visual presentation, learning will be facilitated more by Color Pictures than by Non-Color Pictures. This hypothesis follows from studies that indicate that Color aids in ordering and differentiating visual presentation, thus providing more visual cues and thereby facilitating learning.

Major Hypothesis I is not proven false for the Total Population (N=48) and by exploratory analysis, is empirically

supported for future study using sub-populations similar to Group A (N=30) and Group B (N=18).

Color pictures were more effective than Non-Color (black-and-white) pictures under the PA test conditions of this experiment.

Hypothesis II: The interaction of presentation mode preferences, as expressed by Eye Fixation variables, and presentation mode condition on learning scores should be significant. That is, the pictorial preference as defined by fixation time should be positively related to performance under Color pictorial treatment and negatively related to performance under Non-Color pictorial treatment. The reverse is predicted for Non-Color pictorial preference.

Major Hypothesis II is proven false for the Total Population (N=48) and by exploratory analysis not empirically supported by Group A (N=30) for future study, but is empirically supported for future study using a similar sub-population to Group B (N=18). There was one Aptitude Treatment Interaction between EF Color Stimulus I and success with the Color and Non-Color Picture treatment for Group B.

Hypothesis III: a) Prediction of learning success will be facilitated by the addition of Eye Movement variables to more conventional ability predictors; and b) Prediction of learning success will be facilitated by the addition of Color Card Preference choices to other ability predictors.

Major Hypothesis III is not proven false for the Total Population (N=48) and by exploratory analysis is empirically

supported for future study using sub-populations similar to Group A (N=30) and Group B (N=18)

Selection by subjects of preferred colors appears to function as important predictors for future success with Color and Non-Color pictures.

Conclusions Not Hypothesized

1. The division of the Total Population (N=48) into the Sub-Populations, Group A (N=30) and Group B (N=18), on the basis of subjects Eye Fixation preference change or non-change from Pre- to Post-Learning was important as a method of exploring individual differences and subject characteristics.
2. It seems reasonable to hypothesize for future study that the change in fixating preference from Pre-Learning to Post-Learning will be in the direction of the picture treatment where the subjects achieved the higher learning score.
3. Ten ATI's were found among 7 of the 48 variables and the Color and Non-Color picture treatments for Group B (N=18) and between Group A and Group B, for Color or Non-Color picture treatment. They were in Group B, Color and Non-Color Picture treatment with Glasses, Hidden Figures II, and Color Stimulus, and in Group A vs. Group B, Non-Color Picture treatment with Glasses, Hidden Figures II, Identical Pictures I, Color Stimulus, Center Viewing, and Color Picture treatment with Red.
4. Color-blind subjects as a group did less well with Color

pictures than other subject groupings.

5. Forcing of certain Personal Data and French Ability variables in the Stepwise Regression formula were unproductive of alteration of explanation of variance with the Non-Color and Color Criterion variables and, therefore, further analysis along these lines in future studies appears unwarranted.
6. An interaction effect relative to order of presentation and the Color or Non-Color Treatment was not hypothesized by this study; however, it is noted that there is now some empirical support for maintaining an hypothesis relative to order of presentation interaction for subsequent study.
7. The Eye Movement apparatus developed for this study was demonstrated to be easy to operate and reliable in use.
8. The stimulus materials used in this study functioned well, but the Pre- and Post-Learning simultaneous presentation slides could be improved by new construction procedures.

APPENDIX I

OPENING COMMON PRESENTATION AUDIO

This experiment involves remembering things that

Learning in pairs SLIDE 1

are grouped together in pairs. It is not difficult, but it will require your full concentration. You will be presented with pairs of things that must be remembered together. For example, you might hear the sentence, "The bricks break the window."

The bricks break the window. SLIDE 2

at the same time, you will see helpful information on the screen in front of you. A number of these pairs will be presented. These will be called, "Pairs to remember."

Pairs to remember SLIDE 3

Test SLIDE 4

In the test part, you will then be asked to name out loud the second part of a pair when you are presented with the first part. In our example when the "Brick"

Brick SLIDE 5

is presented alone, you should answer out loud, "window."

To repeat, you are asked to study each of the pictures of paired objects, "Pairs to remember."

Pairs to remember SLIDE 6

as they appear on the screen while listening to the verbal description of the objects in order to learn which objects are presented together. You will be asked to name the missing object in each pair when shown the other object of that pair. Please look at the first slide.

1, 2, 3, 4, 5 SLIDE 7

Now look at each number in turn as I name them: Number One. Number Two. Number Three. Number Four. Number Five.

Now you will be presented the first set of slides.

Pairs to remember SLIDE 8

(PRE-LEARNING PRESENTATION PREFERENCE EYE MOVEMENT TREATMENT CONCOMITANT COLOR/NON-COLOR SET)

The file sharpens the saw. SLIDE 9

The box hides the pliers. SLIDE 10

The marker colors the chalk. SLIDE 11

The wrench adjusts the motor. SLIDE 12

The tripod supports the camera. SLIDE 13

The glove touches the stapler. SLIDE 14

Now give your answers out loud.

Test	SLIDE 15
Marker	SLIDE 16
Wrench	SLIDE 17
File	SLIDE 18
Tripod	SLIDE 19
Box	SLIDE 20
Glove	SLIDE 21

Now here is the second set to remember.

Pairs to remember	SLIDE 22

(In order to test for order of presentation effects on the two criterion tests, the odd-numbered subjects were given the Non-Color Picture treatment as the second set and the Color Picture treatment as the third set. The treatment mode sets were reversed in order of presentation for even numbered subjects, i.e. the Color Picture treatment set was presented second and the Non-Color Picture treatment set was presented third. In each instance the Non-Color Picture sets were identical visually and orally to each other and the same intra-set presentation order was maintained. In each instance the same applied to the Color Picture sets.)

(SINGLE PA LEARNING TRIAL SEQUENCES COLOR PICTURE TREATMENT SET)

The milk fills the bowl.	SLIDE 23
The rock breaks the bottle.	SLIDE 24
The fire burns the bed.	SLIDE 25

The teeth bite the apple.	SLIDE 26
The fork cuts the cake.	SLIDE 27
The pencil tears the paper.	SLIDE 28
The spoon rolls the egg.	SLIDE 29
The hand throws the hat.	SLIDE 30
The bat strikes the cup.	SLIDE 31
The man bends the pole.	SLIDE 32
The axe hits the wood.	SLIDE 33
The car upsets the wagon.	SLIDE 34

Now give your answers out loud.

Test	SLIDE 35
Rock	SLIDE 36
Pencil	SLIDE 37
Spoon	SLIDE 38
Milk	SLIDE 39
Man	SLIDE 40
Teeth	SLIDE 41
Bat	SLIDE 42
Fire	SLIDE 43
Fork	SLIDE 44
Hand	SLIDE 45
Axe	SLIDE 46
Car	SLIDE 47

Now here is the third set for you to remember.

Pairs to remember SLIDE 48

(SINGLE PA LEARNING TRIAL SEQUENCES NON-COLOR PICTURE TREATMENT SET)

The boat rolls the ball. SLIDE 49

The shoe taps the chair. SLIDE 50

The cat jumps the log. SLIDE 51

The foot kicks the house. SLIDE 52

The dog closes the gate. SLIDE 53

The knife cuts the flower. SLIDE 54

The blanket covers the tree. SLIDE 55

The doll opens the book. SLIDE 56

The rope rubs the eye. SLIDE 57

The needle pops the balloon. SLIDE 58

The towel wipes the plate. SLIDE 59

The hammer pulls the bell. SLIDE 60

Now give your answers out loud.

Test SLIDE 61

Cat SLIDE 62

Doll SLIDE 63

Boat SLIDE 64

Rope SLIDE 65

Shoe SLIDE 66

Blanket SLIDE 67

Needle SLIDE 68

Dog SLIDE 69

Foot	SLIDE 70
Knife	SLIDE 71
Towel	SLIDE 72
Hammer	SLIDE 73

Final common presentation audio.

And here is the last set to remember.

Pairs to remember	SLIDE 74

(POST-LEARNING PRESENTATION PREFERENCE EYE MOVEMENT TREATMENT CONCOMITANT COLOR/NON-COLOR SET)

The nail scratches the tape.	SLIDE 75
The cord connects the television.	SLIDE 76
The battery heats the light.	SLIDE 77
The film occupies the reel.	SLIDE 78
The pen marks the slide.	SLIDE 79
The key opens the lock.	SLIDE 80

Now give your answers out loud.

Test	SLIDE 81
Cord	SLIDE 82
Battery	SLIDE 83
Nail	SLIDE 84
Pen	SLIDE 85
Film	SLIDE 86
Key	SLIDE 87

Thank you for helping us. The operator will now remove your head strap. Thank you again.

APPENDIX II

Significant Values Used in this Study for:

r :	.05	.01	.001
N = 48	.24	.33	.45
N = 30	.30	.41	.55
N = 18	.38	.52	.68

F :	.05	.01	.001
Df = 92	3.95	6.98	11.72
Df = 56	4.01	7.10	12.12
Df = 46	4.05	7.21	12.29
Df = 44	4.06	7.24	12.48
Df = 28	4.20	7.64	13.50
Df = 16	4.49	8.53	16.12

Dixon and Massey (1969)

BIBLIOGRAPHY

Allen, W. H. "Audio Visual Communication Research." In Harris, C. W. (ed.) Encyclopedia of Educational Research. (3rd edition) New York: Macmillan, 1960, pp. 115-137.

Attnave, F. "Some Informational Aspects of Visual Perception." Psychology Review, 61: 183-193; 1954.

Biggs, J. B. "Coding and Cognitive Behavior." British Journal of Psychology 60: 287-305; 1969.

Broadbent, D. E. Perception and Communication. New York: Pergamon Press, 1958.

Burnham, R. W., Hanes, R. M., and Bartheson, C. J. Color: A Guide to Basic Facts and Concepts. New York: John Wiley and Sons, Inc., 1963.

Chan, A., Travers, R. M. W., and Van Mondsfrans, A. P. "The Effect of Colored Embellishment of a Visual Array on a Simultaneously Presented Audio Array." Audio Visual Communication Review 13: 159-164; 1965.

Chen, L. and Wang, A. "Color and Form Preferences." Acta Psychologia Sinica 32: 265-269; 1965.

Child, I. L., Hansen, J. A., and Hornbeck, F. W. "Age and Sex Differences." Child Development 39: 237-247; 1968.

Clark, Sandra E. "Retrieval of Color Information from Perceptual Storage System." Dissertation Abstracts 28(9-B): 3893-3894; 1968.

Coffing, D. G. Eye Movement Preferences as Individual Differences in Learning. Unpublished doctoral dissertation. Stanford University, 1971.

Craig, G. Q. "A Comparison Between Sound and Silent Films in Teaching." Brittanica Junior of Educational Psychology 26: 202-206; 1956.

Cronbach, L. J. "The Two Disciplines of Scientific Psychology." The American Psychologist 12: 671-684; 1957.

Cronbach, L. J. and Snow, R. E. Individual Differences in Learning Ability as a Function of Instructional Variables. USOE Contract No. OEC 4-6-061269-1217, March 1969.

Dixon, W. J. Biomedical Computer Program. Revised. Los Angeles: UCLA School of Medicine, 1971.

Dixon, J. W. and Massey, F. J., Jr. Introduction to Statistical Analysis. (2nd ed.) New York: McGraw Hill Book Company, 1969.

Dodge, Raymond. "An Experimental Study of Visual Fixations." Psychology Monograph 8, 4; 1907.

Dwyer, F. M., Jr. "Adapting Visual Illustrations for Effective Learning." Harvard Educational Review 1967: 250-263.

Fantz, R. L. Behavior in Non-Human Primates. Vol. II. New York: Academic Press, 1965.

Fitts, P. M., Jones, R. E., and Milton, J. L. "Eye Movements of Aircraft Pilots During Instrument-Landing Approaches." Aeronautics Engineering Review 9: 1-16; 1950.

French, J. W., Ekstrom, R. B., and Price, L. A. Kit of Reference Tests for Cognitive Factors. Princeton, New Jersey: Educational Testing Service, 1962.

Gagné, R. M. "Problem Solving." In Melton, A. W. (ed.) Categories of Human Learning. New York: Academic Press, 1964, pp. 293-317.

Gagné, Robert M. "Learning and Communication." In Wiman, R. V. and Meierhenry, W. C. (ed.) Educational Media: Theory into Practice. Columbus, Ohio: Charles E. Merrill Publishing Company, 1969.

Glaser, R. "Some Implications of Previous Work on Learning and Individual Differences." In Gagné, R. W. (ed.) Learning and Individual Differences. Columbus, Ohio: Charles E. Merrill Publishing Company, 1967.

Gould, J. D. and Schaffer, A. "Eye Movement Parameters in Pattern Recognition." Journal of Experimental Psychology 74: 225-229; 1967.

Gregory, R. L. Eye and Brain: The Psychology of Seeing. New York: McGraw-Hill Book Company, 1966.

Gurevich, B. Kh. "The Universal Characteristics of Fixation Saccades of the Eye." Biofizika 6: 377; 1961.

Hannah, T. E. and Mc Cormack, P. D. "Monitoring Eye Movements of High and Low Anxiety Subjects During the Acquisition of Competitive and

Non-Competitive Paired-Associate Lists." Canadian Journal of Psychology 22: 1968.

Hoban, C. F., Jr. and Van Ormer, E. B. Instructional Film Research, 1918-1950. (Pennsylvania State University Instructional Film Research Program.) Port Washington, New York: U. S. Naval Training Device Center, Office of Naval Research, SDC 269-7-19, 1950.

Ishihara, S. The Series of Plates Designed as Tests for Colour-Blindness. Tokyo, Osaka: Kanehara and Company, 1936.

Kanner, J. H. and Rosenstein, A. J. "Television in Army Training: Color vs. Black and White." Audio-Visual Communication Review 8: 243-252; 9, 44-49; 1960.

Karsdale, J. S. "The Purdue Eye Camera: A Practical Apparatus for Studying the Attention Value of Advertisements." Journal of Applied Psychology 24: 417-440; 1940.

Lamansky, S. Pfluger's Archiv Fur die Gesamte Physiologie-des Nenschen und der Tiere 2: 418; 1869.

Ling, B. C. "A Genetic Study of Sustained Visual Fixation and Associated Behavior in the Human Infant from Birth to Six Months." Journal of Genetic Psychology 61: 227-277; 1942.

Link, J. D. "A Comparison of the Effects on Learning of Viewing Films in Color on a Screen and in Black and White Over Closed-Circuit Television." Ontario Journal of Educational Research 3: 111-115; 1961.

Long, A. L. "The Influence of Color on Acquisition and Retention as Evidenced by the Use of Sound Films." Unpublished doctoral dissertation. University of Colorado, 1945.

Lumsdaine, A. A. "Instruments and Media of Instruction." In Gage, N. L. (ed.) Handbook of Research on Teaching. Chicago: Rand McNally, 1963, pp. 583-682.

Lunzer, E. A. (ed.), Regulation of Behavior. Vol. 1. New York: American Elsevier, 1968.

Lüscher Color Test." In Scott, I. A. (trans. and ed.) The Lüscher Color Test. New York: Random House, 1969.

Maccoby, E. "The Development of Stimulus Selection." In Hill, John P. (ed.) Minnesota Symposium on Child Psychology. Vol. 3. Minneapolis: University of Minnesota, 1969.

Mackworth, J. F. Vigilance and Attention. Baltimore, Maryland: Penguin Books, 1970.

Mackworth, J. F. "Input-output Models of Skilled Reading." Unpublished manuscript. Department of Psychiatry (Neuro-psychology), Stanford University, 1971.

Mackworth, N. H. "Researches on the Measurement of Human Performance." In Sinaiko, H. W. (ed.) Selected Papers on Human Factors in the Design and Use of Control Systems. New York: Dover Publications, 1961.

Mackworth, N. H. "A Stand Camera for Line of Sight Recording." Perception and Psychophysics 2: 119-127; 1967.

Mackworth, N. H. "The Wide-Angle Reflection Eye Camera for Visual Choice and Pupil Size." Perception and Psychophysics 3: 32-34; 1968.

Mackworth, N. H. and Bagshaw, M. "Eye Catching in Adults, Children and Monkeys: Some Experiments on Orienting and Observing Responses." In Hamburg, D. (ed.), et al., Perception and Its Disorders. Baltimore, Maryland: Proceedings of Association for Research on Nervous and Mental Diseases, 1970.

Mackworth, N. H. and Morandi, A. J. "The Gaze Selects Informative Details within Pictures." Perception and Psychophysics 2: 547-552; 1967.

Mackworth, N. H. and Otto, David A. "Habituation of the Visual Orienting Response in Young Children." Perception and Psychophysics 7: 173-178; 1970.

Mackworth, N. H. and Thomas, E. L. "Head-mounted Eye-Marker Camera." Journal of the Optical Society of America 52: 713-716; 1962.

May, M. A. and Lumsdaine, A. A. Learning From Films. New Haven: Yale University Press, 1958.

McClusky, F. D. and McClusky, H. Y. "Comparison of Motion Pictures, Slides, Stereograph, and Demonstration as a Means of Teaching How to Make a Reed Mat and a Pasteboard Box." In Freedman, F. M. (ed.) Visual Education. Chicago: The University of Chicago Press, 1924, 310-334.

McCormack, P. D. and Haltrecht, E. J. "Monitoring Eye Movements Under Two Conditions of Presentation of Paired-Associate Materials," Canadian Journal of Psychology 20; 1966.

McCormack, P. D. et al. "Monitoring Eye Movements Under Conditions of High and Low Intralist Response (meaningful) Similarity." Psychomic Science 8: 517-518; 1967.

McCormack, P. D., Clemence, W. H. T., and Malabre, M. A. "Monitoring Eye Movements During P. A. Learning Under Three Display Conditions." Psychonomic Science 15; 1969.

McLean, M. V. "Brightness Contrast, Color Contrast and Legibility." Human Factors 7: 521-526; 1965.

Miller, G. A., Galanter, E. H., and Pribram, K. H. Plans and the Structure of Behavior. New York: Holt, Rinehart and Winston, 1960.

Otto, W. and Askov, E. "The Role of Color in Learning and Instruction." Journal of Special Education 2: 155-165; 1968.

Parson, R. J. "Perceptual Selectivity and Information Processing by Fast and Slow Learners in Paired-Associate Learning." Perception and Psychophysics 4: 144-146; 1968.

Prater, M. "Color Uses in Primary Instructional Materials and Possible Implications for Color Deficient Children." Dissertation Abstracts 29 N(1-A): 72-73; 1968.

Pribram, K. H. "The Four R's of Remembering." In Pribram, K. H. (ed.) On the Biology of Learning. New York: Harcourt Brace, 1969, pp. 191-225.

Pribram, K. H. "Toward a Neuropsychological Theory of Person." In Pribram, K. H. (ed.) Brain and Behavior 1: Mood, States and Mind. Baltimore: Penguin Books, 1969.

Roe, A. and Hutchinson, T. "Studies of Occupational History: Part III. The Stability of Occupational Groups of the Roe System." Journal of Counseling Psychology 16: 390-395; 1969.

Rohwer, W. D., Jr. Social Class Differences in the Role of Linguistic Structures in Paired-Associate Learning: Elaboration and Learning Proficiency. USOE Project No. 5-0605, Contract No. OE-6-10-273, November 1967.

Rohwer, W. D., Lynch, S., Levin, J. R., and Suzuki, N. "Pictorial and Vernal Factors in the Efficient Learning of Paired Associates." Journal of Educational Psychology 58: 278-284; 1962.

Sanders, A. F. The Selective Process in the Functional Visual Field. (Institute for Perception.) Soeslerberg, Netherlands: RVO-TNO, 1963.

Scott, I. A. (ed.) The Lüscher Color Test. New York: Random House, 1969.

Snow, R. E., Tiffin, J., and Seibert, W. F. "Individual Differences and Instructional Film Effects." Journal of Educational Psychology 56: 315-326; 1965.

Sokolov, E. N. "The Modeling Properties of the Nervous System in Higher Nervous Activity." Handbook of Soviet Psychology, 1969.

Sokolov, E. N. Perception and the Conditioned Reflex. New York: Macmillan, 1963.

Tampieri, G. "La preferenza formacolore nella percezione visiva infantile." (Preference of form-color in the visual perception of a child.) Archivio de psicologia, neurologia e psichiatria 29: 159-199; 1968.

Travers, R. M. W. "The Transmission of Information to Human Receivers." Audio Visual Communication Review, Vol. 12 (4), Winter, 1964.

Travers, R. M. W. "Studies Related to the Design of Audio-Visual Teaching Materials." Final Report. USOE Contract No. 3-20-003, May 1966.

Travers, R. M. W. (ed.), McCormick, M. C., Van Mondfrans, A. P., and Williams, F. E. Research and Theory Related to Audiovisual Information Transmission. USOE Contract No. 3-20-003, University of Utah, 1964.

Treisman, A. "Contextual Cues in Selective Listening." Quarterly Journal of Experimental Psychology 12: 242-248; 1960.

Utz, W. J. "The Comparative Effect of Color and Black and White Film Clips Upon Rated Perception of Reality." (Doctoral dissertation, University of Illinois) Ann Arbor, Michigan: University Microfilms, 1968. No. 69, 1470.

Vandermeer, A. W. Relative Effectiveness of Instruction by Film Exclusively, Films Plus Study Guides and Standard Lecture Methods. (Technical Report SDS-269-7-13.) Port Washington, New York: Special Devices Center, Office of Naval Research, 1949.

VanderMeer, A. W. Relative Effectiveness of Color and Black and White in Instructional Films. (Pennsylvania State University Instructional Film Research Program.) Port Washington, New York: U. S. Naval Training Devices Center, 1952.

Walker, H. M. and Lev, J. Statistical Inference. New York: Holt, Rinehart and Winston, 1953.

Westheimer, G. "A Note on the Response Characteristics of the Extraocular Muscle System." Bulletin of Mathematical Biophysics 20: 149; 1958.

Wimer, C. C. and Lambert, W. E. "The Differential Effects of Word and Object Stimuli on the Learning of Paired Associates." Journal of Experimental Psychology 57: 31-36; 1959.

Winer, B. J. Statistical Principles in Experimental Design. New York: McGraw-Hill Book Company, Inc., 1962.

Worden, F. G. "Attention and Electrophysiology." In E. Stellar and J. M. Sprague (ed.) Attention and Auditory Electrophysiology. Vol. 1 New York: Academic Press, 1966.

Yarbus, A. L. "Eye Movements During Change in Points of Fixation." Biofizika 1: 76; 1956.

Yarbus, A. L. Eye Movement and Vision. New York: Plenum Press, 1967.

Zinchenko, V. P., Van Chzhi-tzin, and Tarakanov, V. V. "The Formation and Development of Perceptual Activity." (Translation) Soviet Psychology and Psychiatry 2: 3-12; 1963.

Zuckerman, J. V. "Predicting Film Learning by Pre-Release Testing." Audio-Visual Communication Review 2: 49-56; 1954.