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ABSTRACT

This study investigated the effects of color cues as well as the absence of such cues on the recognition of visual images using as subjects 28 college students in a basic communications course. The stimulus materials were slides in three categories: (1) original color (realistic), (2) black and white, and (3) non-realistic color format. Subjects were individually shown 140 stimulus slides for intervals of .5 seconds each. As an immediate post-test each subject was shown the series of stimulus materials plus distractors. A similar recognition session was conducted two weeks later. Analysis of variance procedures were applied to a treatment by subjects design, and in those cases where a significant F-ratio at the .05 level was indicated, further analyses were conducted between all possible pairs of means via a modified "LSD" test. Both color modes were superior to the black and white mode in facilitating immediate recognition of visuals. After a period of two weeks, however, only the non-realistic color mode resulted in significantly higher recognition scores. (VT)

THE EFFECTS OF COLOR REALISM ON PICTORIAL RECOGNITION MEMORY

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INTRODUCTION The value of visual instructional materials in facilitating classroom instruction has been recognized for some time. Research has clearly established the need for carefully prepared and organized materials to effectively augment oral instruction. Fundamental to learning from visuals is the ability to recognize and differentiate various visual displays which have been seen previously. Such storage and retrieval of visual information has been generally termed "Pictorial Recognition Memory".

Numerous researchers have investigated the processes whereby information, both verbal and visual, is stored in the human memory and retrieved from storage. Other investigators have examined the use of visuals in instruction in an attempt to explain, more precisely, how visual material is perceived and stored during learning. Research has been less conclusive, however, in identifying those design characteristics which contributed to improved learner achievement from visual materials as well as in examining the effect on the learning process of variations within each of those design factors.

The need for such research has become increasingly apparent in recent years. Numerous public agencies and private corporations now market great quantities of visual instructional materials and devices for the production of such materials. Teachers, instructional developers and graphic designers, however, have not been provided with a set of research-based guidelines for the use and manipulation of design factors such as color, complexity, contrast and realism in the design, selection and utilization of visuals for instructional purposes. The result of this inequity has, in many cases, led to the production of visuals which interfere with rather than aid instruction.

The relationship between learning from visuals and the processes whereby visual information is stored is a crucial one. All learning is predicated upon the assumption that the information to be learned can be properly stored in memory and accurately retrieved from the memory store at the appropriate time.

Presently, little is known with regard to how the individual forms, tones, colors and relationships within a given visual function in the storage of that image as well as their role in the later retrieval of the visual information.

The investigation of such relationships has been one of the primary purposes of a series of studies currently being conducted at the University of Pittsburgh. This paper represents an initial report on a portion of this series of research projects.

STATEMENT OF THE PROBLEM

During the past fifty years, numerous studies have been conducted concerning the relative effectiveness of visual materials in facilitating student achievement. A serious limitation of these studies is that the visual materials were usually treated as entire units rather than as combinations of many distinct types of cues or stimulus elements. No attempts were made to systematically identify and examine those elements within a visual display which contributed to the improved learning. Rather, the practice of comparing instructional materials as entire units confounded any attempt to isolate and quantitatively define those characteristics which may have aided learning and those which impeded learning.

The use of color in instructional materials is one element which requires further investigation. Color has long been considered a significant factor in the design of visuals for instructional applications. Its use, however, has usually been determined by two considerations totally unrelated to its possible effectiveness as a facilitator of learning. These factors, the aesthetic appeal of color over black and white illustrations and the considerably higher production cost of color visuals have worked, although at opposite ends, to determine the instructional use of this variable.

One reason for this misjudgment of priorities has been the fact that the great majority of the research regarding color has been inconclusive. In a survey of a number of studies relating to the color variable, Otto and Askov (1968) concluded that "the cue value of color in learning is still essentially unclear."

The purpose of this series of studies was to focus specifically upon color as it functions as a memory coding device. In the study reported here, the purpose was to explore the role of color in facilitating the acquisition and retrieval of information from what has been termed pictorial recognition memory.

Recognition memory and more specifically, pictorial recognition memory (PRM) has been studied by many researchers. The vast majority of these studies, however, have dealt with comparisons between verbal and pictorial recognition, with several major theoretical orientations being supported. Most prominent of these have been the "verbal loop hypothesis" suggested by Glanzer and Clark (1963, 1964a, 1964b) and the "dual encoding and retrieval systems" postulated by Paivio, Rogers and Smythe (1968). Essentially, these two orientations argue that verbal and visual information is processed either in a single information processing system (verbal loop hypothesis) or, alternately, that two distinct information processing systems exist, one for verbal information and a separate system for pictorial materials.

Glanzer and Clark (1963) suggest that visual information is first translated into verbal/symbolic information and then stored in the memory in that form. When retrieval of such stored information is required it is retrieved as verbal symbols and retranslated into visual images. The verbal loop hypothesis has found support from other researchers; namely, Lantz and Stefflre (1964) and Smith and Larson (1970).

The contradictory, dual system hypothesis has also drawn wide empirical support. Essentially, this orientation described by Paivio, Rogers and Smythe (1968) and Paivio (1971) conceptualizes a model involving two separate memory systems, one, which processes verbal information as verbal symbols and the second which processes visual information in terms of nonverbal images. While Paivio postulates two distinct systems which can and do function independently of one another, he also suggests that the systems frequently work in conjunction with each other, providing unique interactions and associations in the storage and retrieval of information.

Substantial research exists to support the dual system model. Recent research work in neurophysiology has indicated that the brain incorporates two distinct zones, one which deals with abstract, sequential and verbal processes and the second which controls visual, spatial and perceptual processes. A study by Seamon and Gazzaniga (1973) relates the two different brain areas to the individual information processing systems, verbal and visual. Other, non-physiological evidence provides further support for the dual system orientation. Specifically, these include: Bahrick and Baucher (1968), Bahrick and Bahrick (1971), Paivio and Csapo (1969), Cermak (1971) and Ternes and Yuille (1972) and Levie and Levie (1975).

If, indeed, an independent, non-verbal pictorial memory system exists, it is of great importance to understand how the visual images are processed for storage. Such an understanding would provide significant guidelines for the design and production of visuals which promote optimum retention of information as well as more efficient access and retrieval of that information from the memory store.

Of the many variables in visual design, complexity and realism have been those most easily and frequently manipulated.

Two major theoretical orientations deal with the question of realism and complexity in learning from visual materials.

The first, a group of theories collectively referred to as "realism theories" by Dwyer (1967) include the iconicity theory of Morris (1946), Dale's (1946) cone of experience and the surrogate fidelity theory of Gibson (1954). All of these theories are predicated on the assumption that the more realistic an instructional device, the more effectively it will facilitate learning. This assumption is based on the notion that the more realistic materials will present more visual cues to the learner and thus, give him more information with which to work. Justification for this assumption is provided by the basic theory of stimulus generalization and the concept of cue summation.

A conflicting orientation, however, has also drawn wide support. This group of theorists and researchers has suggested that the "realism theories" do not accurately describe how visual instructional materials function in learning, and in fact, may be in direct contradiction to the true situation.

Broadbent (1958, 1965) has described the human information processing system as a single-channel, limited capacity system which he refers to as the P-system. This system functions much like a filter in that, in times of high information reception, not all information perceived is immediately processed and stored. Rather, the P-system filters out all information beyond its capacity and holds this "overflow" for later processing. The overflow may possibly block other incoming, relevant information. Jacobson (1950, 1951) further supported this contention and indicated that only a small percentage of all information perceived is effectively stored and utilized by the nervous system.

Working from the theory of Broadbent, Travers (1964) focused specifically on the question of realism in instructional materials. He suggested that, to deal with a complex environment, the nervous system must simplify inputs and perceptions. To achieve this end, Travers described a process known as "compression." In describing this phenomenon, he indicated that to maximize the instructional effectiveness of visuals, it may be necessary to discard some elements of a visual which contain little information. This position is supported by empirical research conducted by Cherry (1953), Attneave (1954), Spaulding (1956), Gorman (1972) and Dwyer (1972). The studies reported by Dwyer represent the single, most comprehensive group of studies in this area. He found strong evidence to indicate that the most realistic visuals are not necessarily the most effective in promoting student learning. The relevance of visual realism to the use of color is readily apparent. Color in a great many visual illustrations can represent a significant contribution to the realism depicted in those visuals.

Research related specifically to the use of color has, similarly, been inconclusive. In a number of studies investigating the use of color in instructional visuals (VanderMeer, 1952; Kanner and Rosenstein, 1960, 1961; Katzman and Nyenhuis, 1972) it was generally concluded that color has no significant effect on learner achievement.

More recent studies, however, have reported conflicting data. Color was found to be a significant design factor in research conducted by Bourne and Restle (1959), Saltz (1963), Underwood (1963), Dwyer (1972).

SPECIFIC ORIENTATION OF THE PRESENT STUDY

When the results of those studies related to complexity or color are taken into consideration, it seems apparent that, as Otto and Askov (1968) indicated, the "cue value of color" is not clear. Limited research has focused on the effect of variations within the color mode of presentation as a means whereby the cue value of color may be more adequately investigated and described as it relates to an individual's ability to process, store and retrieve visual images. Since pictorial recognition memory is a basic component of all visual learning, it was the purpose of this study to investigate the effects of color cues as well as the absence of such cues on the recognition visual images.

Two significant research questions are apparent.

1. Does the addition of color information to a visual result in an increase or decrease in a subject's ability to recognize visuals which have been previously viewed?

In this case, the addition of any color cues to a visual display would represent an instance of greater available information. If the addition of color does indeed increase the recognizability of visuals, the cue summation and realism theories would be strongly supported. A finding of decreased recognizability would immensely lend support to the single channel, information overload orientation.

2. If the addition of color information results in a greater degree of recognition, what factor or factors are responsible?

Three explanations to the above question seem tenable. First, if the use of only realistic color cues make the visual more recognizable, it might be concluded that realistically colored visuals elicit more real-life associations within the memory store, thereby facilitating storage and later retrieval of the stored visual information. Second, if the addition of only non-realistic color to a visual display results in a higher degree of recognizability, then a logical conclusion might be that the color cues were particularly unique or distinctive and for that reason were easier to store and retrieve.

The third possible explanation may hold true if no significant differences in recognition levels were found between those visuals employing realistic color cues and those utilizing non-realistic colors. Such a finding would tend to indicate that the mere addition of information gives the viewer more cues to aid in storage and retrieval of the information, a basic contention of the realism theorists.

The present study attempted to explore these theoretical orientations and explanations from an empirical approach. In this study, visuals which incorporated both types of color cueing techniques respectively as well as the absence of such cueing were compared in terms of their relative effectiveness in facilitating pictorial recognition.

STIMULUS MATERIALS

The stimulus materials used in this study were developed from a pool of travel and general geographic scenery slides taken in various parts of the United States and Canada by several amateur photographers. From this pool, a group of 280 slides were selected to be used in the study. Criteria were applied to the selection to eliminate those slides with any verbal material, recognizable human figures or unique objects.

This group of slides was randomly divided in half, 140 slides becoming the stimulus slides and 140 slides used as distractors. Each group was again randomly divided into approximate thirds. One third was retained in the original color (realistic) format. A second third was photographically recopied into black and white slides and the remaining third of each group was recopied and modified by means of color photographic reversal to reproduce a non-realistic color format.

Photographic reversal was used as a means of producing visual materials in which the total number of visual cues were held constant while the degree of realism (color-realistic or non-realistic) could be manipulated.

In this case, all colors were systematically reversed to their opposite or complementary color, i.e. reds and browns were reversed to blues, grays and greens; yellows to violet and whites to black.

The 140 stimulus slides were duplicated to provide two sets.

EXPERIMENTAL PROCEDURE

The data for this study were obtained from 28 college students enrolled in the basic Educational Communications course at the University of Pittsburgh.

Subjects were seated six feet from the screen in a darkened room. The stimulus materials were presented by means of a Kodak Carousel Slide Projector which enlarged the projected image to a standard 16" by 24" size. The research assistant conducting the session was situated to the rear of the S to minimize distraction and facilitate operation of the projection equipment.

The "list learning" procedure for recognition experiments described by Kintsch (1970, p. 10) was employed in the study. Each S was first shown the group of 140 stimulus slides for intervals of .5 seconds each. Immediately thereafter, each S was shown the series of stimulus materials plus distractor materials combined in a random sequence. Each slide was presented for five seconds during which time the S responded verbally "old" or "new", depending upon whether the slide was recognized as being part of the first stimulus series or part of the distractor series. For convenience of presentation as well as a control against fatigue, the series of 280 slides was divided into seven sets of 40 slides each, labeled A, B, C, D, E, F, and G. A rest period of 30 seconds was provided between each set. Each S was run individually and all responses were noted by a research assistant.

A similar recognition session was conducted for each S after a period of two weeks. During this session the combined group of 280 stimulus and distractor slides was presented and S's again responded "old" or "new".

STATISTICAL ANALYSIS

Statistical analysis was conducted by means of analysis of variance procedures applied to a treatment by subjects design. In those cases where a significant F-ratio at the .05 level was indicated by the analysis of variance, further analyses were conducted between all possible pairs of means via the modified LSD procedure.

The raw data means and standard deviations are presented in Tables 1 and 2 and Figures 1 and 2.

Table 1

Immediate Recognition Scores

Treatment	N	Mean	Standard Deviation
Black and White	28	11.82	6.91
Realistic Color	28	16.86	6.13
Non-Realistic Color	28	15.36	7.50

Table 2

Delayed Recognition Scores

Treatment	N	Mean	Standard Deviation
Black and White	28	10.18	6.21
Realistic Color	28	13.57	7.19
Non-Realistic Color	28	15.64	8.97

Figure 1. Immediate Recognition Scores
By Subsets

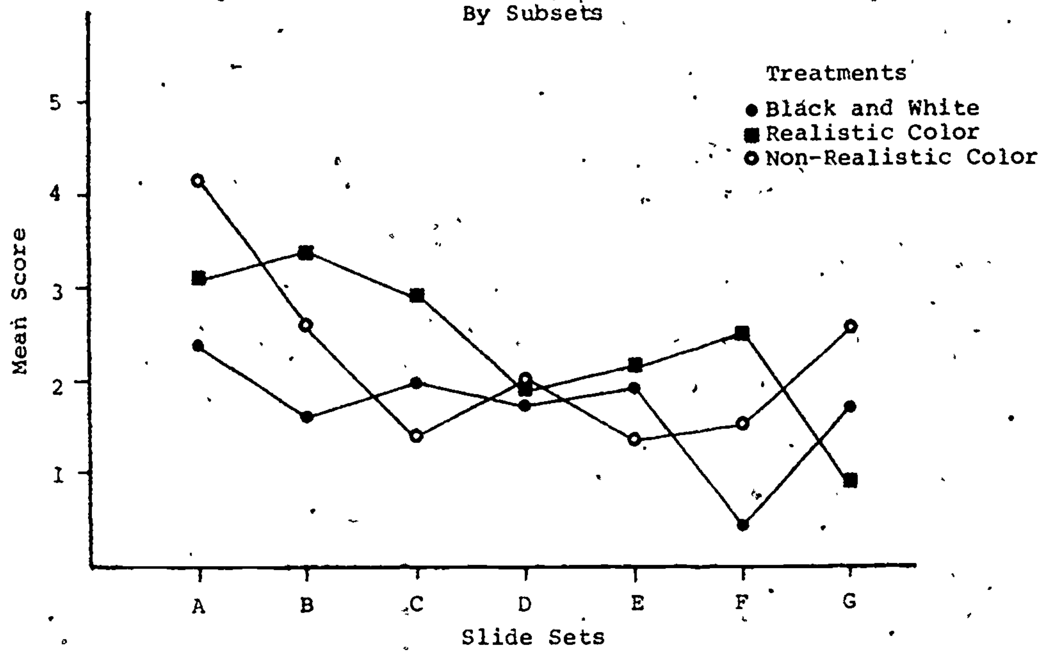
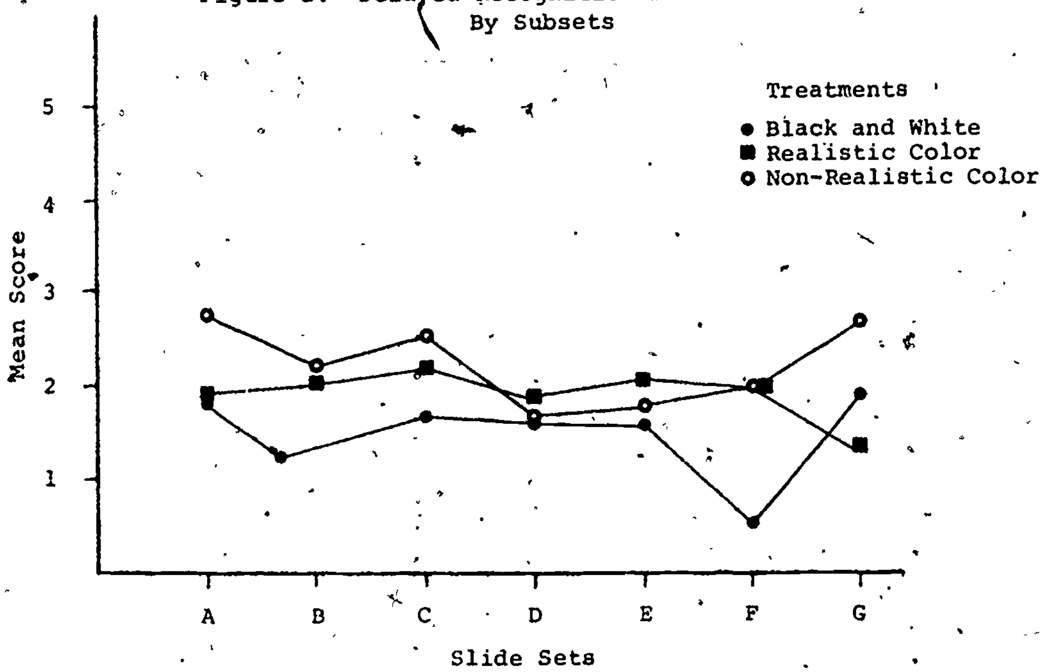


Figure 2. Delayed Recognition Scores
By Subsets



Analysis of variance procedures produced F-ratios of 10.48 - Immediate and 5.74 - Delayed. Both F values exceeded the critical F value at the $p < .01$ level ($F_{.01} = 5.06$, df = 2/50).

Further analyses were conducted via the modified LSD procedure, a somewhat conservative procedure, which however, does control the experimentwise error rate. The results of these pair-wise comparisons are shown in Table 3.

Table 3

Multiple Comparison of Means
Via Modified LSD Test

Immediate	Delayed
RC > BW*	RC = BW
NRC > BW*	NRC > BW*
RC = NRC	RC = NRC

*Significant at $p < .05$ level

As shown in Table 3, both color modes were superior to the black and white mode in facilitating immediate recognition of visuals. After a period of two weeks had elapsed, however, only the non-realistic color mode resulted in significantly higher recognition scores.

DISCUSSION

Based on the findings in this study, a number of summary statements can be made.

1. The use of color cueing techniques tends to increase the recognizability of visuals viewed for short periods of time.

2. Any type of color cueing device tends to facilitate recognition immediately after visuals have been viewed.

3. After extended periods of time, in this case two weeks, only non-realistically colored visuals tend to increase the degree of recognizability of a visual.

These findings tend to support the contention of many researchers that the addition of color cues to a visual will result in increased learning or improved storage and retrieval of information. They do not necessarily, however, support the "realism" orientation in that both realistic and non-realistic color cueing devices were equally effective in facilitating recognition.

Further, the data do not support the contention of Broadbent (1958, 1965) and Travers (1964) that the information processing system may be blocked by irrelevant cues, such as color cues, in times of high information reception. The stimulus materials used in this study were presented rapidly and for very short periods of time, .5 sec. Apparently, even at rates of transmission such as these, the additional information did not "block" the information processing system and impede learning.

In the case of delayed recognition of visuals, the apparent superiority of the non-realistic color cues may be attributed to the uniqueness of the cues. The non-realistic cues would appear to provide unique associations and were therefore easier to retrieve from the memory store.

It can generally be concluded, therefore, that the use of color cueing devices does indeed facilitate the storage and retrieval of visual information. It would appear that the process is aided because of a greater number of visual cues, rather than a more "realistic" visual image. It can be further concluded that extremely distinctive color cues may be useful in helping learners store and retireve visual information to be recalled at much later times.

IMPLICATIONS FOR FURTHER RESEARCH

This paper represents an initial report on a series of related experiments dealing with the effect of color cueing devices in visuals on various aspects of human learning. Currently a systematic investigation into the effects of variables such as rate of presentation of color cued visuals and the relationship between individual learner differences and learning from color visuals is being conducted. The completion of this series of studies along with replications will possibly permit more extensive conclusions to be drawn regarding the role of color in visual learning as well as the establishment of a series of guidelines for use by instructional designers in the development of educational materials which incorporate visual displays.

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