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ABSTRACT

This study investigated the interaction between cognitive lateral functions and pictorial recognition memory for pictures presented in three different color modes. The stimulus materials used were slides selected from a pool of travel and general geographic scenery slides taken in various parts of North America. One third of the slides were retained in the original realistic color format, a second group was produced in nonrealistic color by means of photographic reversal, and a third was recopied onto black and white slides. The original slides were randomly assigned to be copied in such a manner that a total of 60 split-slides were produced. The split-slides allowed for simultaneous projection of two scenes with one in the left visual field and one in the right visual field. Subjects were 30 right-handed male students from a Pennsylvania community college. The list learning procedure was used to present the stimulus materials. Following the treatment presentation, subjects were presented a random distribution of all individual images (stimulus and distractor) and asked to indicate whether they had seen the image before. The findings of the study indicate that both realistic color and black and white processing are more functions of the left than the right hemisphere, while nonrealistic color processing appears to be more a function of the right than the left hemisphere. It is concluded that nonrealistic color in visuals is primarily a cuing device, while realistic color and black and white visuals have both visual and verbal components and may require higher levels of processing. It is suggested that as the components of visuals increase in complexity, lateral function become less specialized and more unified. (1 table, 3 figures, and 28 references) (BBM)

Title:

# Color realism and Hemispheric Laterality

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# COLOR REALISM AND HEMISPHERIC LATERALITY

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Extensive research relative to the use of color as a variable in enhancing learning has led to theories, albeit conflicting about the processing of color information. Other research has utilized findings pertinent to cerebral laterality to suggest how color is stored in memory. Little research, however, has focused on the interaction between color memory and hemispheric lateralization.

The purpose of this study was, therefore, to investigate the interaction between cognitive lateral functions and pictorial recognition memory for pictures presented in three different color modes: realistic color, non-realistic color and monochrome (black and white).

## BACKGROUND RESEARCH

Substantial research has focused on the role of color in visual learning (Dwyer, 1972, 1987; Chute, 1979; Lamberski, 1980). Research reported by Berry & Dwyer (1982) and Berry (1982) investigated the relative effectiveness of realistic and non-realistic color in visual learning tasks. Findings showed that in different tasks, either realistic or non-realistic visuals were superior to monochrome materials These studies suggest that when color is used in a realistic manner, it can supply additional, meaningful verbal or linguistic labels, while the use of color simply as a coding technique (non-realistic) may serve only to increase the overall number of cues, but not provide additional realistic attributes or associations with which to store or retrieve information.

Other researchers have explored the degree of processing of visual information in the right and left cerebral hemispheres (Hellige, 1980, 1983; Bryden, 1982: Corballis, 1983). This research has suggested that tasks may be prioritized to particular locations in either the left or right hemispheres; the left hemisphere associated with verbal processes and the right with visuospatial processes (Bogen, 1977; Gazzaniga, 1985; Sperry, 1984). Hemispheric specialization became a topic of interest after Sperry's conclusions that two separate sides were responsible for distinct cognitive processes (Levy, 1983; Springer & Deutsch, 1985). Studies concerned with abnormal subjects concluded that functions of the right hemisphere were critical for color discrimination (DeRenzi & Spinnler, 1967; Nikolaenko, 1982; Scotti & Spinnler, 1970). Whenever normal subjects' visual fields were tested, the data suggested that some degree of independence of visual analysis and color recognition existed in each half of the brain (Dimond & Beumont 1972). Davidoff (1976) reported a right hemisphere advantage in perception of color stimuli. Questions regarding the lateral functions of the brain were further illuminated in the results of Chute's (1980) study which separated subjects into high visuospatial learners and low visuospatial learners. Color inhibited learning for the low-spatial group and increased learning for the high-spatial group. The implication was that those who were classified as having a low-spatial aptitude might profit less from color information than those classified as being visual or of high-spatial aptitude. Beauvois and Salillant (1985) suggested that color was represented in two separate memory systems; one classified as verbal and the other as visual. This suggestion supported the classic dual coding theory of Paivio (1971) that posits two intradependent but functionally independent systems for learning.

Evidence suggests that many lateral functions tend to cluster in hemispheres with the left specialized for syntactic and verbal skills and the right for visuospatial activities (Gordon, 1986; Hiscock & Kinsbourne, 1987). The left visual half-field/right hemisphere advantage is usually found for visuospatial tasks (Hellige, 1980). However, individuals are lateralized for speech whether right or left-handed with the majority being left hemisphere specialized.

It appears that the perception of color is basically a right hemisphere function although this has not been totally resolved. Results of color studies in which researchers utilized the left and right visual fields to study functions of the hemispheres are at times conflicting. Processing visual information conveyed by color can be affected by a number of variables e.g. both realistic and nonrealistic cues, verbal sequential and visuospatial interrelationships, and task complexity. When tasks are at a low level of difficulty, bilateral activation may be at a low level; whereas as task complexity increases, levels of cognitive processing and integration of hemispheric functions may be enhanced. Although evidence clearly disputes that individuals learn with only one side of the brain, there is some evidence of individual differences relative to hemispheric functions. In addition, many experimental methods have yielded insights into human cognition in which the brain can be viewed as having separate but interacting parts (Gazzaniga, 1989).

Berry (1990) suggested that the role of color in visuals could function in a dual role as either a cue to provide additional information without any realistic attributes or it could serve to convey those attributes of realism associated with the information.

## METHOD

The study utilized as its basis, stimulus materials developed and used by Berry (1982, 1990). These were slides selected from a pool of travel and general geographic scenery slides taken in various parts of the United States and Canada. Slides with any verbal material, unique objects, or recognizable human figures were excluded. The entire collection of materials was randomly divided into thirds. One group was retained in he original realistic color format and a second group was produced in nonrealistic color by means of photographic reversal. In this way, the total number of visual cues were held constant while the degree of realism varied. In addition, a third group was recopied onto black and white slides. The original slides were randomly assigned to be copied in such a manner that a total of sixty split-slides were produced. The sixty split-sides allowed for simultaneous projection of two scenes with one of the left visual field and the other in the right visual field. To insure that each image was presented to the proper visual field, the paired images were separated on the slide a distance equal to four degrees of radius at the projection distance. This resulted in a space of 3.6 inches between each image as viewed by the subject. In this way, the right and left visual fields corresponded to the image size and did not overlap.

A sample of thirty, right-handed, male subjects were drawn from the student population of a Pennsylvania community college. All subjects were volunteers.

The list learning procedure was employed to present the stimulus materials. Subjects were seated approximately thirty inches from an 18.75 in. x 12.50 in. rear projection screen. A Kodak Ektagraphic Slide projector was used to rear project the stimulus slides using an Ilex No. 4 Synchro Electronic shutter to control the amount of time the slides were projected onto the screen. The sixty paired treatment slides were shown to subjects for a period of 200 ms each to eliminate saccadic eye movements. Each individual was instructed to concentrate on a dot at the center of the screen to ensure that the right and left visual fields were properly positioned to observe the respective images. Following the treatment presentation, subjects were presented a random distribution of all individual images (stimulus and distractor) for 5 sec each and asked to respond by saying "new" if the image was seen for the first time or "old" if it had been seen before. Verbal responses were recorded by the researcher.

The design of the study was a two-way repeated measures with two levels (left and right) of the visual field/hemisphere factor and three levels (realistic, nonrealistic, and monochrome) of the color treatment.

## ANALYSIS

Analysis of the data obtained was conducted via the method of Signal Detection Analysis (Swets, 1964). This method has been advocated as a reliable means of assessing pictorial recognition memory (Berry, 1982, 1990; Loftus & Kallman, 1979).

The mean probability of hits and the mean error rates for each treatment and level were calculated as well as the measure of memory sensitivity, d', which was determined from tables developed by Elliot (1964). The d'statistic was transformed to eliminate negative values. These data are presented in Table 1.

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Insert Table 1 about here

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Test reliability coefficients were computed from standard errors and found to be 0.95 or greater for all variables. Analysis of variance procedures for two factor repeated measures were conducted on the d'adjusted, probability of hits, and total error scores. With respect to the analysis of the d'adjusted values, a significant F value ($F=14.90$, $p<.001$) for the interaction of Visual Field and Color was obtained as well as a significant main effect for color ($F=3.85$, $p<.03$). Analysis of the cell means via the Scheffé method indicated that a significant difference existed between the realistic and black and white treatments in the left visual field. This suggested the superiority of nonrealistic color in the left visual field/right hemisphere.

For the probability of hits, a significant interaction ($F=14.16$, $p<.0001$) between type of color and visual field was obtained and a significant F for the color main effect ($F=3.55$, $p<.034$). A Scheffé analysis confirmed that the nonrealistic color treatment was significantly higher than the black and white treatment in the left visual field. This finding would suggest that nonrealistic color materials were recognized better than black and white materials in the left visual field/right hemisphere.

Analysis of variance on the error rates produced a significant F value for the interaction ($F=13.77$, $p<.001$) and a significant F value for the main effect of color ($F=3.85$, $p<.02$). *Post hoc* comparisons via the Scheffé method indicated that the realistic color materials produced significantly more errors than did the nonrealistic color materials in the left visual field/right hemisphere. The nature of the three interactions are illustrated in Figures 1,2, & 3.

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Insert Figures 1, 2, & 3 about here

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In interpreting the findings of this study, it should be remembered that each visual field projects to the contralateral hemisphere of the brain. Consequently, the performance related to recognition in the left visual hemifield is processed in the right cerebral hemisphere and right visual hemifield performance is associated with left hemisphere processing.

The major findings of this study indicated that:

1. Significant interactions occurred between visual fields and modes of color.
2. There was no significant difference for memory of realistic color in either visual field.
3. There was no significant difference for black and white memory in either visual field.
4. Nonrealistic color was remembered significantly better than black and white in the left visual field.
5. There were fewer errors relative to processing of nonrealistic color in the right hemisphere than there were associated with realistic color.

The implications of these findings are that both realistic color and black and white processing are more functions of the left than the right hemisphere while nonrealistic color processing appears to be more a function of the right than the left hemisphere.

## DISCUSSION

The main issue addressed in this study was the relationship between hemispheric lateralization and color mode. Nonrealistic color appears to be processed primarily in the right hemisphere rather than in the left and may serve merely as a cuing device. These findings are supported by the work of Jorgenson, Davis, Opella & Angerstein (1980) which found that color and word responses are left hemisphere processes while color alone involves additional right hemisphere processing. If, indeed, the functions of the right and left hemisphere are divided into two separate systems, one visual and one verbal, where visual is primarily a right hemisphere function and verbal a left hemisphere function, then the processing of nonrealistic color is more a function of the right hemisphere than the left hemisphere. It would appear, therefore, that those individuals classified as being primarily visuospatial (Chute, 1980) would recall color information, whether nonrealistic or realistic, better than monochrome. Realistic color may provide additional verbal components making it more a complex function of the left hemisphere as well as the right. These conclusions are supported by (Gazzaniga, 1989), who suggested that, as information becomes more complex, both intrahemispheric and interhemispheric functions become more unified. These conclusions are also supported by the recent findings of Berry (1990) in which subjects were given a complex verbal masking task in order to inhibit the processing of visual information in the left hemisphere. The patterns of interactions for d'adjusted responses, hit responses, and error scores were highly similar to those obtained in this study.

The findings suggest that nonrealistic color facilitates recognition more so in the right hemisphere than in the left hemisphere, while realistic and black and white visuals are less effective in promoting recognition in the right hemisphere. Nonrealistic color when presented in visuals is primarily a cuing device, while realistic color and black and white visuals have both visual and verbal components any may require higher levels of processing. It appears that as the components of visuals increase in complexity, lateral functions become less specialized and more unified.

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Table 1.
Means and Standard Deviations for Probability of Hits, Error Rates and d' Adjusted, by Treatments and Visual Field/Hemispheric Localization. (N = 30)

| Treatment | P(H) | | Errors | | d' Adjusted | |
|---|---|---|---|---|---|---|
| | M | S.D. | M | S.D. | M | S.D. |
| Left Visual Field / Right Hemisphere | | | | | | |
| Realistic Color | .512 | .126 | 16.22 | 2.10 | 2.03 | .379 |
| Nonrealistic Color | .627 | .200 | 13.33 | 2.96 | 2.31 | .468 |
| Black & White | .432 | .190 | 15.28 | 2.84 | 1.80 | .487 |
| Right Visual Field / Left Hemisphere | | | | | | |
| Realistic Color | .580 | .121 | 14.95 | 2.30 | 2.21 | .415 |
| Nonrealistic Color | .529 | .186 | 15.27 | 2.30 | 2.06 | .356 |
| Black & White | .508 | .189 | 13.78 | 2.86 | 2.05 | .476 |

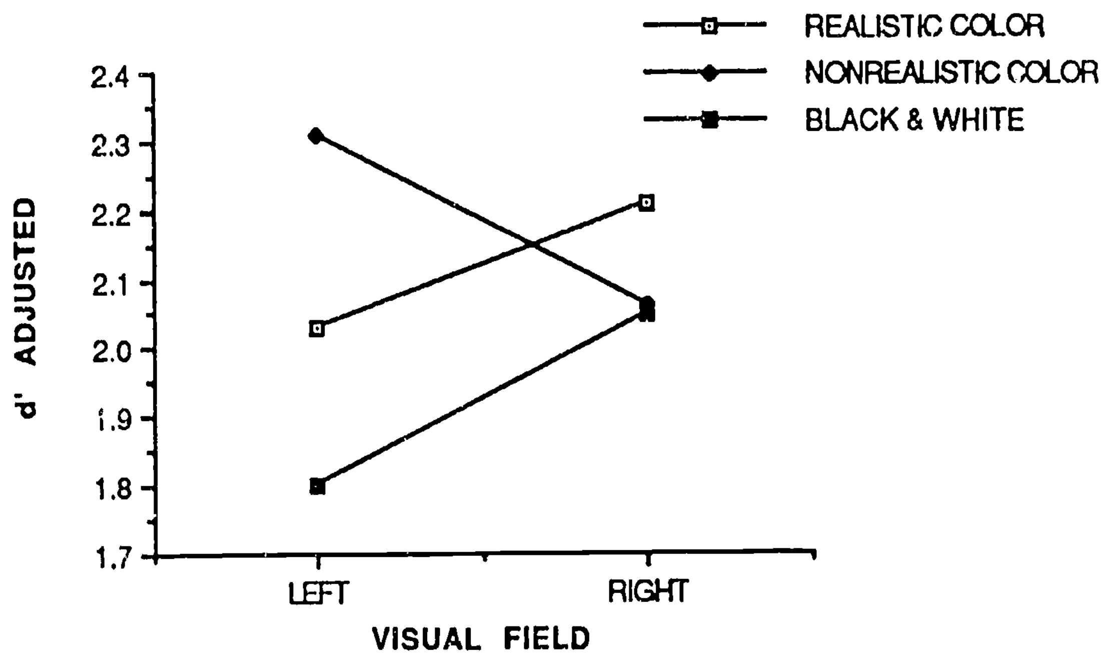


Figure 1. Mean d' Adjusted values for color treatments (realistic, nonrealistic, black & white) by visual fields.

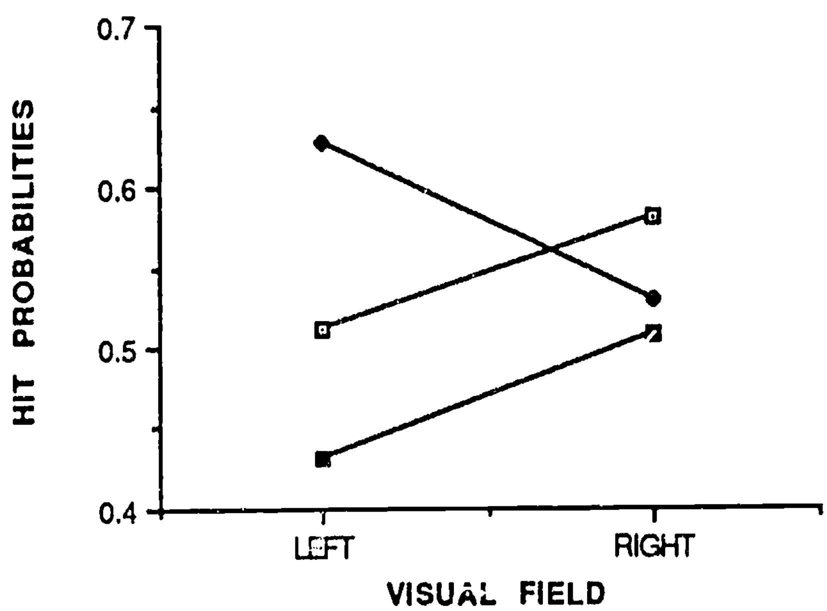


Figure 2. Mean hit probabilities for color treatments (realistic, nonrealistic, black & white) by visual fields.

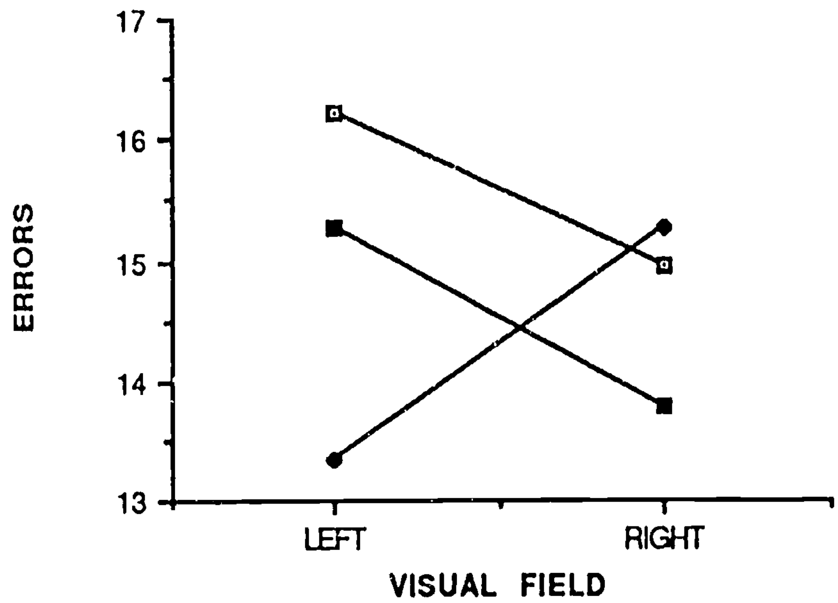


Figure 3. Mean error values for color treatments (realistic,nonrealistic, black & white) by visual field.