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ABSTRACT

The interaction between field dependence/independence and pictorial recognition memory was investigated using pictures in three different color modes: realistic color, non-realistic color, and black and white. The study was designed to further confirm the efficacy of applying signal detection analyses to color recognition memory data as a means of more accurately assessing the role of color in visual information processing. Subjects were 60 graduate and undergraduate university students who were identified as field dependent or independent using the Group Embedded Figures Test. The list learning procedure was employed in which all subjects were first briefly shown the 150 stimulus slides sequentially and then shown a random distribution that included an additional 90 distractor slides. Subjects identified slides as old (seen before) or new (never seen). Results suggest that field independent subjects may be generally superior in any type of pictorial recognition task, regardless of color mode. Realistic color materials tend to produce higher absolute recognition rates, but they also seem to produce higher false alarm (positive response to distractor) rates in relation to overall recognition. Thirty-nine references are listed. (LMM)

THE ROLE OF COGNITIVE STYLE IN PROCESSING COLOR INFORMATION: A SIGNAL DETECTION ANALYSIS

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Introduction:

During the past several years, substantial research has addressed the interaction between the cognitive style of field dependence/independence and how individuals process pictorial information. Research conducted by Wieckowski (1980) and Lertchalolarn (1981) focused on the relationship between cognitive style and the role of color in pictorial recognition memory. The method of signal detection theory has not however, been applied to such research.

The purpose of this investigation was two-fold: (1) to study the interaction between cognitive style, specifically field dependence/independence and pictorial recognition memory for pictures presented in three different color modes; realistic color, non-realistic color and monochrome (black and white); and (2) to further confirm the efficacy of applying signal detection analysis to color recognition memory data as a means of obtaining a more accurate assessment of the role of color in visual information processing.

Related Literature:

The area of cognitive styles has become an area of extensive research interest in recent years. Kogan (1971) defined cognitive style as an individual variation in mode of "apprehending, storing, transforming and utilizing information." This concept was further defined by Ragan (1978) who suggested that cognitive styles represent "psychological dimensions" which describe individual differences in the means whereby information is received, processed and utilized. Cognitive styles can be considered stable psychological attributes. Witkin, Moore, Goodenough and Cox (1977) described the three characteristics of cognitive styles as being: (a) oriented toward "form" rather than "content" related cognitive activities; (b) stable over time, and (c) bi-polar rather than hierarchical as is mental ability.

Field dependence is one such cognitive style which has been researched more extensively than many others. This factor, identified by Witkin, Oltman, Raskin and Karp (1971) is generally defined as the differential ability of individuals to separate figure from ground or overcome "figural embeddedness." Although described and determined on a highly perceptual basis, this attribute is related to many other cognitive, attitudinal and personality behaviors. The perceptual ability for figured disembedding is generally considered to be representative of the more global ability to impose structure upon perceived information. Karp (1963) and Goodenough (1976) have thoroughly reviewed the various correlates of field-dependence.

Field dependence has, however, remained substantially a perceptual ability measure, assessed by the Rod-and-Frame Test or the various embedded figures tests, i.e. Group Embedded Figures Test (Witkin et al, 1971).

Substantial research has focused on the role of color in visualized instruction (Dwyer, 1972, 1978; Berry, 1974; Winn, 1976; Chute, 1979; Lamberski, 1980). This research represents one aspect of the larger theoretical debate which continues regarding visual complexity. It has long been contended that the mere addition of visual cues will increase the ability of the viewer to store and retrieve visual information. This orientation, termed "realism" by Dwyer (1967), has drawn strong theoretical support (Dale, 1946; Morris, 1946; Carpenter, 1953 and Gibson, 1954) and is indeed the major premise of cue summation theory (Severin, 1967). Other researchers (Broadbent, 1958, 1965; Travers, 1964) have, however, taken strong opposition to this "realism" orientation on the grounds that the human information processing system is of limited capacity and that, in times of rapid information reception, irrelevant cues may block the processing of other, relevant information. Studies (Kanner, 1968; Katzman and Nyenhuis, 1972; Dwyer, 1972 and 1979) have investigated this apparent contradiction with conflicting results.

The inclusion or absence of color information can be regarded as one dimension of visual complexity. Color can function in a dual role when used in visual displays. First, it can serve primarily a coding function, providing additional information but not providing any realistic description of the elements of the display. In this case, the effectiveness of color can be predicted by cue summation theory, but not by the realism hypothesis. Second, color can be cues to present a more realistic version of the visual display. In this instance, in addition to providing a greater number of overall cues, it provides the viewer with more realistic attributes or "handles" with which to store and retrieve information. When color is used in this cueing role, its value could be predicted by the realism theories as well as by cue summation theory.

Much past research investigating the differences between color and black and white visuals failed to take into account the fact that realistic color visuals contain intrinsically more information and consequently require more time for processing. In an attempt to resolve this methodological inconsistency as well as to more accurately assess the role of color in the storage and retrieval of visual information, Berry (1974) compared realistic and non-realistic color versions of the instructional materials on the human heart developed by Dwyer (1976). Data suggested that, in those learning tasks where visual materials contributed significantly to the improvement of instruction, realistic color materials were most effective. Later research (Berry, 1977, 1982, 1983) which investigated the color realism/coding question relative to pictorial recognition memory found both realistic and non-realistic color materials superior to black and white visuals. These findings suggested that cue summation theory may provide an accurate description of how color functions in basic information processing tasks such as picture recognition.

A number of researchers have investigated how the aptitude of field dependence/independence relates to an individual's ability to percieve and process both simple/complex and color/monochrome pictorial information.

French (1983) found that field independent subjects experienced less difficulty processing unusually complex material than did field dependent viewers. Color however, was not considered a primary dimension of visual complexity. Research conducted by Wieckowski (1980) and Lertchalolarn (1981) suggests that individuals who differ in terms of field dependence/independence utilize color information differentially in recognizing visuals. Color was shown to facilitate recognition of visuals by subjects who tended toward the field independent end of the continuum, while color appeared to interfere with recognition by field dependent individuals. It is not clear why such findings occurred, however, one possible conclusion may be that color information functioned as a further embedding cue, making it more difficult for field dependents to separate distinct forms within a visual which could be used as recognition cues. It is also not clear why color tended to facilitate recognition by field independent individuals, although one possible explanation may be in the ability of such individuals to effectively disembed specific forms from the visual ground and subsequently use them as cueing devices. Neither of these hypotheses have, however, been adequately addressed by past research on the color variable.

Simple comparison of recognition rates did not, however, take into account the subjects' rate of incorrect responses. It has been suggested by Swets, Tanner, and Birdsall (1964) that in recognition experiments, each observer applies a particular criterion value to each observation. Consequently it could be possible for a subject to identify all stimuli as having been seen previously, the result of which would be not only a high recognition rate, but also a high error rate. Similarly, if the observer were to apply a low criterion and reject all items as not previously seen, the resulting rate would be low with a correspondingly low error rate. It is apparent that analysis of pictorial recognition data should take into account the observer criterion and the resulting rate of error which accompany the reocgnition rate. The method of signal detection theory has been applied to the analysis of recognition data in the past as a means whereby both recognition rate and error rate are taken into account.

Signal detection theory has been accepted as a reliable technique for assessing a subject's ability to describe the occurrence of discrete binary events. The basic model of SDT was described in Swets (1961) and has been used extensively to study the ability of individuals to distinguish the presence of a signal when that signal was mixed with noise. More recently, Grasha (1970) has suggested the use of SDT parameters in the study of memory processes. Signal detection theory has been applied specificially to recognition memory experiments involving pictures in research conducted by Snodgrass, Volvovitz and Walfish (1972), Loftus and Kallman (1979), Loftus, Greene and Smith (1980), Morrison, Haith and Kagan (1980) and Kagan (1980) and Berry (1982, 1983).

The purpose of this investigation was two-fold: (1) to study the interaction between cognitive style differences and pictorial recognition memory for pictures presented in three different color modes; realistic color, nonrealistic color and monochrome (black and white); and, (2) to further confirm the efficacy of applying signal detection analysis to color recognition memory data as a means of obtaining a more accurate assessment of the role of color in visual information processing.

Procedure:

The stimulus materials [illegible] the study were the same as those used by Berry (1977), Wieckowski ([illegible]) and Lertchalolarn (1981). These consisted of 150 stimulus slides and [illegible] distractor slides. All slides were obtained from a pool of travel and geog[illegible] scenery slides taken by several amateur photographers in various parts of the United States and Canada. In selection of the materials, care was exercised to exclude all recognizable human figures, verbal materials and unique objects. The entire collection of materials was randomly divided into approximate thirds. One third was retained as a realistic color group, a second third was recopied into black and white slides and the remaining third was altered by photographic reversal to produce a non-realistic color group. Through photographic reversal, the overall number of color cues could be held constant while the degree of color realism could be manipulated.

The population for the study consisted of 60 students at the University of Pittsburgh. Subjects were drawn from the Schools of Education, Library and Information Science and Business and represented both graduate and under-graduate students.

Subject's relative degree of field dependence/independence was determined using the Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin and Karp, 1971). Based upon similar data from related populations, cutoff points of 11 and 15 were used to define field dependent (11 and below) and field in-dependent (15 and above) groups. To avoid the loss of power associated with three-level blocking, described by Cronbach and Snow (1977), the middle, indeterminate group was deleted from the study.

The list learning procedure was employed, in which all subjects were first shown the group of 150 stimulus slides, sequentially for approximately 500 ms each. Subjects were subsequently presented with a random distribution of all slides (stimulus and distractor) for five seconds each. During that time, subjects responded in writing either "old" (stimulus slide-seen before) or "new" (distractor slide-never seen).

The design of the study followed an ATI configuration with two levels of the aptitude factor and three repeated measures of the color factor.

Findings:

The mean number of hits for each treatment and cognitive style group as well as the measure of sensitivity d' which was determined from tables developed by Elliot (1964) are presented in Table 1. In addition, total mean error rates for each treatment were calculated (total error rate = false alarm rate + miss rate) as suggested by Loftus, Green and Smith (1980) (see Table 1).

Analysis of variance procedures for repeated measures were conducted on the number of hits (recognition scores), d' and the total error scores. Significant F-values were obtained for the main effect of color on the hit rates (F=7.10, p=.001) and for the main effect of cognitive style on the d' data (F=7.59, p=.008).

Table 1

Means and Standard Deviations for Number of Hits, d' and Total Error Rate by Treatments Across Cognitive Style Groups

		Realistic Color		Non-Realistic Color		Black and White	
		Mean	s.d.	Mean	s.d.	Mean	s.d.
Field Dependent (N=27)	Hits	26.74	9.41	24.33	9.94	20.56	10.85
	d'	.133	.172	.107	.336	.200	.392
	Total Error	37.89	4.29	39.63	6.58	39.78	6.61
Field Independent (N=33)	Hits	25.82	7.90	23.33	9.98	22.48	8.08
	d'	.195	.327	.369	.389	.278	.248
	Total Error	37.48	5.01	36.85	5.91	38.24	4.16

The Scheffé procedure for pair-wise comparisons was performed on the means to determine where significant differences existed. The results of these analyses are summarized in Table 2.

Table 2

Summary of statistical analyses for hit scores, d' and total error scores

Hit Scores	d'	Total Error Scores
RC > BW	FI > FD	-

Discussion and Conclusions:

Findings relative to the cognitive style variable of field dependence showed no differences in analysis of the hit rates (recognition score), however a significant main effect for the cognitive style attribute was produced on the d' parameter. This finding would suggest the general superiority of field independent subjects in any type of pictorial recognition task regardless of color mode. Such results are consistent with current theory which suggests that field dependent individuals are better able to impose structure on a relatively undifferentiated field and consequently can more effectively process, store and retain such information. Color was not identified as a significant, contributing factor to this figural restructuring. It should be noted, however, that in the non-realistic treatment, subjects showed the greatest degree of differentiation across the cognitive style factor. This may suggest that when individuals are presented with unique or unfamiliar visual displays, field independent persons use such information more effectively than do field dependent subjects. Such comparisons would seem to merit further investigation.

Since subjects showed no apparent difference in terms of overall error rate or hit rate, it would seem reasonable to conclude that the difference produced in the d' variable is due to differences in the "false alarm" rate (positive response to distractor). This implies a greater processing and storage problem, possibly attributable to less efficient organization of the material in memory. Again, this aspect calls for more extensive exploration.

In terms of the color variable, the analyses of hit scores (correct recognition) showed no interaction with the cognitive style variable, but did show a main effect superiority for the realistic color treatment over the black and white treatment. No differences were produced however, in analyses of the d' values. Such variations are again the result of differences in the false alarm rate. It would seem that even though realistic color materials produce greater recognition values, they also produce higher false alarm rates. This would suggest that the use of realistic color materials may not be as efficient in terms of the accuracy of the response. Such a finding also suggests that the d' parameter is a better overall indicator of response accuracy.

Based on these findings, a number of conclusions can be drawn.

1. Field independent subjects exhibit greater ability to recognize previously seen visuals in terms of the d' parameter.

2. Realistic color materials tend to produce higher absolute recognition rates but not higher d' values.

3. The variables of false alarm rates in relation to overall recognition should be studied further.

4. The method of signal detection theory can and should be applied to color recognition data analysis. In so doing, a more accurate assessment of the recognition and error rate interaction can be made.

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