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ABSTRACT

The purpose of this study was to examine the effect that coding (black and white, and color) and testing mode (visual/verbal) has on the achievement of students categorized as field independent (FID)/field dependent (FD) learners. One hundred eighty-three students enrolled in basic college level educational psychology courses were classified as either field dependent, field neutral, or field independent as a result of their performance on Group Embedded Figures Test (GEFT). Participants read a 2,000 word instructional booklet on the anatomy and functions of the human heart, containing 19 illustrations, either in black and white or with different colors used to highlight information and processes being discussed. Each student immediately received, in a visual or verbal format, four individual multiple-choice criterion tests (drawing, identification, terminology, and comprehension). On the drawing test scores, results indicated a significant difference in cognitive style, in favor of field independent students, color coding, and verbal test. On the identification test, results favcred field independent students and verbal testing. Terminology and comprehension test scores also significantly favored field independent students. Total test score favored field independent students, color coding (b"t color coding did not influence field dependent students), and verbal testing. Results of the study verify that field independent and field dependent learners differ in cognitive processes they use. The concepts of field independence/ dependence is an important variable in the teaching/learning process and color coding and test format remain as viable instructional variables. (Contains 19 references.) (MAS)

Effect of Color Coding and Test Type (Visual/Verbal) on Students Identified as Possessing Different Field Dependence Levels

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Considerable research has been conducted in an attempt to isolate those specific individual differences in variables which have an impact on information processing and acquisition. Much of this research has focused on the relationship which exists between individuals and the way they learn. The usefulness of this cognitive style research depends on its potential to identify specific information processing differences between different types of students. In this regard, cognitive learning style is generally considered to be the way in which an individual interacts with and processes information. The field independence/dependence theory (Witkin, Oltman, Raskin, & Karp, 1971) as a cognitive style construct has been researched extensively because it describes characteristics which are directly related to the learning process and most prescriptive of instructional outcomes. While research on the effect of field independent (FID)/dependent (FD) learning styles on achievement performance has not always been consistent, numerous studies have shown that FID and FD individuals do learn differently. Witkin, Moore, Goodenough, and Cox (1977) have defined field independence and field dependence as "the extent to which a person perceives part of the field as discrete from the surrounding field as a whole, rather than embedded in the field." In general, FID learners are inclined to reorganize or restructure information to suit their specific learning needs; whereas, FD learners are global in that they depend more completely on the external cues (available structure) in the stimulus field.

Since the visual-spatial element (structure) is an important dimension of FID/FD learning construct, researchers have attempted to design visualized instruction according to the characteristics of FID/FD learners, hoping to capitalize on strengths and compensate for weaknesses. The field independence/field dependence continuum, as it is applied to active learning, prescribes the degree to which learners will interact with a visual presentation, that is, whether the learner will merely interact with the instruction as presented or will analyze, reorganize and synthesize the stimulus field to make the content more meaningful and memorable (Ausburn & Ausburn, 1978). Witkin, et al. (1977) have noted that certain individuals interact to superfluous cues in a visualized instructional environment while others are able to identify precisely the critical information contained in a completely visualized environment. Field dependent individuals, when presented a visualized presentation tend not to modify the structure but accept and interact with it as it is presented. They tend to fuse all

segments within the visual field and do not view components discretely. Field independents tend to act upon a visual stimulus, analyzing it when it is organized and providing their own structure when it lacks organization.

The FD/FID cognitive style appears to be especially important in the design of visually related information. Although many studies have examined the effects of visual attributes of learning (Dwyer, 1978, 1987) few have studied the effects of varied visual attributes on specific cognitive learning styles. Research has shown that color-coding helps learners organize or categorize information into useful patterns which enables the learners to interpret and adjust to their environment. Color coding may be considered a strategy in which students enhance or sharpen essential message characteristics by providing structures for the storage of new information . Dwyer (1978, 1987), in an extensive review of research on the impact of color vs. black and white comparison, found color versions to be significantly more effective than the black and white versions in facilitating student achievement of specific educational objectives .

It was hypothesized that color-coded visuals (color) would be more effective than black and white coded visuals (B&W) in enhancing the salient visual cues thereby making them more identifiable and instructional to field dependent learners. The color-coding would attempt to compensate for the restructuring skills absent in field dependent learners and subsequently lead to deeper information processing and increased achievement. This hypothesis seemed plausible since field dependent learners tend to be global in perception (Jonassen & Grabowski, 1993) and would be most inclined to take advantage of the increased structure provided by the color-coding.

If visualization provides structure to the information processing strategies in FID/FD learners, then it would seem to be logical that visual testing of the information would be a more valid assessment strategy. Nitsch (1977) and Battig (1979) have indicated that any change in the retrieval (evaluation) environment from that which occurred in the original learning environment causes marked decrements in learner performance. Under this paradigm information retention level is assumed to be a direct function of the encoding occurring at the presentation stage and the degree to which the retrieval environment recapitulates this encoding (Tulving, 1979). Optimum validity in cognitive assessment of learner information acquisition, apparently, can only be obtained if there is a high degree of congruency between the number of common features in the presentation (encoding) mode and the retrieval (evaluation) mode of instruction, e.g., if visualization is an integral component in facilitating learner encoding of the information, then visualization should also be used in the test items (decoding phase) used to assess learner achievement (Tulving & Thomson, 1973; Jacoby & Craik, 1979). It was hypothesized that the visual test format would be most effective in providing appropriate retrieval stimulus to optimize the achievement of FD learners.

Specifically, the purpose of this study was to examine the effect that coding (B&W and color) and testing mode (visual/verbal) has on the achievement of students categorized as FID/FD learners and to determine if there is an interaction among these variables. It was anticipated that the findings of this study would provide guidelines for teachers and designers of instructional software to be used with students

possessing different cognitive learning styles.

Method

Subjects and Procedure. One hundred eighty-three students enrolled in basic educational psychology courses at The Pennsylvania State University and Virginia Tech University participated in this study. Students were classified as field dependent, field neutral, or field independent as a result of their performance on the Group Embedded Figures Test (GEFT), (Witkin, Oltman, Raskin, & Karp, 1971) and were divided into the different levels based on their mean achievement level on the GEFT. Students who achieved one-half standard deviation above the mean were considered to be field independent, i.e., scores of 16 and above (n=66, M =16.99, SD=1.12); those located one-half standard deviation below were classified as field dependent, i.e., scores 10 and below (n=43, M=7.43, SD=2.40) and those in the middle were classified as neutral, i.e., scores between 11 and 15, (n=74, M=13.04, SD=1.66).

Students in the three GEFT levels were randomly assigned to two treatment groups. The subject content for the study consisted of a 2,000 word instructional booklet on the anatomy and functions of the human heart. Each booklet contained 19 illustrations which were designed to illustrate the content being presented verbally. The illustrations in Treatment I, the black and white version, contained black and white coded line drawings which highlighted the information and processes being presented. Students in Treatment II received the same visuals as did students in Treatment I; however, several different colors were used to highlight the information and processes being discussed. Immediately after receiving their respective treatments students received the drawing test. Each student in each treatment randomly received in a visual or verbal format three separate 20-item multiple-choice criterion tests. Scores achieved on the four individual criterion tests (drawing, identification, terminology, and comprehension) were combined into an 80-item total criterion score. The visual form of the criterion tests utilized only one drawing with four or five letter labels in all items in which it was possible to do so while maintaining clarity and correspondence to the verbal test items (Figure 1).

VERBAL TEST ITEM
When blood is forced out of the right ventricle, in which position is the tricuspid valve?
A. partically opened C. open
B. partically closed D. closed

VISUAL TEST ITEM
The position of the tricuspid valve when blood is forced out of the right ventricle is:

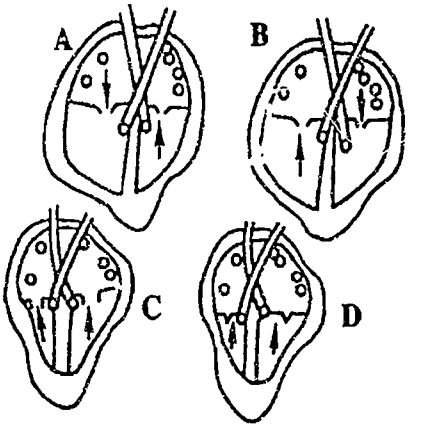

Figure 1. Criterion test items

However, two items in the terminology test and all items in the comprehension test required four drawings. The item stems of both the verbal and visual test questions were verbal and asked the same question. In addition, the visual distracters in the visual tests corresponded to the

verbal distracters in the verbal tests as closely as was reasonable. Following is a description of the individual criterion tests which illustrates the kinds of educational objectives assessed in this study.

Drawing Test. The objective of the drawing test was to evaluate student ability to construct and/or reproduce items in their appropriate context. The drawing test (20 items) provided the students with a numbered list of terms corresponding to the parts of the heart discussed in the instructional presentation. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents.

Identification Test. The objective of the identification test was to evaluate student ability to identify parts or positions of an object. This multiple-choice test (20 items) required students to identify the numbered parts on a detailed drawing of a heart. Each part of the heart, which had been discussed in the presentation, was numbered on a drawing. The objective of this test was to measure the ability of the student to use visual cues to discriminate one structure of the heart from another and to associate specific parts of the heart with their proper names.

Terminology Test. This test consisted of 20 multiple-choice items designed to measure knowledge of specific facts, terms, and definitions. The objectives measured by this type of test are appropriate to all content areas that have an understanding of the basic elements as a prerequisite to the learning of concepts, rules, and principles.

Comprehension Test. The comprehension test consisted of 20 multiple-choice items. Given the location of certain parts of the heart at a particular moment of its functioning, the student was asked to determine the position of other specified parts of the heart at the same time. This test required that the students have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The comprehension test was designed to measure a type of understanding in which the individual can use the information being received to explain some other phenomenon.

Total Test Score. The items containing the four individual criterion tests (drawing, identification, terminology, and comprehension) were combined into an 80-item composite test score. The purpose was to measure total achievement of the varied levels of objectives presented in the instructional unit.

Analysis

A series of 2x3x2 analyses of variance was used to analyze students' achievement on each of the four individual criterion tests and a total test score. The range of scores possible on the total test was 0-80. Main effects considered were cognitive style (field dependent (FD), neutral (N), and field independent (FID)), color-coding (color and B&W) and type of test format (visual and verbal). Interactions among cognitive style, color-coding and testing mode were also of interest. The alpha level was set at .05 for all analyses. Kuder-Richardson 21 reliability coefficients from the visual format test and the verbal format test were both .92.

Results of the individual criterion tests plus the combined total test are as follows.

Results

On the **Drawing test** scores an analysis of variance indicated significance differences on cognitive style, $F(2, 171) = 8.88$, $p<.05$), in favor of field independent students as predicted, on color-coding, $F(1, 171) = 20.91$, $p<.05$), in favor of color-coding as predicted and on the type of test, $F(1, 171) = 7.83$, $p<.05$, in favor of the verbal test which was not predicted. On the **Identification test** scores an analysis of variance indicated significance differences on cognitive style, $F(2, 171) = 6.73$, $p<.05$, in favor of field independent students as predicted and on the type of test, $F(1, 171) = 7.67$, $p<.05$, in favor of the verbal test which was not predicted. On the **Terminology test** scores an analysis of variance indicated significance differences on cognitive style, $F(2, 171) = 12.69$, $p<.05$, in favor of field independent students as predicted. On the **Comprehension test** scores an analysis of variance indicated significance differences on cognitive style, $F(2, 171) = 10.19$, $p<.05$, in favor of field independent students as predicted. However, when all criterion tests were combined into a **Total test score**, an analysis of variance indicated significant differences on cognitive style, $F(2, 171) = 13.40$, $p<.05$, in favor of field independent students as predicted, in color-coding, $F(1, 171) = 5.37$, $p<.05$, in favor of color as predicted (but color-coding did not assist field dependent students) and on type of test , $F(1, 171) = 4.28$, $p<.05$, in favor of the verbal test which was not predicted.

Discussion

The results of the study support the contention that field independent and field dependent learners differ in the cognitive process they use as well as in the effectiveness of these processes in facilitating information acquisition. This finding is also consistent with previous reviews of the literature that have concluded that field independent learners exhibit an active hypothesis-testing strategy towards learning, whereas field dependent learners tend to employ a more tentative or spectator approach to learning (Witkin, et al., 1977; Goodenough, 1976). This study verifies the fact that field independent learners are able to perceive relevant information as discrete from their background and restructure information in a manner conducive to facilitating memory and recall (Tulving, 1968). It also lends support to the contention that field dependent learners tend to have difficulty separating relevant items in the percept from the irrelevant background. The figure-ground confusion experienced by the field dependent learners seemed to be especially acute when perceiving a relatively complex stimulus without having provided organized structure. Apparently, when field dependent learners interact with a complicated stimulus field, the field remains complicated because they attempt to remember the entire stimulus percept.

While the internal variable of interest in this study was the cognitive style of field dependents-independent students, the external variables of interest were color-coding and test format. In terms of color-coding it was hypothesized that the color-coding would make the relevant cues more obvious to the field dependent learners, thereby reducing achievement differences between the field independent and the field dependent learners. The color-coding mean was significantly higher on the total test than the black & white mean. However, the color-coding illustrations apparently provided an insufficient structure for the field dependent learners since achievement was not significantly enhanced. This result may be explained by the fact that possibly the covert rehearsal

activity of merely receiving the color - coded structures was not sufficiently intense for the field dependent learners to investigate the level of information processing necessary to facilitate increased comprehension of the intended content (Bransford, 1979). The performance of the field dependent learners might have changed significantly if the directions in the instructional booklet had indicated that the color-coded structures were designed to help them organize the information and that they would not only have to understand the functions of the human heart but would also have to perform on a test measuring knowledge of heart related terminology and the functions of the various parts of the heart during the diastolic and systolic phases. In addition, the fact that there was not a color-coded dependent measure for the groups that experienced the color-coded treatment may have negated any possible advantage of these treatments. This should be investigated in future work.

The hypothesis that optimum validity in cognitive assessment of learner information acquisition would be obtained if there was a high degree of congruence between the number of common features in the visual presenting (encoding) mode and the retrieval (evaluation) mode was not realized in this study. Students who had received the visualized presentation and the verbal test format achieved significantly higher scores than did students who received the visual tests. A number of explanations may be proposed in attempting to interpret this finding. Glanzer and Clark (1963) have advanced the notion of a single information-processing system (verbal-loop hypothesis); they contend that visual information is translated into and stored in verbal/symbolic form. When this information is to be retrieved, it is retranslated from the verbal/symbolic form back to the original visualization. If this situation prevailed then it would be reasonable to expect that student performance on the more familiar verbal oriented tests would be higher than on the unfamiliar visual tests. Additionally, Holliday, et al (1977), have argued from a zero-sum standpoint that display of visuals in a test may result in the readers paying more attention to one cue and less to another, resulting in reduced effectiveness of the visualization.

Other researchers (Craik & Tulving, 1975; Moscovitch & Craik, 1976; Fisher & Craik, 1977) have proposed the notion that sensory feature processing precedes semantic analysis and that visual information processing need not unfold in lockstep fashion with antecedent features. This is an important point, because unless sensory information is coded in a usable configuration it is lost. Under these circumstances, information retention is assumed to be a direct function of the encoding at the presentation stage and the degree to which the retrieval environment recapitulates this encoding (Battig, 1979; Tulving, 1979). The results of this study seem to indicate that the visual portrayal (rehearsal) of the information being presented was not sufficiently intense enough to optimize coding of the information so that the presentation of similar cues in the evaluation mode would enhance the retrieval of the intended information.

In summary, the results of this study indicate that the concepts of field dependence/field independence is an important instructional variable in the teaching/learning process and that color-coding and test format remain as viable instructional variables for further experimental exploration.

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