The Effects of Highlight Color on Immediate Recall in Subjects of Different Cognitive Styles

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(ABSTRACT)

Much of the research investigating color as an image characteristic for enhancing recognition memory has focused on comparisons between black-and-white images and full color images. These comparisons have only recently been extended to differentiate how color impacts learners of different cognitive style and in particular how color influences field dependency. Learners predisposed to field-dependence continually demonstrate a lower capacity than field-independent learners in terms of performance tasks where organizing or restructuring visual information is required. By using color as a mechanism to highlight objects within a visual field, we potentially increase figure-ground separation, which may help facilitate learning for field-dependents in instances where visual information is present. Thus this study undertook to examine the effects highlight color offers as a means of addressing individual learner differences. Undergraduate students were identified on the field-dependence-independence continuum using the Group Embedded Figures Test. Each student then received an instructional lesson on the anatomy of the heart where images were presented in one of four color variations; black-and-white, full realistic color, realistic highlight color, or contrived highlight color. All participants were given two tests following the instructional lesson, one for identification and the other for terminology. Test scores for the two tests indicated no differences for any variation of the color variable. Field-independents were observed to outperform field-dependents in all instances for both tests.

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Chapter I

INTRODUCTION

Research involving the use of visual images compared to verbal representation suggests that images increase the level of learning when applied to specified tasks (Levin, Anglin, & Carney, 1987; Paivio, 1986). The effectiveness associated with the use of visual images raises a question that often accompanies any attempt to prepare a set of visual materials used for instructional communication. That question concerns what type of image will be most effective for communicating information that facilitates learning for the instructional objectives.

Past research lends support to the belief that realism is the preferred type of image to best utilize visual effectiveness (Higgins, 1972; Stewig, 1989; Vollen, 1972). Other research studies argue that learners do not necessarily need highly embellished or realistic stimuli in order to recognize the attributes of objects or situations (Berry, 1984; Dwyer, 1978; Joseph & Dwyer, 1982). If realism is not the best method for visual effectiveness, then how do we decide the level of rendering that best suits an instructional purpose? It is generally agreed that the type of instruction is a vital component for determining the level of realism and the mode of rendering if images are to assist in and facilitate learning. Future research concerned with visual effectiveness then should include some measure of the characteristics which are needed to attain specific educational objectives for different types of students (Dwyer, 1976).

During the past several years, a notable trend has emerged in advertising for the increased use of black-and-white images mixed with color. The effects of this new advertising approach have not been determined, but until recently this combination of mixing color with black-and-white images could not affordably be utilized. Presenting this combination of image characteristics tends to add emphasis or draw focus to specific objects within the visual field. It also impacts the figure-ground relationship for the objects in the image and directs attention to the relevant stimuli or product features. The figure-ground relationship is the basis for how we define and separate objects from within surrounding spaces (Driver & Baylis, 1996). Presenting images mixed with such a distinct contrast in color characteristics raises the question as to what effect this type of presentation has on viewers in terms of image recognition and recall memory.

Mixing color or any other object characteristics may create images that challenge our prior knowledge of those objects and our perceptions for their appearance. This added complexity may benefit some viewers and not others. Learners classified as field-dependent in terms of cognitive style demonstrate difficulty in making figure-ground separations, and instead tend to view images holistically (Witkin, Moore, Goodenough, & Cox, 1977). As a result, field-dependents do not perform as well on tasks involving visual stimuli as learners classified field-independent. Since the use of color as a mechanism to highlight objects potentially increases figure-ground separation, this presentation format may help to facilitate learning for field-dependents in instances where visual information is present. If describing images by mixing color characteristics can be shown to assist field-dependent learners, then this knowledge will benefit instructional designers who incorporate images related to corresponding instructional objectives.

Purpose of the Study

This study is an experimental exploration involving color as an image characteristic. The intent is to evaluate images described as black-and-white, full color, or highlight color and the effect these rendering characteristics have on recognition memory and recall for learners classified as field-dependent and field-independent in terms of their cognitive style. Results should help provide direction for implementing color into instructional images for print and electronic use.

Review of Literature

Research investigating the effects of color images on learning supports the notion that full color is preferred by viewers in all instances versus any other presentation format. This is understandable when we consider that color is an integral component for describing objects and observing phenomena of all types. Because color can help to distinguish and organize the objects within a visual field, it is important to understand how learners process visual information and how color influences an individuals ability to learn from visual information.

Perception

The sensory systems are responsible for gathering information and making it available to the various registers that are used to process information in short-term and long-term memory. Perception is the result or process of interpreting and understanding that sensory information. As sensory information enters the visual system, useful knowledge about an object's edges, contours, and noticeable changes are preserved, while other less useful, or unchanging information is omitted or discarded (Ashcraft, 1989; Stern & Robinson, 1994). How we react to visual stimuli is greatly affected by the way we perceive visual information and how we use our prior experiences for interpretation. This is the basis for the belief that we all perceive our environment and construct knowledge about it differently (Jonassen, 1985; Rieber, 1994).

Stern and Robinson (1994) describe three basic steps in the process of perception: selection, organization, and interpretation. Selection is based on the individual's frame of reference or the unique way that one sees the world. Information processed into long-term memory is available as a reference for new stimuli entering the processing system and works to form a frame of reference for how an individual views new visual stimuli. This frame of reference is affected by a variety of demographic factors including age, gender, race, background, occupation, and education. Stern and Robinson report that people are more likely to perceive stimuli that are somewhat unusual versus the tendency to become less sensitive to certain stimuli that are experienced repeatedly. In other words, we tend to notice stimuli that needs our attention.

In the normal environment observers are not confronted with single objects. Therefore, visual objects are perceived correctly only if their features are identified and then bound together. This organization becomes the basis for how we interpret the information available in the stimulus. Whether they are handmade (Chirographic) or photographic in nature, pictures can supply the same kind of visual stimulus as objects in the environment. As cited by Levie (1987), “perspective theory is based on the equivalence of the pattern of light rays coming from a natural scene and from a picture of the same scene drawn in proper perspective. This was the starting point for Gibson’s (1971) definition of ‘picture’ which states that ‘... a picture is a surface so treated that a delimited optic array to a point of observation is made available that contains the same kind of information that is found in the ambient optic arrays of an ordinary environment’” (p. 31). Another way of saying this is that a blank sheet of paper contains very little information. Once we place lines or shapes on the page, the paper immediately begins to communicate dimension and direction. Increasing the intensity or contrast for one shape versus another creates the impression that one object is receding while the other object advances (Ching, 1943).

Levie (1987) lists three major types of activity that normally occur for picture perception: (a) attention and scanning, (b) interpreting significant figures and cues, and (c) perceiving global meaning. These activities are very similar to the description offered by Stern and Robinson (1994) for visual perception. Picture perception, then is the process of recognizing that a marked surface such as a piece of paper contains information about objects other than itself – information about the depicted content (Levie, 1987). When either form of visual stimulus (pictures or real objects) is presented, the viewer must be able to organize and define the elements within the stimulus in order to apply any interpretation to that information. The question this raises is whether or not a picture supplies as much information as the real stimulus.

Pictures present information about three-dimensional objects on a two-dimensional surface. When viewing these types of images (pictures) we are confronted with similar patterns that are available when we see real objects. Depending on the level of what Gibson (1954) has termed "fidelity", images can serve as surrogates for the actual stimuli by delivering the visual characteristics that we would expect to find in real objects. If similar information is available in surrogate form as is available in a three-dimensional object, then recognition for the two stimuli should elicit a similar response. Gibson maintains that pictures provide a higher level of fidelity for objects than words do. This is supported by Wileman (1980) who defines text or verbal representations as abstractions requiring the additional knowledge of a common language for understanding.

Strass, DeLoache, and Maynard (1977) provide evidence of pictures as surrogates in a study investigating infant recognition of two-dimensional representations. Their results indicate that five-month-old infants are capable of perceiving the similarity between the information they extract from a three-dimensional object and a two-dimensional version of the object. The infants responded similarly regardless of whether the novel and familiar stimuli were real objects or photographs of the objects. A second experiment provided support that infants are indeed capable of extracting distinctive features from two-dimensional stimuli.

Image fidelity defines the level in which a surrogate matches the real object. The differences between a line drawing and a drawing containing tonal value are measured in terms of abstraction (Dwyer, 1978; Wendt, 1956; Wileman, 1980). In general, a drawing with tonal value conveys more information about the object drawn in that it provides more information about surface texture and other related properties (Ching, 1943). However, this added information does not necessarily imply increased learner performance. Moore and Sasse (1971) found that for three types of images depicting different levels of tonal value, that line drawings elicited a significantly higher number of responses than either paintings or photographs. Although paintings showed a higher mean score for the youngest subjects tested, photographs overall were shown to be the least effective type of picture. In research comparing different levels of image abstraction, results do not always support increased realism as an indicator for increased learning. Dwyer (1978) and Joseph (1987) also provide evidence that line drawings are better suited to facilitating learning than realistic images in certain instances. This evidence supports the idea that the level of realism necessary for any image to facilitate learning is determined by the instructional objectives and not by the level of realism alone.

The question of realism and how effectively it facilitates learning has been disputed for many years. Early theories as discussed by Dwyer (1978) include “the iconicity theory identified by Morris (1946), Dale’s (1946) cone of experience, and the sign similarity orientation developed by Carpenter, (1953)”(p. 6). Dwyer termed these the “realism theories” and they form the basis for cue summation theory. Cue summation predicts that as the number of cues available is increased, the learner will be provided more information from which to learn (Severin, 1967a). For example, Goldstein, Chance, Hoisington, and Buescher (1982) found that pictorial recognition memory for dynamically presented material was significantly better than memory for the same material presented statically. They suggest that the additional cues for movement provide information to the learner that is not available in the static presentation and that this increased information affected responses because movement more closely resembles the way we encounter visual stimuli in the environment.

Severin (1967b) suggests that “multiple-channel communications appear to be superior to single-channel communications when relevant cues are summated across channels; neither is superior when redundant between channels, and are inferior when irrelevant cues are combined” (p. 397). Cues must be relevant in order to add to the available information. In the example above, movement was a cue that added information relevant to the intended task. Moore, Burton, and Myers (1996) support this view. They consider cue summation as both the addition of cues within and across channels. They cite Miller (1957) in support of this approach:

> When cues from different modalities (or different cues within the same modality) are used simultaneously, they may either facilitate or interfere with each other. When cues elicit the same responses simultaneously, or different responses in the proper succession, they should summate to yield increased effectiveness. When the cues elicit incompatible responses, they should produce conflict and interference (p. 78).

Moore, Burton, and Myers (1996) conclude that some evidence appears to support the superiority of multiple-channel presentations over single-channel presentations when cues are summed across channels. This is not the case if neither channel is superior or when content is redundant or irrelevant across channels.

Another consideration for image effectiveness is related to cue summation and the use of visual or verbal cues. Images present the visual characteristics of objects. As the amount of information increases, images become more complex, and this complexity may present the learner with information that is difficult to organize. If prior experience is limited, the learner may have difficulty in selecting and attending to the portions of the image that are related to the instruction. The use of labels, arrows, or other cues can assist a learner by providing direction to important information and organizing the image in terms of its parts.

In two studies with fourth graders, Beck (1987) found that the use of labels improved learning versus using no labels at all. Beck also found that using pictures with or without cues increased learning versus verbal information alone. This finding for the superiority of visual cues for instruction supports previous research. Canelos, Taylor, and Dwyer (1985) found visualized mediated instruction superior to verbalized mediated instruction and that the use of visual cues aids in the recall of information for tasks related to the instructional objectives. These findings support the use of cues for improving learner performance.

One characteristic that adds further to the fidelity or realism of an image is represented by color. In research testing for responsiveness, objects presented in realistic color have been shown to induce a greater number of descriptive words versus objects displayed in black-and-white or as simple line drawings (Higgins, 1972). Higgins concludes that the mode of rendering and the type of objects presented have an impact on the kind of verbal responses elicited by pictorial stimuli. While a color photograph of an object retains most of the distinctive information present in the object itself, black-and-white photographs, as well as line drawings have different subsets of cues

(Strass, DeLoache, & Maynard, 1977; Vollen, 1972). In terms of image complexity, color adds to the level of detail available.

Image complexity can be viewed as a continuum from realistic imagery to totally abstract symbols (Wileman, 1980). In studies where images are compared based on the additional characteristic of color, learners consistently recognize more color images than for similar images in black-and-white (Berry, 1991b). This is especially true for realistically colored images. However, Berry provides evidence that contrived color also increases recognition responses. This lends support to cue summation in that the only difference between the black-and-white images and the color images presented to the learners is the added characteristic of color. It is important to note, however, that Berry's use of contrived color may have resulted in a novelty effect. The use of contrived color may alter the features of the objects enough to cause difficulty with binding the features of the objects. Additional attention is required to solve feature binding problems (Ashby, Maddox, Prinzmetal & Ivry, 1996), and if viewer attention was elevated, then this may describe some of the variance observed in the differences for the contrived images versus the black-and-white images.

If realistic color is a requirement then it must be included. For example, color can serve as a sign for the specific condition of an object, such as when we compare the differences between ripe and unripe fruit. In this case color is necessary as an image cue if the learner is to make a decision about which fruit is suitable for consumption, and which is not (Knowlton, 1966). In this case, the increased level of realism provides more relevant information to the learner and increases the chances of picking the ripe fruit.

Increasing realism in an image and increasing student achievement however, is not a one-to-one correlation. As the amount of visual information increases, the opportunity for learning increases, but the actual learning is dependent upon the what the viewer brings to that information. Viewer perception is the result or process of interpreting and understanding sensory information based on prior experience.

Cues provide one mechanism for helping learners organize complex images that may extend beyond their range of experience. The use of cues can direct or focus attention to areas that are important to the instructional objectives and this organizational strategy can help compensate for the lack of prior knowledge learners bring when encountering visual information or visual stimuli.

Although increased levels of realism can bring the learner closer to an actual event (Goldstein, Chance, Hoisington & Buescher, 1982), other studies indicate that students cannot efficiently respond and learn from visualized instruction if they have difficulty in identifying the crucial features of a visual stimulus (Dwyer, 1978). The real objective for an image then, should not be how much realism can be presented, but rather how much information is necessary that allows the learner to understand and comprehend the depicted stimuli.

COLOR

Color is a normal and expected characteristic that defines objects in every day life. Color can also describe function by showing change. In general, viewers who are provided with visual information prefer color. This is not because the color makes the objects more real but is probably the result of conditioning, in that viewers have come to expect color with visual information (Dwyer, 1978). Color can attract attention and help organize information so that viewers are directed to meaningful and relevant segments of a stimulus (Dwyer & Lamberski, 1982-83; Tufte, 1990). As such, color provides us with useful information about the various stimuli we recognize and react to as part of our daily activities.

Color not only describes objects by referencing their pigments but also by cueing our perception for those objects based on our prior experience. Berry (1991a) suggests that the role of color in visuals can function in a dual role as either a cue to provide additional information without any realistic attributes or to convey those attributes associated with the information. We know from experience that many organisms are deliberately colored in patterns that warn us of their potential danger. But, without prior knowledge for this perceptual cue we have no reason to suspect the consequences of ignoring these signs. In a similar fashion, many fabricated signs share this same characteristic in that we sense the meaning of these signs and react to them based on our knowledge of the consequences (Knowlton, 1966). In these examples color serves to attract our attention and cue us to specific information related to the stimuli.

A number of research studies have focused on the variable of color in instruction (Berry 1982; Dwyer, 1978; Dwyer & Lamberski, 1982-83; Lamberski, 1982). Color is investigated by comparing responses to visual stimuli presented in different color modes. Comparisons can include realistic color, colors that are commonly associated with the object; contrived color, colors that are considered non-realistic; and, black-and-white which also includes levels of gray or halftone. Research findings suggest that merely adding color to images is not an indication for increased learning. Color has not been shown to facilitate learning unless the color is directly related to the instructional objectives (Dwyer & Lamberski, 1982-83).

In studies of recognition memory, color has been shown to increase responses for previously viewed images (Berry, 1977, 1982, 1990, 1991a; Waltz & Berry, 1991). Evidence supports this even in cases where the color is contrived or non-realistic. For example, in a comparison of realistic color, black-and-white, and contrived color landscape pictures, Berry (1977) found that the use of color cueing techniques tends to increase the recognition of visuals viewed for short periods of time. That any type of color cueing device tends to facilitate recognition immediately after visuals have been viewed. And that after extended periods of time, in this case two weeks, only non-realistically colored visuals tend to increase the degree of recognition (Berry, 1977). This finding lends support to cue summation theory in that the only difference between the images viewed by the learners is represented by the color characteristic. Other studies investigating recall memory confirm these results and provide evidence for the superiority of color images over similar images rendered in black-and-white (Berry, 1991; Berry & Dwyer, 1982; Dywer, 1978; Waltz & Berry, 1991).

In general, subjects prefer realism to other types of pictorial rendering and when given a choice may even show a preference for black-and-white photos over carefully drawn color illustrations (Vollen, 1972). Color that does not add to realism but is depicted in a contrived fashion is not preferred and sometimes classified as a lower level illustration. Using Gibson's (1954) "low-to-high fidelity continuum" for pictorial illustrations, Vollen (1972) suggests rating pictures appearing in contrived color at the low fidelity end of the scale, pictures appearing in black-and-white at the middle of the scale, and pictures appearing in authentic color at the high fidelity end of the scale.

Given a choice though, subjects of all ages prefer color over black-and-white for similar types of images (Dwyer, 1976; Higgins, 1972; Vollen, 1972; Winn & Everett, 1979).

The least preferred method of rendering is when color is presented in a contrived fashion for realistic images (Berry, 1991a). Color comparisons indicate that contrived color does not facilitate learning and in fact lowers performance for instructional tasks beyond simple recognition. Results of numerous investigations indicate that recall for non-realistic color images is significantly lower than for all other treatment variations (Berry, 1991a; Berry & Dwyer, 1982). These findings indicate that realistically colored materials are the most effective in facilitating visual recall and that non-realistically colored materials are the most difficult to recall. In this case it can be said that non-realistic color does not aid recall but instead interferes with the ability to recall (Berry, 1991a).

In an analysis of color research, Winn and Everett (1979) observed that the affective factors of color go way beyond the general finding that subjects prefer color over black-and-white media. In a study rating image effectiveness, Winn and Everett found that subjects can and will rate images based on color and that age and gender also make a difference for how images are perceived in terms of their positive and negative values. Research suggests that the attention gaining value of color can be arranged in a specific order, and that children or persons more susceptible to affective influences prefer warmer colors while older, more reserved persons prefer cooler colors (Winn & Everett, 1979). In other testing for responsiveness, Higgins (1972) concluded that the mode of rendering and the type of objects presented have an impact on the kind of verbal responses elicited by pictorial stimuli with color images eliciting more responses from learners than black-and-white images.

Other investigations support the idea that all visuals are not necessarily equal in effectiveness when applied to facilitating student achievement (Dwyer, 1976, 1978). Winn and Everett (1979) conclude "that color is an important cueing device, that color improves a learner's ability to recall both relevant and irrelevant material, and that color is important to the meaning of a picture when it is a critical attribute of the pictured object or when attention is drawn to it" (p. 148). In a review of the research, Dwyer and Lamberski (1982-83) made the following observations: 1) color can be of value in non-meaningful tasks; 2) the application of color to meaningful tasks appears related to the interaction between learner and the material; and 3) if color is central to the concept being presented and if students focus attention on it, color can facilitate learning. The purpose of this review was to provide evidence of color cueing and coding and a framework for future investigations. As stated by Dwyer and Lamberski, further research is needed in this area before any definite conclusions can be proposed.

Color coding not only applies to pictorial stimuli, it can also be useful in other types of information. Used as a highlight code (underlining, shading, arrows, or printed words), color can facilitate learner performance when used for directing attention and highlighting relevant information (Dwyer & Lamberski, 1982-83). A study conducted jointly by the Xerox Corporation and the London Borough of Hammersmith and Fulham is a case in point. The objective of this study was to identify accurately the effect of highlight color in collecting Council Tax arrears. This study specifically tested response rates for color and black-and-white reminder notices. The color version contained highlight color strategically placed both in the main text and for the outstanding arrears balance. Subjects were divided into two equal groups by sorting randomly based on the amount owed in taxes. The study covered two separate months and included 21,500 taxpayers the first month and 13,000 the second. Results of this study showed a similar pattern for both months. The group receiving the highlight color version of the reminder had a greater level of response than the group receiving the black-and-white reminders (Briggins, 1993). The significance of this study is two-fold. First, it clearly indicates that the use of color increases responses – in this case, payment of taxes. Secondly, it indicates the availability of color to create personalized documents at low cost.

A more recent example of color coding is evident in the many advertisements in use today that selectively use color mixed with black-and-white images. These complex images are relatively new in terms of our exposure to advertising media. The first use of color in newspaper advertising appeared in the Milwaukee Journal in 1891, but the first newspaper advertisement in full color did not appear until 1937. By the 1970s color had become commonplace in every visual medium, and television advertising had become virtually 100% color (Dunn & Barban, 1978). In the late 1980s, advertisers began to explore the use of mixing color formats to highlight specific information within images. This presentation without doubt is effective for gaining attention and increasing the level of curiosity we have for these images (Alesandrini, 1983).

Research on the effects of this mixed color presentation are not yet available, but clearly this use of color provides viewers with a unique way for viewing familiar objects. Because color was prohibitively expensive in the past, it was seldom used in the production of instructional materials. This may explain why color images seemed so impressive as reported by subjects in past studies. If the majority of images are presented in back-and-white, any contact with color images would certainly raise the level of attention for most viewers.

As the power of technology increases, the use of color or black-and-white images will not be primarily a function of what is available or affordable, but rather which choice we interpret to be most effective. As stated previously, past research results suggest that although realistic images are preferred by the subjects, that this offers no real advantage over the use of black-and-white images for enhancing instructional communication (Berry, 1984; Dwyer, 1976). The preference for color by the subjects though is significant when considering future research that explores the use of color images in instruction. Recent technological advances make it possible for practical applications of color to expand into our every day life. Because color is naturally expected when we see images, it is reasonable to include this characteristic in some form unless it detracts from the effectiveness of an image or how the image is perceived.

Instructional designers often do not take time to adequately match the type of image with the targeted instruction, relying rather on available visual information to do the job. In many cases this involves the use of realistic images which Dwyer (1978) maintains is not an indicator of increased learner performance. It is equally important to note that the improper use of color can increase the complexity for an image. Color used for instructional purposes must serve a direct connection to the overall information being delivered. That is, without some knowledge of why the color is present, viewers are likely to add additional meaning to objects presented in a visual message. This is because color is perceived based on the prior experience of each learner. This increased complexity can decrease learner performance.

Research in color should look at ways color can enhance viewer strategies for visual stimuli. Dwyer (1978) has shown that color line drawings facilitate learning in the instance of his heart model. However, if the purpose of a visual image is to represent an object, then realistic color is preferred over black-and-white. Future research should look at ways to increase the effectiveness of images so that information that needs to be transmitted is transmitted effectively for all types of learners.

COGNITIVE STYLE

The field of cognitive psychology is permeated by three assumptions: that mental processes exist; that people are active information processors; and that mental processes and structures can be revealed by time and accuracy measures (Ashcraft, 1989). One form of mental processing, cognitive style, has been defined as “the characteristic, self-consistent patterns of organizing and processing information or the characteristic, self-consistent modes of functioning which individuals show in their perceptual and intellectual activities” (Witkin, Oltman, Raskin, & Karp, 1971, p. 3). As it applies to visual perception, cognitive style can be tested and is defined in terms of field dependency. The basic issue in this aspect of cognitive style is the extent of an individual's ability to overcome the context of embedding. In other words, the ability to perceive relationships among parts of a stimulus field and reorganize those parts or impose structure to those parts. Witkin et al. (1971) refer to this as an increase in "articulation of experience" (p. 7).

This thinking behavior is a constant characteristic that each learner brings to any stimulus event and extends to the broader psychological dimension of self or body concept (Rush, 1990). The concept of self is the part of psychological differentiation related to self-nonself segregation, wherein attributes, needs, and feelings are recognized as being one's own and distinct (Witkin, Oltman, Raskin & Karp, 1971). Individuals with a more articulated mode of cognitive functioning are found to differ from those with a more global mode of cognitive functioning in terms of their sense of self. Field-independents are characterized by the articulated concept for sense of self. They view themselves and their body as a whole and the parts of the body as discrete yet interrelated and structurally joined. This implies that field-independents see themselves in terms of their own structure and not dependent upon external sources for definition. Field-dependents have a less developed sense of separate identity and demonstrate a reliance on external sources for definition of their attitudes, judgments, sentiments, and views of themselves (Witkin, Oltman, Raskin & Karp, 1971).

Witkin and colleagues (1971) also report the observation of consistent sex differences for the field dependency dimension. Men and boys tend to be more field-independent than woman and girls. Although these differences are small, they are nonetheless consistent, based on available evidence, and seem to become noticeable around the age of eight. Age related differences are more pronounced during later years, with an increase toward field-independence up to age 15, leveling off in mid-life until sometime in the late thirties when a gradual move toward field-dependence is observed.

The field dependency construct describes the way a person perceives their environment or the knowledge they have of their environment. Witkin, Oltman, Raskin and Karp, (1971) refer to field dependency as the approach a person brings with them to a given stimulus or their "... perceptual style. In a field-dependent mode of perceiving, perception is strongly dominated by the overall organization of the surrounding field, and parts of the field are experienced as 'fused.' In a field-independent mode of perceiving, parts of the field are experienced as discrete from organized ground" (p. 4). The level at which an individual can perceive globally determines the difficulty they may encounter when asked to perform tasks related to visual stimuli. Research studies consistently indicate that field-independent learners outperform field-dependent learners on virtually all visually related tasks (Carrier, Joseph, Krey, & LaCroix, 1983; Descy, 1990; Dwyer & Moore, 1992, February; Fleming, 1984; Moore, 1985; Moore &

Bedient, 1986; Witkin, Moore, Goodenough, & Cox, 1977).

It is generally agreed that field-independents adapt to all types of visual presentation better than field-dependents. Field-independents display the necessary skills that allow them to re-structure visual information on their own, in-order-to gain understanding. Learners classified as field-dependent have consistently shown a lesser ability to re-structure images or understand their underlying structural complexities, and tend to view the objects in visual presentations holistically. This implies a need for developing ways of presenting visual information that helps to facilitate learning for field-dependents.

When viewers are confronted with complex images, the ability to separate specific information from within the surrounding area is often required in-order-to transfer that information to other tasks. This can be as simple as a recognition response or involve application of the learned visual information to a task such as drawing or labeling. The ability to recall information from visual images and apply that information in another context is greatly diminished if the learner cannot separate or re-structure the objects presented from the surrounding field.

Witkin, Moore, Goodenough, and Cox (1977) note 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 complex visualized environment. For this reason researchers have attempted to design visual instruction according to the characteristics of field-dependent and field-independent learners, hoping to capitalize on strengths and compensate for weaknesses.

Research evidence shows that color coding can help learners organize or categorize information into useful patterns which enables the learners to interpret and adjust to their environment (Dwyer & Moore, 1992). A review of research by Dwyer (1978) on color versus black-and-white comparisons, found that the color versions were significantly more effective than the black-and-white versions in facilitating student achievement of specific educational objectives. “These results seem to provide substantial evidence that color, in fact, is a viable instructional variable” (p. 149).

Dwyer and Moore (1992), examined the effect that coding (black-and-white and color) has on the achievement of students categorized as field-dependent and field-independent. Students were given two visually oriented criterion tests. One required the students to draw and label a diagram and the other was an identification test where the students had to label a drawing. Prior to these tests students were provided with a 2000 word instructional booklet on the anatomy of the heart. Two versions were used: a black-and-white version, containing black-and-white coded line drawings which highlighted the information, and a color version, containing the same visuals as the black-and-white version accept that different colors were used to illustrate the information. Results of this study confirmed earlier research by Moore and Bedient (1986) that field-independent learners outperform field-dependent learners on criterion measures, and is supported by other similar research (Dwyer & Moore, 1995).

It terms of pictorial recognition memory, Berry (1977; 1982; 1991b) offers evidence that both realistic and non-realistic color materials are superior to black-and-white images. Comparisons for recognition using color as a variable indicate that field-independent learners benefit most when color is available while color seems to interfere with recognition for field-dependents. Results of this study suggest the general superiority of field independent subjects in any type of pictorial recognition task regardless of color mode. These findings also support earlier research by Wieckowski (1980) suggesting that individuals who differ in terms of field dependence/independence utilize color information differently in recognizing visuals. One reason offered in earlier studies for why this occurs is that color adds one more embedding cue, making it even more difficult for the field-dependents to separate distinct forms from within the images as recognition cues (Berry, 1984). Berry notes "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" (p. 40).

A number of studies have addressed the effects of visual complexity on recall memory (Atang, 1984; Dwyer, 1978). In addition to these, Jesky and Berry (1991) cite other studies that found pictures better than words in both immediate and delayed recall for outline drawings over detailed drawings (Sampson, 1970), and that found realistic color visuals to be superior to either black-and-white or line drawing visuals in a recall memory task (Alfahad, 1990). Jesky and Berry looked at the effect of the interaction between cognitive style differences (field-dependence/field-independence) and various degrees of visual complexity on pictorial recall memory. Subjects were grouped based on their level of field dependency and shown three different collections of common household items randomly arranged on a neutral background. Three levels of complexity were presented for these items: realistic full color, realistic black-and-white, and black-and-white line drawings. Jesky and Berry conclude that the cognitive style factor of field dependency was not significantly related to recall memory under the varied levels of the visual factor. They did conclude that recall memory was related to the visual presentation mode (Jesky & Berry, 1991).

Additional evidence for the effects of presentation mode is provided in a study by Moore and Dwyer (1991) using Dwyer's heart anatomy material as the basis for the instructional information, field dependency was tested based on two instructional treatments: a black-and-white version, containing black and white coded line drawings which highlighted the information, and a color version, containing the same visuals as the black-and-white version accept that in this case seven different colors highlighted the information. As expected, for students receiving the black-and-white treatments, field-independent students achieved significantly higher scores on both the terminology and comprehension tests than the field-dependent students. This finding confirms other similar results for field dependent-independents. However, it was predicted that the color-coded illustrations would make the relevant cues more obvious to the field-dependent learners, and thereby improve their achievement on the verbal tests. The results supported this prediction (Moore & Dwyer, 1991).

These results suggest that color can be used as a cue to highlight information and that the use of color can help facilitate learning for field-dependents. As cited by Rush (1990),

> "Strategies that impose structure on visual fields via supplantation, cueing, advance organizers, enlargement, shading, or the use of color, etc., attempt to compensate for the restructuring skills absent in the field-dependent learners (French, 1983; Salomon, 1972). The literature supports the notion that field-dependent learners benefit from the restructuring aspect of these strategies, while field-independent learners

are not hindered by this imposed structure (Britain, 1979; Fleming et al, 1968; Grieve & Davis, 1971; Satterly & Telfer, 1979)" (p. 5).

Recent evidence continues to support the findings of earlier research related to field dependency. As noted time and again, field-dependent learners do not demonstrate the same use of visual information that field-independent learners do. The inability of field-dependents to separate or modify the structure of an image prevents or limits their capability to use the available information in other types of applications. Comparisons between field-dependent and field-independent learners are made based on how they perform on criterion measures. If visual information is presented in a way that helps field-dependents organize and separate the objects within an image, then any increased learning should impact their scores positively when compared to field-independents? The question is how to do this without introducing an irrelevant cue that increases the image complexity thereby making the embedded objects within the image more difficult to organize.

Summary

The effectiveness associated with the use of visual images raises a question that often accompanies any attempt to prepare a set of visual materials used for instructional communication. That question concerns what type of image will be most effective for communicating information that facilitates learning for the instructional objectives.

Research suggests that images increase the level of learning for specific tasks when compared to verbal representations (Levin, Anglin & Carney, 1987; Madigan, 1983; Paivio, 1986;). One explanation for why this occurs is that pictures are easier to remember than words (Levie, 1987). Although the reasons remain uncertain as to the exact process, Paivio (1971, 1986) presents extensive support as evidence that dual coding explains this apparent superiority for picture memory. Dual coding describes information processing in terms of two separate and distinct mental systems, one verbal and the other nonverbal. According to this hypothesis, visual information is encoded in both the verbal and nonverbal systems while verbal information is encoded in only the verbal system. Since the ability to remember verbal and nonverbal information is dependent upon the associations we make to the stimulus information, two systems increase the number of chances to make those associations in memory.

How we understand and use visual information depends on how we perceive a visual stimulus. In general, the way we perceive visual information for three-dimensional objects and images of objects on two-dimensional surfaces is very similar (Levie, 1987; Stern & Robinson, 1994). Gibson (1954) suggests that images can serve as “surrogates” for actual stimuli by delivering the visual characteristics that we would expect to find in real objects. He maintains that pictures provide a higher level of fidelity for objects than words do and as a result are more realistic.

However, increasing realism in an image and increased student achievement is not a one-to-one correlation. Although increased levels of realism can bring the learner closer to an actual event (Goldstein, Chance, Hoisington & Buescher, 1982), studies indicate that students cannot efficiently respond and learn from visualized instruction if they have difficulty in identifying the crucial features of a visual stimulus (Dwyer, 1978). As the amount of visual information increases, the opportunity for learning increases (Severin, 1967a), but the actual learning is dependent upon the level of experience the viewer brings to that information and how the image depicts the visual elements. The real objective for any image then should not be how much realism can be presented, but rather how much information is necessary that allows the learner to understand and comprehend the depicted stimuli.

Images are capable of delivering extraordinary levels of realistic detail. However, the interpretation of that information is unique to each individual (Jonassen, 1985; Rieber, 1994). As a result, the most important factor concerning the effectiveness of the transfer of information between a viewer and visual stimuli is represented by the past individual experiences the viewer brings to that event. These experiences form the frame of reference any individual brings to any new visual stimuli (Stern & Robinson, 1994).

Viewers also bring differences in terms of their ability to re-structure visual stimuli or their environment based on their cognitive style (Ross, 1990; Witkin, Oltman, Raskin, & Karp, 1971). Field-dependents show a definite lack of ability for experiencing parts of a visual field as discrete from organized ground. This inability hinders any attempt they make to re-structure visual information on their own in order to gain understanding. Research evidence supports the fact that field-independent learners outperform field-dependent learners on all types of visually related tasks and that field-independents adapt to all types of visual presentation better than field-dependents (Witkin, Moore, Goodenough, & Cox, 1977).

In general, most images are intended to facilitate learning. Whether this learning is the result of intentional or incidental information depends on the level of involvement of the viewer and how much attention is directed toward the stimulus. Visual strategies provide one solution which can assist in directing the viewer's attention to relevant information presented in an image. Cues provide a mechanism for helping learners organize complex images that may extend beyond their range of experience. The use of cues can direct or focus attention to areas that are important to the instructional objectives and this type of organizational strategy has been shown to compensate for perceptual deficiencies learners may bring to visual information or visual stimuli.

Because color is considered to be a viable variable for instruction, it can be used as a cueing device in order to help viewers navigate complex images (Tufte, 1990). The use of color in recent advertising suggests that color highlighting attracts attention and directs the viewer to relevant information. Although no evidence is currently available to support this, color in this instance works to restructure the image by elevating the importance of the relevant objects. In addition, Moore and Dwyer (1991) provide evidence that color can increase field-dependents performance on criterion tasks when used as a cueing device. Since field-dependents display an inability to restructure images on their own, the use of color highlighting presents a possible solution for restructuring images of all types. If color successfully increases student achievement and color cueing helps field-dependents, then it seems reasonable to investigate the potential color provides as an image strategy for all types of images.

Currently, Moore and Dwyer (1991) provide the only evidence supporting the use of color as a cue for field-dependents. Their findings involve images presented as line drawings. For this reason, additional information is needed in order to more fully understand the potential color cueing provides in terms of image effectiveness for learners of all types.

Significance of the Study

This study will provide information on the effects of different methods of rendering used to describe an image. Specifically, the results will indicate the usefulness of color as a cueing device when mixed with a predominately black-and-white image. Past research has not dealt with this type of comparison. Because digital technology makes it possible to specify color selectively, using color as a cueing device for highlighting specific areas of an image is now an option for instructional information. Producing those images quickly at relatively low cost also makes this an attractive alternative to standard full color or black-and-white images.

Selectively adding color to images traditionally required longer periods of time to develop and was subject to increased production costs. With the advent of color desktop printers and the increased use of electronic projection equipment, incorporating color materials into presentations and instructional materials now appears more readily available. As a result, we can expect a dramatic increase related to the use of color in visual communication materials of all kinds.

For this reason it is important to understand the impact color makes when applied to specific instructional objectives that require presenting information visually. Color can enhance instruction by providing a means of emphasizing important elements of visual information for students who have difficulty organizing such information. If color is used purposefully and not as a gimmick or "just because it is available," it can become a powerful tool for attracting attention and guiding viewers to relevant information. This study supports the use of color in a constructive manner and should add to the existing literature dealing with visual communication.

Research Questions

Based upon the review of literature, this proposal seeks to answer the following research questions concerning relationships between full color images, black-and-white images, color highlight cues, and cognitive style. Specifically, how cognitive style (field-dependence, field-independence) is influenced by the use of color in visual imagery.

1. Does the use of highlight color cues affect student performance on a memory recognition task?

2. Do students grouped by cognitive style (field dependency) differ in performance when presented images using color highlighting cues versus images presented totally in full color or black-and-white?

Hypotheses

These questions were investigated by an experimental research study investigating the use of color as a method of highlighting selected elements within an image. Because this cueing (highlight color) will cause those objects to function separately from the whole image, we should observe a noticeable difference in test scores for subjects classified as field-dependent for this type of presentation versus similar presentations in full color or black-and-white. Test results or scores should then serve to support the following hypotheses:

H_1: Test scores for images presented in black-and-white with color used as a highlight cue will be greater than test scores for images presented in full color or black-and-white.

H_2: Field-dependent subjects will perform as well as field-independent subjects when presented images where color highlighting is used as an image characteristic.

H_3: Test scores for images using realistic highlight color will be greater than test scores for images using contrived highlight colors.

Chapter II describes the methodology and procedures of the study including the research design. Chapter III presents an analysis of the data, a discussion of the results, conclusions excogitated from the findings, and implications and suggestions for further research.

Chapter II.

METHODOLOGY

This chapter describes the procedures that were employed for this study, including a description of the test instrument and demographic information about the students who participated. Because this research involved human subjects, the rights of each individual were recognized throughout the study. Each student received an explanation outlining the examination process and assurances that all results of their individual participation would be analyzed only as grouped data. Confidentiality for all participants will be maintained by the author.

A 3 x 4 experimental design was employed to explore the following variables; cognitive style (field dependent, field-neutral, and field independent) and color (black-and-white, realistic color, contrived highlight color, and realistic highlight color). Students were randomly assigned to one of the four color treatment groups. These groups were defined as follows:

Control Group	Images rendered totally in black-and-white.
Realistic Color Group	Images rendered totally in realistic color.

Contrived Highlight Color Group	Images rendered in black-and-white with portions highlighted using a single color hue.
Realistic Highlight Color Group	Images rendered in black-and-white with portions highlighted using realistic color.

Research Instrument

The instrument for this experimental research consisted of a 2000-word instructional lesson containing both text and images on the anatomy of the human heart. These materials were developed originally by Dr. Francis M. Dwyer and modified by permission for the purposes of this research (Appendix I). Four separate treatments were produced from this instructional lesson consisting of both verbal and visual information. Each treatment differed only in terms of the color variable.

Each treatment was produced in the form of a booklet, consisting of 21 pages, sized 7.0” × 8.5” and spiral bound. Of the 21 pages, one page is for directions and the remaining twenty pages for concepts and functions on the heart integrated by prose text and the accompanying visualization. Visual information consisted of a realistic drawing of the human heart which appeared on each page of the lesson. The only difference in the treatments was the use of color as a rendering characteristic for the heart image. All booklet pages were clearly numbered, with the text appearing in the lower half of each page. Directions on the first page indicated to the learner that the instructional lesson was being used to investigate the relative effectiveness of visual illustration which accompanied printed instruction.

The first treatment presented the learner with images rendered entirely in black-and-white. The second treatment presented images rendered in full realistic color. The remaining two treatments presented learners with images rendered in black-and-white and include areas highlighted by color which are key to the text – one, where the highlight color was realistic and the other, where the highlight color consisted of a single contrived hue. These four treatments represent the variations of the variable of color which was investigated (see Appendix II for a comparison). The text appears identical in format for each color treatment booklet.

No limit was imposed on the student for the amount of time spent with the lesson material presented in the booklets. Students were further instructed at the end of the lesson to review the instructional materials, and when ready, to raise their hand as an indication that they are prepared to receive the first of two tests, one on identification and the other on terminology.

These two tests (identification, terminology) were selected from the four available in the original instrument as adequate measures for the variables. The other tests, drawing and comprehension, were omitted. Although these tests do measure student retention of the information presented, it was felt that test results on drawing and comprehension added very little to the scope of this investigation.

The first test (identification) evaluated student ability to identify parts or positions of an object. This multiple-choice test required the student to identify the numbered parts on a detailed drawing of a heart. Each part of the heart discussed in the lesson is numbered on the drawing. The objective here was to measure the ability of the student to use visual cues to discriminate one structure from another and to associate the parts of the heart with their respective names. The second test (terminology) consisted of items designed to measure knowledge of specific facts, terms, and definitions. These results indicate understanding of the basic concepts related in the lesson. The total test score combined the two individual criterion tests into a composite score for the purpose of measuring total achievement of the objectives in the instructional unit.

Each of the four booklets was coded and matched with a coded test so that the students who saw the heart images in full color or black-and-white saw a similar reference image on the identification test. Although the terminology test did not include a reference image, it was also coded to match the identification test in order to maintain consistency for the test procedure.

Pilot Test

A pilot test was conducted in order to evaluate the author's modifications to the original research instrument and to elicit any comments related to the modified instructional booklets. Five graduate students in the department of Teaching and Learning at Virginia Tech participated. Each student in this pilot test saw the same version of the instructional booklet.

As a result of the pilot test, two additional changes were made to the test booklets. The first change was related to the appearance of the text in the booklets. The text was changed from all upper case, as it appeared in the original instrument, to both upper and lower case. Student comments indicated that this change would make the text easier to read. The second modification was related to the labels appearing in conjunction with the heart images. This resulted in shifting the image labels on several pages in order to clarify the connection between the label and the image. Similar changes were also applied to the test materials in order to maintain overall consistency with the instructional booklets.

Human Subjects Testing Approval

Approval for testing human subjects was granted by the Institutional Review Board (Appendix III) at Virginia Tech on October 14th, 1998. Experimental testing began the following Monday, October, 19th, and continued through December, 3rd, 1998 (see Appendix IV for dates and times).

Participants

For the purposes of this study, the test subjects represent the accessible population of undergraduate students attending Virginia Tech during the fall of 1998 which were available from multiple classes representing the core curricula for undergraduate students at Virginia Tech. A random selection from this group was obtained through sign-up sheets. Students were encouraged to participate on a volunteer basis. Any extra credit for student participation in the study was handled through the individual classes and was in no way associated with the test results used in the experiment or the materials presented in the instructional lesson.

A total of 497 students signed up to participate (see Appendix IV). Out of this total, 292 actually took part in the study. From that number a total of 16 were eliminated – 9 graduate students; 6 students who indicated prior experience with the subject matter, and 1 student who withdrew after the first test. Participants were also screened for color-blindness. This involved only a written response on the consent form indicating a prior condition for color-blindness. No students indicated they were color blind and thus none were eliminated from the study for this reason. The remaining 276 students are represented by the data in this study.

Group Embedded Figures Test

All participants in the study were administered the Group Embedded Figures Test (GEFT). This test was employed to classify the students in terms of their cognitive style. The GEFT is a group-administered, twenty-five item test carried out in three timed sections (2, 5, and 5 minutes each) where students are asked to trace one of eight simple figures embedded within figures of greater complexity. The reliability for this test is reported at .82. The ease of administration and scoring for this test, as well as the reported reliability and validity make the GEFT a satisfactory substitute for the Embedded Figures Test in research testing requiring Group Testing (Witkin, Moore, Goodenough, & Cox, 1971).

Students participating in this study were classified as field-dependent (FD), field-neutral (FN), and field-independent (FI) based on their performance on the GEFT. Students achieving one half standard deviation

(2.19) (SD = 4.383) above the mean (M = 11.975) were considered to be FI, while students achieving one half standard deviation below the mean were considered FD. Students within one-half standard deviation above or below the mean were considered FN. The frequency of scores for the complete sample are represented below.

FROM (≥)	TO (<)	COUNT
0	2	3
2	4	11
4	5	12
5	7	19
7	9	14
9	11	45
11	13	35
13	14	43
14	16	45
16	18	49
	TOTAL	276

Sequence of Events

The order of events for conducting the experiment were determined in advance and outlined including the verbal instructions. As a result, the students in each session heard precisely the same instructions delivered in the same order. Students selected seats on a random basis as they entered the classroom and were given the consent form to read and sign (see Appendix

V) as they entered the room. As a group, the students were then asked to indicate on the consent form the dates for any prior instruction related to the heart or the names of any courses they were currently taking related to human physiology. Students were also asked to indicate whether or not they had ever been classified as being color blind.

After reading and signing the consent forms, the students were tested for field dependency using the Group Embedded Figures Test (GEFT). This test was administered according to the instructions included in the manual provided with that test. Students were asked to provide only the last four digits of their student number and to include demographic information for age, date and sex. They were instructed not to include their name on this form.

After completing the GEFT, students were randomly provided with one of the four versions of the heart booklet. This was accomplished by distributing the booklets in order from one-to-four starting with the first student seated on the left side in the front, and proceeding around the room until all students had a booklet. At that point, the students were instructed to begin the instructional lesson. Each student was also instructed to raise his/her hand when ready to begin the testing portion of the experiment. No time limits were set for completing the instructional lesson or the two tests in the experiment, however, the entire time consumed for each student did not extend beyond one hour in length.

This procedure was repeated for each group of students in each test session. As a result of these procedures, the number of students participating in each treatment for the color variable as classified by cognitive style is presented below.

Number	Color Format	GEFT Classification
18	Black and white	Field-dependent
20	Contrived highlight color	Field-dependent
20	Realistic highlight color	Field-dependent
24	Realistic color	Field-dependent
27	Black and white	Field-independent
21	Contrived highlight color	Field-independent
23	Realistic highlight color	Field-independent
23	Realistic color	Field-independent
23	Black and white	Field-neutral
26	Contrived highlight color	Field-neutral
28	Realistic highlight color	Field-neutral
23	Realistic color	Field-neutral
276		

Student performance comparisons are based on the scores of the student's responses for each test. The means (average) for each group will be compared to evaluate any differences within the field-dependency attribute and the effects of the color/black-and-white treatments.

Chapter III.

RESULTS AND CONCLUSIONS

This chapter reports the findings of the study. Results are presented relevant to each research hypothesis, followed by a discussion of the findings as they pertain to the associated research questions. A general summary completes this chapter along with the author's conclusions.

The purpose of this study was to compare the effects of images rendered in different variations of color on recognition and recall memory, specifically for learners classified as field-dependent and field-independent in terms of their cognitive style. Based upon the review of literature, the following research questions were proposed related to the use of color:

1. Does the use of highlight color cues affect student performance on a memory recognition task?

2. Do students grouped by cognitive style (field dependency) differ in performance when presented images using highlight color cues versus images presented totally in realistic color or black-and-white?

These research questions were evaluated based on the performance test scores from two separate memory tasks. The first task, an identification test, required the student to correctly label the parts of the heart. This test included the image of the heart as it was represented in the instructional lesson. The second task, a terminology test, required the student to answer multiple choice questions related to the parts of the heart. This test included no image. Based on the type of image (realistic color, realistic highlight color, contrived highlight color, black-and-white) and student cognitive style (field-dependent, field-neutral, field-independent), a 3 x 4 factorial analysis of variance (ANOVA) was employed to interpret the data for scores of each test (see Appendices VI, VII, & VIII).

A summary ANOVA along with the table of means is presented for each individual test (Identification, Terminology) and the total score of both tests (see Tables 1, 2, & 3). Results of the analysis are presented based upon support, or the lack of support, for each of the hypotheses as presented in Chapter 1. Discussion related to each hypothesis is presented with the results. This is followed by a general summary of the findings at the end of this chapter.

Table 1. Means and standard deviations ( ) for the correct number of responses on the Identification Test.

	Field Dependent	Field Neutral	Field Independent	TOTAL
Black & White	11.722 (4.127) n=18	14.130 (4.104) n=23	14.000 (4.666) n=27	13.441 (4.403) n=68
Contrived Highlight Color	11.900 (5.241) n=20	14.538 (4.072) n=26	16.381 (2.924) n=21	14.328 (4.463) n=67
Realistic Highlight Color	12.900 (4.340) n=20	13.750 (4.567) n=28	16.043 (4.150) n=23	14.254 (4.500) n=71
Realistic Color	11.458 (4.625) n=24	12.870 (4.049) n=23	14.435 (3.691) n=23	12.900 (4.267) n=70
TOTAL	11.976 (4.562) n=82	13.840 (4.199) n=100	15.138 (4.034) n=94	13.728 (4.425) N=276

Table 2. Means and standard deviations ( ) for the correct number of responses on the Terminology Test.

	Field Dependent	Field Neutral	Field Independent	TOTAL
Black & White	7.667 (4.814) n=18	10.000 (5.018) n=23	10.037 (4.800) n=27	9.397 (4.918) n=68
Contrived Highlight Color	8.950 (4.322) n=20	10.308 (4.306) n=26	11.714 (4.638) n=21	10.343 (4.484) n=67
Realistic Highlight Color	8.750 (4.575) n=20	9.750 (4.502) n=28	11.870 (4.703) n=23	10.155 (4.695) n=71
Realistic Color	8.125 (3.837) n=24	9.783 (5.054) n=23	9.957 (4.017) n=23	9.271 (4.347) n=70
TOTAL	8.378 (4.311) n=82	9.960 (4.640) n=100	10.840 (4.575) n=94	9.790 (4.614) N=276

Table 3. Means and standard deviations ( ) for the correct number of total responses for both tests (Identification and Terminology).

	Field Dependent	Field Neutral	Field Independent	TOTAL
Black & White	19.389 (7.777) n=18	24.130 (8.460) n=23	24.037 (8.383) n=27	22.838 (8.394) n=68
Contrived Highlight Color	20.850 (8.592) n=20	24.846 (7.770) n=26	28.095 (6.870) n=21	24.672 (8.160) n=67
Realistic Highlight Color	21.650 (7.618) n=20	23.500 (8.239) n=28	27.913 (7.977) n=23	24.408 (8.275) n=71
Realistic Color	19.583 (7.644) n=24	22.652 (8.294) n=23	24.391 (7.121) n=23	22.171 (7.850) n=70
TOTAL	20.354 (7.815) n=82	23.800 (8.099) n=100	25.979 (7.778) n=94	23.518 (8.194) N=276

Analysis of the Data

Hypothesis #1: Test scores for images presented in black-and-white with color used as a highlight cue will be greater than test scores for images presented in full color or black-and-white.

The results of the analysis of variance (Appendix VI) for the identification test indicate that the main effect for image type was not significant, $\underline{F}$ (3, 264) = 1.749, $\underline{p} > .05$. Similar results were also found for the terminology test. As shown in Appendix VII, the main effect for image type was again not significant, $\underline{F}$ (3, 264) = 1.027, $\underline{p} > .05$. The total score for both tests, as indicated in Appendix VIII, also shows no significance for image type, $\underline{F}$ (3, 264) = 1.638, $\underline{p} > .05$. See Tables 1, 2, and 3 for mean scores for all tests and total scores for both types of tests.

Discussion:

Although the mean scores for image type are higher for the highlight color treatments in all test instances, these results offer no support for the use of either realistic or contrived highlight color as a cue for improving recall memory for images versus the use of black-and-white or realistic images (see Tables 1, 2, and 3, for mean scores).

Berry (1991b) offers evidence that recognition memory is increased based on the additional characteristic of color, especially realistic color. In addition, Berry suggests that images presented in contrived color also increase recognition responses. While it may be true that color increases recognition for images, the findings presented in this study provide no evidence to support increased memory for images presented in either realistic color, contrived color, or black-and-white. This was true for both the identification test, where the image of the heart was included, and the terminology test where no image appeared.

Cue summation theory predicts that as the number of cues available is increased, the learner will be provided more information from which to learn (Severin, 1967a). Dwyer (1978) supports this in a review of research on color versus black-and-white comparisons, where he concludes that the color versions were significantly more effective than the black-and-white versions in facilitating student achievement for specific instructional objectives. Winn and Everett (1979) offer further support that color is an important cueing device, that color improves a learner's ability to recall both relevant and irrelevant material, and that color is important to the meaning of a picture when it is a critical attribute of the pictured object or when attention is drawn to it. Used as a highlight code (underlining, shading, arrows, or printed words), color can facilitate learner performance when used for directing attention and highlighting relevant information (Dwyer &

Lamberski, 1982-83). The findings presented in this study however, offer no support for increased learning based upon the additional image cue of highlight color. No significant differences were found for images presented in either version of highlight color, realistic (M=10.155) or contrived (M=10.343), as compared to images presented in full realistic color (M=9.271) or black-and-white (M=9.397). These results do provide support to the contention that the level of realism necessary for any image to facilitate learning is determined by the instructional objectives and not by the level of realism alone (Dwyer, 1978; Joseph, 1987; Moore & Sasse, 1971).

Hypothesis #2: Field-dependent subjects will perform as well as field-independent subjects when presented images where color highlighting is used as an image characteristic.

Significant results for field dependency were obtained for both the Identification Test (field-dependent, M=11.976; field-independent, M=15.138), F (2, 264) = 12.423, p <.05 in Appendix VI, and the Terminology Test (field-dependent, M=8.378; field-independent, M=10.840), F (2, 264) = 6.727, p <.05 in Appendix VII. The total score (field-dependent, M=20.354; field-independent, M=25.979) also yielded a significant finding as indicated in Appendix VIII, F (2, 264) = 11.434, p <.05. However, no significant interaction between image type and field dependency was observed for either identification, F (6, 264) =

.581, $p > .05$; terminology, $F(6, 264) = .316$, $p > .05$; or for the total score, $F(6, 264) = .443$, $p > .05$. For each image variation presented, the field-independents outperformed the field-dependents (see Tables 1, 2, and 3 for mean scores).

Discussion:

These results suggest that the performance scores for the field-dependents in this study were not affected by the use of highlight color images any more than the performance scores for the field-independents. As a result, these findings provide no support for the use of highlight color cues as a means to increase memory recognition performance for students classified field-dependent in terms of their cognitive style.

It is generally agreed that field-independents adapt to all types of visual presentation better than field-dependents. Research studies consistently show that field-independent learners outperform field-dependent learners on virtually all visually related tasks (Carrier, Joseph, Krey, & LaCroix, 1983; Descy, 1990; Dwyer & Moore, 1992, February; Fleming, 1984; Moore, 1985; Witkin, Moore, Goodenough, & Cox, 1977). The results of this study add support to these earlier findings.

The ability to recall information from visual images is greatly diminished if the learner cannot separate or re-structure the objects presented from the surrounding field. Since learners classified as field-dependent have consistently shown a lesser ability to re-structure images or understand their underlying structural complexity, it was predicted that highlight color could be used to help separate or re-structure the primary elements of an image, and as a result, might help to facilitate learning for the field-dependents.

Evidence to support this contention is provided by Dwyer and Moore (1991). Results of their research suggest that color-coded illustrations can be used to make the relevant cues more obvious to field-dependent learners. Results of this study however, do not support their findings. No differences were observed for any variation of color when used as an additional cue for the relevant objects within the images presented.

Hypothesis #3: Test scores for images using realistic highlight color will be greater than test scores for images using contrived highlight colors.

The results of the analysis of variance (Appendix VI) for the identification test did not produce significant results for image type, F (3, 264) = 1.749, $p > .05$, and therefore, do not support the use of one type of highlight color versus the other as a cue to increase student performance. Similar results were also found for the terminology test in Appendix VII, F (3, 264) = 1.027, $p <.05$, and the total score in Appendix VIII, F (3, 264) = 1.638, $p <.05$ (see Tables 1, 2, and 3 for mean scores).

Discussion:

The mean scores for image type do not indicate increased student performance for the use of either realistic or contrived highlight color as a cue for improving recall memory for images. This finding was not expected.

In past studies, color has been shown to increase recognition responses for previously viewed images (Berry, 1997, 1982, 1990, 1991a; Waltz & Berry, 1991). In addition, these studies indicate that images appearing in color will consistently be remembered better than images appearing in black-and-white. This superiority for color includes images presented in contrived colors - colors not usually associated with the objects in the image.

Color comparisons also indicate that contrived color does not facilitate learning and in fact lowers performance for instructional tasks beyond simple recognition. Results of numerous investigations indicate that recall for non-realistically colored images is significantly lower than for all other treatment variations (Berry & Dwyer, 1982; Berry, 1991a). The results of the current study do not support these earlier observations. No differences were observed in student performance for images presented in either application of highlight color (contrived or realistic), or the realistically colored images.

Conclusions

A statistical analysis of the data indicates no differences for the type of image used for the instructional lesson employed in this study. This result suggests that performance on a memory recognition task is not influenced by the use of color highlight cues. In terms of student performance, the current results provide no support for the use of highlight color as a cueing mechanism to increase learning for relevant information presented in an image. The undergraduate students who participated in this study performed no differently for images appearing in black-and-white, realistic color, or both types of highlight color. This observation would suggest that the additional characteristic of color was unnecessary in terms of student comprehension for the image information.

In terms of image color, it was predicted that objects presented in realistic color would increase student performance compared to similar objects presented in contrived colors. This was not supported by the results comparing the different color treatments. In terms of color, this finding suggests that student performance for image recognition is not affected by color differences. These findings may indicate that the image used in this study contained a high level of relevant information, and therefore, the additional characteristic of color was unnecessary for the types of tests used to measure student performance.

There were significant differences in student performance based on cognitive style. Field-independents outperformed field-dependents in all cases for the tests given in this study. These results suggest that performance scores are not influenced for students classified by cognitive style when images are presented using highlight color cues any differently then when images are presented in realistic color or in black-and-white. However, it was predicted that the use of highlight color would assist the field-dependent students by directing their attention to the relevant information in the images. The results did not support this prediction. This observation suggests that highlight color images offer no help for students classified as field-dependent in terms of facilitating learning and performance on criterion measures.

As a result of these findings, we can conclude that recognition memory is not necessarily affected when highly detailed images are presented in full color, black-and-white, realistic highlight color, or contrived highlight color. We can also conclude that field-independent learners will outperform field-dependent learners in all cases for these types of images. These conclusions are supported by the analysis of the results for each hypothesis tested and are consistent with prior research findings which contend that field-independent learners tend to score higher on criterion measures than field-dependent learners when information is presented visually. Because the findings of the current study are consistent with past findings for field dependency, no further research is suggested by these results.

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Appendix I

Correspondence to/ from Dr. Francis M. Dwyer

Date: Tue, 18 Aug 1998 11:10:22 -0400
X-Sender: fmd@email.psu.edu
Mime-Version: 1.0
To: "Gary M. Worley" <gworley>
From: Francis Dwyer <fmd@psu.edu>
Subject: Re: Research Instrument Request

Gary:

Permission granted.. to do whatever it takes. Mike has a good idea of what the materials are. How are you defining realistic highlighted color?

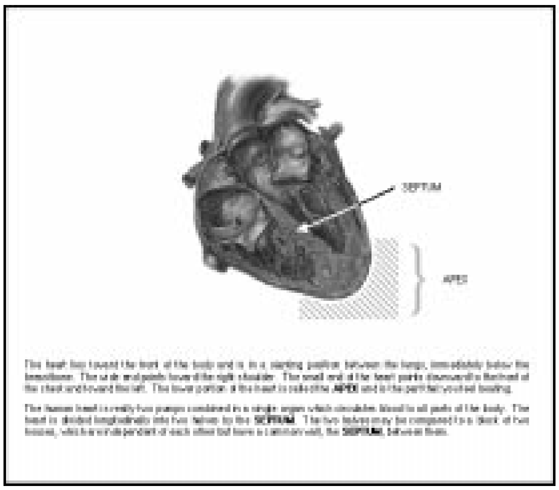
>Dr. Dwyer,
>
>I am a graduate student in the College of Human Resources and Education at Virginia
>Tech. In preparation for my graduate research, I am writing you to request permission to
>use a modification of your research instrument dealing with the heart. Specifically, I
>would like to modify the heart images to reflect the use of both realistic highlight color
>and contrived highlight color.
>
>In discussions regarding this research proposal, Dr. D. Mike Moore (my Course Advisor
and Committee Chairman) suggested that I contact you with this request. He introduced us
once at the AECT Conference in New Orleans.
>
>I am interested in investigating the use of highlight color cues with realistic images and
>how this presentation format affects test scores for subjects classified by cognitive style
>(field dependency). As previously stated, my proposal is to modify your heart
>instrument to include a realistic full color treatment, a realistic black-and-white
>treatment, a realistic color highlight treatment, and a contrived color highlight
>treatment.
>
>With your permission, I would like to proceed with the modification of the heart
>instrument. Please let me know if this is agreeable with you or if you require any
>additional information from me related to my proposed research.
>
>Very Sincerely Yours,
>
>Gary M. Worley

>Graduate Student in Instructional Technology
>Doctoral Candidate, Teaching and Learning

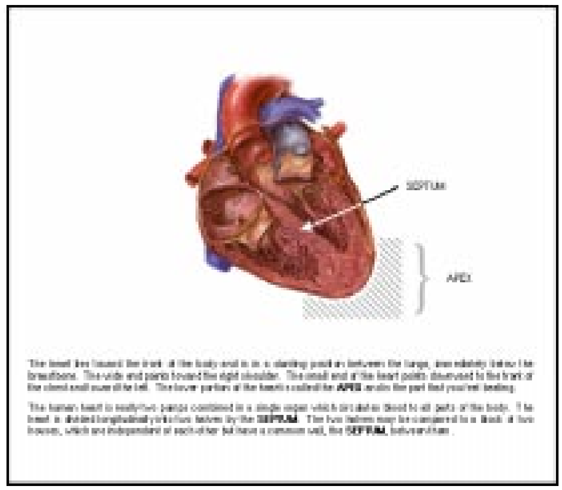
Appendix II

Instructional Booklet Page Variations

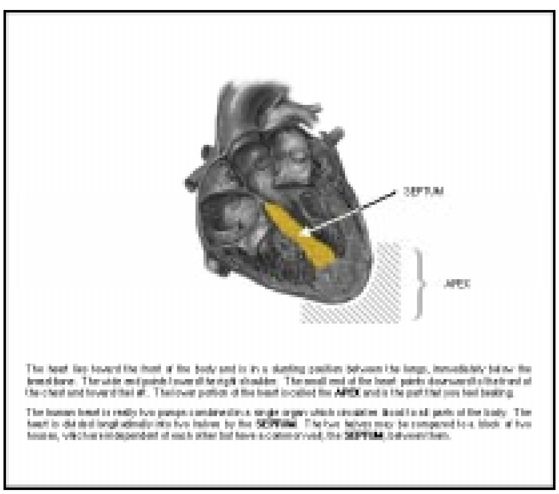
Black-and-White



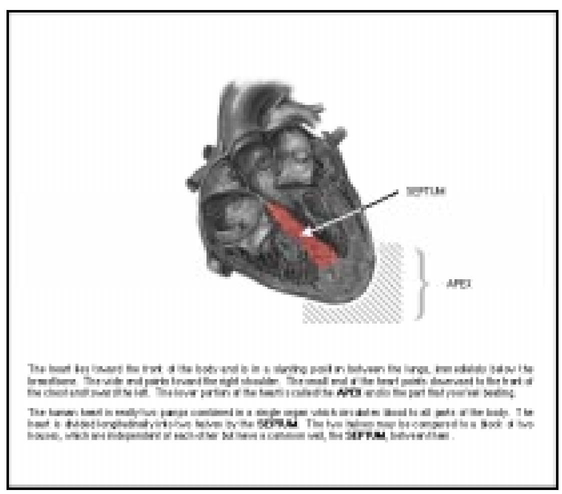
Full Color



Contrived Highlight Color



Realistic Highlight Color



Appendix III

Human Subjects Approval Letter

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Office of Sponsored Programs
301 Burruss Hall
Blacksburg, VA 24061-0249
(540)231-5281 Fax: (540)231-4384

MEMORANDUM

TO: Gary M. Worley

FROM: H. T. Hurd
Director

DATE: October 14, 1998

SUBJECT: IRB EXEMPTION APPROVAL/The Effects of Highlight Color on Immediate Recall in Subjects of Different Cognitive Styles - IRB #98-252

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status.

Best wishes.

HTH/baj

cc: Jan Nespor

A Land-Grant University—125th Anniversary
An Equal Opportunity / Affirmative Action Institution

Appendix IV

Testing Schedule and Participation Totals

DATE	TIMES SCHEDULED	Signed Up	Participated
19 OCT 98	9:00 AM to 12:00 noon	18	7
21 OCT 98	10:00 AM to 12:00 noon	10	5
22 OCT 98	10:00 AM to 12:00 noon	16	10
26 OCT 98	9:00 AM to 12:00 noon	9	4
27 OCT 98	9:00 AM to 4:00 PM	25	19
28 OCT 98	9:00 AM to 4:00 PM	39	39
29 OCT 98	10:00 AM to 12:00 noon	29	14
02 NOV 98	10:00 AM to 12:00 noon	13	6
03 NOV 98	9:00 AM to 4:00 PM	31	21
04 NOV 98	9:00 AM to 12:00 noon	19	9
16 NOV 98	9:00 AM to 12:00 noon	58	33
17 NOV 98	9:00 AM to 4:00 PM	88	44
18 NOV 98	9:00 AM to 12:00 noon	43	21
19 NOV 98	9:00 AM to 4:00 PM	73	43
20 NOV 98	9:00 AM to 12:00 noon	8	5
02 DEC 98	10:00 AM to 12:00 noon	8	6
03 DEC 98	9:00 AM to 4:00 PM	10	6
TOTAL		497	292

Appendix V

Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Consent Form

PROJECT TITLE: The Effects of Images on Immediate Recall

INVESTIGATOR: Gary M. Worley
email: gworley@vt.edu

ADVISOR: Dr. David M. Moore, Dissertation Committee Chairman

PURPOSE: Depicting visual information in many areas of communication involves the use of images. This project looks at the role images play with text in presenting information.

PROCEDURE: You will be participating in a study dealing with the potential effects of using images in instruction and how different images impact the learning of different educational objectives.

The Experimental Procedure is as follows:

1. As a group you will participate in taking a visually oriented pretest.
2. You will be randomly assigned to one of four treatment groups.
3. Once you complete your self-paced instructional booklet you will receive two tests designed to measure your achievement of different educational objectives.

The expected time involved with your participation is approximately 45 minutes. However, no set time limit will be applied.

ANONYMITY: You will receive a code number so that only you and the investigator will know who did the experimental work; therefore, your data will be anonymous. All data will be kept in the investigator's data management system which is secure, by physical separation, from external inquiry. The data will not be analyzed on an individual basis. It will be analyzed collectively and statistical analysis will be conducted to show group comparisons. As a result, it will be impossible to identify any single participant in the study.

RISKS: There should be no more than minimal risks to you from participating in this study. The classroom setting will be as normal and as comfortable as possible.

BENEFITS: There are no benefits to you, but your participation in this research might help contribute to the knowledge base on learning and instructional design. Besides that you will receive instruction on the anatomy and physiology of the human heart.

COMPENSATION: All participants in the study do so on a volunteer basis without [illegible]

FREEDOM TO WITHDRAW: Participants are free to refuse to participate and to withdraw at any time without penalty. You can withdraw by informing Gary Worley at any time or by contacting Dr. Mike Moore.

APPROVAL: This project has been approved by the Institutional Review Board (IRB) - Dr. Jim Burger (IRB Representative for the Department of Teaching and Learning) and Dr. Tom Hurd (Chairman of the University IRB).

By signing below, you indicate that you have read and understood the informed consent and conditions of this project, that you have had all your questions answered, and that you give your voluntary consent for participation in this project.

If you participate, you may withdraw at any time without penalty.

Signature

ID Number Date

INVESTIGATORS:

Gary Worley, Graduate Student	231-[illegible]
Mike Moore, Advisor	231-[illegible]
Jim Burger, IRB Representative	231-[illegible]
H.T. Hurd, Chair IRB	231-[illegible]

Thank you for participating!

Appendix VI

Summary ANOVA table for the number of correct responses on the identification test.

	DF	Sum of Squares	Mean Square	F-value	P-value
Field Dependency	2	450.388	225.194	12.423	<.0001
Image Type	3	95.101	31.700	1.749	.1574
Field Dependency * Image Type	6	63.182	10.530	.581	.7455
Residual	264	4785.659	18.127		

Appendix VII

Summary ANOVA table for the number of correct responses on the terminology test.

	DF	Sum of Squares	Mean Square	F-value	P-value
Field Dependency	2	279.404	139.702	6.727	.0014
Image Type	3	63.974	21.325	1.027	.3812
Field Dependency * Image Type	6	39.329	6.555	.316	.9286
Residual	264	5482.840	20.768		

Appendix VIII

Summary ANOVA table for the number of correct responses as represented by the total score for both tests.

	DF	Sum of Squares	Mean Square	F-value	P-value
Field Dependency	2	1437.309	718.654	11.434	<.0001
Image Type	3	308.797	102.932	1.638	.1810
Field Dependency * Image Type	6	167.051	27.842	.443	.8496
Residual	264	16593.499	62.854		

Permanent Address

115 Southampton CT.
Blacksburg, VA 24060
(540) 961-2709

Gary M. Worley

EDUCATION

Doctorate of Philosophy, **Curriculum and Instruction**, May 1999
Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg, VA

Dissertation: The effects of highlight color on immediate recall in subjects of different cognitive styles

Advisor: David M. Moore

Master of Education, **Curriculum and Instruction**, December, 1994
Virginia Polytechnic Institute and State University, Blacksburg, VA

Bachelor of Arts, **Art**, June 1978
Virginia Polytechnic Institute and State University, Blacksburg, VA

AFFILIATIONS

Xplor International, 1997 – present

International Visual Literacy Association, 1999 – present

RELATED EXPERIENCE

Professional

Director, Production Services, Virginia Tech, July 1995 – present

- Committee Chair for Innovative Printing Initiative
  Outcome: successful migration of all mainframe printing to a network recovery based operation.
- Lead role in evaluation efforts for new services
  Outcome: implementation of new support functions including: PhotoCD, color laser printing, CD duplication, wide format inkjet printing, distributed network printing
- Provide administrative leadership for university in-house service organization employing 44 FTEs with an approximate yearly budget of $4 million

Manager, PhotoGraphic Services, Virginia Tech, 1991 – July 1995

- Re-structured service unit to operate as a cost recovery operation
- Developed long range plan for transition to digital production
- Provided administrative leadership for department employing 11 FTEs with an approximate yearly budget of $300,000

Systems Administrator, Media Services, Virginia Tech, 1988-1989

- Provided consultation to university faculty and staff on software, digital output equipment, and configuration issues
- Setup and maintenance of all departmental computing resources
- Provided programming support for output file management
- Served as department liaison for networking
- Integrated high resolution imagesetter service for campus support of Printing Services and other university departments
- Provided on-line documentation for software configuration and digital output file preparation in support of university wide production services

Graphic Designer, Learning Resources Center, Virginia Tech, 1977-1988

- Provided support for research illustration
- Designed and prepared slide presentations in support of instruction and research
- Developed and integrated digital slide services for campus wide support facility
- Evaluated software products and provided consultation related to digital output

Teaching

Instructor, Department of Teaching and Learning, Virginia Tech, Blacksburg, VA, Summer, 1998; Summer, 1997; Summer, 1996; Summer, 1995

- Co-taught graduate class on presentation graphics and photo imaging

Instructor, Department of Art, Virginia Tech, Blacksburg, VA, Summer, 1994

- Introduced and co-taught undergraduate class on 3D computer design

Instructor, Department of Art, Virginia Tech, Blacksburg, VA, Fall 1989

- Taught undergraduate introductory graphic design course

Teaching Assistant, College of Education, Virginia Tech, Blacksburg, VA, Fall 1988; Fall 1989

- Provided assistance for computer graphics course
- prepared visual materials
- graded student projects
- provided design assistance

Software Proficiencies

Vector Based Graphic Design: Adobe Illustrator, Macromedia Freehand

Page Layout: Adobe PageMaker, Microsoft Word, Acrobat

Presentation: Microsoft PowerPoint, Adobe Persuasion, Lotus Freelance

Raster Based Graphic Design: Adobe PhotoShop

Other: Microsoft Excel, Ray Dream Designer, Adobe Pagemill, HyperCard

JURIED ART EXHIBITIONS

1987, Hunterdon Art Center, 31st National Print Exhibition, Clinton, NJ
Wallingford Art Center, National Print Exhibit, Wallingford, PA
Newark Art Library, Traveling National Print Exhibition, Newark, NJ

1985, Hunterdon Art Center, 29th National Print Exhibition, Clinton, NJ
Newark Art Library, Traveling National Print Exhibition, Newark, NJ
Muhlenburg College Gallery, National Print Exhibit, Allentown, PA

1980, Somerville Art Center, 5th National Print Competition, Somerville, NJ

1977, Hunterdon Art Center, 21st National Print Exhibition, Clinton, NJ
Trenton Art Center, National Print Exhibit, Trenton, NJ
Squires Gallery, 8th Virginia State Student Exhibition, Blacksburg, VA

1976, Squires Gallery, 7th Virginia State Student Exhibition, Blacksburg, VA

SELECTED SPECIFIC ACCOMPLISHMENTS

Over the years, since the start of my professional career, I have been involved in the preparation and design of hundreds of images used in both presentation media and published documents. My involvement with these images spans a wide range of production techniques including drawings and digital artwork. Preparation includes areas of conceptual design as well as production considerations for all types of output. As a result of this experience, my current duties include administrative support as required for design and production consulting for all university presentation materials.

1998, Designed slides for statewide presentation “Virginia Tech Today” given by University President Paul Torgersen

1997, Designed and delivered “Network Printing” presentation to university administration on digital printing technologies

1996, Provided web design and HTML coding for Information Systems Annual Report
Provided web page design and images for Information Systems web page

1995, Conducted “Digital Output” workshops for faculty and staff of Virginia Tech coordinated through the New Media Center

Provided web design and images for the University (Virginia Tech) web page

1994, Designed and produced slide presentation for Dr. Robert C. Heterick, Jr., President of EDUCOM, delivered at CAUSE conference

Developed and produced a series of electronic handouts on creating output files for digital output

1993, Design and preparation of slides for a talk given by the Vice President for Information Systems to the National Science Foundation

Designed slides for presentation “Benefits of Restructuring” given by Vice President for Information Systems

Designed slides for presentation “Virginia’s Economy” given by Vice President for Information Systems

1992, Developed electronic versions of new university identity design for output on mainframe and personal desktop printers

Designed slides for presentation “Blacksburg Electronic Village” given by Robert C. Heterick, Jr., President of EDUCOM

1991, Designed slides for presentation “Campus Master Planning” given by the Committee Chair for Facilities Planning at Virginia Tech

Designed slides for presentation “2nd Century Campaign” given nationally by the Vice President for Development

1990, Designed first campus produced digital color booklet on “The Development and Production of Large-seeded Virginia-type Peanuts, for distribution at the 1990 International Peanut Forum, Amsterdam, The Netherlands

Converted university seal to digital formats suitable for a wide range of media

1988, Animated university logo for video presentation using Genigraphics Artwork

1986, Designed first campus produced digital slide presentation on “The implementation of computers at Virginia Tech”, presented by Dr. David Roselle to the IBM Corporation

1983, Illustrated technology manual on Ergonomics for the IBM Corporation, written by Martin G. Helander

1982, Researched and produced maps of the Battle of Fredericksburg, a PBS presentation on the American Civil War, narrated by Dr. James I. Robertson

1980, Designed emblem for national agricultural organization, Country of Panama

1979, Animated educational film “You See What You Say”, distributed by International Film Bureau, Inc., 1980 winner of the Silver A Award given by the Northeast Conference at their modern language film festival in Washington, D.C.