Effects of Field Dependent-Independent Cognitive Styles and Cueing Strategies on Students' Recall and Comprehension

Yu Cao

Dissertation submitted to the faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Curriculum and Instruction

John K. Burton, Chair
Peter E. Doolittle
Barbara B. Lockee
David M. Moore
Ken R. Potter

September 6, 2006
Blacksburg, VA

Keywords: Cognitive Style, Cueing Strategy, Instructional Message Design, Color

Effects of Field Dependent-Independent Cognitive Styles and Cueing Strategies on Students' Recall and Comprehension

Yu Cao

(ABSTRACT)

The purpose of this study was to examine whether cueing strategies embedded in computer delivered text messages affected the recall and comprehension of students who differed in their field dependent-independent cognitive style orientations. Two hundred thirty-eight undergraduate students of Virginia Tech participated the study, and 219 sets of valid data were used for the statistical analyses. All participants were given the Group Embedded Figures Test to determine their level of field dependence-independence. They were then randomly assigned to one of three treatment groups that varied in their use of cueing strategy. The first treatment group featured computer delivered text messages with color-highlighted-keywords, the second group featured the same textual content with color-highlighted-key-phrases, and the third group was a control group that featured the same content and employed no cueing strategy. Participants were administered two tests following the treatments, one that assessed knowledge of terminology and another that assessed comprehension.

A 3 x 3 Analysis of Variance was conducted to explore the main effects for field dependency and cueing strategy and any interaction effect between the two factors. The results showed that field independents outperformed field dependents in all tests. There were no significant differences for the three treatments; the cueing strategies employed in this study had no effect on participants' learning. A significant interaction was seen between field dependency and cueing strategy. However, the results of a one-way ANOVA are unexpected: the cueing strategies employed did not improve field dependents' performance on the assessments and actually hindered the performance of field independents.

DEDICATION

This work is dedicated to my parents for believing in me and being my strength during this process. Without their lifelong encouragement, support, and unconditional love, I would not have reached this achievement.

ACKNOWLEDGEMENTS

This accomplishment would not have been possible without many people's help and support. To those individuals, I would like to express my deepest appreciation.

I want to show my greatest gratitude to my advisor, Dr. John Burton, for his guidance throughout my doctoral study. He provided a tremendous amount of support, advice, and direction and always encouraged and supported me whenever the odds seemed overwhelming. No matter what kind of challenges I faced, I knew he would be there help me overcome them. I will always be eternally grateful for his help. Special thanks to Dr. Peter Doolittle for providing me with research participants, helping me design pretest questions, and allowing me to use his research interface. His humor, generosity, and support made this research progress smoothly. I also want to extend my thanks to Dr. Mike Moore for his wisdom and thoughtful feedback throughout my research efforts. He has graciously guided me through the research analysis with clarity and expertise. Much appreciation also goes out to Dr. Barbara Lockee for offering encouragement and direction whenever I needed. Her expertise in research and teaching was truly inspiring. Finally, I would like to thank Dr. Ken Potter, who has been being so understanding and supportive throughout my study. His useful advice, constant inspiration, and willingness to listen supported me on this journey.

Thanks also to Dr. Jane Falls for her kind support during my research study. I want to give special thanks to Terry Davis, Lori Berry, and Nancy Nolen, who were always willing to help. My thanks also go to my colleagues and friends for their support and friendship.

Finally, special thanks to the most important person in my life: my husband David. His love and support not only made my life better but also helped me reach this milestone. He has spent a tremendous amount of time reviewing my document and offering meaningful advice. He

also provided me with the computer-based instructional materials used in my study, which saved me much time and effort. He is my strongest backup, and I know I can always count on him. I look forward to many more years of joy, love, and happiness together.

TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 1: INTRODUCTION AND REVIEW OF LITERATURE

Introduction

Individual learner differences are believed to be an important concern in the design, development, and implementation of instructional materials and curricula (Skinner, 1954). Each individual has preferred ways of acquiring, structuring, and processing information. Fundamental issues for education and, in particular, for computer-based instruction concern the effects of individual differences on the effectiveness of teaching and learning and on the design and development of learning environments to maximize learners' strengths and minimize their weaknesses (Graff, 2003; Magoulas, Papanikolaou, & Grigoriadou, 2003; Snow, 1997).

Investigations of individual differences have led to the determination that there are styles of thinking called cognitive styles. Messick (1976) described cognitive styles "represent consistencies in the manner or form of cognition …" and the influence of cognitive styles "extends to almost all human activities that implicate cognition, including social and interpersonal functioning" (p. 5). Students with different types of cognitive styles may need different instructional strategies to suit their information processing needs and learner preferences. When the characteristics and limitations of cognitive-style affect learning effectiveness, the variable becomes a significant factor in planning the structure and presentation mode of instruction, and instructional designers must take it into consideration (Witkin & Goodenough, 1981). Instructional designers who wish to design effective instructional experiences for delivery by computer may need to be aware of the potential impact of cognitive styles on learning performance and consider how to accommodate individual differences in a comprehensive and integrated manner.

The construct of field dependence-independence (FDI), as one of the cognitive style dimensions, has been extensively researched and is viewed as one of the most significant factors when contemplating educational problems (Ausburn & Ausburn, 1978; Witkin & Goodenough, 1981). Chinien and Boutin (1993) state that "field-dependence/field-independence, which constitutes an important aspect of individual differences among students regarding the way they acquire and process information, appears to hold promising potential for the design and development of effective instructional materials" (p. 307). Messick (1976) differentiates field independent and field dependent people the following way:

> The field independent person tends to articulate figures as discrete from their backgrounds and to easily differentiate objects from embedding contexts, whereas the field dependent person tends to experience events globally in an undifferentiated fashion. Field independent (or analytical) individuals have more facility with tasks requiring differentiation and analysis. (p. 5)

Most likely, people whose cognitive style is field independence tend to notice details and have greater analytical and differentiating ability compared to field dependent people, who tend to view events globally without considering the details, such as accepting a entire section of a text message without focusing his or her attention on the important information. As a result, when a task requires noticing important words and phrases embedded within a computer screen full of information, field dependent learners may need additional assistance to guide their attention to the critical information.

Davis (1991) suggests that since field dependent learners have difficulty selectively attending to relevant cues, especially when they are presented with distracting cues, using instructional techniques that focus field dependent learners' attention on critical features of the information to be learned could accommodate that kind of attentional difficulty and lead to improved learning performance. Ausburn and Ausburn (1978) also state that if individuals encounter tasks that require processing information in a manner that they are unable to accomplish because of their cognitive style, then appropriate instruction should be designed to help the individual overcome these information processing difficulties. Future research should be conducted to examine individual differences in information processing, especially in memory and attention, which would directly impact the design of instructional strategies aimed at accommodating the deficiencies of field dependent learners (Tinajero & Paramo, 1998).

In computer-based instruction, the way the computer screen is perceived and the way the information on it is presented can impact its instructional effectiveness (Card, Moran, & Newell, 1983; Grabowski, 1995; Winn, 1993). Researchers emphasize that the form of the message affects what information is attended to and perceived by learners, especially in the early stages of information processing (Grabowski, 1995; Winn, 1993). Glynn and Britton (1984) state that reading and extracting important information from instructional text involves a number of cognitive processes. These processes are associated both with the text content and its physical characteristics. They also point out that the limited capacity of working memory requires learners to make a distinction between the important information and enriched or irrelevant content. However, some learners (such as those who are field dependent) may have problems making a distinction between the important content and elaborative content (Duchastel, 1982; Glynn, Britton, & Tillman, 1985). In these cases, providing appropriate cues within the text content may help field dependent learners focus on the text components that are most important. Hershberger (1964) asserted, “in order to promote optimal learning by reading it would appear advantageous to cue the student as to the importance of the material he is reading at the time he is reading it" (p. 289).

Gagné's (1985) theory regarding the conditions of learning suggests that the internal processes of learning can be influenced by external events. Mayer (1984) also emphasizes that for learning to take place, information must first be perceived or selected. Since field dependent learners often have difficulty selectively attending to relevant cues and may need aids in disembedding relevant information, they may be accommodated by instructional strategies that focus their attention on critical features of the information. Cueing strategies are externally presented aids that can be employed as an information processing strategy to assist field dependent learners in effectively dissembedding and selecting relevant key information from computer delivered text messages. The employment of cueing strategies may be of more assistance to field dependent learners, who have a greater need for specific structuring of instructional material than field independent learners.

This study attempted to examine the effects of field dependent-independent cognitive styles and cueing strategies on students' recall and comprehension. Color-highlighted keywords and color-highlighted key phrases are the two salient cueing devices that were chosen for this study. The purpose of this experiment, therefore, was to examine the performance of field dependent and field independent learners presented with computer-based textual information that featured either color-highlighted keywords or color-highlighted key phrases as critical cues in the text presentation.

With the advanced integration of computers in the teaching and learning process, it is important to provide guidelines to instructional designers for the design and development of effective instructional text materials that accommodate learners' particular cognitive style, thereby diminishing the differential learning gains between field dependent and field independent learners. The results of this study help to explain which students learn better under what learning conditions and which learners may need additional support and assistance to be successful in learning. The information resulting from this study should make contributions to a growing knowledge base that will assist instructional designers in creating effective instructional experiences for a wide spectrum of learners with individual differences in learning.

Review of Literature

The purpose of this review is to examine the current literature related to the effects of field dependent-independent cognitive styles and cueing strategies in the instructional design process. Before combining the two distinct disciplines of field dependence-independence and cueing strategies into an investigation, it is necessary to (a) review literature related to cognitive style, with particular emphasis on Witkin's theory of field dependence-independence (FD/FI), which many researchers believe shares characteristics with information processing, (b) introduce cueing strategy, including its functions for learning and the effects of color as a cueing strategy aiding in learners' recall/comprehension, and (c) explore the connections between field dependency and cueing strategies.

Cognitive Styles

Cognitive psychologists have attempted to understand the nature of human intelligence and how people think. The theory of cognitive style emerged during the 1950s, when cognitive psychology placed greater emphasis on the active role of individuals in information processing and on individual differences in cognitive functioning (Goodenough, 1976). Ausburn and Ausburn (1978) stated that individuals have different, preferred ways of gaining, storing, processing, and using information. These types of differences in cognitive functioning are referred to as *cognitive styles*. An individual's particular cognitive style is pervasive throughout all of his or her school learning and life problem-solving activities (Cross, 1976). The concept of cognitive style has continued to be explored in the educational, psychological, and organizational research literature for almost 40 years (Pithers, 2002).

There are different definitions of cognitive style, as researchers have emphasized different aspects. Rule and Grippin's (1988) definition describes cognitive style as "an individual's preferred mode of perceiving information and/or cognitive functioning, thus including both perceptual and intellectual functioning" (p. 1). Cognitive styles have also been defined as "stable attitudes, preferences, or habitual strategies determining a person's typical modes of perceiving, remembering, thinking, and problem solving" (Messick, 1976, p.5). In 1971, Witkin and his colleagues described cognitive style 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). Witkin (cited in Messick, 1986) further refined cognitive style as "a bridge between perception and personality, between cognition and affect, between socialization and social behavior" (p. 115). These definitions focus on the discussion of structures and processes associated with information perception rather than how much or what people perceive. In other words, it refers to how individuals differ in perceiving information instead of how much information they perceive. The concept of cognitive style for this study was defined as the individual's self-consistent patterns of perceiving, organizing, thinking, remembering, and problem solving.

Cross (1976) believes that knowledge of cognitive styles can facilitate the selection of appropriate teaching practices. By analyzing the relationship between cognitive styles and educational practice, Messick (1984) summarizes that cognitive styles are educationally important because (a) they might provide a basis for manipulating the format of presentations and the degree of structure of instructional materials to meet the characteristics of learners, (b) they can improve teachers' performances through the awareness of cognitive styles of their own and their students, (c) they emphasize the belief that education should not only concerned with the students' knowledge acquisition but also with students' manners of thinking, and (d) they can modify the learning environments to meet the stylistic characteristics of learners.

Knowledge of cognitive styles related to how individuals process information has great value to both psychologists and instructional designers since specific learners characteristics can interact with learning outcomes and with the form of instruction (Jonassen & Grabowski, 1993). Instructional designers may need to consider the cognitive styles of their target audiences and how these cognitive styles may influence the way they design and produce their instructional materials. An awareness of the individual differences among learners regarding the way they perceive information has tremendous potential benefits for the design and development of effective instructional materials (Graff, 2003; Magoulas et al., 2003; Witkin et al., 1971). Among all the cognitive styles, the dimension of field dependence and independence, which reflects one's mode of perceiving, remembering, and thinking, has emerged as one of the most frequently studied cognitive style (Jonassen & Grabowski, 1993; Messick, 1976; Saracho, 1989; Witkin, Moore, Goodenough, & Cox, 1977). It has drawn much research attention over the years and "has had the widest application to educational problems" (Witkin et al., 1977 p. 1). Reardon and Moore (1988) summarized that the reasons that field dependence-independence stands out from other cognitive styles are because it "involves perceptual and problem-solving ability, structuring a stimulus field, breaking up or disembedding such a field, suppressing irrelevant information, and dealing with high information load, all of which are relevant to the instructional process" (p. 354).

Field Dependence and Field Independence

With the rapid development of computer technologies as educational tools, the role of cognitive style in computer-based instruction begins to draw more research attention. Numerous research studies have explored the importance of learners' cognitive style and the role of field dependence and independence in teaching and learning (Burton, Moore, & Holmes, 1995). In examining the inherent visual features and attributes of computer-based instruction, the role of field dependence and independence may play a key role in the effective design of instructional environments (Chinien & Boutin, 1993; Sadler-Smith, 1996; Weller, Repman, Lan, & Rooze, 1995).

Field dependence and independence refers to the degree "to which the organization of the prevailing field dominates perception of any of its parts" (Witkin et al., 1971, p. 7). It is an expression of an individual's cognitive psychological structure to separate contextual information (Witkin & Goodenough, 1981). It also describes "the degree to which a learner's perception or comprehension of information is affected by the surrounding perceptual or contextual field" (Jonassen & Grabowski, 1993, p. 87). Witkin et al. (1977) found that bodily and visual cues usually correspond with each other, but when they do not, people tend to rely on one or the other. Messick (1976) describes this dimension as:

> …a consistent mode of approaching the environment in analytical, as opposed to global, terms. It denotes a tendency to articulate figures as discrete from their backgrounds and a facility in differentiating objects from embedding contexts, as opposed to a countertendency to experience events globally in an undifferentiated fashion. (p. 14)

The definition utilized for this study was created by Witkin in 1978 and states that, “the tendency to rely primarily on internal referents in a self-consistent way we designate a *field-independent* cognitive style. The tendency to give greater credit to external referents is a *field-dependent* cognitive style” (Witkin, 1978, p. 16).

The degree of field dependence or field independence could also be described as a continuum, with field independent at one end and field dependent at the other end. In the middle of the continuum is the group termed “field mixed” or “field neutral”, who do not have a clear orientation (Liu & Reed, 1994). Witkin et al. (1977) elaborate,

> Because at one extreme of the performance range perception is strongly dominated by the prevailing field, that mode of perception was designated “field dependent.” At the other extreme, where the person experiences items as more or less separate from the surrounding field, the designation “field independent” was used (p. 7).

Historical Development of Field Dependence-Independence

If field dependence and independence is to be considered an important variable in the design of computer-delivered text materials, it is useful to be aware of the depth and breadth of this style and how its conceptualization has changed over time. It is also critical to clarify the interpretation of field dependence and independence as utilized in this study.

The field dependent-independent construct has been continuously revised and extended since it was first described (Witkin & Goodenough, 1981). The most influential studies on the nature and origins of individual differences in field dependency began in the 1940s and were conducted by Witkin and his associates. Witkin’s investigations on the psychology of cognition were directly influenced by Gestalt Psychology, which led him to view individual consistencies in the matter of perceiving and thinking as critical psychological phenomena and also shed light on the determining role of needs and values in perception (Messick, 1986).

Witkin believed that the construct of field dependence-independence has a continually changing structure. By incorporating findings of new data and insights from different areas of psychological study and identifying stylistic differences among people in perceptual and cognitive function, Witkin has periodically tried to define and extend the conceptual framework (Goodenough, 1986; Witkin & Goodenough, 1981). Figure 1 demonstrates the pyramidal structure of the development of the field dependent-independent construct, with the general differentiation construct on the top of the structure and the specific perception of upright located on the base.

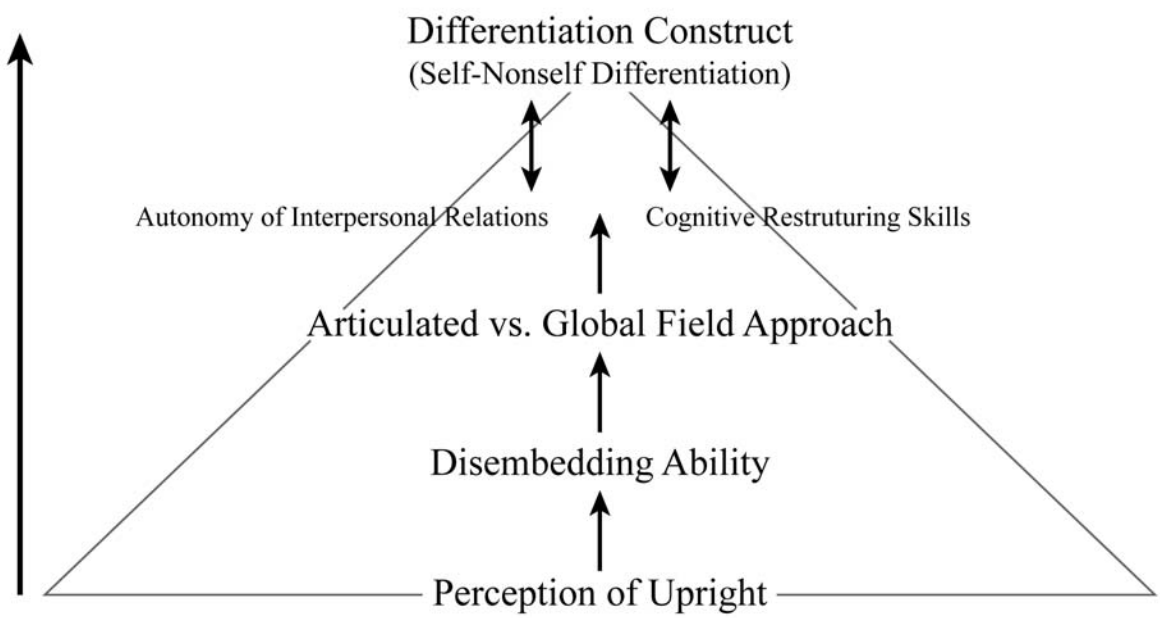


Figure 1. Pyramidal structure illustrating the development of the field dependent-independent construct.

The concepts of field dependence (FD) and field independence (FI) were first introduced by Witkin and his associates in 1954 to describe individual differences in tendencies to rely primary either on external visual cues or internal gravitational or body sensations for the perception of the upright. Later, they tried to link people's performance to their ability to visually separate an item from a complex context or *field*. Usually, the item was a simple geometric shape that was hidden or embedded in a more complicated drawing. In these situations, field independents demonstrated a greater ability to overcome a given organizational context and separate or disembed the relevant information from the surrounding stimuli; on the other hand, field dependents had lesser competence when performing such tasks. They viewed fields as given and performed less analysis and structuring than field independents. Further studies in this area led the individual differences construct to be designated as an articulated versus global field approach and perceived as an ability to overcome embedding contexts in various perceptual and intellectual activities (Witkin et al., 1977). In the early 1960s, Witkin and his associates began to place the description of field dependence and independence in a broad theoretical framework of psychological differentiation that reflected the higher-order construct of self/nonself segregation and the balance of interpersonal competencies and restructuring skills (Pizzamiglio & Zoccolotti, 1986; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962). If describing the modification and developments of the field dependent and independent cognitive styles using a pyramidal structure, the most specific perception of upright can be placed at the base and the most general differentiation construct can be viewed as standing at the apex (Goodenough, 1986).

Perception of Upright. Herman A. Witkin, a world-renowned investigator of cognitive styles, began his study of cognitive style by examining individual differences in perception of the upright in space. In the late 1940s, using a Rod-Frame Test (RFT), a Body Adjustment Test (BAT), and a Rotating Room Test (RRT), Witkin and his associates undertook studies to measure subjects' variations in perception of the upright as influenced by a surrounding field

(Witkin & Goodenough, 1981). The question they asked was, "how important are visual cues in perceiving the vertical direction of space?" (Goodenough, 1986, p. 5).

The direction of the perceived upright is primarily determined by a set of information: first, the field around us, which is usually perceived from the surrounding visual environment, and second, the direction of gravity, detected through sensations from the body. Witkin and his associates (Witkin & Goodenough, 1981; Witkin et al., 1977) proposed that visual referents and body sensations both provided an accurate sense of the location of the upright, whether these two kinds of determinants were used alone or combined with each other as the referents.

In the Rod-Frame Test (RFT), the subjects were required to sit in a completely dark room. All subjects could see was a luminous square frame, within which was a luminous rod, pivoted at the center of the frame, which could be tilted to the left or right. With the frame tilted, subjects were asked to adjust the rod to the upright according to their perception. Witkin and his associates found that individuals differed dramatically in how they performed this task. For example, some of the subjects aligned the rod with the surrounding frame, no matter what the position of the frame. At the opposite extreme, some of the subjects adjusted the rod regardless of the position of the surrounding frame. They viewed the rod as discrete from the visual frame of reference and determined the upright according to their sense of the position of the body.

Another test developed to determine the role of the visual and bodily standards in perception of the upright is the Body Adjustment Test (BAT). In this test, subjects were seated in a small tilted room, which could be moved clockwise or counterclockwise. The chair in the tilted room could also be titled clockwise or counterclockwise but independently of the room. The subject was asked to adjust the chair from an initially tilted position to the upright. With the surrounding room in a tilted position, some subjects aligned themselves with the tilted room and reported that they were in a perfect upright position. Witkin and Goodenough (1981) stated, "such subjects were using the external visual field as the primary referent for perception of the upright, essentially to the exclusion of sensations from the body" (p. 9). Subjects who considered the body as the primary referent for perception of the upright were able to adjust their body to the true gravitational upright. Cross (1976) reported that there was substantial correlation between RFT and BAT and that "people who ignored the tilt of the room also ignored the slant of the frame; these people were described as field independents. Field dependents, on the other hand, relied consistently on the surroundings, the room or the frame, for their orientation" (p. 117).

In the Rotating Room Test (RRT), the external field provided correct cues for subjects to perceive the upright. When the direction of the force on the body was changed, the visual referents remained upright. The room and the subject were rotated in a circle. The subject was seated in a tilted chair within a small upright room driven around a circular track. The subject was required to adjust his or her body or the room in which he or she was seated to the upright position. If the subject believed that the postural sensations were produced by the gravity on his or her body, he or she would tilt the body and room to align with that force. On the other hand, if the subject depended more on his or her surrounding visual field, he or she would tend to identify body and room as upright in his or her initial positions. Witkin and Goodenough (1981) pointed out that the RFT and BAT depended on the internal cues of the body and led to a more accurate perception of upright. However, individuals who relied on the external field were more successful in the RRT. Individuals were consistent across all these three tests; success on the BAT and RFT was inversely related to the RRT and vice versa, which indicates that "neither a field-dependent nor field-independent mode of functioning is uniformly good or bad in their consequences for perception of the upright in space" (Witkin & Goodenough, 1981 p. 14).

Witkin et al. (1954) stated that these three tests were designed to investigate the extent to which subjects determine the upright by adherence to the axes of the visual field or resist the influence of the external field through internal cues of their bodies. With these tests, the interpretation of external versus internal orientation was shown to be extended to a more general dimension of perceptual analysis called field dependence (Ramirez III & Castaneda, 1974). Witkin and his colleagues (1981; 1954) summarized that (a) individuals are markedly different from each other in perceiving information and have their own preferred way of locating the upright, (b) individuals tend to be self-consistent in their manner of reliance on external fields or bodies, (c) individuals' characteristic modes of orientation tend to remain stable over long periods of time, and (d) these characteristic modes of information processing have to be taken into consideration so as to fully understand individual's perception of the upright. In general, field dependent people differ remarkably from field independent people in "how they perceive the upright, rather than in how accurately they perceive the upright" (Goodenough, 1986, p. 11).

Perception of Disembedding. In the early 1950s, with their development of the Embedded-Figure Test (EFT), Witkin and his associates found that field independence in the perception of upright was related to success in locating embedded figures (Witkin, 1950; Witkin et al., 1954). It led to a new interpretation of the conceptualization of the field dependence construct and expanded the scope of their analysis of perception. Field dependence and independence had been redefined as a disembedding or perceptual-analytical ability in perceptual functioning (Witkin et al., 1962). Although the EFT did not involve either orientation toward the upright nor body position, it was quite similar to the RFT and BAT in that subjects needed to disembed or separate an item from surrounding fields (Witkin et al., 1977). The EFT required that a subject, after being shown a simple geometric figure, extract that figure from within a more complex pattern in which it had been hidden or embedded. In order to disembed and locate the simpler shape, it was necessary to break up and identify the various components of the complex context.

Witkin and his colleagues developed the Group Embedded Figures Test (GEFT) in 1971, which can be administered to a group of subjects at once and is scored according to how many correct responses are made during a certain time period. The GEFT has since become the most commonly used test of field dependence and independence (Oltman, Raskin, & Witkin, 1971). The use of this test eliminates the need for the equipment required to perform the BAT and RFT. It is comprised of a test booklet containing 25 complex test figures. Subjects are asked to locate a simple figure within each complex figure and then outline it. Researchers concluded that this instrument appears to have desirable measurement characteristics and provides reliable and valid data to support most of the research efforts and reported outcomes related to field dependent-independent cognitive styles (Pithers, 2002; Thompson & Melancon, 1987).

Researchers (Witkin & Goodenough, 1981) found that subjects who had difficulty disembedding a simple figure from a complex design were the same ones who had difficulty separating the body or rod from the room or frame in orientation tests; they were referred as field dependents. On the other hand, subjects who found it easy to overcome the influence of a complex design and locate a simple figure within it and thus impose structure on unstructured perceptual information were referred to as field independent. Subsequent studies indicated that such tests assess subjects' ability to perform cognitive restructuring (Witkin et al., 1977).The results of studies involving the EFT and GEFT indicated that the field dependent-independent construct had a more general application in social and learning contexts as opposed to only in spatial orientation contexts.

Articulated versus Global Field Approach. Further investigations on individual differences in disembedding ability expanded this research area (Witkin & Goodenough, 1981). An articulated versus global dimension was discovered, which represents a person's ability to overcome an embedding context. This dimension focuses on the relationship between disembedding ability in perception, intellectual functioning, and structuring ability.

Research evidence suggests that disembedding ability is associated in the perceptual and intellectual domains with the ability to impose structure on an unstructured field. In other words, in addition to having difficulty disembedding perceptually, field dependents have difficulty solving problems that require taking a critical element for solution out of context and using it in a different context (Witkin & Goodenough, 1981). This finding indicates that individuals perform the same level of disembedding or articulated ability across perceptual and intellectual activities, which confirmed a central hypothesis of field dependent-independent cognitive styles that "…individual differences in expressions of articulated functioning in one area are related to expressions in other areas …" (Goodenough, 1976, p. 676).

Studies on the relation between disembedding and structuring ability led to an understanding that disembedding ability is related to cognitive restructuring with a perspective that there is a more "active" or more "passive" action between field independents and field dependents when they are dealing with the unstructured context. With a relatively articulated cognitive style, the individual is more likely to see the parts of the field as distinct from the ground, analyze or synthesize details and parts of a figure, and examine and organize the whole structure of the field in a new way. By contrast, with a relatively global cognitive style, an individual's pattern recognition is strongly governed by the organization of the field, and the individual experiences difficulty in distinguishing figures from the background due to a lack of restructuring ability. Instead, the individual relies more on external referents in making perceptual judgments, such as social contexts and information provided by others. Field independents tend to experience the components of a structured field analytically, distinguish an element from a given field's organizational background, and impose structure on a field that lacks clear structure. Field dependents tend to perceive a complex stimulus globally and are more likely follow the presented visual field structure and view an unstructured field as "given". They are not good at such structuring and analytical activity (Fitzgibbons, Goldberger, & Eagle, 1965; Ford, 2000; Goodenough, 1976; Pithers, 2002; Witkin & Goodenough, 1981).

Psychological Differentiation. To accommodate new findings and insights that were found in other personality areas and would not be described under the articulated versus global construct, Witkin and his associates placed the description of field dependence and independence in a broad theoretical framework of psychological differentiation in 1962 (Witkin et al., 1962; Witkin et al., 1977). Differentiation revealed individual differences in terms of autonomy versus reliance on external referents (Davis & Cochran, 1990). An articulated versus global field approach became one manifestation of degree of differentiation. Witkin stated that the degree of differentiation is an essential feature of the structure of any system (Witkin et al., 1962). In brief terms, it refers to the "complexity of structure of a psychological system" (Witkin, 1978, p. 15).

The most obvious application for instruction and learning resulting from the theory of psychological differentiation is self-nonself segregation, which has two sub-dimensions: autonomy of interpersonal relations and cognitive restructuring (Jonassen & Grabowski, 1993). Witkin (1978) believes that with the development of the field dependent-independent concept, the self-nonself segregation aspect of differentiation becomes centrally important to psychological differentiation. There are more definite and firmer boundaries "between an inner core of attitudes, feelings, and needs identified as the self, and the outer world, particularly other people" (Witkin, Goodenough, & Oltman, 1979, p. 1127). The degree of self-nonself segregation was thought to influence the degree that people rely on internal or external frames of reference in processing information (Witkin, 1978). Furthermore, Witkin emphasized that the tendency to rely primarily on internal or external referents is very important and is likely to influence the development of a more impersonal or interpersonal orientation. It is also likely to affect a person's cognitive restructuring ability, whether the person will restructure a field on his or her own or follow the dominant information as given. The internal referent refers to self, while the external referent refers to outer world sources. Witkin and his associates (1979) hypothesized that field dependents are assumed to have a less self-nonself segregation, with greater connectedness between self and other people or external referents; less autonomy; and more global functioning both socially and intellectually. They stated that this lesser autonomy and greater connectedness with others is believed to promote the development of greater interpersonal competencies and social skills in relatively field dependent people. On the other hand, field independent people are assumed to have more self-nonself segregation with a more articulated body concept and a greater sense of personal identity. They also have greater cognitive restructuring skills and greater autonomy from external sources of information—especially from other people—when performing intellectual activities or interacting in a social situation. Theoretically, this degree of self-nonself segregation leads to a more impersonal orientation among field independents since they are able to function with greater autonomy; they appear to have greater polarity between self and others that impedes the development of interpersonal competencies (Witkin et al., 1979; Witkin et al., 1977).

A key difference between field dependents and field independents is the cognitive restructuring ability. The term cognitive restructuring refers to, "1) providing structure for an ambiguous stimulus complex, 2) breaking up an organized field into its basic elements, and 3) providing a different organization to a field than that which is suggested by the inherent structure of the stimulus complex" (Riding & Cheema, 1991, p. 198). The cognitive restructuring ability of a field independent person is derived from the ability to draw upon internal referents (Witkin et al., 1962). Jonassen and Grabowski (1993) report that cognitive restructuring skills have been viewed as essential to problem solving, which can affect learning and instruction. Cognitive restructuring is often necessary when learning occurs. Witkin (1978) reports that studies found a difference between field dependents and field independents when they were provided ambiguous information and under a unstructured context; however, no differences were found when unambiguous situations with inherent structure were applied. The results showed that field dependents could perform the same as field independents when instructional materials were well organized and structured.

Although the field dependent-independent construct has been described as a cognitive style, it is important to be keep in mind that cognitive restructuring is defined as an ability dimension, which holds implications for its relationship with measures of intelligence (Witkin & Goodenough, 1981). However, since field dependent people are likely to have greater interpersonal competency but also greater difficulty in cognitive restructuring, and field independent people are likely to have lesser interpersonal competency and greater cognitive restructuring skills, it is hard to conclude that there is an overall preference for field independence over field dependence. To improve students' academic achievement, instructional designers should place no value judgments on field dependence or field independence but instead explore the interaction between cognitive style, instructional strategies, and tasks or situations.

Characteristics of Field Dependence-Independence

As one of many constructs included in the category of cognitive styles, field dependence-independence shares several features with other cognitive styles: they are process variables, pervasive dimensions of individual functioning, stable and consistent over time as well as across domains, and bipolar and value-neutral (Witkin, 1978; Witkin & Goodenough, 1981). There are also characteristics that differentiate field dependent people from field independent people. Although most people demonstrate some traits of both styles, the following characteristics are meant to describe extreme behaviors (Saracho, 1989). To design an effective instructional process, it is beneficial for instructional designers to possess knowledge of these characteristics.

Decades of research on both perceptual and problem solving tasks indicate that individuals are different in the ways they perceive information. These characteristics reflect individual’s preferred modes of relating to, classifying, assimilating, and organizing their environment (Ramirez III & Castaneda, 1974). Field independent individuals are active in processing information with a hypothesis-testing approach. They analyze existing organization and impose structure on a field when it lacks a clear or inherent one (Witkin & Goodenough, 1981). They focus their attention on task-relevant information and ignore distractions better than field dependent individuals (Davis & Cochran, 1990). Field independents who approach a field in an analytical way and extract elements from its complex background have greater disembedding ability in perceptual functioning and better cognitive restructuring than field dependents (Jones, 1993). However, an inverse relationship was found between the cognitive restructuring skills and social skills among field independents; that they maintain more personal distance when communicating with others, are less sensitive to social cues, and have been characterized as being demanding, inconsiderate, manipulative, and cold and distant in relationships (Witkin & Goodenough, 1981).

Field dependent individuals are passive in perceiving information, taking a spectator approach to concept attainment and accepting the structure of a field as it exists. They tend to perceive information in a holistic manner, are less flexible in their search strategies, and have a difficult time to attending to relevant cues, especially if presented with distractions or nonsalient attributes or cues (Davis & Cochran, 1990). Field dependent learners may require more explicit instruction and feedback when undertaking problem solving tasks, more detailed descriptions about instructional goals and objectives, and more externally reinforcement than field independent learners (Witkin et al., 1977). Garity (1985) found that field dependent individuals (a) seek verbal and nonverbal feedback, (b) are motivated by social approval, (c) prefer to be emotionally and physically close to others, and (d) are more sensitive to faces and social cues. Ramirez III and Castaneda (1974) report that field dependents did best on verbal tasks during intelligence tests and were sensitive to others' opinions.

Researchers (Goodenough, 1976; Witkin & Goodenough, 1981; Witkin et al., 1977) have summarized the differences between these two styles in terms of psychological domain, social domain, and learning context. In the psychological domain, "FIs have a distinctive internalized frame of reference, whereas FDs rely more on external referents. In the social domain, FDs have greater interpersonal and social skills, whereas FIs have a more impersonal orientation and pay less attention on social cues" (Jones, 1993, p. 199). This leads to implications for learning situations: "FDs are disadvantaged in unstructured situations, whereas FIs tend to provide their own structure more readily; FDs prefer directions and feedback, whereas FIs are less dependent on feedback; FDs rely more on others for information, whereas FIs are less influenced by peers" (Jones, 1993, p. 199).

Reviewing the characteristics of field dependent and independent learners from an educational perspective, researchers (Thompson & Thompson, 1987; Witkin et al., 1977) summarized field dependent-independent characteristics related to learning (see Table 1).

Table 1

Characteristics of Field Dependent-Independent Learners

	Field Independent Learners	Field Dependent learners
1	Impose organization on unstructured field	Take organization of field as given
2	Greater use of mediational processes such as analyzing and structure	Less effective use of mediational processes
3	An active, hypothesis-testing role in learning	A passive, spectator role in learning
4	Learning curve is discontinuous in that there is no significant improvement in learning of a new concept until the appropriate hypothesis is found, then sudden improvement	Learning curve is continuous in that gradual improvement is seen as relevant cues are sampled
5	Less dominated by the most salient cues in learning	More dominated by salient cues in learning
6	Use structures and reorganize materials for more effective storage and retrieval of information	Use existing organization materials in cognitive processing
7	Internally defined goals and reinforcements	Externally defined goals and reinforcement
8	Prefer to learn general principles and acquire them more easily	Prefer to learn specific information and acquire it more easily
9	Intrinsic or task-oriented form of motivation	Extrinsic forms of motivation
10	Learn better on learner-central learning task	Learn better with socially relevant information

This comparison provides a concise summary and insight into how field dependent and independent individuals differ in their respective approaches to learning. Davis (1991) states that both field dependent and field independent learners have unique strengths in learning. Field dependent learners are superior in social skills, whereas field independent learners are superior in cognitive restructuring skills. Moreover, he points out that even though neither end of the continuum is clearly superior in concept attainment or intelligence, educators place more value on those characteristics associated with field independent learners. Psychologists and educators also view these characteristics as leading to better learning performance.

Information Processing Theory and Field Dependence-Independence

Messick (1967) describes cognitive styles as “information processing habits” (p. 190) and proposed that such a characterization would improve further understanding of field dependence-independence perception functioning and problem solving. Differences in information processing behaviors between field dependent learners and field independent learners can be indicated as one explanation for variations in learning (Chinien & Boutin, 1993). In addition, Messick (1986) also reports that one of the major traditions providing the historical underpinnings for Witkin’s contribution to research on cognitive styles is an emphasis on regularities in information processing.

Davis and Cochran (1982; 1989b) state that there is a link between field dependency and information processing in that field dependents are different from field independents in the three general stages of the information processing model of cognition: attentional processes in the sensory-memory stage, encoding of information into short-term memory, and the retrieval processes of long-term memory. Davis (1991) reported that field dependent learners were found to be less efficient in analyzing, organizing, attending, encoding, and processing information.

Tinajero and Paramo (1997) reported that learners with different cognitive styles pay attention to different aspect of information; encode, store, and recall information differently; and think and comprehend in different ways.

Goodenough (1976) proposed a hypothesis that field independent learners and field dependent learners differ in terms of attentional processes. He states that in solving concept-attainment problems, field dependent learners are mainly dominated by the most noticeable or salient features of a stimulus. They tend to ignore many other features of a complex stimulus and are easily distracted by irrelevant cues. These differences become more amplified when irrelevant cues are presented and as the amount of information is increased. A study by Blowers and O'Conner (1978) supports Goodenough's hypothesis. They found that, compared to field independents, field dependents used more time and had greater eye movement during the Rod-Frame Test, which implied that field dependent subjects have problems selectively attending to the relevant part of a visual field and need to scan more of the visual stimulus in the selection process. The same results were found in a study by Shinar, McDowell, Rackoff, and Rockwell (1978). A study by Avolio, Alexander, Barrett, and Sterns (1981) reported that when subjects were asked to attend to or isolate a relevant stimulus from a competing, irrelevant stimulus, field dependent subjects were found to make more errors than field independent subjects in both visual and auditory modes. It indicates that field dependent learners are generally less efficient in attending to relevant cues than field independent learners, especially when relevant cues are presented with distracting cues (Davis & Cochran, 1990; Jolly & Reardon, 1985). Davis and Cochran (1990) suggested, "attentional differences could be accommodated by teaching techniques which help focus a field-dependent child's attention on critical features of the information to be processed or learned" (p. 12).

Davis and Cochran (1982) proposed that there is a possibility that field dependent learners differ from field independent learners in encoding information into short-term memory/working memory. Cochran and Davis (1987) found that field independent learners have larger working memory capacity than field dependent learners. They concluded that field independent-dependent cognitive restructuring differences are related to working memory capacity and may influence verbal task performance. If field independent readers have more working memory capacity, they are likely to process textual integration during reading more efficiently than field dependent readers (Cochran & Davis, 1987). These results confirmed the impact of information-processing mechanisms on field dependent-independent differences (Cochran & Davis, 1987; Davis & Cochran, 1982). Frank (1983) studied encoding on a recall task using an encoding-specificity paradigm. The results of this study showed that field dependent and field independent learners had no differences in performance when the recall cues were the same as those presented during acquisition. However, when the recall cues were different, field independent learners performed better than field dependent learners in encoding processes. The difficulties with selecting attention also resulted in less efficient encoding, short-term memory, and long-term memory processes.

Berger and Goldberger (1979) found no differences between field dependent and field independent subjects on simpler learning tasks. However, field independents did recall significantly better than field dependents in more difficult interference tasks. The results indicated that there were little or no differences between field dependent and field independent individuals under low cognitive information load; however, when large amounts of information were to be processed, field independent individuals were more accurate and efficient in their recall and recognition performance (Davis & Cochran, 1982, 1990). A later study by Lange

(1995) supported this notion and reported that when cognitive load is high, only the most salient and vivid features are easily encoded by field dependents. In addition, Berger and Goldberger (1979) suggested that by providing field dependent learners ample time and practice activities, the encoding differences between field dependents and field independents could be accommodated.

Davis and Cochran (1990) stated that memory differences exist between field dependent and field independent learners in some long-term memory storage and organizational processes. Spiro and Tirre (1980) studied the recall of information presented in a prose passage and indicated that field independent learners are more likely than field dependent learners to employ previous information as a means of facilitating recall. A number of studies (Brooks, Dansereau, Spurlin, & Holley, 1983; Pierce, 1980; Strawitz, 1984) also indicated that field independent learners generally performed better in the recall, perhaps because of the organization and structuring processes they utilize in storing and retrieving information. In 1979, Davis and Frank (as cited in Davis & Cochran, 1982) reported:

> (a) that field independent learners tend to cluster more than field dependent learners, (b) that word lists with more difficult patterns of organization are recalled better by field independent learners, and (c) that field independent learners have better recall when given the opportunity to organize the material (p. 6).

Davis (1991) recommends that in order to accommodate field dependent learners' difficulties with long-term memory, they should be provided with organizational and structural aids, such as outlines and objectives, and direct instruction using appropriate strategies.

In summary, field independent individuals perform better than field dependent individuals in selective attention, encoding to short-term memory, and long-term memory processes. Field independent learners are also more efficient than field dependent learners in information-processing factors. Examining field dependence-independence from an information-processing framework may help instructional designers create effective computer-based instruction to accommodate field dependent learners' special learning needs.

Field Dependence-Independence and Academic Achievement

Field dependence and independence has been recognized as having important educational implications (Ausburn & Ausburn, 1978; Canelos, Taylor, & Gates, 1980). Many experimental studies have shown the impact of field dependence and field independence on the learning process and on academic achievement. Davis (1991) summarized that there have been two general research approaches: one examined the relationship between field dependency and academic achievement using samples from different curriculum subjects and across different grade levels; the other focused on identifying appropriate instructional design strategies that might accommodate the differential learning characteristics of students with different field dependent-independent cognitive styles. Although field dependency has been extensively investigated and reviewed in diverse domains of psychology (Witkin & Goodenough, 1981), the review of literature for this study focuses on exploring the effects of field dependent-independent cognitive styles on teaching and learning.

Tinajero and Páramo (1997; 1998) concluded that field dependence and independence is related to overall academic achievement. Witkin and his associates stated that field independent learners have been found to perform significantly better than field dependent learners in mathematics, science, engineering, and architecture (Witkin et al., 1977). Field independent learners have also been found to be better at concept attainment (Goodenough, 1976). Although Goodenough showed that there were no differences in grade point average between field dependent and field independent students, there was a trend that field independent student were more likely to choose courses related to science and field dependent students were more likely to include courses from the humanities and social sciences (Witkin & Moore, 1974). Meanwhile, other researchers reported that field dependents and field independents perform equally well on a simple learning task; however, as the learning task becomes more difficult, field independent learners perform better than field dependent learners (Daniels & Moore, 2000; Davis & Cochran, 1989a; Niaz & Logie, 1993; Witkin & Goodenough, 1981).

Davey and Menke (1989) studied the impact of individual differences on the acquisition of reading skills and concluded that field independent readers perform better than field dependent readers on measures of reading comprehension. They indicated that field independent readers might have better comprehension abilities because of their higher cognitive skills in areas such as organization of knowledge recall, use of context cues, use of imagery, and active hypothesis-test behaviors. Other studies supported and confirmed this relationship (Annis, 1979; Cochran & Davis, 1987; Collins-Eiland, Dansereau, Brooks, & Holley, 1986; Garner & Cole, 1986).

Nasser and Carifio (1993) studied the effects of cognitive style and Piagetian logical reasoning on solving an algebra word problem in which certain key context features were provided. Their assumption was that context might play a significant role in influencing how students approach, analyze, and restructure word problems. Thirty-seven college students and one hundred ninety-three high school students took part in the study. They found that field independent students performed higher across all of the problem features. The results indicated that there is an impact of cognitive style and context features in mediating a student's ability to solve algebra word problems.

Liu and Reed (1994) conducted an experimental study that explored the relationship between cognitive styles and learning strategies in a hypermedia-based second language learning environment. They discovered that field dependent learners showed different learning patterns from field independent learners in that field dependent learners watched more video clips to obtain a global view of the whole instruction, while field independent learners paid more attention to the relationship of the structure of the instructional materials. Field independent learners also used the index tool more than field dependent learners. They also found that field dependent learners were comfortable manipulating the courseware without worrying about getting lost, while field dependent learners tended to follow the provided sequences. The results of this study supported the assumption that field dependent people are holistic and require external help, while field independent people are serialistic and possess internal cues to help them solve problems. Although there was little difference in the use of support strategies such as help, map, note taking, and exercise tools, the use of hypermedia in instruction did provide a promise for instructors to find ways to match instruction-type to learning style.

By examining the achievement of nursing students who were enrolled in a two-year distance learning Bachelor of Health Science program, Luk (1998) reported that field independent learners performed significantly better than field dependent ones. Results of this study indicated that the field dependent learners might have trouble succeeding if the instructional package is not organized and does not have explicit instruction in problem-solving techniques.

Tinajero and Páramo (1997) examined the relationship between field dependency and academic achievement in various school subjects using the Rod-Frame Test and the Group Embedded Figures Test. Their sample consisted of 408 students between the ages of 13 and 16.

They found several interesting results that had significance for future studies. Field independent learners performed better than field dependent learners in general and in a number of specific subjects when the researchers examined the results of the Group Embedded Figures Test. However, based on the Rod-Frame Test, they did not find a relationship with academic achievement. They also found that between-sex differences could help explain the relationship between field independence and academic achievement in that boys and girls performed differently in certain subjects.

Tinajero and Páramo (1998) also reviewed literature about the relationship between field dependency and academic achievement in the areas of language, mathematics, natural sciences, social sciences, art, music, computer science, and overall achievement in school. They reported that with the exception of a study by Witkin, et al. (1977), all studies indicated that field independent students perform better at school than field dependent students. They suggested (1997; 1998) that future research examine the between-individual differences in information processing strategy—especially in memory and attention—that directly impact academic achievement. They also suggested exploring possible intervention strategies specifically aimed at accommodating the deficiencies of highly field dependent students.

Donnarumma, Cox, and Beder (1980) investigated the relationship between field dependence-independence and the successful completion of the General Educational Development Test (GED). They reported that, "57.1% of the field dependents dropped out of the program, 33.3% failed, and 9.5% passed the GED. In contrast, of the field independents, 31.6% dropped out, 15.8% failed and 52.6% passed" (p. 227-228). Their findings supported the hypothesis that field independent learners would outperform field dependent learners.

Meanwhile, they suggested that providing dynamic design formats to facilitate student's diverse information processing approaches might increase learning performance.

Knappenberger (as cited in Demick, 1998) asserted that many researchers have tried to set up a positive connection between field dependence-independence and intelligence by stating that individuals who performed better on the embedded figure test will also perform better on intelligence test; however, results of empirical studies have not provided overwhelming evidence to support this assumption. While many authors have reported a significant association between field dependence-independence and achievement, others have not found a relationship (Abouserie, Moss, & Barasi, 1992; Burwell, 1991; Canino & Cicchelli, 1988; Chandran, Treagust, & Tobin, 1987; Fitzgerald & Semrau, 1998; Kini, 1994; Noble & Frank, 1985; Roberge & Flexer, 1984).

Some contradictory results have also been obtained. Fleming (1984) examined the relationship between field dependence-independence and the design of instructional materials by investigating the eye movements of learners studying print materials that featured text and pictures. Twenty-four graduate students were randomly assigned to one of two page layout treatments: pictures-first-then-words or words-first-then-pictures. The design variables were text complexity (simple or complex) and page layout. Learner variables were gender, cognitive style (field dependence-independence), and prior knowledge. The dependent variable was visual attention as indicated by eye-movement data. The results indicated that cognitive style by layout revealed no differences for the verbal area but significant differences for the pictorial area. Field independent subjects looked longer and more often at picture areas on the complex page than did field dependents, which was not predicted and inconsistent with other studies (Witkin & Moore, 1974).

Greco and MaClung (1979) studied the effects of using attention-directing techniques during instruction on field dependent and independent learners. The audio portions of a slide-tape lesson were manipulated by supplementary sound audio narration and attention-directing audio narration. They reported that field independent learners performed superior than field dependent learners. Contrary to their original hypothesis, field independent students benefit more from attentional-directing strategies than the field dependent students.

Joseph (1987) investigated the effectiveness of observable visual imagery strategies for the encoding of verbal information from a computer-based instruction. A special attention was also given to the effectiveness of the strategy for field dependent-independent learners. Fifty-four undergraduate and graduate students with aged from 20 to 54 were randomly assigned to one of three treatment groups: (a) control group with no visual or rehearsal strategies imbedded in computer-presented text, (b) text with line drawings presented on a handout, or (c) text with observable visual imagery rehearsal. Four criterion tests (drawing, identification, terminology, and comprehension), which were designed to assess achievement of different learning objectives, were used to measure the performance. Subjects were identified as field dependent or field independent based on the Embedded Figures Test. Results showed that field independent subjects who reviewed text with line drawings performed better than field independent subjects who received no illustrations or rehearsal strategy. Field independent subjects scored markedly lower when required to engage in the observable visual imagery strategy. Compared to field independent subjects, field dependent subjects performed better when required to engage in the observable visual imagery rehearsal than received text with no illustrations and line drawings.

Tinajero and Páramo (1997) summarized the deficiencies of previous studies that likely caused the inconsistent results regarding the relationship between field dependency and academic achievement: (a) most of the previous research investigated the relationship in specific school subjects; few studies involved simultaneous assessment of achievement across full academic subjects, (b) there was a lack of consideration of the possible effects of other variables on the observed relationship and the possible confounding effects of intelligence, and (c) researchers have paid little attention to the bidimensionality of the field dependent-independent construct and the unipolar dimension of restructuring ability, which may indicate that the Rod-Frame Test and the Group Embedded Figures Test are measuring different things. Furthermore, they concluded that the origin of the inconsistency might be the wide diversity of methods used for evaluating achievement, the variety of instructional methodologies, or the degree of structuring of teaching materials (1998).

Field Dependency and Design of Instruction

Gagné (1982) has stressed the importance of integrating cognitive styles into the design of curriculum and instruction and emphasized the incorporation of internal (cognitive) and external (affective) domain components into instruction. He further stated that the critical key to effective instruction lies in understanding the scope of students' learning or cognitive styles and to designing instructional materials that can act in response to students' individual needs. The design of instruction for field dependent learners requires careful attention. Numerous researchers have attempted to determine the relationship between field dependency and the design of instructional materials (Abraham, 1985; Canelos et al., 1980; Daniels & Moore, 2000; Dwyer & Moore, 1992b; Fleming, 1984; Greco & McClung, 1979; Joseph, 1987; Kiewra & Frank, 1986; Myers, 1997; Reardon & Moore, 1988; Rickards, Fajen, Sullivan, & Gillespie, 1997; Summerville, 1998; Weller, Repman, & Rooze, 1994).

Satterly and Telfer (1979) examined the relationship between cognitive style and advance organizers in learning and retention. One hundred and eighty subjects aged ranged from 14 to 15 were randomly assigned to three treatment groups (lessons, lessons with advance organizers, and lessons with advanced organizer plus specific reference to its organizing properties). A significant interaction between instructional treatments and cognitive style was observed that indicated that in the complex task of processing material, field dependent students required more help in being made aware of the structure of the materials so as to facilitate their knowledge acquisition.

Kiewra and Frank (1986) examined the recall and recognition performance of 108 undergraduate students who were identified as field dependent or field independent by finishing the Hidden Figures Test (HFT). Three independent factors were examined in this study. Each of these three factors have two levels: Cognitive style (field independence, field dependence), notetaking (structured, unstructured), and recall (cued, free). The results of the 2x2x2 factorial ANOVA indicated that field independent students performed better than field dependent students. Field dependent learners recalled more of the textual material when provided with structure during both acquisition and recall. However, cues provided at the acquisition stage should match the cues provided in the testing stage; otherwise, it will hinder field dependents' recall performance.

A study by Reardon and Moore (1988) investigated the use of varying formats for presenting complex visual information in the form of a fictitious map. They attempted to determine whether manipulating the display format of those visuals would affect students' learning performance from them. Ninety-two subjects were randomly assigned to three treatment groups: additive, part-by-part, and intact visuals. The GEFT test was used to measure the levels of field dependency. The results indicated no significant difference in learning among the three treatment formats, but field independent students performed better than field dependent students on the learning task. The data supported the notion that providing structure and separating complex information into a more manageable format would aid field dependent students' learning performance.

Myers (1997) examined the relationship between field dependence-independence and the type of visual presentation format (color, black and white, or line drawings) used in a computer-based tutorial on identifying human tissue samples. Two hundred and four college students were randomly assigned to one of the three treatment groups after being administrated the Group Embedded Figures Test. No significant interaction was found between cognitive style and treatment. However, there was a significant difference between field dependents and field independents in terms of their learning performance; field independents scored significantly higher on the posttest than field dependents. Myers indicated that less complex visual are not required to increase the effectiveness of field dependents' ability to learn from a computer-based instructional system.

Chobot (1984) studied the interactive effects of field dependence and adjunct questions on learning from prose. One hundred and four graduate students were randomly assigned to three treatment conditions (adjunct prequestions inserted before the prose passage, adjunct postquestions inserted after the prose passage, and no questions). The GEFT was used to measure the field dependence orientation of subjects. The findings showed that under the no question condition, field independents scored higher than field dependents. Providing questions before the prose passage facilitated field dependents' short-term retention of knowledge more than either questions after the test or no questions.

Hsu and Dwyer (2004) examined the instructional effects of various levels of adjunct questions inserted within hypermedia programs and concluded that using higher-order adjunct questions for certain kinds of learning not only can improve the learning of field independent learners but also can improve the achievement levels of field dependent learners. Rickards and his associates studied the relationship between signaling, note taking, field dependency, and text comprehension and recall (Rickards et al., 1997). They suggested that note taking in the presence of signals enhanced the recall of field dependents but not field independents; field independents automatically used a tacit structure strategy when left to their own devices, and field dependents had more effective learning when induced to use additional learning strategies, such as note taking. Their results contradicted an earlier study of Annis (1979), who examined the effects of cognitive styles and learning technique effectiveness. Annis found that even though a passage was well organized, field dependent students did not perform as equally well as field independent students in completing items of high-structured importance, regardless of whether the passage was organized or unorganized. However, a study by Dwyer and Moore (2001) suggested that when combining specific directions and color-coded illustrations in the content of the instructional materials, field dependent students can perform as equally well as field independent students.

Canelos, Taylor, and Gates (1980) examined field dependence-independence cognitive styles and the effects of three levels of visual stimulus on students' information processing ability. They concluded that compared to field independents, field dependent students had information processing deficiencies when learning from complex visuals on more difficult instructional objectives. The results also showed that if the same instructional procedures were used for all students, field dependent learners might have more difficulty interacting with certain materials. One way to compensate for this disadvantage is to provide some variation in instruction that accommodates individual learner's cognitive styles. Weller, Repman, and Rooze (1994) studied field dependency and the effectiveness of four treatments in computer-based instruction. The four treatments varied according to the presence of advance or structural organizers and navigational cues. They reported that field independent learners performed better than field dependent learners did across all treatments.

Hahn (1984) studied three modes (conventional lecture, multimedia package, and computer-assisted method) of teaching university students how to use a particular program to conduct a computer search of several databases. Hahn (1984) found that field independent students performed significantly better than field dependent ones, but there was no significant interaction effect between cognitive style and modes of searching. Daniels and Moore (2000) examined the interaction between field dependency and learner control of presentation mode within an educational hypermedia environment. The GEFT was administrated to assess the level of field dependency. One hundred and twenty-two high school students were randomly assigned to either the control group (program control of presentation mode) or the treatment group (learner control of presentation mode). The study reported no significant interaction between field dependency and media selection but indicated that field independents scored significantly higher than field dependents in both experimental groups.

By examining variables that may be important in the design of instructional content tailored to accommodate individual cognitive differences, Summerville (1998) conducted a study that explored three variables—awareness of cognitive style, field dependence-independence, and match or mismatch of instructional environment to cognitive style—and their effect on students' academic achievement in a hypermedia learning environment. One hundred and seventy-seven undergraduate students participated the study. Half of the subjects had knowledge of their cognitive style. Subjects were divided into field dependent or field independent groups based on their scores on the Group Embedded Figures Test. The instructional material was a Hypercard stack that was designed to teach students how to design Hypercard Stacks. There were two treatments; each one was designed to accommodate the special needs of either field dependents or field independents. The treatment designed for field independents had minimal structure and less instructional support. In contrast, the treatment designed for field dependents was highly structured and featured extensive instructional support. A 2x2x2 multivariate analysis of variance (MANOVA) was used to identify the interactions between the three variables. The results indicated that awareness of cognitive style and matching/mismatching with instructional treatments did not affect participants' academic performance. However, one interesting finding was that field independent students who were assigned to the treatment designed to accommodate field dependent students' special learning needs "had a tendency to blame external resources for their perceived lack of success" (p.441).

Field Dependency and Instructional Technology

Throughout the extraordinary development of technology in the past century, instructional technology, a dynamic emerging field, has gone through rapid changes, expansion, and divergence and has been widely used to support and enhance the teaching and learning process and accommodate students' learning needs (Chin, 1994; Daniels & Moore, 2000; Glennan & Melmed, 1996). Although there are disagreements about its meaning and the boundaries of the field, the definition which is most appropriate for this review is that "instructional technology is the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning" (Seels & Richey, 1994, p.

9). The definition not only emphasizes the importance of using instructional media and technology to support learning, it also encompasses the analysis of the design, development, implementation, evaluation, and management of instructional processes. It demonstrates the vital role of “theories and practices derived from behavioral, cognitive, and constructivist theories in the solution of instructional problems” (Seels & Richey, 1994, p. 9).

Instructional technology has also been identified as the field of instructional design and technology since professionals in the field often use “systematic instructional design procedures and employ a variety of instructional media to accomplish their goals” (Reiser, 2001 , p.53). Because the analysis of learners’ needs and characteristics is one of the critical components to designing an effective teaching and learning process (Dick, Carey, & Carey, 2001), it is assumed that learners’ field dependent-independent cognitive styles might be a factor to consider in the design of effective technology-enhanced learning environments.

The relationship between the field dependent-independent cognitive style and the field of instructional design and technology have been studied for decades; this corresponded with the investigation between cognitive style and instructional text (Thompson, 1988), the personalized system instruction (PSI) (Jacobs, 1982), hypermedia (Leader & Klein, 1994; Summerville, 1998), distance education (Brenner, 1997; Chen, 1998; Riddle, 1992; Thompson & Knox, 1987), and computer-based instruction (Hettinger, 1988; Ikegulu & Ikegulu, 1999; Post, 1987; Smith, 1974; Thompson, 1989; Whyte, Knirk, Casey, & Willard, 1991). Although the results of these studies are not consistent, they provide some significant findings that are worth noting: (a) instructional treatments can be specifically designed to match learners’ cognitive style learning trait, (b) the development of cognitive restructuring skills can be fostered by appropriate educational efforts, (c) technology-enhanced courses can be designed to accommodate and address learners' cognitive styles. Post (1987) also points out that further study is needed to explain the variance in student achievement when students are exposed to instructional technology-enhanced learning materials.

Instructional technology can help tailor instruction to meet individual learner's needs and abilities (Glennan & Melmed, 1996). Daniels and Moore (2000) stated that instructional technologies have served an important role in facilitating teaching and learning, especially in accommodating individual students' unique learning needs. One of the driving technologies has been the use computer-based instruction (CBI), which can be used to accommodate and improve instruction for large numbers of diverse students.

Researchers have begun to focus their attention on the design of the instructional messages that are being sent to the learners as well as the methods of delivery (Fleming & Levie, 1978). Instructional designers must consider how message form and structure influence information processing (Winn, 1993) and make the instructional materials minimize cognitive processing burdens so that learners' mental effort is spent on processing task relevant information so as to enhance learning performance. The psychological characteristics of the user and the design of the computer interface need to be taken into consideration during the instructional design process (Card et al., 1983). Therefore, issues such as learners' individual differences in perceiving information and how those differences interact with on-screen message design to impact learning performance should be considered.

Instructional designers have studied the field dependent-independent construct with the belief that instructional materials can be designed to compensate for individual learner differences (Ausburn & Ausburn, 1978). French (1983) reported that most studies concerned with determining the relationship between cognitive style and design of instructional strategies have manipulated the presentation strategies of the instructional materials. To compensate for the restructuring skills absent in field dependent learners, strategies that impose structure on instructional materials via different cues have been implemented. Researchers (Grieve & Davis, 1971; Satterly & Telfer, 1979) support the view that field dependent learners benefit from the restructuring aspect of these strategies, while field independent learners are not hindered by this imposed structure. Since computer-based instruction is an individual or independent type of learning experience, attention-directing learning strategies should help learners identify relevant information that should be learned.

With the advanced development and integration of computer technologies in teaching and learning processes, instructional designers have more opportunities to design learning environments that meet diverse learners' needs and desires. Since an individual's cognitive styles are somewhat stable and consistent across time and tasks, and if the individual is having difficulty processing specific types of information because of cognitive style, it is very likely that one can modify the instructional design of the learning materials and situation to overcome this difficulty. To design effective instructional materials, instructional designers should specifically address learners' preferences and needs by providing them with stylistically appropriate cues and organizing the instructional content so as to improve their learning (Sadler-Smith, 1996).

Cueing Strategies

Instructional designers have studied the field dependent-independent construct with the belief that instructional materials might be designed and used to compensate for individual learner differences (Ausburn & Ausburn, 1978). These materials would be structured to eliminate cognitive style bias against field dependent students (Crow & Piper, 1983). Witkin, et al. (1977) argued that since field dependent learners view the dominant arrangement of a field as a given and have difficulties departing from that arrangement, the effects of cue salience are more prominent for field dependents than for field independents. Gagné's (1985) theory regarding the conditions of learning suggests that the internal processes of learning can be influenced by external events. Dick, Carey, and Carey (2001) also address this in their instructional design model when they assert that using cues to search information stored in memory is one of the essential functions of the "condition" component for behavioral objectives. The provision of cueing strategies as external events may direct the attention of learners by providing clues as to what aspects of the materials to attend to for successful learning.

Inserting cues in the instructional text provides a mechanism to help learners organize complex information, as the use of cues can direct or focus their attention on areas that are important to the instructional goals and objectives (Dwyer, 1978). These types of instructional strategies have been shown to compensate for students who have perceptual deficiencies in comprehending visual information (Dwyer, 1978). Flemming and Levie (1978) stated, "one of the most obvious manipulations of the learning environment is that of modifying the instructional stimuli to be presented" (p. 112). They added, "instructional messages can control the effective stimulus either by adding or subtracting cues or by making cues more or less salient (prominent, noticeable)" (p. 112). They believe that "learning is facilitated where critical cues are salient (dominant, apparent, conspicuous)" (1978, p.115). They also point out that if the cues added to an instructional message can facilitate learning if they are familiar to the learners and direct their attention to the relationship between the new information and the previous knowledge. "Simply reminding the learner how new facts relate to old both adds an element of familiarity to the new and changes isolated (meaningless) new facts into meaningful additions and extensions of previous cognitive structures and relationship" (Fleming & Levie, 1978, p.

122). Thus, simply focusing students' attention on the critical information within a text message might not be enough to guarantee a successful learning performance; additional assistance might be needed to help learners understand the meaning of the key information or concepts.

Researchers have defined cueing from different perspectives. Goldstein (1981) describes cueing as "a type of rehearsal strategy that involves the presentation of a word associate (usually a category name) to be utilized for the retrieval of items in recall" (p. 22). Turcott (1986) defines cueing as "a technique whereby individual stimuli or elements within a visual array are made distinct from each other" (p. 9). He states that a cueing device refers to "a specific attribute (color, arrows, or shading) which is used to make specific elements distinct to the viewer" (p. 10). Partee (1984) defines a cue as "a verbal or visual strategy by which the perceiver's attention is focused upon perceptual information" (p. 12). Dwyer (1978) has defined cueing as "the process of focusing learner attention on individual stimuli within the illustration to make the essential learning characteristics distinct from other stimuli" (p. 158). Other authors in instructional message design use the term *indicating cues* (Brown, 1978; Brown, Lewis, & Harcleroad, 1973). Brown (1978) mentions that indicating cues have also been commonly referred to in the literature as *attention-directing techniques* or merely *cues*. Cues also have been described as *attention-getting devices* (Norman, 1969) or *attention gaining techniques* (Dwyer, 1978). Since this study dealt with cues used in a computer-delivered text message, "cueing strategy" was defined as an attention-directing strategy designed to focus learners' attention on specific information within a computer-based text message with the intention of improving their acquisition of the desired skills and knowledge.

Cues have been categorized as verbal cues and visual cues (Anderson & Armbruster, 1985). Verbal cues include instructional objectives, advance organizers, adjunct questions, signal phrases, and other similar strategies. Visual cues include type styles, text color, underlining, capitals, typographic cuing achieved by manipulating the typeface of text, and similar strategies. Allen (1975) summarized the literature on visual cues and reported that “relevant cues which emphasize material to be learned within an instructional communication may increase the learning of that material for all [intellectual] ability groups.” (p. 151). Dwyer (1972; 1978) described visual cues as attention-directing techniques that can be utilized within instructional materials to focus learners’ attention on certain stimuli or critical aspects of the materials.

Bloom (1976) provides several important views about cues for instructional designers. First, cues must be understood and comprehended by the learners. If cues are familiar and have been used by the learners before, they are more likely to be easily learned in a new context. Second, different learners may respond differently to particular cues. Some students may learn better when provided with verbal cues, while others may learn better when provided with visual cues. Researchers and instructional designers have focused much attention on finding the best *one* form of presenting cues to facilitate learning, which may not be the best approach. Finally, Bloom indicates that the development of new technologies might allow for a variety of instructional methods to help learners to secure the cues they need for learning.

Functions of Cueing Strategies

Dwyer (1978) reported that the ability to focus attention on relevant cues is fundamental to learning. During instruction, the primary function of cues is to direct students’ attention and reduce the amount of time necessary to acquire the desired information. He states that cueing strategies have been employed to improve learning and that these strategies have been identified as “being effective in attracting and sustaining student attention for extended period of time …”

(p. 159) and they have been identified as effective tools "in focusing, isolating, and structuring information being transmitted" (p. 159).

Dwyer (1978) described two functions of instructional cueing strategies. The first function is to assist learners in extracting the intended instructional stimuli from their overall perceptual fields. The second function is to provide elaborated relevant information or stimuli to help learners to completely understand the information that they perceive. Similarly, Stewart (1988) identified two functions of cueing strategies: (a) as an instructional strategy, cues enable the learner to recognize the expected learning goals and implement appropriate methods to finish the task, and (b) cues represent the structure and organization of the text and activate the learning schema.

Gagné (1985) proposed a theory describing nine events of instruction. He described gaining attention as the initial event of instruction. There is a perception that learning could be enhanced by eliminating many of the extraneous stimuli which may interfere with that learning (Dwyer, 1972, 1978). The environment contains a large amount of information that could potentially be input into the human mental system. Due to the limitations of the human system to process all available stimuli simultaneously, "the perceptual system must be highly selective" (Dember & Warm, 1979, p. 125). During this process, attention plays an important role in selecting key information from the complex environment. "The concept of attention is the focusing of awareness" (Dember & Warm, 1979, p. 125). By focusing attention, some stimuli are attended to while other stimuli are disregarded (Moore, Burton, & Myers, 2003). This process has been identified as selective attention and defined as "the ability to attend voluntarily to some attributes of the stimulus array and to ignore other attributes" (Enns & Girgus, 1985, p. 319). Cueing strategies may provide an effective way to gain the attention of a learner. Cues can direct a student to attend to the most critical features of a computer-based display and allow important instructional information to be emphasized. The attention-gaining cues also can serve as an organizational function to help learners understand the relationships between ideas and improve learning (Taylor, Canelos, Belland, Dwyer, & Baker, 1987).

Information Processing Theory and Cueing Strategies

To understand the functions of cueing strategies in instructional processes, it is important to be aware of the theoretical background related to information processing theory. Cognitive information processing is a branch of cognitive psychology that considers how people perceive, process, and act on information and focuses on attention, perception, and memory (Ausubel, 1968). Gredler (2001) states that information processing theory discusses the "basic steps in the way individuals obtain, code, and remember information, is the central theory of the cognitive perspective" (p. 169). Cognitive psychologists have offered numerous explanations about how people mentally process information. The nature of cognitive process can be extremely helpful to instructional designers not only in understanding what they want students to learn but also how learners can effectively learn it (Ormrod, 2003).

The origin of information-processing models can be traced to Atkinson and Shiffrin's (1968) model of memory, which suggests that memory consisted of a sensory register, a short-term store, and a long-term store. This multistage model presents a single, long-term store for human memories (Gredler, 2001). According to Atkinson and Shiffrin, learners are assumed to receive information from the environment and then transform it for storage for future retrieval. Sensory memory helps learners organize the information they receive from the environment and begin the process of recognizing and coding it. Since information can only exist in the sensory memory for an extremely brief period—about 0.5-2.0 seconds (Gredler, 2001)—learners must choose to attend to the information if it is to continue on for future processing. Figure 2 demonstrates the multistage nature of cognitive information processing (Driscoll, 2000).

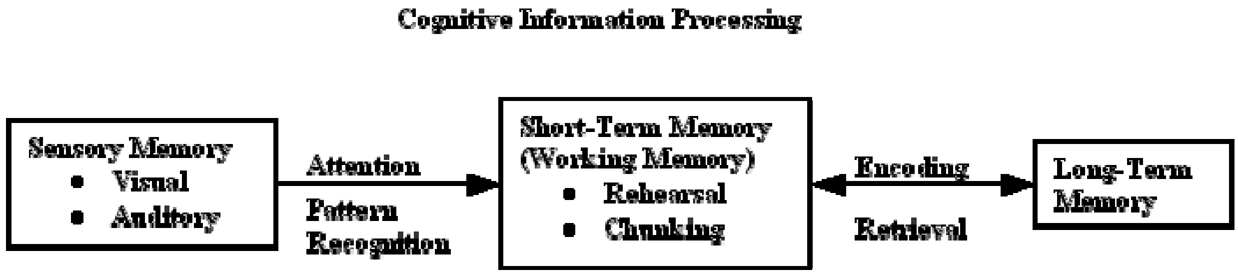


Figure 2. Cognitive Information Processing

Short-term memory or working memory is the stage in which *attention* has been paid and permits learners to store information temporarily and make connections with previous information. Working memory is where much of our thinking or cognitive processing occurs (Ormrod, 2003). In this stage, information can be encoded into some meaningful form and transferred into long-term memory. Unfortunately, short-term memory is limited in its capacity and duration (Gillani, 2003). People only can attend to a small amount of information at any one time. Because of this limited capacity, only a very small amount of information in one's sensory register can move on to working memory (Ormrod, 2003). Gredler (2001) emphasizes that information in short-term memory can only be maintained for about 20 seconds without being rehearsed. It is therefore critical that students pay attention to the information they are supposed to learn. Wilshire (1989) states that in the human information processing system, the major weakness is the short-term memory. He adds that in order to design effective instruction, recognizing the limitations of short-term memory and the need for providing appropriate retrieval cues is very important. Miller (1956) stated that short-term memory could only hold five to nine "chunks" of information (seven plus or minus two); a chunk refers to any meaningful unit and could include digits, words, chess positions, or people's faces. The concept of chunking and the limited capacity of short-term memory became a basic element of all subsequent theories of memory (Owens, 2002).

Long-term memory is the last step in information processing. This is where learners remember and apply information long after it has originally been learned. Klatzky (1980) described long-term memory as a mental dictionary of concepts and their associations to each other and further described it as a "storehouse" (1975, p. 12), with unlimited capacity for storing information. She proposed two important hypotheses about long-term memory that are worth noting. The first one is that long-term memory is a permanent store, although sometimes people cannot remember everything. The forgetting phenomenon has been described as a retrieval problem in that the information is there, but people cannot catch it. Driscoll (2000) reports that the process of retrieval can be greatly affected by the cues available to learners at retrieval time. "Whatever cues are used by a learner to facilitate encoding will also serve as the best retrieval cues for that information at test time" (p. 103). A characteristic of information that is stored in long-term memory is that it must have meaning and it must be integrated with related prior knowledge. She suggests that the more meaningful the information, the more it likely to be remembered. Gagné (1985) believes that information stored in long-term memory is organized as schemas. A schema is an organized body of knowledge about a specific topic that helps learners relate pieces of information to existing information. They are influential in how new information is interpreted and stored in long-term memory (Rumelhart & Ortony, 1977).

Gredler (2001) emphasizes that there are several essential components of learning, including, (a) the organization of information to be learned, (b) the learner's prior knowledge of the instructional content, and (c) the processes involved in perceiving, comprehending, and storing information. An awareness of these components can assist instructional designers in designing processes that increase learners' performance. Norman (1969) stated, "the capacity of the human to deal with incoming information is severely limited. It is as if at some stage of the analysis of incoming information only a small portion of the incoming signal is selected for further processing" (p. 3). He concluded that attention-getting devices could be implemented to help learners "(1) perceive, (2) conceive, (3) distinguish, (4) remember, and (5) shorten 'reaction time'" (p. 9). It seems apparent that strategies that focus learner attention are related to the psychological aspects of visual and verbal information processing and thus extremely important to learning.

Perception and Attention

Fleming (1987) emphasizes that perception, attention, and learning are intertwined together practically and theoretically. Perception and attention should be analyzed in terms of cueing strategies. Figure 3 shows a modified version of a figure created by Driscoll (2000) that demonstrates the effects of cues in information processing.

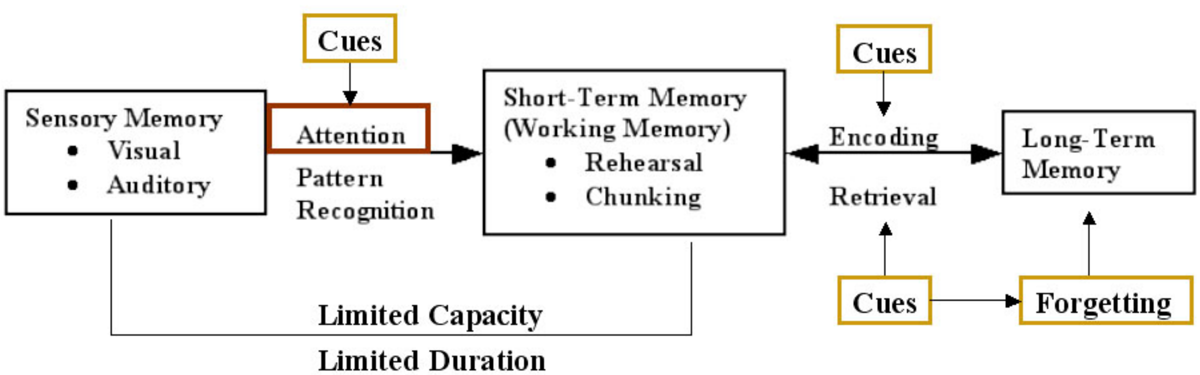


Figure 3. Effects of cues in information processing (modified from Driscoll, 2000)

Perception. Ausubel (1968) described perception as involving "an immediate content of awareness" (p. 56) of an object or event prior to the cognitive processing of that object or event. The amount of information that people received is unlimited, but the total information processing capacity is limited. Since people only can attend to a limited amount of information at one time, perception is a selective process (Ausubel, 1968; Burbank & Pett, 1989; Fleming & Levie, 1978). Ausubel (1968) states that this selection process is based on individuals' experiences, expectations, goals, and individual differences. People scan the available information and select certain parts of it for processing. In limiting the amount of information presented, instructional designers should use only pertinent information and provide visual or verbal cues to help focus learners' attention on key points (Burbank & Pett, 1989). Burbank and Pett add that "perception is organized, so arrange material in keeping with the subject matter. Use arrows, numbers or other cues to direct the learner's perceptions" (p. 529). In addition, they state that since expectations influence perception, the use of appropriate formats and cues such as headings can help learners know what to expect. Alessi and Trollip (1991) also point out that perception may be facilitated by presentation design factors such as, "detail and realism, the use of sound versus visuals, color, characteristics of text such as its size and font, animation, and position of screen elements …" (p. 11).

Attention. Attention is an important cognitive process that allows learners to selectively address particular stimuli for successful learning (Rieber, 1994). All human learning is dependent on the learner's ability to attend to stimuli and correctly perceive them (Alessi & Trollip, 1991). Learners selectively focus on information they believe is important and ignore information they consider unimportant.

Attention in learning has been long recognized by cognitive researchers (Driscoll, 2000). James (as cited in Norman, 1969), in discussing the principles of memory and attention in human information processing, noted that attention allows us to perceive, conceive, distinguish, and remember things better. Information must first be noticed in order to be remembered in long-term memory. Therefore, learners selectively attend to certain stimuli based on their learning goals. Since learning is positively affected when strategies are used to direct learners' attention to relevant information (Ausubel, 1968; Rothkopf, 1966), an important aspect of instruction is in structuring the learning environment so that the learners' attention can be focused (Bruning, Schraw, & Ronning, 1995).

There are two kinds of attention (Rieber, 1994). One is subconscious, such as during sensory input; the other is consciously, such as during selective attention, which occurs when people focus on one set of information while purposely ignoring or blocking other incoming information. Kahneman (1973) introduced another model of attention that supported Rieber's opinion that attention is made up of unconscious and conscious processes. The model presents the idea that attention can be viewed as a learning strategy that can be improved.

Researchers provided several theoretical models of attention that explained how information would be focused on during information processing. Broadbent's (1958) filter model of attention describes how learners select a message to process. It states that selective attention acts similar to a filter to block some information and let other types of information pass on to the processing unit. Between the large capacity sensory memory and the processing unit down the line, there is only a single channel for transmitting information. Therefore, only a small amount of available information is selected for the further processing. Broadbent stated that a particular message could be selected and attended to on its physical basis. However, later studies indicated that attention is not based solely on the physical characteristics of the stimulus (Klatzky, 1975; Treisman, 1964). Klatzky (1975) stated that learners might also select messages based on semantic content. Treisman (1964) believed that learners would attenuate messages based on their physical properties but not filter them out. Thus, attention is more like the attenuator, which turns down the volume of the unattended channels instead of blocking them out. She explained that all incoming signals are go through a preliminary test, which not only examines their physical characteristics, but also analyzes their contents. The test determines which information will be attended to and which will not.

Some researchers (Anderson, 1982; Van Dijk & Kintsch, 1983) have proposed a theory on selective attention that indicates that important text elements are better learned and recalled because extra attention is allocated to them. Anderson explains it as follows:

(1) Text elements are processed to some minimal level and graded for importance.

(2) Extra attention is devoted to elements in proportion to their importance.

(3) Because of the extra attention, or a process supported by the extra attention, important text elements are learned better than other elements. (p. 292)

The theory predicts "a positive relationship between text element importance, attention focused on those elements, and eventual learning" (Reynolds & Shirey, 1988, p. 82). Reynolds and Shirey add that inserting cues in the text can make particular text elements become more important.

Driscoll (2000) described attention as "a state, a resource, or a process" (p. 276). Attention as a state occurs "when a learner maintains an attitude of expectation, alert to information and heedless of distractions" (p. 276). Those features exist in learners who are interested in what they are learning. For students who are not interested in the instruction or are unable to focus their attention, they are easily distracted from a learning task. "Attention as a resource refers to a learner's capability of selectively allocating more attention to one of several simultaneously occurring events … attention as a process involves selecting particular information for future analysis and interpretation over other, available information" (p. 277). A learner's ability to attend to information is a cognitive development process. Young learners can easily focus their attention on one thing or another. However, they can also easily have their attention drawn to irrelevant objects and events. As learners become older, their ability to focus attention on a particular task improves and they are less likely to be distracted by irrelevant occurrences (Dempster & Corkill, 1999).

Gaining attention is listed as the first of the nine events of a successful instructional experience (Gagné, 1985). Similarly, Keller's (as cited in Driscoll, 2000) model of motivational design suggests that the first process of instruction is gaining attention of learners and engaging them in the learning activity before any instruction and learning occur. Thus, knowledge cannot be obtained unless the learner is in some way oriented to incoming information. Since the human memory system cannot recognize all of the information it receives and pass it to short-term memory, attention acts to filter out the less important information and select the more important information for future processing. McKeachie (1988) states that learning strategies aimed at helping learners' attentional processes can influence how much attention is paid and how much information reaches short-term memory for future processing.

The various models and theories of attention provide valuable guidelines to help educators gain an understanding of the role of attention in information processing. Norman (1969) asserts that "one thing that must certainty be true of the study of attention is that it cannot be divorced from the study of other cognitive phenomena" (p. 37).

In summary, information processing theory provides the theoretical base for understanding the effects of field dependent cognitive styles and cueing strategies in learning. By analyzing these relationships, instructional designers can obtain a better understanding of learners' individual differences and employ effective strategies to accommodate their needs and enhance learning.

Field Dependency and Cueing Strategies

The cognitive style of field dependence-independence has been widely used for determining how well learners can restructure information based on salient cues and field arrangement. Research has indicated that field dependent learners have more difficulty learning conceptual information when cues are missing and lack the ability to impose meaningful structure on the material (Weller et al., 1995; Witkin et al., 1977). There have been many studies looking at how field dependent and field independent learners process information; however, there are a lack of studies that have explored the relationship between information-processing strategies and FDI (Tinajero & Paramo, 1997). Some researchers have suggested that a close relationship exists between cueing strategies and field dependence-independence (Carrier, Davidson, Higson, & Williams, 1984; Weller et al., 1995). Witkin, et al. (1977) stated that cue salience and cue relevance are particularly important for field dependent learners for tasks involving problem solving or hypothesis formation. Dickstein (1968) found that field dependent learners tended to ignore cues that were not dominant in the information field, whereas field independent learners sampled more cues regardless of their saliency. Witkin et al. (1977) reported that since field dependent learners lack the ability to internally reorganize or structure information, they obtain greater achievement when provided with cues that are more relevant. Figure 4 demonstrates the relationship between cueing strategies and field dependence according to information-processing theory. This figure was created based on information from Daniels (1996).

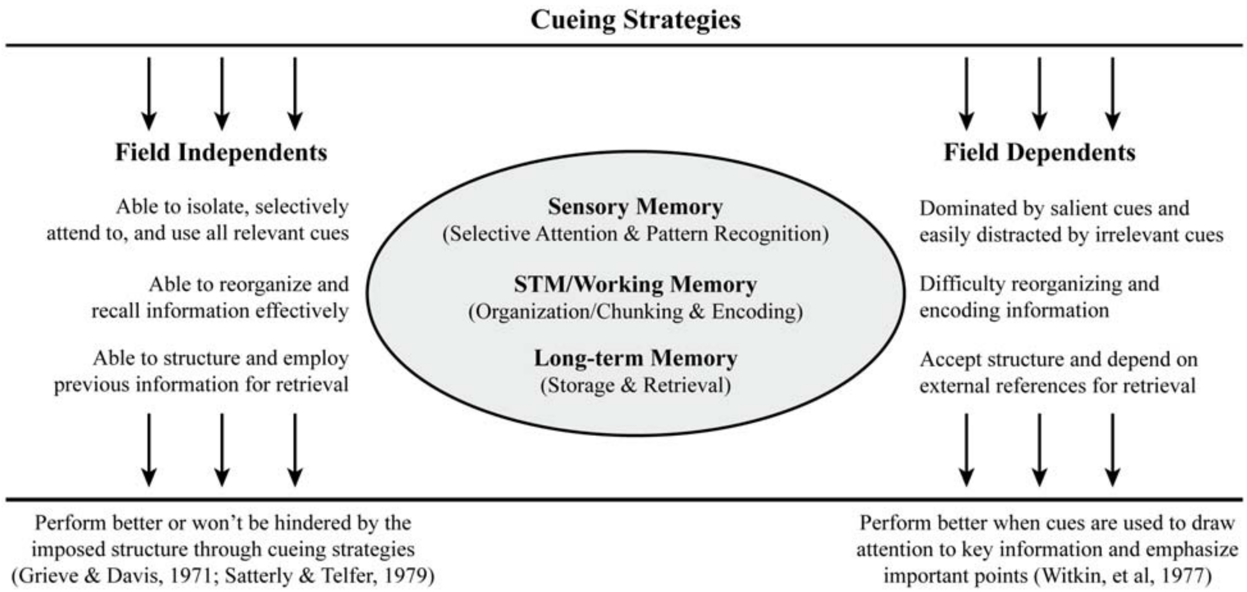


Figure 4. Relationships between cueing strategies, field dependence-independence, and information-processing theory.

Snow (1997) emphasized the need to identify learners' individual differences in an effort to enhance their strengths and minimize their weaknesses. It is the instructional designer's responsibility to consider how to best serve the needs of students who differ in their cognitive style, especially if the cognitive style has been shown to interact with computer-based instructional strategies. Because field dependent learners function best on social competencies and rely on external referents and cues, they may be at a disadvantage in a computer-based learning environment because they may be required to work independently and interact with a visually complex computer screen. Witkin, et al. (1977) summarized that field dependents may learn as equally well as field independents when cues are salient and relevant. They suggest that field dependent learners perform effectively and efficiently when cues are used to draw attention to key information and emphasize important points. They also suggest that learners perform better in educational-vocational contexts in which the instruction is suited to their cognitive style (Witkin & Goodenough, 1981; Witkin et al., 1977). Witkin and Goodenough (1981) further add that a number of studies have made it quite clear that competence in cognitive restructuring dimensions may be improved through appropriately designed educational programs.

Cueing Strategies and Academic Achievement

Various cueing strategies have been identified for helping learners focus attention. They include narration, music, pictures, animations, diagrams, arrows, underlining, labeling, color coding, font or text size variations, movement, shading, texture, questions, concept maps, and advance organizers (Burton et al., 1995; Dwyer, 1978; Higgins & Cocks, 1999; Levie & Lentz, 1982). Most studies on the effects of cueing strategies on academic achievement have involved directing attention to specific information within visuals in the instructional message (Downs, 1989; Downs & Jenkins, 2001; McIntyre, 1981). The research yielded mixed results. Most of the studies resulted in positive results attributable to the cueing strategies (Beck, 1987; Dinnel & Glover, 1985; Dwyer & Moore, 1992b; Goldstein, 1981; Higgins & Cocks, 1999; Levie & Lentz, 1982; Martel, 1992; Mayer, 1989; McIntyre, 1981). However, some researchers reported negative or non-significant research findings (Owens, 2002; Pienkowski, 2002; Worley & Moore, 2001).

Although much research has explored the effects of cueing strategies that complement visual imagery on facilitating student achievement, the effectiveness of cueing strategies in computer-delivered text messages has not been investigated in terms of their effects on the achievement of students with differing cognitive styles. Future research should be conducted to clarify this issue.

Instructional Message Design

Researchers have begun to identify the elements of the message that can be manipulated during the instructional message design process to facilitate learner achievement (Lamberski &

Mayers, 1980). Grabowski (1991) described message design as a process of “planning for the manipulation of the physical form of the message” (p. 206). Here, the message works as a medium to communicate between a sender and a receiver. Studies of message design have suggested that the message should be clearly defined in order to provide optimum instructional effectiveness and efficiency in the learning process (Lamberski & Mayers, 1980). To guarantee that efficient learning will occur, “the stimulus material for learning must be available and clearly perceivable by the learner” (Dwyer, 1978, p. 158). Fleming and Levie (1978) have defined instructional message design as “the process of manipulating, or planning for the manipulation of, a pattern of signs and symbols that may provide the conditions for learning (p. xi). They also stress that instructional designers must find a way to magnify or emphasize the critical features in the instructional message. However, Seels and Richey (1994) feel that Fleming and Levie’s definition and explanation of instructional message design “limited messages to the pattern of signs or symbols that modifies the cognitive, affective or psychomotor behavior” (p. 31). For purposes of this study, instructional message design can be defined as the process of manipulating the learning conditions that encompass the pattern of signs or symbols (words or pictures) that have been viewed as the media to communicate learning. This process is usually conducted by teachers or instructional designers before the instruction commences.

With the advancement of computer technologies and the integration of multimedia into the curriculum, instructional messages can be delivered using graphics and animations as well as text, However, researchers (Heines, 1984; Soulier, 1988) have determined that 80 to 90 percent of the information in computer-based instruction is still presented using text. This highlights the importance of text message design when delivering instructional content via computer screen.

How information is constructed by the reader to gain comprehension from text materials is an important issue for teaching and learning (Bennett, 1989). Text design has been identified as one of the factors that influences learners' comprehension of the learning information. McConaughy (1985) suggests that one of the essential aspects of text comprehension is the ability to attend to and focus on important or relevant items within the text and to exclude the nonessential items. Bennett (1989) follows the same reasoning and states that the information comprehension process is "an interactive and assimilative process between the learner and text. It is depended upon the strategies and/or cues used by the learner to gain meaning" (p.53). To increase comprehension, instructional designers should look at the text design and learner differences together.

Well designed text can be used to help learners organize and locate information and facilitate the transformation and comprehension of material during information (Hannafin & Hooper, 1993). Burbank and Pett (1989) provide a number of principles and guidelines for designing text messages and instructional content. They suggest that effective instructional design should "use variations in size, color, brightness, and shape or employ novel visuals to attract attention" and add that "to hold attention, be certain that the material presented is meaningful to the learners" (p. 528). According to Burbank and Pett's (1989) suggestions on text design, instructional designers can improve students' learning achievement by using (a) "a list or outline of the content to assist learners in organizing information" (p. 531), (b) "bullets, numbers or white space to separate and attend on key items" (p. 531), (c) red or blue colors to attract attention, and (d) color to provide structure, emphasize relevant cues, and distinguish critical items from irrelevant ones. Burtank and Pett add that when developing textual materials, it is better to consider the characteristics of the audience, the information to be presented, and the way the audience will process the information.

Meyer (1975) has suggested that text structure can be manipulated to influence free recall performance by inserting cues or signals that emphasize how ideas are related and which ideas are most important. Signaling or cueing content and structure has been demonstrated to facilitate low or average learners' recall performance (Meyer, Brandt, & Bluth, 1980). Pace (1982) summarized text message designers should assist readers in acquiring new information by highlighting important ideas and reducing the density of the information load. According to Jonassen and Kirschner (1982), to capture and focus attention during reading, designers should use "linguistic, spatial, and typographic cues to the form, function, sequence, content, and importance of segments of a passage" (p. 123). They add that during the design process, several aspects should be considered: the nature of the target audience, such as their cognitive/learning style; the expected outcomes of the text message; and certain text characteristics that can affect perception of the information.

Typographic Cues and Color

Learning from instructional text is a demanding task that involves many cognitive processes, including recognizing the words and identifying the important ideas within the text (Glynn & Britton, 1984; Lipton, 1990; Mayer, 1984). The ability of learners to distinguish the most important information within a text message and give it the proper attention is key for successful academic achievement (Gibson, 1976). The limited capacity of working memory require learners to distinguish core and enrichment content by allocating more attention to the text components they perceive as most important (Glynn & Britton, 1984; Glynn et al., 1985). Since some learners may have difficulty making those judgments, instructional designers can assist them through the incorporation of certain strategies that signal important elements within the text (Glynn, 1978; Glynn & Britton, 1984).

Researchers (Tannenbaum, Jacobson, & Norris, 1964) have demonstrated that learning from text involves two distinct components: the content itself and the structure or form of the content. Visual devices such as typographic cuing address the structure or form of the content. Typographical cues have successfully been used to guide learners' processing of text and affect comprehension (Glynn, 1978; Glynn & Britton, 1984). Meyer and Rose (1998) emphasize that typographic cues can be used to signal the organization, structure, and meaning of instructional text. The impact of these design strategies are often under-estimated and disregarded (Bowen & Castle, 1987; Lipton, 1990).

Color is an attribute of text that has been used as a cueing strategy (Kennedy, 1971; Roberts, 1994; Stewart, 1986). Color is "identified through the coordination of the human eye and brain" (Birrell, 1967, p.101) and can vary in both hue and brightness (Fleming & Levie, 1993; Schiffman, 2001). In instructional contexts, color has been identified as an attention gaining and sustaining device that can be used to aid in the organization of important instructional content (Dwyer, 1978; Jones, 1989). Today, text and color are common components for most visual learning on computer screens (Jackson, 1998). With the advancement of computer display technologies, a wide variety of colors and highlighting techniques are available that may be used to improve the presentation of graphic and textual information (Morrison & Vogel, 1998; Wu & Yuan, 2003). Dwyer and Lamberski (1982) stated that color can be used to highlight text structure to aid organization of important instructional content.

The use of color in teaching and learning is not new. As early as 1900, Nellie Dale (as cited in Hinds & Dodds, 1968) had already started to employ color to assist with language learning. Color has since been applied to isolated intentional concepts and to peripheral concepts (Sabo & Hagen, 1973). Although the role of color has not been defined as the primary instructional variable in computer-based instruction, it appears to have some impact on learning (Galitz, 1993; Hannafin, Hannafin, & Hooper, 1996). Sabo and Hagen reported that learners' recognition of central concepts was improved when color cues differentiated the intentional concepts from the peripheral concepts. This ability improved with age.

Jones (1989) reported that color manipulation can be a more effective strategy than modifying text size and style when learners are trying to find information within a large block of text. Dwyer (1978) feels that the use of color in media "increases the effectiveness of the material by making it more attractive, thereby evoking more attentive behavior on the part of the learner" (p. 144). Legge, Parish, Luebker, & Wurm (1990) claim that the use of color affects reading. Furthermore, they point out that color can be used to enhance readers' ability to search and locate information, comprehend information, emphasize important details, simplify differences, and recall information when necessary.

Dwyer and Lamberski (1982) found that color as cueing strategy can attract viewers' attention and organize information so that viewers are directed to meaningful and relevant segments of a stimulus. They observed that if color is central to the concept being presented, and if students focus attention on it, it can facilitate learning. Dwyer and Moore (1992a) stress that color coding can help learners organize and categorize information into useful patterns that enable them to interpret cues and adjust to their environment. In a study conducted with high school and college students, Dwyer (1972) found that optimum learning takes place when students are actively involved in looking and listening for specific information. Moore and Dwyer (1992) investigated the effect of black and white and color coding of information on the achievement of field dependent and field independent learners. They concluded that salient cues could be important for field dependent learners in information processing.

Birrel (1967) stated that color is a sensation that “is one of the most stimulating aspects of our environment” (p. 108). Although color draws attention because it attracts a people’s eyes (Galitz, 2002), Fleming and Levie (1993) stress that different levels of sensory stimulation impact the attention-drawing power. In a visual message, attention can be directed by the use of contrasting color. Warm colors such as red or orange commands people’s attention, while cool colors such as blue and green withdraw from people’s eyes (Williams, 1994). Birrel also concluded that yellow, orange, and red are warm colors that have a more stimulating effect than cooler colors such as blue, green, and violet. Hannafin and Peck (1988) suggest using warm colors on a computer screen to cue students to new information during instruction. Other researchers (Watson, 1987; Williams, 1994; Wu & Yuan, 2003) recommend that when choosing colors for foregrounds, text, and backgrounds, light colored backgrounds should be combined with dark colored foregrounds or text for better contrast. Black text on a white screen has been viewed as the most effective way to design computer-based text messages. “The most recommended text color is black presented on a light-colored background of low intensity, either off-white or light grey” (Galitz, 2002, p. 637) Galitz also supports the idea of using yellow to highlight important elements on the computer screen.

Galitz (1993; 2002) summarized some concerns about using color on a computer screen as follows: (a) color has a extremely high capability for drawing attention, (b) inappropriate use of color may cause visual fatigue, (c) some people may have color-viewing deficiencies, such as colorblindness, (d) some color may have cultural connotations, and improper use can cause confusion, and (e) the effectiveness of color in improving learning from computer-based instruction has yield mixed results. In conclusion, he suggested that the value of color depends on the "task being performed, the colors selected, the number of colors used, and the viewing environment" (2002, p. 629).

Through their studies on the effects of color-coded instructional materials on learners' reading performance, Hinds and Dodds (1968) concluded, "color, through its stimulation, rivets and holds the attention of the learners" (p. 46). Lamberski (1980) summarized studies that involved color codes in reading and concluded that color-coded instructional materials were preferred by learners. Learning rates and performance were also improved.

Research on Color in Education

Studies on color cueing strategies have not yielded definitive conclusions, "and the use of color in instructional methods and materials seems to be based primarily upon intuition" (Knafle, 1974, p. 234). Two main cueing strategies involving the addition of color to text messages have been used: colored text and color-highlighted text (also known as highlighting or shading). Colored text involves modifying the color of certain text to distinguish it from the surrounding text. One example would be changing the text of interest to red when the surrounding text is written in black. In this case, the text itself is colored. Color-highlighted text involves highlighting certain text with a color, similar to using a highlighter pen to shade printed text. In this case, the text itself is not colored, but the area surrounding the text in shaded with color.

Numerous studies have attempted to investigate the effectiveness of colored text in facilitating learners' information processing (Dwyer & Lamberski, 1982; Hinds & Dodds, 1968; Legge et al., 1990; Lin, 1997; Sabo & Hagen, 1973). However, the effectiveness of color highlighting as a cue for directing readers' attention has received minimal attention in the literature (Fowler & Barker, 1974; Gaddy, 1996). In addition, studies analyzing the differences between the effects of color-highlighted *key words* and color-highlighted *key phrases* on learners' comprehension of text messages are also absent.

Lin (1997) examined the impact of different combinations of background color, text color, and text brightness in computer-based instructional program on the affection, perception, and cognition of elementary school students in Taiwan. Three hundred and thirty-two students were assigned to one of 16 groups, which represented the total number of combinations between eight background colors and two text brightnesses. The results indicated that text color had significant effects on the affection and perception of learners but not on their cognition.

Buhalis (1998) investigated the relationship between changing the color of key information and improved knowledge acquisition. One hundred and twenty students were randomly selected from a community college to participate in this pretest-treatment-posttest experimental study. Key information in the treatments was enhanced in colors of red, green, and blue. This study did not find consistent results that indicated that the instructional treatments improved knowledge acquisition as verbal aptitude increased from low to high. However, the one-way ANOVA indicated that there was a significant difference when the low and medium aptitude groups received key information using red text on a white background.

A study by Wu and Yuan (2003) investigated how different types of highlighting and color combinations affected reading performance. For this study, participants were asked to search for information in a table. There were four highlighting conditions: standard (without highlighting), blinking, reverse video, and color. They found that highlighting significantly improved participants ability to search for information in a table; the most effective highlighting method was to use red colored text.

Many students prefer to add visual cues when they read or study. By examining about 200 randomly selected used textbooks in a college bookstore, Fowler and Barker (1974) found an interesting result in that 92 percent of these textbooks contained significant application of “emphasizing techniques”, such as highlighting of text as a cue to readers to important content. Glynn, et al. (1985) stated that the reason students highlight or underline content in textbooks is to compensate for the lack of author-provided cues that distinguish the salient points from the surrounding text. Their interesting finding led Fowler and Barker to conduct a study to determine if highlighting was effective as an aid for retaining instructional material. Participants were asked to read two scientific articles with the total length of approximately 8,000 words. The participants were randomly assigned to four treatment groups: an active highlighting group, who highlighted the articles while reading them; a passive highlighting group, who read the articles highlighted by the active highlighting group; an experimenter-highlighted group, who read articles which had been highlighted by the experimenter; and a control group, who read articles with no highlighting. Yellow highlighters were used to do all highlighting. Participants in the experimenter-highlighted group did significantly better on the retention test than did the control group. The study also indicated that highlighting could effectively aid in recall if used on only 5% of the information in a textual message. It is best to use cues sparingly so that readers’ processing capabilities are not overly burdened (Glynn et al., 1985). A later study by Lorch, Lorch, and Klusewitz (1995) supported this finding.

Gaddy (1996) conducted a study that examined the effects of color-highlighted text on students’ academic achievement and the impact of various highlighting colors used as attention-guiding cues. In this study, 120 college students were required to read a 2,400-word text passage that was presented in the form of an eight-page, double-spaced booklet using12-point, Times

New Roman type. In the passage, particular statements were either left unmarked, underlined, or highlighted in yellow, blue, or pink. The results of the study showed that participants who read text passages containing highlighted or underlined statements were more likely to focus on and recall cued information than non-cued information. In addition, highlighting color had no significant effect on recall. Gaddy points out that when color-highlighted texts are provided to participants, “they will influence the participants’ perception of the importance of various information encountered during the reading process” (p. 18).

Gaddy’s findings support the observations made by other researchers that visually distinct information embedded in text will be remembered more than indistinct information (Cashen & Leicht, 1970; Fowler & Barker, 1974; Glynn, 1978; Glynn et al., 1985; Lorch et al., 1995). However, Cory (1990) reported an opposite conclusion; subjects who received highlighted and underlined treatments did not perform better than subjects in a control group who received no cues. “People’s preferences are not always a reliable guide to the most efficient displays. With computers, designing screen displays to ‘help’ users is easy, but not always effective” (Cory, 1990, p. 70).

Highlighting of text is now widely used in computer-based programs. Most word processing programs provide users with the ability to highlight sections of text, and even the Internet search engine Google provides a useful feature in which a user’s search terms are highlighted on certain results pages. (Riggott & Suda, 2004). Individual search terms are highlighted in different colors, allowing users to easily find what they are looking for before they read the entire screen.

Although color-highlighted text has been used practically on computer displays, most of the empirical studies on the effects of this kind of cueing strategy on learners’ academic performance have been conducted using print-based instructional materials. Prestera (2003) emphasizes that relatively few studies have specifically addressed the use of color in the context of computer-based instruction. Researchers suggest that the results of research using print-based media should not be generalized to screen-based media; new studies must take place using computer-based instructional materials (Kolers, Duchnicky, & Ferguson, 1981; Schwier & Misanchuk, 1993).

Even though color as a message design variable has received considerable attention due to its apparent value to the learning process, the results of the research findings have often been contradictory and inconclusive (Chute, 1979; Lamberski, 1972). Lamberski (1980) summarized that this lack of conclusive evidence related to cognitive learning may be because researchers “failed to analyze the interrelatedness of color as a variable to other components within a learning system” or “had research design flaws that prohibited meaningful interpretation of results” (p. 7). Chute stated that research using color-based variables has not taken into account the influence of individual differences and that color cues might differentially influence students who differ on some cognitive variable. For example, the effects of color on field dependent learners’ academic performance may differ from its effects on field independent learners’ performance.

Significance of the Study

There are two factors that influence learning: the internal process of learning and the external events (Gagné, 1985). In this study, the internal process of learning refers to individual differences in the cognitive style field dependence-independence. The external event refers to the implementation of cueing strategies that help learners focus on critical information within text messages. Gagné stresses that the internal processes of learning can be influenced by external events. Instructional designers should have knowledge of learners' cognitive style to facilitate their selection of appropriate teaching practices to better meet learners' particular ways of perceiving, organizing, and processing information (Cross, 1976; Graff, 2003; Jonassen & Grabowski, 1993; Magoulas et al., 2003; Messick, 1984).

Cronbach and Snow (1977) point out that the role of individual differences in learning and the relevance to the selection of instructional strategies has been a widely investigated theme since the 1950s. Students do not all learn alike or at the same rate, and not all instructional materials will work for every student. Appropriate instructional materials and methodologies should be implemented to provide learners with extra help in areas where they are weak. Cronbach and Snow (1981) assert that, "the substantive problem before us is to learn which characteristics of the person interact dependably with which features of instructional methods" (p. 493). They believe that research is needed to fill this tremendous gap.

Numerous studies have reported significant interactions between field dependence-independence and instructional treatment (Abraham, 1985; Frank, 1984; Satterly & Telfer, 1979). However, very little research has been done on the relationship between information-processing strategies—such as cueing—and field dependent-independent cognitive styles (Tinajero & Paramo, 1997). There is a lack of evidence concerning the use of specific attentional or organizing devices as instructional support to compensate for learners with particular cognitive-style deficiencies (Reardon & Moore, 1988). In addition, although color as a type of cueing strategy has been shown to help learners attend to and organize information, there have been relatively few studies that have specifically investigated the effects of using color cues within text messages delivered through computer-based instruction (Prestera, 2003).

The key difference between field dependents and field independents is the cognitive restructuring ability that is the necessary for successful learning (Jonassen & Grabowski, 1993). Field dependents have less ability in cognitive restructuring. When learning requires cognitive restructuring to encode, store, and retrieve information, field independent learners perform better than field dependent learners (Witkin et al., 1971). However, field dependents can perform as well as field independents when instructional materials are well organized and structured (Witkin, 1978). Since field dependent learners are mainly drawn to the most noticeable or salient features of a stimulus and are generally less efficient in attending to relevant cues than field independent learners (Davis & Cochran, 1990), the addition of textual cues could help draw field dependent learners' attention to important words, phrases, or other content that they are expected to learn.

Cues embedded in an instructional message that are familiar and/or that direct learners' attention to the relationship between new knowledge and concepts to previous knowledge can facilitate learning (Fleming & Levie, 1978). The purpose of the cueing strategies used in this study was not only to focus attention on key words but also to enhance students' understanding of the meaning of the key words by making connections between prior knowledge and the new information. It was thought that field dependent learners who received color-highlighted key phrases would perform better than field dependent learners who received color-highlighted key words. The reasoning was that the phrases would not only help field dependent learners pay attention to key words but also enhance their understanding of the meaning of the key words by emphasizing the relationship between prior knowledge and the new information. In other words, highlighting phrases would do better than highlighting single words. However, there has been no robust empirical evidence to support it.

As discussed earlier, since field dependent learners have difficulty disembedding and restructuring important information, they may need additional support and assistance to help them locate and attend to critical information within a text message, especially when the message is presented on a computer screen. Although there is much literature on accommodations and interventions for field dependent learners, it is difficult to locate studies involving the use of color as a cueing strategy to enhance field dependent learners' performance with computer-based text messages. There is a particular lack of research examining the differences between the effects of color-highlighted key words and color-highlight key phrases on the performance of field dependent learners. Further studies are necessary.

Research Questions and Hypotheses

This study was an experimental exploration intended to ascertain whether cueing strategies embedded in computer delivered text messages affect the recall and comprehension of students who are classified as field dependent or field independent in terms of their cognitive style. The results should provide practical implications for instructional designers as well as those who seek to accommodate field dependent learners' deficiencies in cognitive restructuring.

Based on the preceding review of literature and relevant theories, several research questions emerged concerning the interaction between field dependent-independent cognitive styles and cueing strategies. More specifically, the following research questions were identified and provided the basis for the subsequent study:

1. Do cueing strategies affect learners' academic performance?
2. Do field independent learners outperform field dependent learners in their academic performance?

3. Will the use of either a color-highlighted-keyword cueing strategy or a color-highlighted-key-phrase cueing strategy help field dependent learners improve their learning?

Based on these questions, the following research hypotheses were developed for this study:

1. Participants who receive a colored-highlighted-keyword cueing strategy or color-highlighted-key-phrase cueing strategy will score higher on a posttest than participants who receive no cueing strategy.
2. Participants with a field independent cognitive style will score higher on a posttest than participants with a field dependent cognitive style.
3. Participants with a field dependent cognitive style who receive a color-highlighted-key-phrase cueing strategy will score higher on a posttest than participants with a field dependent cognitive style who receive either a color-highlighted-keyword cueing strategy or no cueing strategy.

CHAPTER II: METHODOLOGY

This chapter describes the participants, experimental materials, and procedures that were utilized for the investigation of the research hypotheses. The first section discusses the selected research design and identifies the experimental variables. The second section describes the participants in this study. The third section describes the development process used to create the experimental materials and accompanying test materials. The final section describes the experimental procedures and how the data was analyzed.

The preceding research questions were explored by conducting an experimental study that investigated the effects of cueing strategies on the performance of college students possessing different levels of field dependence-independence. The Group Embedded Figures Test (GEFT) was administrated to assess participants' levels of field dependence-independence. The instructional treatments for this study were modified versions of materials originally developed by Francis M. Dwyer (1967). The participants' learning performance was evaluated by a posttest that included two parts: a terminology test and a comprehension test.

Research Design

A 3 x 3 posttest-only factorial research design was used to determine if the treatments resulted in a variance in test scores. The independent variables were level of field dependent-independent cognitive style (field dependent, field neutral, and field independent) and type of cueing strategy (instructional material with no cueing strategies, color-highlighted-keyword cueing strategy, or color-highlighted-key-phrase cueing strategy). The dependent variable was participants' posttest scores. Table 2 illustrates the layout of the experiment.

Table 2

Treatment Groups in 3x3 Experimental Study Format.

Types of Cueing Strategies	Field Dependent-Independent Cognitive Styles		
	Field Dependent	Field Neutral	Field Independent
Non Cueing Strategies			
Color-highlighted-keyword			
Color-highlighted-key phrase			

Participants

The participants in this study were undergraduate students who were recruited from a population of students enrolled in an EDHL (Education and Health) Personal Health class at Virginia Polytechnic Institute and State University (Virginia Tech) in Spring of 2006. Students were encouraged to participate on a volunteer basis. As an incentive, students who completed this research study received course credit at the end of the semester. The course credit they received from the class had no association with any results they obtained in the study.

Two hundred thirty-eight students completed the entire experiment. Of those, 19 were eliminated from the data analysis because of their pre-knowledge of the instructional materials or because they submitted incomplete data. As a result, 219 sets of data were actually used for the statistical analysis. Participants were also screened for color-blindness. This involved a question on the survey they completed when they were registering for the study. No participants indicated that they were color-blind; therefore, none were eliminated from this study for this reason. Of the remaining 219 participants, 73 were female and 146 were male. The age range of the participants was between 18-25.

Experimental Materials

The main variables of interest in this study were field dependent-independent cognitive style and cueing strategy (highlight color used within a text message). The measurements of each of these variables are discussed in the following sections.

Group Embedded Figures Test

The Group Embedded Figures Test (GEFT) was administrated to classify each participant's level of field dependency. The GEFT is a modification of the Embedded Figures Test for use with group of subjects. It requires each subject to locate simple geometric figures within more complex geometric designs within a specified time limit (Witkin et al., 1971). The estimate of reliability of the GEFT is reported at .82 (Witkin et al., 1971).

The GEFT test was presented in a booklet form. During the GEFT test, participants were required to finish all 25 items within 12 minutes. Within each complex figure was embedded one of eight simple figures, participants were asked to trace the simple figure with a pencil. In the first two minutes, participants worked on seven practice items, which were not scored. In the following ten minutes, participants completed the 18 items that comprised the actual test. The completed tests were individually scored by the researcher. The total possible score ranged from 0 to 18. Omitted items were scored as incorrect (Witkin et al., 1971).

Participants in the study were classified as field dependent (FD), field neutral (FN), or field independent (FI) based on their scores on the GEFT test. Participants who scored greater than one-half standard deviation above the mean were considered field independent, while participants who scored less than one-half standard deviation below the mean were considered field dependent. Participants whose scores fell within one-half standard deviation above or below the mean were considered field neutral (Dwyer & Moore, 1991-1992).

Dwyer's EIM Content and Criterion Tests

The Experimental Instructional Materials (EIM) developed by Francis M. Dwyer (1967) were modified and used in this investigation. Permission to modify the instructional content based on the purpose of this research was approved by Dwyer on October 3, 2005 (Appendix A). The original EIM consisted of a 2000 word text accompanied by images of the human heart, along with four criterion tests: a drawing test, identification test, terminology test, and comprehension test. A total criterion test can be obtained by combining scores from the four tests. The instructional material was designed to be used alone or with accompanying visualization and verbal labels (Dwyer, 1967). The EIM were originally designed to be delivered in a 21-page print booklet on the anatomy of the human heart. For the purpose of this study, the instructional materials were modified and adapted to a computer-based form. Information from each page of the booklet was presented on a single Web page. The design and development of the computer-based materials were based on the instructional program created by David Halpin (2005). Permission to use and modify this instructional program was obtained. Since this research study intended to investigate the effects of cueing strategies and field dependency on students' posttest performance by using color highlighting on various sections of text, it was decided to eliminate the possible confounding variable of color images. Therefore, the color graphics of the human heart that accompanied each page of text were changed to black and white images using Adobe Photoshop.

Three separate treatments were developed from Dwyer's instructional materials. The content of each treatment was presented by a series of Web pages and accessed using a Web browser. The content in each treatment was identical. Each treatment differed only in terms of the method used to present key words and key phrases. Participants in each treatment group viewed the same introduction screens and accessed the screens of information sequentially. There were two navigation buttons on the bottom of each screen: Previous Screen and Next Screen. Participants advanced from one screen to another using these navigation buttons. The amount of time participants spent with the instructional materials was limited to 25 minutes. Ogle (2002) confirmed that 25 minutes would be enough for the majority of participants to complete the human heart materials. He added, “the time limit was used to control for time spent on the instructional material as a confounding variable” (Ogle, 2002, p. 49). Once participants reached the last page of the instruction, there was a button to take them to the posttest. Participants were not allowed to return to the instructional materials once they clicked the test button. To help limit this action, the Back button on the Web browser was removed from the browser window.

In the control treatment (Appendix B), the instructional content on each screen was presented using black text. None of the text was highlighted to direct learners’ attention to key words or phrases.

The second treatment (Appendix C) was the color-highlighted-keyword treatment. In this treatment, the instructional content on each screen was presented using black text. In addition, selected key words were highlighted using a yellow color in an attempt to help participants focus their attention on important terminology. Galitz’s work on user interface design (2002) suggested that using yellow to highlight important elements on a computer screen could significantly improve readers’ content recognition. The use of yellow to highlight text has been widely used in previous research that investigated color-highlighted text on students’ academic performance (Cory, 1990; Fowler & Barker, 1974; Gaddy, 1996; Riggott & Suda, 2004). The use of key words has played an important function in the process of reading (Veatch, Sawicki, Elliott, Flake, & Blackey, 1979). Researchers (Konopak & Williams, 1988; Veatch et al., 1979) also point out that the use of key words is a very simple but extremely powerful technique to aid in students' reading comprehension. O'Sullivan and Pressley (as cited in Palinesar & Brown, 1987) reported superior results using key words with secondary level students who were experiencing academic difficulties. Students who used the key word strategy performed better.

The third treatment (Appendix D) was the color-highlighted-key-phrase treatment. In this treatment, the instructional content on each screen was presented using black text. In addition, selected key phrases were highlighted using a yellow color in an attempt to help participants focus their attention on important concepts. This was based on Fleming and Levie's (1978) description of memory, which states that cues that assist learners in making connections between new information and previous knowledge can facilitate learning. Simply focusing learners' attention on key words within the instructional message is not necessarily enough to enhance recall and comprehension performance. Effective cueing strategies must also be provided to assist learners in understanding the meaning of the key words. The following procedure was used to select key phrases for highlighting:

1. Concise phrases were chosen to support the meaning of key words.
2. Key phrases were matched to corresponding questions on the posttest
3. The proposed key phrases were then reviewed by three subject matter experts in the areas of instructional design, distance learning, and educational psychology. The subject mater experts examined the instructional content, checked the accuracy of the design both for content and key phrases, evaluated the assessment criterion, and recommended revisions. Based upon these comments, the final phrases were chosen for highlighting.

Test Instruments

Student achievement was measured by a computer-based posttest administered immediately after the treatments. The test was used to measure participants' ability to recall the knowledge they learned from the instructional materials. Two criterion tests (terminology test and comprehension test) were selected from the four criterion tests originally developed by Francis M. Dwyer (1978). The other two tests, drawing and identification, were not used in this study since measuring visual-based outcomes was not the main purpose of this study. The terminology test consisted of 20 multiple-choice questions designed to measure participants' knowledge and understanding of facts, terms, and definitions related to the human heart. Dwyer (1978) states that "The objectives measured by this type of test are appropriate to all content areas which have as a prerequisite to the more complicated types of learning a comprehensive understanding of the basic elements (terminology, fact, and definition) indigenous to the discipline" (p. 45). The comprehension test also consisted of 20 multiple-choice test items. This test required participants to demonstrate a thorough understanding of the operational functions of the heart. They were tested on their familiarity with the relationship and interdependency of the terms and functions. KR-21 reliability coefficients of .83 for the terminology test and .88 for the comprehension test were reported by Dwyer and Moore (1991-1992).

Participants received the terminology test first and then the comprehension test. Each set of the scores was recorded in the database and analyzed separately. In addition, the terminology test score and the comprehension test score for each participant were combined into a total test score. The purpose of this was to measure students' overall achievement of the information presented in the instructional materials.

Pilot Study

Before conducting the main study, a pilot study was conducted to evaluate the appropriateness of the research procedures, the content and structure of the computer based instructional materials, and the assessment instruments. Four undergraduate and four graduate students from Virginia Tech participated in the pilot study. All of the participants went through the process of registering for the study, interacting with the instructional materials, and completing the GEFT test and the achievement test. Feedback and suggestions were gathered and were used to improve the design of the final research study. In general, pilot study participants felt the instructional content was clear and easy to follow and that the study had a logical organization and sequence.

As a result of the pilot study, two modifications related to the instructional materials and the experimental interface were incorporated in the final study design. The first modification was related to the instructional content of the human heart on each page of the treatments. Originally, visuals of the human heart on each page of the booklet were eliminated from the computer-based instructional content because of the concern of the potential confounding effect of the images and their colored labels. Participants might have felt confused viewing the images, which had colored labels attached, and the instructional content, which could potentially have different color highlighted key words or key phrases. According to participants in the pilot study, including visual aids within each page of treatments would have helped them understand and comprehend the content better. Therefore, the color images of human heart that were originally included on each page of Dwyer’s booklet were changed to black and white images and inserted back into the computer-based instructional content. The second modification was related to the navigation of the experimental interface. Since there were 23 pages within each treatment, participants reported that it was hard for them to keep track of their progress and control their reading speed in order to finish the instructional materials within allotted the time limit. To help solve this problem, a label in the form of “Page: 10 of 23” was added to the upper right corner of each page of the treatments.

Procedure

Expedited Status approval for testing human subjects was granted by the Virginia Tech Institutional Review Board on February 2, 2006 (Appendix E). The experimental study began on February 9 and continued through April 13, 2006.

This research study was carried out using the experimental interface of the Educational Psychology Research Group (EPRG). Permission to use this interface was obtained from Peter Doolittle. The experimental interface consisted of two parts: the participant interface and the research interface. The participant interface allowed users to (a) sign up for the study, (b) complete demographic information, (c) schedule an in-person session, (d) make changes to the date and time of a previously scheduled in-person session, and (e) request an email reminder about the pre-scheduled in-person session. The research interface allowed users to (a) link to the research treatments, (b) take the knowledge questionnaire, and (c) take the posttest.

Students who intended to participate in this study were directed to the participant interface to register for the study and schedule an in-person session. Once they clicked the Initial Registration button on the interface, they were guided to a new page to select a username and password, enter their email address, officially join the study, and complete the demographic survey. After students officially joined the study, completed the survey, and scheduled an in-person session, a confirmation email was sent to the email account they provided. Each participant was assigned a computer generated identification code for tracking his or her GEFT, knowledge questionnaire, and posttest score. In the demographic survey, they were asked to provide information about their gender, age, ethnicity, academic major, and academic level.

There was an additional question to determine if any participants were colorblind. Color blindness is found in about eight percent of males and 0.4 percent females, and the most common form of color blindness is red and green, which affects about 2.5 percent of the population (Hartley, 1985; Szul, 1995). Because the treatments in this study involved manipulating colors on text, participants who had color perception deficiencies needed to be eliminated from the study. Participants who indicated that they were colorblind were eliminated from the study.

Before participants attended their in-person sessions, they were randomly assigned to one of the three treatment groups by the interface. When participants logged into the interface during the in-person sessions, they were automatically directed to view the instructional materials corresponding to the treatment group to which they had been assigned. The in-person sessions were conducted in a Mac computer lab on the Virginia Tech campus. There were six stations in the Mac lab. Each station had one Mac laptop that was set up with a login page for participants of the study. In total, 70 treatment sessions were conducted. Each treatment session lasted one hour.

At the beginning of each in-person session, the researcher read a detailed explanation outlining the research process. Participants were asked to complete the GEFT test first. They were asked to write their name and email address on the GEFT booklet so that their scores could be entered into the database later. They were given two minutes to work on the 7 practice items, and then 10 minutes to take the actual test. Standard oral directions from the manual for the Group Embedded Figures Test (Witkin et al., 1971) were given during the test to ensure that all participants received the same message.

When participants finished the GEFT test, they were asked to log into the research interface to complete the knowledge questionnaire, interact with the instructional materials, and complete the posttest. There was no interaction between participants during the session. The knowledge questionnaire consisted of a seven-item knowledge checklist and a five item self-rating. It solicited information concerning the participants' pre-knowledge of the anatomy and functioning of human heart. Based on the findings of previous studies, "some instructional effects were stronger for low-experience learners than for high-experience learners" (Mayer & Moreno, 1998, p. 315). The seven-item knowledge checklist instructed participants to "please place a check mark next to the items that apply to you" and contained the following 7 items:

1. I have taken a human anatomy/physiology class.
2. I frequently watch medically related television shows.
3. I can name the 4 chambers of the heart.
4. I know the difference between epicardium, endocardium, and myocardium.
5. I know the difference between auricles and ventricles.
6. I can describe the functions of the heart valves.
7. I can describe the flow of blood through the heart.

The five-item self-rating assessment asked participants to rate their knowledge of the human heart on a scale of very low, somewhat low, average, somewhat high, or very high. Each positive answer on the knowledge checklist was calculated as one point. Each item of the self-rating assessment was scored from 1 (very low) to 5 (very high). The scores were then added together, and the data from any participant who scored above 8 were eliminated from the study.

Once participants finished the pre-knowledge questionnaire, they began interacting with the instructional materials. On the last page of each treatment, participants were directed to take the posttest. Once they finished the posttest, participants were free to leave. All of the participants were able to complete the entire study within one hour.

Data Analysis

Data for this study consisted of GEFT test scores and recall scores on the terminology test, comprehension test, and total test. The test scores were automatically recorded in a database. Participants' performance on GEFT test were scored by the researcher based on the answer keys provided in the manual for the Group Embedded Figures Test (Witkin et al., 1971) and manually entered into the database. Based upon their scores on the GEFT, participants were classified into three groups: field dependent, field independent, and field neutral. All data were exported to SPSS to perform the statistical analyses.

A descriptive analysis was first conducted to generate detailed information, including means, standard deviation, and frequency data, to describe and infer characteristics of the participants. The test scores were then analyzed. Each of the criterion tests was designed to measure a different type of learning task (Dwyer, 1978). The terminology test was designed to test students' knowledge of specific facts, terms, and definitions of the human heart. The comprehension test required students to have a thorough understanding of the working of heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. Berry and Dwyer (1982-1983) emphasized that "the comprehension test was designed to measure a type of understanding that occurs when the individual understands what is being communicated and can use the information being received to explain some other phenomenon occurring simultaneously" (p. 271). Based on the type of cueing strategy (non-cueing, color-highlighted-keyword, color-highlighted-key-phrase) and level of student cognitive style (field dependent, field neutral, field independent), a 3 x 3 factorial analysis of variance

(ANOVA) was employed to interpret the data from each test and determine any main effects for cueing strategy and field dependency, as well as any interaction effect. The alpha level for all analyses was set at .05 ($p \leq .05$).

CHAPTER III: RESULTS AND DISCUSSION

The purpose of this study was to determine whether cueing strategies embedded in computer delivered text messages affected the recall and comprehension of students who were classified as field dependent, field independent, or field neutral. Based upon the review of literature, the following research questions concerning field dependency and cueing strategies within a computer-based learning environment were presented:

1. Do cueing strategies affect learners' academic performance?
2. Do field independent learners outperform field dependent learners in their academic performance?
3. Will the use of either a color-highlighted-keyword cueing strategy or a color-highlighted-key-phrase cueing strategy help field dependent learners improve their learning?

Results of Analysis

Participants took the Group Embedded Figures Test (GEFT) to determine their level of field dependency. The participants then read a Web site with text and graphics presenting information on the anatomy and functioning of the human heart. Following the first two tasks, participants took a 40-item test of recall consisting of two parts: a 20-item terminology test and a 20-item comprehension test. By the end of the experiment, four main scores were obtained for each participant: (a) GEFT score, (b) terminology test score, (c) comprehension test score, and (d) total test score.

Group Embedded Figures Test (GEFT)

Participants' level of field dependency was determined using the Group Embedded Figures Test via the same procedures used by Dwyer and Moore (1991-1992). Participants who scored greater than one-half standard deviation above the mean were considered field independent, while participants who scored less than one-half standard deviation below the mean were considered field dependent. Participants who scored within one-half standard deviation above or below the mean were considered field neutral. The range of the GEFT scores in this study was 0 to 18, the mean was 13.21, and the standard deviation was 4.45. Of the 219 participants, 63 were classified as field dependents (score equal to or below 11), 63 were classified as field neutral (score greater than 11 but less than 16), and 93 participants were classified as field independents (score equal to or above 16).

When participants signed up for the study, they were assigned a computer generated identification code, and the interface randomly assigned them to a specific treatment group. Of the 63 field dependent participants, 22 were assigned to the non-cueing treatment, 15 were assigned to the color-highlight-keyword cueing strategy treatment, and 26 were assigned to the color-highlight-key-phrase cueing strategy treatment. Of the 63 field neutral participants, 23 were assigned to the non-cueing treatment, 19 were assigned to the color-highlighted-keyword cueing strategy treatment, and 21 were assigned to the color-highlighted-key phrase cueing strategy. Of the 93 field independent participants, 27 were assigned to the non-cueing treatment, 34 were assigned to the color-highlighted-keyword cueing strategy treatment, and 32 were assigned to the color-highlighted-key phrase cueing strategy. Table 3 displays the breakdown of participants to treatment groups.

Table 3

Assignment to Treatment Groups by Cognitive Style

	Treatment Groups			
Cognitive Style	Non Cueing	Color Key Words	Color Key Phrases	Total
Field Dependent	22	15	26	63
Field Neutral	23	19	21	63
Field Independent	27	34	32	93
Total	72	68	79	219

Posttest Scores

Participants' scores on the terminology test and comprehension test were based on the number of correct responses given on the respective parts of the test. Total test scores were calculated based on the number of correct responses given on both the terminology and comprehension parts of the posttest. Scores on the terminology test ranged from 2 to 20 (out of 20 possible), and scores on the comprehension test ranged from 0 to 20 (out of 20 possible). The following tables report the means and standard deviations for the terminology test (Table 4), comprehension test (Table 5) and combined total overall scores (Table 6).

Table 4

Means and Standard Deviations for the Terminology Test

		Level of Field Dependency			
Cueing Strategy		FD	FN	FI	Total
Non Cueing	*M*	9.14	9.91	12.33	10.58
	SD	3.51	4.35	4.03	4.17
	n	22	23	27	72
Color-Highlighted-Keyword	*M*	9.40	10.05	12.03	10.90
	SD	4.29	3.24	4.31	4.14
	n	15	19	34	68
Color-Highlighted-Key-Phrase	*M*	9.00	11.00	10.16	10.00
	SD	3.39	3.55	3.84	3.66
	n	26	21	32	79
Total	*M*	9.14	10.32	11.47	10.47
	SD	3.60	3.75	4.14	3.98
	n	63	63	93	219

Note. FD = Field Dependent; FN = Field Neutral; FI = Field Independent

Table 5

Means and Standard Deviations for the Comprehension Test

		Level of Field Dependency			
Cueing Strategy		FD	FN	FI	Total
Non Cueing	*M*	6.18	8.22	11.81	8.94
	SD	3.20	3.61	5.14	4.73
	n	22	23	27	72
Color-Highlighted-Keyword	*M*	6.47	7.37	10.03	8.50
	SD	2.90	5.09	4.39	4.55
	n	15	19	34	68
Color-Highlighted-Key Phrase	*M*	6.96	9.10	8.16	8.01
	SD	3.13	4.37	3.41	3.65
	n	26	21	32	79
Total	*M*	6.57	8.25	9.90	8.47
	SD	3.07	4.33	4.52	4.31
	n	63	63	93	219

Note. FD = Field Dependent; FN = Field Neutral; FI = Field Independent

Table 6

Means and Standard Deviations for the Total Test

		Level of Field Dependency			
Cueing Strategy		FD	FN	FI	Total
Non Cueing	*M*	15.32	18.13	24.15	19.53
	SD	6.10	7.46	8.54	8.32
	n	22	23	27	72
Color-Highlighted-Keyword	*M*	15.87	17.42	22.06	19.40
	SD	6.06	7.54	8.03	7.88
	n	15	19	34	68
Color-Highlighted-Key Phrase	*M*	15.96	20.10	18.31	18.01
	SD	5.97	7.15	6.24	6.53
	n	26	21	32	79
Total	*M*	15.71	18.57	21.38	18.94
	SD	5.94	7.35	7.91	7.58
	n	63	63	93	219

Note. FD = Field Dependent; FN = Field Neutral; FI = Field Independent

Hypothesis Tests

In the following section, a summary of the results in relation to each of the three research hypotheses is presented. This is followed by a discussion of those results.

Hypothesis One

Participants who receive a color-highlighted-keyword cueing strategy or color-highlighted-key-phrase cueing strategy will score higher on a posttest than participants who receive no cueing strategy.

Participants who received the color-highlighted-keyword treatment scored higher (*M* =10.90, *SD* = 4.14) on the terminology test (Table 4) than participants who received the color-highlighted-key-phrase treatment (*M* = 10.00, *SD* = 3.66) and participants who received non-cueing treatment (*M* = 10.58, *SD* = 4.17). However, the results of the factorial ANOVA (Appendix F) conducted using the terminology test scores indicated that there was no significant main effect for cueing strategy, $F(2, 210) = .292$, $p > .05$.

Participants who were in the non-cueing treatment condition scored higher (*M* = 8.94, *SD* = 4.73) on the comprehension test (Table 5) than participants in the color-highlighted-keyword (*M* = 8.50, *SD* = 4.55) and color-highlighted-key-phrase treatments (*M* = 8.01, *SD* = 3.65). The results of the factorial ANOVA (Appendix G) conducted using the comprehension test scores indicated that there was no significant main effect for cueing strategy, $F(2, 210) = .764$, $p > .05$.

The overall total test score (Table 6) for participants who received the non-cueing treatment condition was higher (*M* =19.53, *SD* = 8.32) than the overall total score for participants who were in the color-highlighted-keyword treatment (*M* = 19.40, *SD* = 7.88) and color-highlighted-key-phrase treatments (*M* = 18.01, *SD* = 6.53). The factorial ANONVA conducted with the total test scores (Appendix H) showed no significant main effect for cueing strategy, $F(2, 210) = .436$, $p > .05$.

The mean scores of the terminology test, comprehension test, and total test were not significantly different among students who were assigned to the three treatment groups. The results did not support the hypothesis that participants receiving the color-highlighted-keyword cueing strategy or color-highlighted-key-phrase cueing strategy would score higher on a posttest than participants in the control group (no cueing strategy). Therefore, it appears that the cueing strategies employed in this study had no effect on participants' performance.

Hypothesis Two

Participants with a field independent cognitive style will score higher on a posttest than participants with a field dependent cognitive style.

Significant results for field dependency were obtained for the terminology test (field dependent, $M = 9.14$; field independent, $M = 11.47$), $F(2, 210) = 6.684$, $p < .05$ in Appendix F, the comprehension test (field dependent, $M = 6.57$; field independent, $M = 9.90$), $F(2, 210) = 13.678$, $p < .05$ in Appendix G, and the total test score (field dependent, $M = 15.71$; field independent, $M = 21.38$), $F(2, 210) = 12.145$, $p < .05$ in Appendix H. The results indicated that significant mean differences exist among groups of participants classified as field dependents, field neutrals, and field independents (see Tables 4, 5, and 6 for mean scores).

Table 7

Test of Homogeneity of Variances: One-way ANOVA of Field Dependency

Dependent Variable	*Levene's Statistic*	*Sig.*	*df1*	*df2*
Terminology Test Scores	2.277	.105	2	216
Comprehension Test Scores	7.493	.001	2	216
Total Test Scores	5.798	.004	2	216

To determine which field dependency groups differed, a Post Hoc multiple comparison procedure was conducted for each dependent variable. The multiple comparisons were performed using either the Tukey or Games-Howell test based upon whether Levene's test indicated homogeneity or unequal variance, respectively. Since the homogeneity of variance assumption was not violated with the terminology test score (see Table 7) as the dependent variable, the Tukey test was used in analyzing the groups' mean differences (Appendix I). The results indicated that there was a significant difference between field dependents and field independents. Field independents (Mean = 11.47) scored significant higher than field dependents (Mean = 9.14).

Although "a basic assumption underlying the analysis of variance is that each of our populations has the same variance" (Howell, 2002, p. 323), in practice, the assumption can be violated with relatively negligible effects. Since the homogeneity of variance assumption was violated with the comprehension test score and the total test score as dependent variable (see Table 7), the Games-Howell test was used in analyzing the groups' mean differences. The Games-Howell test was designed for unequal variance and used with unequal group size; this test appears to do better than the Tukey test if variances are very unequal. (Howell, 2002; Klockars, Hancock, & McAweeney, 1995). The results of the Games-Howell test showed that there was a significant difference between the field dependent group and the field independent group on the comprehension test (Appendix J) and total test (Appendix K). The comprehension test scores of the field independent group (M = 9.97, SD = 4.52) and field neutral group (M = 8.25, SD = 4.33) were significantly higher than the comprehension test scores of the field dependent group (M = 6.57, SD = 3.07). The total test scores of the field independent group (M = 21.38, SD = 7.91) and field neutral group (M = 18.57, SD = 7.35) were also significantly higher than the total test scores of the field dependent group (M = 15.71, SD = 5.94). By assessing the scores of the terminology test, comprehension test, and the combined total test, the field independent group had the highest mean score of the three groups, while the field dependent group had the lowest mean score of the three groups (see Tables 4, 5, and 6 for mean scores).

For each cueing strategy variation presented, field independent participants outperformed field dependent participants (see Tables 4, 5, and 6 for mean scores). The results did support the hypothesis that participants with a field independent cognitive style orientation would score higher on a posttest than participants with a field dependent cognitive style orientation.

Hypothesis Three

Participants with a field dependent cognitive style who receive a color-highlighted-key-phrase cueing strategy will score higher on a posttest than participants with a field dependent cognitive style who receive either a color-highlighted-keyword cueing strategy or no cueing strategy.

A significant interaction between type of cueing strategy and field dependency was observed for the comprehension test, $F(4, 210) = 3.036$, $p < .05$ (Appendix G) and the overall total test, $F(4, 210) = 2.547$, $p < .05$ (Appendix H). There was no significant interaction effect between type of cueing strategy and field dependency for the terminology test, $F(4, 210) = 1.373$, $p > .05$ (Appendix F). A significant interaction indicates that "the effect of one variable depends on the level of the other variable" (Howell, 2002, p. 429). In this study, the performance on the comprehension test and overall test for participants who were classified as field dependent, field neutral, and field independent was dependent on the type of cueing strategy they received.

To further examine the differences in scores among field dependency groups assigned to different types of cueing strategies, one-way ANOVA simple effects were conducted. "The analysis of simple effects can be an important techniques for analyzing data that contain significant interactions" (Howell, 2002, p. 432), and it has been identified "as the effect of one factor (independent variable) at one level of the other factor" (p. 432).

Field dependence-independence. A simple effects test using comprehension test scores indicated that there was no significant mean difference between field dependent participants in the three treatment groups (non-cueing treatment, $M = 6.18$; color-highlighted-keyword treatment, $M = 6.47$; color-highlighted-key-phrase treatment, $M = 6.96$; $F(2, 210) = 0.231$, $p > .05$; see Table 8). Similarly, no significant mean differences were found between field dependent participants in the three treatment groups using the total test score (non-cueing treatment, $M = 15.32$; color-highlighted-keyword treatment, $M = 15.87$; color-highlighted-key-phrase treatment, $M = 15.96$; $F(2, 210) = 0.053$, $p > .05$; see Table 9). The desired outcome for this hypothesis was that field dependent learners would be aided by the use of the color-highlighted-key-phrase cueing strategy. The lack of a significant difference in scores for field dependent participants between the cueing strategy treatment groups indicated that the use of a cueing strategy did not help field dependent learners in their ability to recall information. Therefore, participants with a field dependent cognitive style who received a color-highlighted-key-phrase cueing strategy did not score higher on a posttest than participants with a field dependent cognitive style who received either a color-highlighted-keyword cueing strategy or no cueing strategy. Hypothesis three was not supported.

Table 8

One-way ANOVA of Simple Main Effects: Field Dependence, Treatment Groups, and Comprehension Test

	Sum of Squares	*df*	*Mean Square*	*F*	Sig
Between Groups	7.461	2	3.730	.387	.681
Within Groups	577.968	60	9.633		
Total	585.429	62			

Table 9

One-way ANOVA of Simple Main Effects: Field Dependence, Treatment Groups, and Total Test

	Sum of Squares	*df*	*Mean Square*	*F*	Sig
Between Groups	5.390	2	2.695	.074	.929
Within Groups	2185.468	60	36.424		
Total	2190.857	62			

A significant mean difference was found between the comprehension test scores of field independent participants in the different treatments $F(2, 210) = 6.088$, $p < .05$ (Appendix L). Field independents who received the non-cueing strategy treatment ($M = 11.81$) scored significantly higher on the comprehension test than field independents who received color-highlighted-key-phrase cueing strategy treatment ($M = 8.16$). The same simple main effect was also found with the overall total test score, $F(2, 210) = 5.145$, $p < .05$ (Appendix M).

Treatment groups. A significant mean difference was found between the comprehension test scores of field dependents, field independents, and field neutrals who received the color-highlighted-keyword cueing strategy treatment, $F(2, 210) = 5.130$, $p < .05$ (Appendix P). Field independents who received the color-highlighted-keyword cueing strategy treatment (*M* = 10.03) scored significantly higher on the comprehension test than field dependents who received the same treatment (*M* = 6.47). The same simple main effect was also found with the overall total test score, $F(2, 210) = 4.933$, $p < .05$ (Appendix Q).

A simple effects test indicated that there was no significant mean difference between the comprehension test scores of field dependents, field independents, and field neutrals who received the color-highlighted-key-phrase treatment (Field Dependent group, *M* = 6.96; Field Neutral group, *M* = 9.10; Field Independent group, *M* = 8.16; $F(2, 210) = 1.770$, $p > .05$; see Table 10). Similarly, there was no significant mean difference between the total test scores of field dependents, field independents, and field neutrals who received the color-highlighted-key-phrase treatment (Field Dependent group, *M* = 15.96; Field Neutral group, *M* = 20.10; Field Independent group, *M* = 18.31; $F(2, 210) = 1.998$, $p > .05$.; see Table 11). The results showed that the color-highlighted-key-phrase cueing strategy had no significant effect on the immediate recall of participants who were classified as field dependent, field independent, and field neutral.

Table 10

One-way ANOVA of Simple Main Effects: Color-Highlighted-Key-Phrase Treatment, Field Dependency, and Comprehension Test

	Sum of Squares	*df*	*Mean Square*	*F*	Sig
Between Groups	53.998	2	26.999	2.079	.132
Within Groups	986.990	76	12.987		
Total	1040.987	78			

Table 11

One-way ANOVA of Simple Main Effects: Color-Highlighted-Key-Phrase Treatment, Field Dependency, and Total Test

	Sum of Squares	*df*	*Mean Square*	*F*	Sig
Between Groups	203.341	2	101.671	2.475	.091
Within Groups	3121.646	76	41.074		
Total	3324.987	78			

A significant mean difference was found between the comprehension test scores of field dependents, field independents, and field neutrals who received the non-cueing treatment (control group), $F(2, 210) = 12.448$, $p < .05$ (Appendix N). Field independents who received the non-cueing strategy treatment ($M = 11.81$) scored significantly higher on the comprehension test than field dependents who received the same treatment ($M = 6.18$). The same simple main effect was also found with the overall total test score, $F(2, 210) = 9.935$, $p < .05$ (Appendix O).

Summary. Field independents performed significantly better than field dependents when they received either the color-highlighted-keyword treatment or the non-cueing treatment. There was no significant mean difference between field dependents and field independents who received the color-highlighted-key-phrase treatment. Therefore, there are fewer mean differences observed between field independents and field dependents when they receive a color-highlighted-key-phrase treatment as opposed to a color-highlighted-keyword treatment or a treatment with no cueing strategy.

Figure 5 graphically illustrates the interaction between type of cueing strategy and level of field dependence-independence when looking at comprehension test scores. Field independents outperformed field dependents in all three treatment groups.

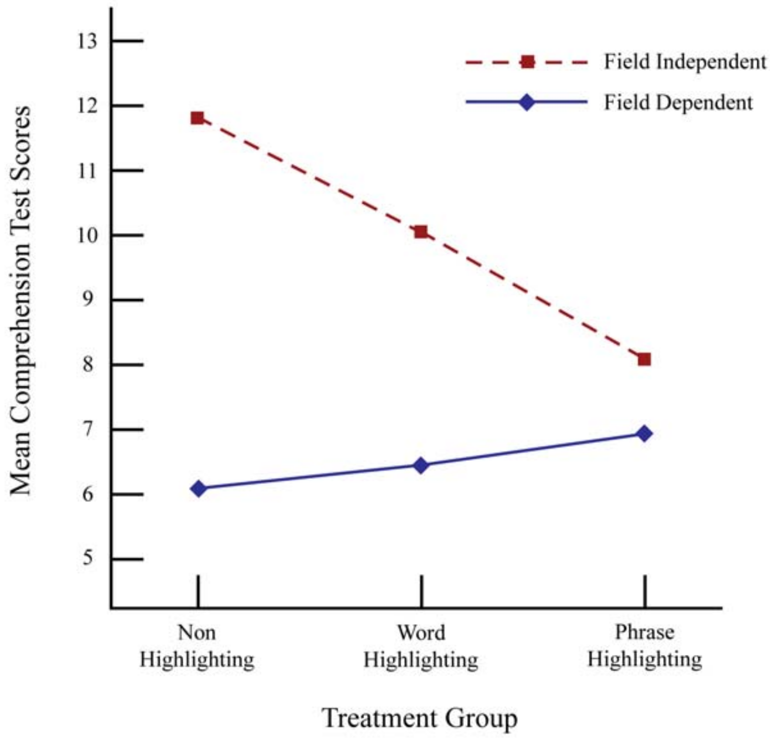


Figure 5. Interaction effect between the types of cueing strategies and the levels of field dependence-independence for the comprehension test.

The figure also demonstrates that the difference between field dependents and field independents in the color-highlighted-key-phrase treatment was less than in the non-cueing treatment. In other words, the color-highlighted-key-phrase cueing strategy had a stronger effect on field independents than on field dependents even though the effect was not significant. The effect is negative since the mean comprehension test score of field independents dropped progressively from 11.81 (Non-cueing treatment) to 10.03 (color-highlighted-keyword treatment) to 8.16 (color-highlighted-key-phrase treatment). This result was unexpected.

Discussion

Hypothesis one was based on the assumption that inserting cues in instructional text can help learners organize complex instructional content, identify relevant information, direct their attention to important words and phrases, and facilitate their eventual learning (Anderson, 1982; Bloom, 1976; Burbank & Pett, 1989; Dick et al., 2001; Driscoll, 2000; Dwyer, 1972, 1978; Fleming & Levie, 1978; Norman, 1969; Reynolds & Shirey, 1988; Stewart, 1988; Taylor et al., 1987). In other words, cueing strategies—regardless of which cues are used—tend to assist in learning. However, no differences in student performance were observed when either a color-highlighted-keyword cueing strategy or color-highlighted-key-phrase cueing strategy was used. Thus, hypothesis one was not supported.

Previous research into the effects of cueing strategies on students' academic performance has produced mixed results. A large majority of studies have indicated that the use of cueing strategies has a significant effect on students' knowledge acquisition (Buhalis, 1998; Dinnel & Glover, 1985; Dwyer & Moore, 1992b; Gaddy, 1996; Glynn & Britton, 1984; Goldstein, 1981; Higgins & Cocks, 1999; Lin, 1997; Mayer, 1989; Richards, 1980; Wu & Yuan, 2003). Other studies have indicated that there are no significant differences in achievement between participants who receive cueing strategies (Cory, 1990; Owens, 2002; Pienkowski, 2002; Worley & Moore, 2001). Results from the current study showed no statistically significant differences among the assessment scores of students who received different cueing strategies, further adding to the mixed results in the area of cueing strategy research.

Field independents' increased cognitive competency and greater restructuring skills have made them more adaptive in educational contexts, and their achievements are more valued within the educational setting (Davis, 1991). Field dependents have been viewed as passive learners in perceiving learning information. They are more disadvantaged in unstructured situations, and they require more explicit instruction and more detailed descriptions than field independents when performing problem solving tasks (Davis & Cochran, 1990; Goodenough, 1976; Jones, 1993; Witkin & Goodenough, 1981; Witkin et al., 1977). Studies have shown that field independent learners are more successful than field dependent learners when performing learning tasks that involve higher order thinking skills, such as restructuring of information (Daniels & Moore, 2000; Davis & Cochran, 1989a; Niaz & Logie, 1993; Witkin & Goodenough, 1981).

It is generally agreed that there is a significant association between level of field dependency and academic achievement (Chou & Lin, 1998; Daniels & Moore, 2000; Davis, 1991; Donnarumma et al., 1980; Dwyer & Moore, 1991-1992; Goodenough, 1976; Lin & Davidson, 1994; Lin, 1997; Luk, 1998; Moore & Dwyer, 1991; Nasser & Carifio, 1993; Tinajero & Paramo, 1997, 1998; Weller et al., 1994; Witkin et al., 1977). Previous research has indicated that learners who are more field independent achieve better than learners who are more field dependent. The results of the current study show that field independents scored significant higher on all three posttests than field dependents in all experimental groups, which provides further evidence to support these earlier findings.

The results of this study confirmed that the field dependence-independence cognitive style is a significant variable in teaching and learning (Burton et al., 1995; Messick, 1984; Pithers, 2002; Witkin, 1976). The findings of this study also support the statement that "field dependence/field independence, which constitutes an important aspect of individual differences among students regarding the way they acquire and process information, appears to hold promising potential for the design and development of effective instructional materials" (Chinien & Boutin, 1993, p. 370). Instructional designers who intend to design effective instruction should be aware of the potential impact of field dependence-independence on learning performance. By considering learners' individual differences and special learning needs, they can create instructional materials that positively influence learners possessing both types of cognitive style.

Employing salient cues in instructional text has been identified as an effective method for directing students' attention to areas that are important (Fleming & Levie, 1978). Researchers believe that instructional materials should be designed and structured to compensate for individual differences and to eliminate cognitive style bias against field dependent learners (Ausburn & Ausburn, 1978; Crow & Piper, 1983; Witkin et al., 1977). Witkin, et al. (1977) suggest that since field dependents are passive in perceiving information and are more likely to have difficulty attending to the information they are supposed to learn, the effects of using cueing strategies may be more prominent for field dependents than field independents. Results of previous studies (Cashen & Leicht, 1970; Fowler & Barker, 1974; Gaddy, 1996; Glynn, 1978; Glynn et al., 1985; Lorch et al., 1995) also indicate that visually distinct information embedded in text messages should be remembered more than indistinct information.

The mean scores of both the comprehension test and the overall test showed that field dependents' performance was not significantly improved when two types of cueing strategy treatments were employed. The findings indicate that the performance scores for field dependent learners in this study were not affected by cueing strategies. As a result, these findings provide no support for the use of cueing strategies as a means for increasing memory recognition performance for students who are classified as field dependent in terms of their cognitive style.

Hypothesis three was also proposed based on the statement of Fleming and Levie (1978) that "simply reminding the learner how new facts relate to old both adds an element of familiarity to the new and changes isolated (meaningless) new facts into meaningful additions and extensions of previous cognitive structures and relationships" (p.122). Therefore, field dependent participants who received the color-highlighted-key-phrase treatment were expected to perform better than field dependent participants who received the color-highlighted keyword treatment and non cueing treatment. However, the hypothesis was not confirmed by this research.

Some researchers (Grieve & Davis, 1971; Satterly & Telfer, 1979) believe that field independent learners are not hindered by imposed structure or restructuring aspects of instructional strategies. However, the results of this study showed that performance of field independent participants was inhibited by the introduction of two types of cueing strategies. Field independent participants who received a color-highlighted-keyword treatment or a color-highlighted-key-phrase treatment performed worse than those who received a non-cueing treatment. While this is contrary to expectations, there may be some explanation. By providing open-ended questions on a satisfaction questionnaire and from post-treatment conversations with field independent students in her study, Summerville (1998) discovered an interesting result. She found that field independents who were assigned to an instructional environment designed to address field dependents' special learning needs with highly structured instructional content and more instructional support and directions were more likely to attribute their perceived lack of success to external sources. In addition, when conducting the pilot study for this research, one subject who was identified having a field independent cognitive orientation pointed out that the color highlighted key words and key phrases used as cueing strategies (which were implemented to support field dependent learners) were in fact distracting. Jonassen and Grabowski (1993) summarized that "offering deliberate structural support with salient cues…" is a kind of instructional condition that "capitalize[s] on the preferences of the *field* dependent student and challenge[s] the *field* independent student…" (p. 97). Therefore, even though the performance of field independent participants in this study was unexpected, there may be some explanation provided by previous research.

Conclusion

Cronbach and Snow (1981) believe that instructional methods can be designed to compensate for some learners' deficiencies. Good educators have always adapted their instructional methods to accommodate individual differences among learners (Snow, 1976). Furthermore, Snow pointed out that the difficulty of designing and developing appropriate instructional materials lies in adapting instruction to improve achievement for some learners without making it worse for others. Individuals may have different responses to the same stimuli because of their unique experiences and different cognitive styles. These differences affect the nature of the relationship that learners have with the stimuli or information that will be processed. Designers who do not account for cognitive styles when creating instructional materials could end up creating materials that are biased to a certain style or mismatched to their learners (Jonassen & Grabowski, 1993).

Since 1940s, the construct of field dependence-independence has been extensively studied. The construct is considered one of the most significant factors in teaching and learning (Ausburn & Ausburn, 1978; Burton et al., 1995; Reardon & Moore, 1988; Witkin & Goodenough, 1981). Researchers (Carrier et al., 1984; Weller et al., 1995; Witkin et al., 1977) believe that there is a close relationship between field dependency and cueing strategy. Witkin et al. (1971) suggest that instructional treatments might be designed to accommodate the different needs of field dependent and field independent learners. Since field dependent learners lack the ability to cognitively restructure and reorganize information, the use of relevant cues to aid in information processing can lead them to greater achievement (Witkin et al., 1977).

Consequently, based on analysis of individual learners' cognitive style and their reactions to certain instructional strategies, educators might be able to adapt instructional treatments to the learning needs of field dependent learners without hindering the learning performance of field independent learners.

This study was designed to explore the relationship between the field dependence-independence cognitive style and various cueing strategies when looking at students' performance in a computer-based instructional environment. To begin with, it was expected that the use of a color-highlighted-keyword cueing strategy or a color-highlighted-key-phrase cueing strategy would lead participants to perform better than participants receiving the same instructional content presented in a non-cueing strategy format. This was not supported by the resulting analysis comparing the different cueing strategy treatments. A statistical analysis of the data indicated that there were no differences attributable to the types of cueing strategies used with the instructional materials employed in this study. This result suggests that students' academic performance is not influenced by the use of cueing strategies. In terms of the performance of the undergraduate students who participated in this study, the current results provided no support for the use of color-highlighted-keywords and color-highlighted-key-phrases as cues to increase the learning of relevant information presented in computer-based instructional text messages.

As expected, there were significant differences in student performance based on cognitive style. Field independent learners performed better than field dependent learners on all tests of recall and comprehension, which supports previous research in the area of field dependence-independence.

It was predicted that cueing strategies would serve as externally presented aids to assist field dependent learners in disembedding and selecting key information by directing their attention to the relevant information in computer delivered text message. However, the data did not provide a statistically significant result to support the prediction. Findings from this study suggest that the academic performance of field dependent learners is not affected by cueing strategies. In other words, the use of color-highlighted key words and color-highlighted key phrases does not assist field dependent learners in learning.

It was anticipated that the performance of field independent learners would not be hindered when they were placed in an instructional environment designed to capitalize on the inclination of field dependent learners. However, an unexpected result was discovered from this study: field independent learners' performance decreased when presented with the cueing strategies employed in this study.

In closing, field independent learners outperformed field dependent learners when presented with instructional text messages containing color-highlighted-key words, color-highlighted-key-phrases, or no cues. In addition, it appears that the cueing strategies employed in this study offer no help for field dependent learners in terms of facilitating learning and performance on criterion measures. Even though it was expected that field independent learners would not be hindered by cueing strategies, the results of this study did not match the prediction. Considering the results of this study and the potential ineffectiveness of cueing, there may be opportunities for future researchers to explore under what conditions cueing strategies would or would not be effective. However, no direct evidence to support further research was found in this study.

REFERENCES

Abouserie, R., Moss, D., & Barasi, S. (1992). Cognitive style, gender, attitude toward computer-assisted learning and academic achievement. *Educational Studies, 18*, 151-152.

Abraham, R. G. (1985). Field Independence-dependence and the teaching of grammar. *TESOL Quarterly, 19*(4), 689-702.

Alessi, S. M., & Trollip, S. R. (1991). *Computer-based instruction: Methods and development* (2th ed.). Englewood Cliffs, NJ: Prentice Hall.

Allen, W. H. (1975). Intellectual abilities and instructional media design. *AV Communication Review, 23*, 139-170.

Anderson, R. C. (1982). Allocation of attention during reading. In A. Flammer & W. Kintsch (Eds.), *Discourse processing* (pp. 292-305). New York: North-Holland.

Anderson, T. H., & Armbruster, B. B. (1985). Studying strategies and their implications for textbook design. In T. M. Duffy & R.Waller (Eds.), *Design usable texts* (pp. 159-178). Orlando, FL: Academic Press.

Annis, L. F. (1979). Effects of cognitive style and learning passage organization on study technique effectiveness. *Journal of Educational Psychology, 71*(5), 620-626.

Atkinson, R. C., & Shriffin, R. M. (1968). Human memory: A proposed system and its control processes. In J. Spence (Ed.), *The psychology of learning and motivation* (Vol. 2). New York: Academic.

Ausburn, L. J., & Ausburn, F. B. (1978). Cognitive styles: Some information and implications for instructional design. *Educational Communications and Technology Journal, 26*(4), 337-354.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York: Holt, Rinehart and Winston.

Avolio, B. J., Alexander, R. A., Barrett, G. V., & Sterns, H. L. (1981). Designing a measure of selective attention to assess individual differences in information processing. *Applied Psychological Measurement, 5*, 29-42.

Beck, C. R. (1987). Pictorial cueing strategies for encoding and retrieving information. *International Journal of instructional Media, 14*(4), 332-345.

Bennett, L. T. (1989). Visual literacy: A factor of text design and reading instruction. In R. A. Braden & D. G. Beauchamp & L. V. W. Miller & D. M. Moore (Eds.), *About visuals: Research, teaching and applications* (pp. 53-58). Blacksburg, VA: Virginia Tech University.

Berger, E., & Goldberger, L. (1979). Field dependency and short-term memory. *Perceptual and Motor Skills, 49*, 87-96.

Berry, L. H., & Dwyer, F. M. (1982-1983). The effects of dogmatism on students' ability to profit from visualized instruction: Realistic and non-realistic color. *International Journal of Instructional Media, 10*, 267-278.

Birrell, V. L. (1967). *Color and design: A basic text.* Unpublished doctoral dissertation, Columbia University, New York.

Bloom, B. S. (1976). *Human characteristics and school learning*. New York: McGraw-Hill.

Blowers, G. H., & O' Connor, K. P. (1978). Relation of eye movement to errors on the rod-and-frame test. *Perceptual and Motor Skills, 46*, 719-725.

Bowen, R. J., & Castle, T. J. (1987). Evaluating graphic design: The "brand X" method. *Performance and Instruction, 26*, 10-13.

Brenner, J. (1997). *An analysis of student's cognitive styles in asynchronous distance education course at a community college*. Richlands, VA: Southwest Virginia Community College.

Broadbent, D. E. (1958). *Perception and communication*. London: Pergamon.

Brooks, L., Dansereau, D., Spurlin, J., & Holley, C. (1983). Effects of headings on text processing. *Journal of Educational Psychology, 75*, 292-302.

Brown, J. W. (1978). *Educational media yearbook*. New York: R. R. Bowker.

Brown, J. W., Lewis, R. B., & Harcleroad, F. F. (1973). *AV instruction: Technology media and methods*. New York: McGraw-Hill.

Bruning, R. H., Schraw, G. S., & Ronning, R. R. (1995). *Cognitive psychology and instruction*. Upper Saddle River, NJ: Merrill and Prentice Hall.

Buhalis, H. J. (1998). *The efficacy of computer screen visual display design and color-enhanced text on learning effectiveness when presenting stimulus material for knowledge acquisition to community college students.* Unpublished doctoral dissertation, Wayne State University, Detroit, MI.

Burbank, L., & Pett, D. (1989). Designing instructional materials: Some guidelines. In R. A. Braden & D. G. Beauchamp & L. V. W. Miller & D. M. Moore (Eds.), *About visuals: Research, teaching and applications* (Vol. 527-534). Blacksburg, VA: Virginia Tech University.

Burton, J. K., Moore, D. M., & Holmes, G. A. (1995). Hypermedia concepts and research: An overview. *Computers in Human Behavior, 11*(3/4), 345-369.

Burwell, L. B. (1991). The interaction of learning styles with learner control treatments in an interactive videodisc lesson. *Educational Technology, 31*, 37-43.

Canelos, J. J., Taylor, W. D., & Gates, R. B. (1980). The effects of three levels of visual stimulus complexity on the information processing of field-dependents and field-independents when acquiring information for performance on three types of instructional objectives. *Journal of Instructional Psychology, 7*(2), 65-70.

Canino, C., & Cicchelli, T. (1988). Cognitive styles, computerized treatments on mathematics achievement and reaction to treatments. *Journal of Educational Computing Research, 4*(3), 253-264.

Card, S. K., Moran, T. P., & Newell, A. (1983). *The psychology of human-computer interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Carrier, C., Davidson, G., Higson, V., & Williams, M. (1984). Selection of options by field-independent and dependent children in a computer-based concept lesson. *Journal of Computer-Based Instruction, 11*(2), 49-54.

Cashen, V. M., & Leicht, K. L. (1970). Role of the isolation effect in a formal educational setting. *Journal of Educational Psychology, 61*, 484-486.

Chandran, S., Treagust, D. F., & Tobin, K. (1987). The role of cognitive factors in chemistry achievement. *Journal of Research in Science Teaching, 24*(2), 145-160.

Chen, L. L. (1998). *Web-based distance instruction: Design and Implications of a cybercourse model.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, St. Louis, MO.

Chin, S. S. F. (1994). The integration of instructional technology in Hong Kong Education. *CUHK Educational Journal, 22*(2), 321-330.

Chinien, C. A., & Boutin, F. (1993). Cognitive style FD/I: An important learner characteristic for educational technologists. *Journal of Educational Technology Systems, 21*(4), 303-311.

Chobot, M. C. (1984). *The interactive effects of field dependence and adjunct questions on learning from prose by library/information science students.* Unpublished doctoral dissertation, The Catholic University of America, Washington, D. C.

Chou, C., & Lin, H. (1998). The effects of navigation map types and cognitive styles on learners' performance in a computer-networked hypertext learning system. *Journal of Educational Multimedia and Hypermedia, 2*(2-3), 151-176.

Chute, A. G. (1979). Analysis of the instructional functions of color and monochrome cueing in media presentations. *Educational Communication and Technology Journal, 24*(7), 251-263.

Cochran, K. F., & Davis, J. K. (1987). Individual differences in inference processes. *Journal of Research in Personality, 21*, 197-210.

Collins-Eiland, K., Dansereau, D. F., Brooks, L. W., & Holley, C. D. (1986). Effects of conversational noise, locus of control, and field dependence/independence on the performance of academic tasks. *Contemporary Educational Psychology, 11*(2), 139-149.

Cory, K. A. (1990). *Effects of display variables and cognitive field orientation on time to learn a task.* Unpublished doctoral dissertation, University of Michigan, Ann Arbor, MI.

Cronbach, L. J., & Snow, R. E. (1977). *Aptitudes and instructional methods: A handbook for research on interactions*. New York: Irvington.

Cronbach, L. J., & Snow, R. E. (1981). *Aptitudes and instructional methods: A handbook for research on interactions*. New York: Irvington.

Cross, K. P. (1976). *Accent on learning: Improving instruction and reshaping the curriculum*. San Francisco, CA: Jossey-Bass.

Crow, L. W., & Piper, M. K. (1983). A study of the perceptual orientation of community college students and their attitudes toward science as they relate to science achievement. *Journal of Research in Science Teaching, 20*(6), 537-541.

Daniels, H. L. (1996). *Interaction of cognitive style and learner control of presentation mode in a hypermedia environment.* Unpublished doctoral dissertation, Virginia Tech, Blacksburg, VA.

Daniels, H. L., & Moore, D. M. (2000). Interaction of cognitive style and learner control in a hypermedia environment. *International Journal of Instructional Media, 27*(4), 369-383.

Davey, B., & Menke, D. (1989). The importance of cognitive style in children's acquisition of reading skill. *Early Child Development and Care, 51*, 49-64.

Davis, J. K. (1991). Educational implications of field-dependence-independence. In A. Wapner & J. Demick (Eds.), *Field dependence-independence: Cognitive style across the life span* (pp. 149-176). Hillsadle, NJ: Lawrence Erlbaum Associates.

Davis, J. K., & Cochran, K. F. (1982, March). *Toward an information processing analysis of field-independence.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Davis, J. K., & Cochran, K. F. (1989a). An information processing view of field dependence-independence. *Early Child Development and Care, 51*, 31-47.

Davis, J. K., & Cochran, K. F. (1989b). An information processing view of field dependence-independence. *Early Child Development and Care, v43*, 129-145.

Davis, J. K., & Cochran, K. F. (1990). An information processing view of field dependence-independence. In O. N. Saracho (Ed.), *Cognitive style in early education* (pp. 61-78). New York: Gordon and Breath Science.

Dember, W. N., & Warm, J. S. (1979). *Psychology of perception* (2nd ed.). New York: Holt, Rinehart and Winston.

Dempster, F. N., & Corkill, A. J. (1999). Interference and inhibition in cognition and behavior: Unifying themes for educational psychology. *Educational Psychology Review, 11*, 1-88.

Dick, W., Carey, L., & Carey, J. O. (2001). *The systematic design of instruction* (5th ed.). New York: Addition-Wesley Educational.

Dickstein, L. S. (1968). Field-dependence and concept attainment. *Perceptual and Motor Skills, 27*, 635-642.

Dinnel, D., & Glover, J. A. (1985). Advance organizers: Encoding manipulations. *Journal of Educational Psychology, 77*(5), 514-521.

Donnarumma, T., Cox, D., & Beder, H. (1980). Success in a high school completion program and its relation to field dependence-independence. *Adult Education, 30*(4), 222-232.

Downs, E. (1989). *The effects of cueing strategy, level of information, and motion condition on children's interpretation of implied motion in pictures.* Unpublished doctoral dissertation, University of Florida, Gainesville, FL.

Downs, E., & Jenkins, S. J. (2001). The effects of grade level, type of motion, cueing strategy, pictorial complexity, and color on children's interpretation of implied motion in pictures. *The Journal of Experimental Education, 69*(3), 229-242.

Driscoll, M. P. (2000). *Psychology of learning for instruction* (2th ed.). Needham Heights, MA: Allyn & Bacon.

Duchastel, P. C. (1982). Textual display techniques. In D. H. Jonassen (Ed.), *The technology of text: Principles for structuring, designing, and displaying text* (pp. 167-191). Englewood Cliffs, NJ: Educational Technology.

Dwyer, F. M. (1967). Adapting visual illustrations for effective learning. *Harvard Educational Review, 37*, 250-263.

Dwyer, F. M. (1972). *A guide for improving visualized instruction*. State College, PA: Learning Services.

Dwyer, F. M. (1978). *Strategies for improving visual learning: A handbook for the effective selection, design and uses of visual learning materials*. State College, PA: Learning Services.

Dwyer, F. M., & Lamberski, R. J. (1982). A review of the research on the effect of the use of color in the teaching-learning process. *International Journal of Instructional Media, 10*(4), 303-328.

Dwyer, F. M., & Moore, D. M. (1991-1992). Effect of color coding on visually and verbally oriented tests with students of different field dependence levels. *Journal of Educational Technology Systems, 20*(4), 311-320.

Dwyer, F. M., & Moore, D. M. (1992a, February). *Effect of color coding on cognitive style.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Washington, DC.

Dwyer, F. M., & Moore, D. M. (1992b). Effect of color coding on visually and verbally oriented tests with students of different field dependence levels. *Journal of Educational Technology Systems, 20*(4), 311-320.

Dwyer, F. M., & Moore, D. M. (2001). The effect of gender, field dependence and color-coding on student achievement of different educational objectives. *International Journal of Instructional Media, 28*(3), 309-318.

Enns, J. T., & Girgus, J. (1985). Developmental changes in selective and integrative visual attention. *Journal of Experimental Child Psychology, 40*, 319-337.

Fitzgerald, G. E., & Semrau, L. P. (1998). The effects of learner differences on usage patterns and learning outcomes with hypermedia case studies. *Journal of Educational Multimedia and Hypermedia, 7*(4), 309-331.

Fitzgibbons, D. J., Goldberger, L., & Eagle, M. (1965). Field dependence and memory for incidental material. *Perceptual and Motor Skills, 21*, 743-749.

Fleming, M. L. (1984, January). *Visual attention to picture and word materials as influenced by characteristics of the learners and design of the materials.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Dallas, TX.

Fleming, M. L. (1987). Displays and communication. In R. M. Gagné (Ed.), *Instructional technology: Foundations* (pp. 233-260). Englewood Cliffs: NJ: Lawrence Erlbaum Associates.

Fleming, M. L., & Levie, W. H. (1978). *Instructional message design: Principles from the behavioral sciences*. Englewood Cliffs, NJ: Educational Technology.

Fleming, M. L., & Levie, W. H. (1993). *Instructional message design: Principles from the behavioral and cognitive sciences* (2th ed.). Englewood Cliffs, NJ: Educational Technology.

Ford, N. (2000). Cognitive styles and virtual environments. *Journal of the American Society for Information Science, 51*(6), 543-557.

Fowler, R. L., & Barker, A. S. (1974). Effectiveness of highlighting for retention of text material. *Journal of Applied Psychology, 59*(3), 358-364.

Frank, B. M. (1983). Flexibility of information processing and the memory of field-independent and field-dependent learners. *Journal of Research in Personality, 17*, 89-96.

Frank, B. M. (1984). Effect of Field Independence-Dependence and Study Technique on Learning from a Lecture. *American Educational Research Journal, 21*(3), 669-678.

French, M. (1983). *Aptitude sensitive instruction.* Unpublished Doctoral Dissertation, Monash University, Victoria, Australia.

Gaddy, M. L. (1996). *Studying from highlighted material: The role of color in memory for text.* Unpublished Master's thesis, San Jose State University, San Jose, CA.

Gagné, R. M. (1982). Development in learning psychology: Implications for instructional design and effects of computer technology on instructional design and development. *Educational Technology, 22*(6), 11-15.

Gagné, R. M. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinehart, & Winston.

Galitz, W. O. (1993). *User-interface screen design*. Wellesley, MA: QED Information Science.

Galitz, W. O. (2002). *The essential guide to user interface design: An introduction to GUI design principles and techniques* (2th ed.). New York: John Wiley & Sons.

Garity, J. (1985). Learning styles: Basis for creative teaching and learning. *Nurse Education, 10*(12), 12-15.

Garner, C. W., & Cole, E. G. (1986). The achievement of students on low-SES settings: An investigation of the relationship between locus of control and field dependence. *Urban Education, 21*(2), 189-206.

Gibson, J. T. (1976). *Psychology for the classroom*. Englewood Cliffs: NJ: Prentice-Hall.

Gillani, B. B. (2003). *Learning theories and the design of e-learning environment*. Lanham, MD: University Press of America.

Glennan, T. K., & Melmed, A. (1996). *Fostering the use of educational technology: Elements of a national strategy*. Santa Monica, CA: Rand Critical Technologies Institute.

Glynn, S. M. (1978). Capturing readers' attention by means of typographical cuing strategies. *Educational Technology, 18*, 7-12.

Glynn, S. M., & Britton, B. K. (1984). Supporting readers' comprehension through effective text design. *Educational Technology, 24*(10), 40-43.

Glynn, S. M., Britton, B. K., & Tillman, M. H. (1985). Typographic cues in text: Management of the reader's attention. In D. H. Janassen (Ed.), *The technology of text* (pp. 192-209). Englewood Cliffs, NJ: Educational Technology.

Goldstein, D. (1981). *The effects of cued rehearsal strategies and manipulation of materials upon recall in severely retarded students.* Unpublished doctoral dissertation, Georgia State University, Atlanta, GA.

Goodenough, D. R. (1976). The role of individual differences in field dependence as a factor in learning and memory. *Psychological Bulletin, 83*(4), 675-694.

Goodenough, D. R. (1986). History of field dependent construct. In M. Bertini & L. Pizzamiglio & S. Wapner (Eds.), *Field dependence in psychological theory, research, and application: Two symposia in memory of Herman A. Witkin* (pp. 5-14). Hillsdale, NJ: Lawrence Erlbaum Associates.

Grabowski, B. L. (1991). Message design: Issues and trends. In G. J. Anglin (Ed.), *Instructional technology: Past, present, and future* (pp. 202-212). Englewood, CO: Libraries Unlimited.

Grabowski, B. L. (1995). Message design: Issues and trends. In G. J. Anglin (Ed.), *Instructional technology: Past, present, and future* (2th ed., pp. 222-232). Englewood, CO: Libraries Unlimited.

Graff, M. (2003). Learning from Web-Based Instructional Systems and Cognitive Style. *British Journal of Educational Technology, 34*(4), 407-418.

Greco, A. A., & McClung, C. (1979). Interaction between attention directing and cognitive style. *Educational Communications and Technology Journal, 27*(2), 97-102.

Gredler, M. (2001). *Learning and instruction: Theory into practice* (4th ed.). Upper Saddle River, NJ: Merrill Prentice Hall.

Grieve, T. D., & Davis, J. K. (1971). The relationship of cognitive style and method of instruction to performance in ninth grade geography. *Journal of Educational Research, 65*, 137-141.

Hahn, J. S. (1984). An exploratory study of the relationship between learner cognitive styles and three different teaching used to teach computer literacy with the Pittsburgh information retrieval system (PIRESTS). *International Journal of Instructional Media, 11*(2), 147-158.

Halpin, D. M. (2005). *The effects of locus of control and navigational control on the performance of students in a hypermedia environment.* Unpublished doctoral dissertation, Virginia Tech, Blacksburg, VA.

Hannafin, K. M., & Peck, K. L. (1988). *The design, development, and evaluation of instructional software*. New York: Macmillan.

Hannafin, M. J., Hannafin, K. M., & Hooper, S. R. (1996). Research on and research with emerging technologies. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 378-402). New York: Simon & Schuster Macmillan.

Hannafin, M. J., & Hooper, S. R. (1993). Learning principles. In M. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (2th ed., pp. 191-231). Englewood Cliffs, NJ: Educational Technology.

Hartley, J. (1985). *Designing instructional text*. London: Kogan Page.

Heines, J. (1984). *Screen design strategies for computer-assisted instruction*. Bedford, MA: Digital Press.

Hershberger, W. A. (1964). Self-evaluation responding and typographical cuing: Techniques for programming self-instructional reading materials. *Journal of Educational Psychology, 55*(5), 288-296.

Hettinger, A. A. (1988, January). *Operationalizing cognitive constructs in the design of computer-based instruction.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, New Orleans, LA.

Higgins, N. C., & Cocks, P. (1999). The effects of animation cues on vocabulary development. *Reading Psychology, 20*(1), 1-10.

Hinds, L. R., & Dodds, W. (1968). Words in color: Two experimental studies. *Journal of Typographic Research, 2*(1), 43-56.

Howell, D. C. (2002). *Statistical methods for psychology* (5th ed.). Pacific Grove, CA: Wadsworth Group.

Hsu, P. S., & Dwyer, F. M. (2004). Effect of level of adjunct questions on achievement of field independent/field dependent learners. *International Journal of Instructional Media, 31*(1), 99-106.

Ikegulu, P. R., & Ikegulu, T. N. (1999). *The effectiveness of window presentation strategy and cognitive style of field dependence status on learning from mediated instructions*. Louisiana.

Jackson, L. L. S. (1998). *Developing and validating an instrument to analyze the legibility of a Web page based upon text style and color combinations.* Unpublished doctoral dissertation, The George Washington University, Washington, D. C.

Jacobs, R. L. (1982, April). *The relationship of cognitive style to the frequency of proctor/student interactions and achievement in a PSI course.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Dallas, TX.

Jolly, E. J., & Reardon, R. (1985). Cognitive differentiation, automaticity, and interruptions of automatized behaviors. *Personality and Social Psychology Bulletin, 11*, 301-314.

Jonassen, D. H., & Grabowski, B. L. (1993). *Handbook of individual differences, learning, and instruction*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Jonassen, D. H., & Kirschner, P. A. (1982). Introduction to section two: Explicit techniques for structuring text. In D. H. Jonassen (Ed.), *The technology of text: Principles for structuring, designing, and displaying text* (pp. 123-136). Englewood Cliffs, NJ: Educational Technology.

Jones, M. K. (1989). *Human-computer interaction: A design guide*. Englewood Cliffs: NJ: Educational Technology.

Jones, S. (1993). Cognitive learning styles: Does awareness help? A review of selected literature. *Language Awareness, 2*(4), 195-207.

Joseph, J. H. (1987, February). *Field-dependence/Independence and the mathemagenic effects of observable visual Imagery rehearsal for learning from computer-presented text.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Atlanta GA.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kennedy, L. D. (1971). Textbook usage in the intermediate-upper grades. *The Reading Teacher, 24*(8), 723-729.

Kiewra, K. A., & Frank, B. M. (1986). Cognitive style: Effects of structure at acquisition and testing. *Contemporary Educational Psychology, 11*(3), 253-263.

Kini, A. S. (1994, February). *Effects of cognitive style and verbal and visual presentation modes on concept learning in cbi.* Paper presented at the annual meeting of American Educational Research Association, New Orleans, LA.

Klatzky, R. L. (1975). *Human memory: Structures and processes* (2th ed.). San Francisco: W. H. Freeman and Company.

Klatzky, R. L. (1980). *Human memory* (2th ed.). New York: Freeman.

Klockars, A. J., Hancock, G. R., & McAweeney, M. J. (1995). Power of unweighted and weighted versions of simultaneous and sequential multiple-comparison procedures. *Psychological Bulletin, 118*, 300-307.

Knafle, J. D. (1974). Color cues in word perception. *Journal for Reading Behavior, 6*(3), 233-247.

Knappenberger, N. (1998). *The effects of the interaction between cognitive style and instructional strategy on the educational outcomes for a science exhibit.* Unpublished doctoral dissertation, University of Virginia, Charlottesville, VA.

Kolers, P. A., Duchnicky, R. L., & Ferguson, D. C. (1981). Eye movement measurement of readability of C.R.T. displays. *Human Factors, 23*(5), 517-527.

Konopak, B., & Williams, N. (1988). Using the keyword method to help young reader learn content material. *Reading Teacher, 41*(7), 682-687.

Lamberski, R. J. (1972). *An exploratory investigation on the instructional effect of color and black and white cueing on immediate and delayed retention.* Unpublished Master's thesis, The Pennsylvania State University, University Park, PA.

Lamberski, R. J. (1980). *The effect of a verbal and visual color code on self-paced instruction and testing for retention on different tasks.* Unpublished doctoral dissertation, The Pennsylvania State University, University Park, PA.

Lamberski, R. J., & Mayers, B. E. (1980, April). *The efficiency of a color or black/white code in learning and test materials.* Paper presented at the annual meeting of the American Educational Research Association, Boston.

Lange, A. (1995). Define audio/video redundancy from a limited-capacity information processing perspective. *Communication Research, 22*(1), 86-115.

Leader, L. F., & Klein, J. D. (1994, February). *The effects of search tool and cognitive style on performance in hypermedia database searches.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Nashville, TN.

Legge, G., Parish, D., Luebker, A., & Wurm, L. (1990). Comparing color contrast and luminance contrast. *Psychophysics of reading, 7*(10), 2002-2009.

Levie, W. H., & Lentz, R. (1982). Effects of text illustrations: A review of research. *Educational Communications and Technology Journal, 30*(4), 195-232.

Lin, C. H., & Davidson, G. (1994, February 16-20). *Effects of linking structure and cognitive style on students' performance and attitude in a computer-based hypertext environment.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Nashville, TN.

Lin, M. J. H. (1997, March). *The effect of color design in Chinese CAI software.* Paper presented at the annual meeting of the Popular Culture Association/American Culture Association, San Antonio, TX.

Lipton, E. B. (1990). *The effects of typographic cueing on retention.* Unpublished doctoral dissertation, University of Southern California, Los Angeles.

Liu, M., & Reed, W. M. (1994). The relationship between the learning strategies and learning styles in a hypermedia environment. *Computers in Human Behavior, 10*(4), 419-434.

Lorch, R. F. J., Lorch, E. P., & Klusewitz, M. A. (1995). Effects of typographical cues on reading and recall of text. *Contemporary Educational Psychology, 20*, 51-64.

Luk, S. C. (1998). The relationship between cognitive style and academic achievement. *British Journal of Educational Technology, 29*(2), 137-147.

Magoulas, G. D., Papanikolaou, K., & Grigoriadou, M. (2003). Adaptive web-based learning: Accommodating individual differences through system's adaptation. *British Journal of Educational Technology, 34*(4), 511-527.

Martel, C. (1992). *Effects of graphic cueing strategies in text-based instruction on comprehension and retention.* Unpublished master's thesis, Concordia University, Montreal, Canada.

Mayer, R. E. (1984). Aids to prose comprehension. *Educational Psychologist, 19*(1), 30-42.

Mayer, R. E. (1989). Systematic thinking fostered by illustrations in scientific text. *Journal of Educational Psychology, 81*(2), 240-246.

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90*(2), 312-320.

McConaughy, S. (1985). Good and poor readers comprehension of story structures across different input and output modalities. *Reading Research Quarterly, 20*, 219-231.

McIntyre, W. A. (1981). *The effects of visual cue elaboration on cognitive tasks with different modes of presentation.* Unpublished doctoral dissertation, Boston University, Boston, MA.

McKeachie, W. J. (1988). The need for study strategy training. In C. E. Weinstein & E. T. Goetz (Eds.), *Learning and study strategies: Issues in assessment instruction, and evaluation* (pp. 3-10). San Diego: Harcourt Brace Jovanovich.

Messick, S. (1967). The criterion problem in the evaluation of instruction: Assessing possible, not just intended, outcomes. In M. C. Wittrock & D. Willey (Eds.), *The evaluation of instruction: Issues and problems* (pp. 183-202). New York: Holt, Rinehart, & Winston.

Messick, S. (1976). Personality consistencies in cognition and creativity. In S. Messick & Associates (Eds.), *Individuality in learning* (pp. 4-22). San Francisco: Jossey-Bass.

Messick, S. (1984). The nature of cognitive styles: Problems and promise in educational practice. *Educational Psychologist, 19*(2), 59-74.

Messick, S. (1986). Herman Witkin and the meaning of style. In M. Bertini & L. Pizzamiglio & S. Wapner (Eds.), *Field dependence in psychological theory, research, and application* (pp. 115-118). Hillsdale, NJ: Lawrence Erlbaum Associates.

Meyer, A., & Rose, D. H. (1998). *Learning to read in the computer age*. Cambridge, MA: Brookline Books.

Meyer, B. J. F. (1975). *The organization of prose and its effects on memory*. New York: American Elsevier.

Meyer, B. J. F., Brandt, D. M., & Bluth, G. J. (1980). Use of top-level structure in text: Key for reading comprehension of ninth graders. *Reading Research Quarterly, 16*(1), 72-103.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81-97.

Moore, D. M., Burton, J. K., & Myers, R. J. (2003). Multiple-channel communication: The theoretical and research foundations of multimedia. In D. H. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology: A Project of the Association for Educational Communications and Technology* (2nd ed., pp. 979-1005). New York: Simon & Schuster Macmillan.

Moore, D. M., & Dwyer, F. M. (1991). Effect of color-coded information on students' level of field dependence. *Perceptual and Motor Skills, 72*(2), 611-616.

Moore, D. M., & Dwyer, F. M. (1992, March). *Effects of color coding on cognitive style.* Paper presented at the annual meeting of the Eastern Educational Research Association, Hilton Head, SC.

Morrison, J., & Vogel, D. (1998). The impacts of presentation visuals on presentation. *Information and Management, 33*(3), 125-135.

Myers, R. G. (1997). *The interaction between the cognitive style of field dependence and visual presentation in color, monochrome, and line drawings.* Unpublished dissertation, University of Pittsburgh, Pittsburgh, PA.

Nasser, R., & Carifio, J. (1993). *The effects of cognitive style and piagetian logical reasoning on solving a propositional relation algebra word problem.* Paper presented at the North England Educational Research Organization, Portsmouth, NH.

Niaz, M., & Logie, R. H. (1993). Working memory, mental capacity and science education: Towards an understanding of the "working memory overload hypothesis". *Oxford Review of Education, 9*(4), 511-525.

Noble, J. P., & Frank, B. M. (1985). Field independence-dependence and verbal restructuring. *Journal of Experimental Education, 54*(1), 28-33.

Norman, D. A. (1969). *Memory and attention: An introduction to information processing*. New York: John Wiley & Sons.

Ogle, T. (2002). *The effects of virtual environments on recall in participants of differing levels of field dependence.* Unpublished doctoral dissertation, Virginia Tech, Blacksburg, VA.

Oltman, P. K., Raskin, E., & Witkin, H. A. (1971). *Group embedded figures test*. Palo Alto, CA: Consulting Psychologists Press.

Ormrod, J. E. (2003). *Educational psychology: Developing learners* (4th ed.). Upper Saddle River, NJ: Pearson Education.

Owens, R. (2002). *An investigation to explore the effects of cueing strategies that complement animated visual imagery in facilitating student achievement of different educational objectives.* Unpublished doctoral dissertation, The Pennsylvania State University, University Park, PA.

Pace, A. J. (1982). Analyzing and describing the structure of text. In D. H. Jonassen (Ed.), *The technology of text: Principles for structuring, designing, and displaying text* (pp. 15-27). Englewood, NJ: Educational Technology.

Palinesar, A., & Brown, D. (1987). Enhancing instructional time through attention to metacognition. *Journal of Reading Disabilities, 20*(2), 66-75.

Partee, G. L. (1984). *The instructional effect of varied layout and design formats in facilitating student achievement of different educational objectives.* Unpublished doctoral dissertation, The Pennsylvania State University, State College.

Pienkowski, N. (2002). *The effects of cueing learners to a transfer problem prior to instruction.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Pierce, J. W. (1980). Field Independence and Imagery-Assisted Prose Recall of Children. *Journal of Educational Psychology, 72*(2), 200-203.

Pithers, R. T. (2002). Cognitive learning style: A review of the field dependent-field independent approach. *Journal of Vocational Education & Training., 54*(1), 117-132.

Pizzamiglio, L., & Zoccolotti, P. (1986). Individual differences: Cerebral structure and cognitive characteristics. In M. Bertini & L. Pizzamiglio & S. Wapner (Eds.), *Field dependence in psychological theory, research, and application* (pp. 27-44). Hillsdale, NJ: Lawrence Erlbaum Associates.

Post, P. E. (1987). The effect of field independence/field dependence on computer-assisted instruction achievement. *Journal of Industrial Teacher Education, 25*(1), 60-67.

Prestera, G. (2003). *Effects of Contextual Color on Recall: Border Color as a Lesson and Posttest Cue for Factual and Conceptual Information Presented in Computer-Based*

Information. Unpublished doctoral dissertation, Pennsylvania State University, State College, PA.

Ramirez III, M., & Castaneda, A. (1974). *Cultural democracy, bicognitive development and education*. New York: Academic Press.

Reardon, L. B., & Moore, D. M. (1988). The effects of organization strategy and cognitive styles on learning from complex instructional visuals. *International Journal of Instructional Media, 15*(4), 353-363.

Reiser, R. A. (2001). A history of instructional design and technology: Part I: A history of instructional media. *Educational Technology Research and Development, 49*(1), 53-64.

Reynolds, R. E., & Shirey, L. L. (1988). The role of attention in studying and learning. In C. E. Weinstein & E. T. Goetz & P. A. Alexander (Eds.), *Learning and study strategies: Issues in assessment, instruction, and evaluation* (pp. 77-100). San Diego: Harcourt Brace Jovanovich.

Richards, J. P. (1980). Notetaking, underling, inserted questions and organizers in text: Research conclusions and educational implications. *Educational Technology, 29*, 5-11.

Rickards, J. P., Fajen, B. R., Sullivan, J. F., & Gillespie, G. (1997). Signaling, notetaking, and field Independence-dependence in text comprehension and recall. *Journal of Educational Psychology, 89*(3), 508-517.

Riddle, J. (1992, February). *Distance education and learners' individual instructional procedures designed to accommodate the learning characteristics of field-dependent and field-independent learners.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Washington, D. C.

Riding, R., & Cheema, I. (1991). Cognitive styles: On overview and integration. *Educational Technology, 11*(3/4), 193-215.

Rieber, L. P. (1994). *Computers, graphics, and learning*. Madison, WI: Brown & Benchmark.

Riggott, M., & Suda, B. (2004). *Enhance usability by highlighting search terms*. Retrieved September 08, 2005, from the World Wide Web: http://www.alistapart.com/articles/searchhighlight/

Roberge, J. J., & Flexer, B. K. (1984). Cognitive Style, Operativity, and Reading Achievement. *American Educational Research Journal, 21*(1), 227-236.

Roberts, A. B. (1994). Visual verbal relationships. In D. M. Moore & F. M. Dwyer (Eds.), *Visual literacy: A spectrum of visual learning* (pp. 193-208). Englewood Cliffs, NJ: Educational Technology.

Rothkopf, E. Z. (1966). Learning from written instructive materials: An exploration of the control of inspection behavior by test-like events. *American Educational Research Journal, 3*(4), 241-249.

Rule, D. L., & Grippin, P. C. (1988, February). *A critical comparison of learning style instruments frequently used with adult learners.* Paper presented at the annual meeting of the Eastern Educational Research Association, Miami Beach, FL.

Rumelhart, D. E., & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson & R. J. Spiro & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge* (pp. 99-136). Hillsdale, NJ: Lawrence Erlbaum Associates.

Sabo, R. A., & Hagen, J. W. (1973). Color cues and rehearsal in short-term memory. *Child Development, 44*(1), 77-82.

Sadler-Smith, E. (1996). Learning styles and instructional design. *Innovations in Education and Training International, 33*(4), 185-193.

Saracho, O. N. (1989). Cognitive Style: Individual Differences. *Early Child Development and Care, 53*, 75-81.

Satterly, D. J., & Telfer, I. G. (1979). Cognitive style and advance organizers in learning and retention. *British Journal of Educational Psychology, 49*, 169-178.

Schiffman, H. R. (2001). *Sensation and perception: An integrated approach* (5th ed.). New York: John Wiley & Sons.

Schwier, R. A., & Misanchuk, E. R. (1993). *Interactive Multimedia Instruction.* Englewood Cliffs, NJ: Educational Technology Systems.

Seels, B. B., & Richey, R. C. (1994). *Instructional technology: The definition and domain of the field*. Washington, DC: Association for Educational Communications and Technology.

Shinar, D., McDowell, E. D., Rackoff, N. J., & Rockwell, T. H. (1978). Field dependence and driver visual search behavior. *Human Factors, 20*, 553-559.

Skinner, B. F. (1954). The science of learning and the art of teaching. *Harvard Educational Review, 24*, 86-97.

Smith, R. A. (1974). *An exploratory study of cognitive learning style components for achievement using computer simulation games*. Dissertation Abstracts International, 35, 5077A.

Snow, R. E. (1976). Aptitude-treatment interactions and individualized alternatives in higher education. In A. S. Messick (Ed.), *Individuality in learning* (pp. 268-293). San Francisco: Jossey-Bass.

Snow, R. E. (1997). Aptitudes and symbol system in adaptive classroom teaching. *Phi Delta Kappan, 78*(5), 354-360.

Soulier, J. S. (1988). *The design and development of computer based instruction*. Newton, MA: Allyn & Bacon.

Spiro, R. J., & Tirre, W. C. (1980). Individual differences in schema utilization during discourse processing. *Journal of Educational Psychology, 72*, 204-208.

Stewart, A. (1986, April). *Principles for the design of instructional text.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Stewart, A. (1988, January). *Towards a theory of instructional text design.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, New Orleans, LA.

Strawitz, B. (1984). Cognitive style and the acquisition and transfer of the ability to control variables. *Journal of Research in Science Teaching, 21*, 133-141.

Summerville, J. B. (1998, February). *The role of awareness of cognitive style in hypermedia.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, St. Louis, MO.

Szul, L. F. (1995). *The effect of color variations in screen text on the accuracy of proofreading from a video display terminal.* University of Pittsburgh, Pittsburgh, PA.

Tannenbaum, P. H., Jacobson, H. K., & Norris, E. L. (1964). An experimental investigation of typeface connotations. *Journalism Quarterly, 41*, 65-73.

Taylor, W., Canelos, J., Belland, J., Dwyer, F. M., & Baker, P. (1987). *The effects of program embedded learning strategies, using an imagery cue strategy and an attention directing strategy, to improve learning from Microcomputer Based Instruction (MCBI).* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Atlanta, GA.

Thompson, B., & Melancon, J. G. (1987). Measurement characteristics of GEFT. *Educational and Psychological Measurement, 47*, 199-212.

Thompson, G., & Knox, A. B. (1987). Designing for diversity: Are field-dependent learners less suited to distance education programs of instruction? *Contemporary Educational Psychology, 12*(1), 17-29.

Thompson, M. E. (1988, January). *Individualizing instruction with microcomputer produced text.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, New Orleans, LA.

Thompson, M. E. (1989). Field articulation and the design of information for microcomputers. In R. A. Braden & D. G. Beauchamp & L. V. W. Miller & D. M. Moore (Eds.), *About* *visuals: Research, teaching and applications* (pp. 429-434). Blacksburg, VA: Virginia Tech University.

Thompson, M. E., & Thompson, M. E. (1987, February). *Field dependence-independence and learning from instructional text.* Paper presented at the annual meeting of the Association for Educational Communications and Technology, Atlanta, GA.

Tinajero, C., & Paramo, M. F. (1997). Field dependence-independence and academic achievement: A re-examination of their relationship. *British Journal of Educational Psychology, 67*, 199-212.

Tinajero, C., & Paramo, M. F. (1998). Field dependence-independence cognitive style and academic achievement: A review of research and theory. *European Journal of Psychology of Education, 13*(2), 227-251.

Treisman, A. M. (1964). Monitoring and storage of irrelevant message and selective attention. *Journal of Verbal Learning and Verbal Behavior, 3*, 449-459.

Turcott, S. D. (1986). *The effects of cueing strategies, method of presentation, and locus of control on student achievement on a criterion task.* Unpublished doctoral dissertation, Boston University, Boston.

Van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse processing*. New York: Academic.

Veatch, J., Sawicki, F., Elliott, G., Flake, E., & Blackey, J. (1979). *Key words to reading: The language experience approach begins* (2nd ed.). Columbus, OH: Bell & Howell.

Watson, D. (1987). *Developing CAL: Computers in the curriculum*. London: Harper & Row.

Weller, H. G., Repman, J., Lan, W., & Rooze, G. (1995). Improving the effectiveness of learning through hypermedia-based instruction: The importance of learner characteristics. *Computers in Human Behavior, 11*(3-4), 451-465.

Weller, H. G., Repman, J., & Rooze, G. E. (1994). The relationship of learning, behavior, and cognitive style in hypermedia based instruction: Implications for design of HBI. *Computers in the Schools, 10*(3), 401-420.

Whyte, M. M., Knirk, F. G., Casey, R. J., & Willard, M. L. (1991). Individualistic versus paired/cooperative computer-assisted instruction: Matching instructional method with cognitive style. *Journal of Educational Technology Systems, 19*(4), 299-312.

Williams, R. (1994). *The non-designer's design book: Design and typographic principles for visual novice*. Berkeley, CA: Peachpit Press.

Wilshire, D. T. (1989). Effectiveness and efficiency of elaboration using computer-assisted instruction. In R. A. Braden & D. G. Beauchamp & L. V. W. Miller & D. M. Moore

(Eds.), *About visuals: Research, teaching and application* (pp. 466-480). Blacksburg, VA: Virginia Tech University.

Winn, W. (1993). Perception principles. In M. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (2th ed., pp. 55-126). Englewood Cliffs, NJ: Educational Technology.

Witkin, H. A. (1950). Individual differences in ease of perception of embedded figures. *Journal of Personality, 19*, 1-15.

Witkin, H. A. (1976). Cognitive style in academic performance and in teacher-student relations. In S. Messick & Associates (Eds.), *Individuality in learning* (pp. 35-72). San Francisco, CA: Jossey-Bass.

Witkin, H. A. (1978). *Cognitive styles in personal and cultural adaptation*: Clark University.

Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., & Karp, S. A. (1962). *Psychological differentiation*. New York: John Wiley & Sons.

Witkin, H. A., & Goodenough, D. R. (1981). *Cognitive styles: Essence and origins*. New York: International Universities Press.

Witkin, H. A., Goodenough, D. R., & Oltman, P. K. (1979). Psychological differentiation: Current status. *Journal of Personality and Social Psychology, 7*, 1127-1145.

Witkin, H. A., Lewis, H. B., Hertzman, M., Machover, K., Meissner, P. B., & Wapner, A. (1954). *Personality through perception: An experimental and clinical study*. New York: Haper & Brothers.

Witkin, H. A., & Moore, C. A. (1974, April). *Cognitive style and the teaching learning process.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, Illinois.

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research, 47*(1), 1-64.

Witkin, H. A., Oltman, P. K., Raskin, E., & Karp, S. A. (1971). *A manual for the embedded figures test*. Palo Alto, CA: Consulting Psychologists.

Worley, G. M., & Moore, D. M. (2001). The effects of highlight color on immediate recall on subjects of different cognitive styles. *International Journal of Instructional Media, 28*(2), 169-179.

Wu, J., & Yuan, Y. (2003). Improving searching and reading performance: the effect of highlighting and text color coding. *Information and Management, 40*(7), 617-637.

Appendix A: Correspondence to/from Dr. Francis M. Dwyer Regarding Heart Materials

Date Sent:	Monday, October 03, 2005 12:33 PM
From:	Frank Dwyer <fmd@psu.edu> Add to Address Book
To:	Carrie/Yu Cao
Status:	☐ Urgent ☐ New Update Status
Subject:	RE: Instructional materials for Human Heart

Message: Permission granted as long as Dr. Moore is on your committee. I would appreciate receiving a copy of the proposal and completed dissertation..... good luck!

>Dear Dr. Dwyer,
>
>This is Yu Cao. I'm a doctoral student at Virginia Tech. My major is
>Instructional Technology. This semester, I'm working on my Prospectus document
>(proposal for the methodology of my dissertation). Dr. Mike Moore, who is on
>my committee, recommended that I use the instructional materials and criterion
>tests for the human heart that you developed for visual learning. I would like
>your permission to use the instructional materials and test items.
>
>My research topic is "Effects of Field Dependent-Independent Cognitive Styles
>and Cueing Strategies on Students' Academic Performance". The purpose of the
>study is to ascertain whether cueing strategies embedded in computer delivered
>text messages affect the academic performance of students who are classified
>as field-dependent and field-independent in terms of their cognitive style. I
>plan to convert the paper-based booklet into a computer-based instruction.
>
>If you need any further information about my study, I would be happy to
>provide. I appreciate your kindly help.
>
>Yu Cao

-- ____________________

Francis M. Dwyer
Professor of Education
Instructional Systems Program
310 B Keller Building
Penn State University
University Park, Pa. 16802
Tel. 814-863-7382
Fax 814-865-0128
fmd@psu.edu

```
_________________
> ("`-''-/").___..--''"`-._
>  `6_ 6 ) `-. ( ).`-.__.`) WE ARE ...
> (_Y_.)' ._ ) `._ `. ``-..-' PENN STATE!
> _ ..`--'_..-_/ /--'_.' ,'
> (il),-'' (li),' ((!.-'
```

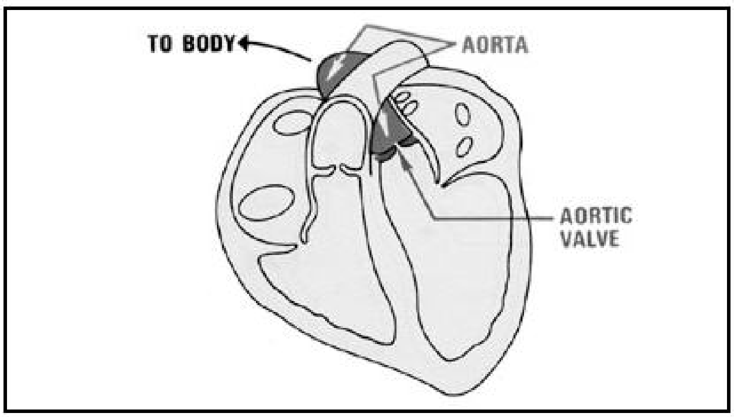
Appendix B: Sample Screen from the Control Treatment

The Human Heart

The Parts of the Heart

The Aorta

The contraction of the left ventricle pumps blood through the entire body. For this reason, it is the largest, strongest, and most muscular section of the heart. When the left ventricle is filled with blood, it contracts, resulting in pressure opening the aortic valve. The aortic valve is similar to the other flap-like valves; the valve stops the backward flow of blood to the left ventricle and opens for the forward flow of blood to the aorta.



The aorta is the large artery that carries the blood away from the heart back to the various parts of the body.

prev screen
next screen

Appendix C: Sample Screen from the Color-Highlighted-Keyword Treatment

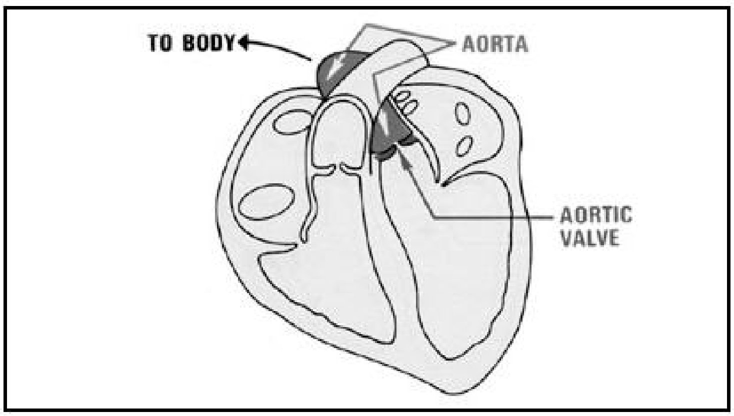
Page: 10 of 21

The Human Heart

The Parts of the Heart

The Aorta

The contraction of the left ventricle pumps blood through the entire body. For this reason, it is the largest, strongest, and most muscular section of the heart. When the left ventricle is filled with blood, it contracts, resulting in pressure opening the aortic valve. The aortic valve is similar to the other flap-like valves; the valve stops the backward flow of blood to the left ventricle and opens for the forward flow of blood to the aorta.



The aorta is the large artery that carries the blood away from the heart back to the various parts of the body.

prev screen next screen

Appendix D: Sample Screen from the Color-Highlighted-Key-Phrase Treatment

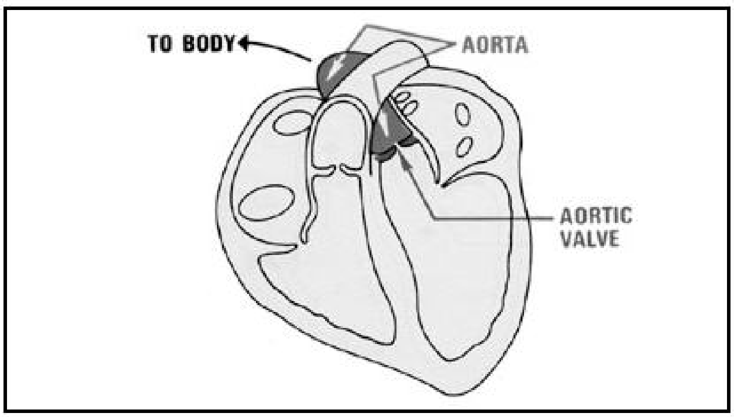
Page: 10 of 21

The Human Heart

The Parts of the Heart

The Aorta

The contraction of the left ventricle pumps blood through the entire body. For this reason, it is the largest, strongest, and most muscular section of the heart. When the left ventricle is filled with blood, it contracts, resulting in pressure opening the aortic valve. The aortic valve is similar to the other flap-like valves; the valve stops the backward flow of blood to the left ventricle and opens for the forward flow of blood to the aorta.



The aorta is the large artery that carries the blood away from the heart back to the various parts of the body.

prev screen next screen

Appendix E: Institutional Review Board Approval

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects) Chair
Assistant Vice President for Research Compliance
1880 Pratt Drive, Suite 2006(0497), Blacksburg, VA 24061
Office: 540/231-4991; FAX: 540/231-0959
email: moored@vt.edu

DATE: February 2, 2006

MEMORANDUM

TO: John K. Burton Teaching and Learning
Peter E. Doolittle Teaching and Learning
Yu Cao EDCI

FROM: David Moore

SUBJECT: **IRB Expedited Approval:** "Effects of Field Dependent-Independent Cognitive Styles and Cueing Strategies on Students' Academic Performance" IRB # 06-043

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective February 1, 2006.

Virginia Tech has an approved Federal Wide Assurance (FWA00000572, exp. 7/20/07) on file with OHRP, and its IRB Registration Number is IRB00000667.

cc: File
Department Reviewer: Jan K. Nespor

A Land-Grant University - Putting Knowledge to Work
An Equal Opportunity/Affirmative Action Institution

Appendix F: ANOVA Table for Terminology Test

Source	*df*	*SS*	*MS*	*F*	*Sig.*
Field Dependency (F)	2	199.576	99.788	6.648	.002
Cueing Strategies (C)	2	8.757	4.379	.292	.747
F x C	4	82.438	20.609	1.373	.244
Error	210	3152.154	15.010		

Appendix G: ANOVA Table for Comprehension Test

Source	*df*	*SS*	*MS*	*F*	*Sig.*
Field Dependency (F)	2	442.298	221.149	13.678	.000
Cueing Strategies (C)	2	24.694	12.347	.764	.467
F x C	4	196.322	49.080	3.036	.018
Error	210	3395.375	16.168		

Appendix H: ANOVA Table for Total Test

Source	*df*	*SS*	*MS*	*F*	*Sig.*
Field Dependency (F)	2	1236.083	618.042	12.145	.000
Cueing Strategies (C)	2	44.416	22.208	.436	.647
F x C	4	518.511	129.628	2.547	.040
Error	210	10686.682	50.889		

Appendix I: Multiple Comparisons of Terminology Test Scores for Field Dependency

Dependent Variable: Terminology Test

Tukey HSD test

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-1.17	.69	.206	-2.80	.45
FN	FI	-1.16	.63	.162	-2.64	.33
FI	FD	2.33*	.63	.001	.85	3.81

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent

*$p < .05$

Appendix J: Multiple Comparisons of Comprehension Test Scores for Field Dependency

Dependent Variable: Comprehension Test

Games-Howell test

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-1.68*	.73	.035	-3.27	-9.29
FN	FI	-1.65	.67	.057	-3.34	3.71
FI	FD	3.33*	.67	.000	1.91	4.76

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent

*$p < .05$

Appendix K: Multiple Comparisons of Total Test Scores for Field Dependency

Dependent Variable: Total Test

Games-Howell test

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-2.86*	1.29	.047	-5.68	-3.10
FN	FI	-2.80	1.18	.060	-5.70	9.38
FI	FD	5.66*	1.18	.000	3.06	8.27

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent

*$p < .05$

Appendix L: Simple Main Effects – Field Independence, Treatment Groups, and Comprehension Test

Test of Homogeneity of Variance

Levene Statistic	*df1*	*df2*	*Sig.*
4.809	2	90	.010

One-way ANOVA: Field Independence and Treatment Groups

Dependent Variable: Comprehension Test

	SS	*df*	*MS*	*F*	*Sig.*
Between Groups	196.866	2	98.433	5.263	.007
Within Groups	1683.263	90	18.703		
Total	1880.129	92			

Multiple Comparisons of the Means

Dependent Variable: Comprehension Test

Games-Howell

Treatment Group (I)	Treatment Group (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Non Cueing	Key Words	1.79	1.11	.330	-1.22	4.79
Key Words	Key Phrases	1.87	1.07	.135	-.44	4.19
Key Phrases	Non Cueing	-3.66*	1.13	.008	-6.47	-.85

* The mean difference is significant at the .05 level.

Appendix M: Simple Main Effects - Field Independence, Treatment Groups, and Total Test Scores

Test of Homogeneity of Variance

Levene Statistic	*df1*	*df2*	*Sig.*
4.215	2	90	.018

One-way ANOVA: Field Independence and Treatment Groups
Dependent Variable: Total Test

	SS	*df*	*MS*	*F*	*Sig.*
Between Groups	523.663	2	261.832	4.504	.014
Within Groups	5232.165	90	58.135		
Total	5755.828	92			

Multiple Comparisons of the Means
Dependent Variable: Total Test
Games-Howell

Treatment Group (I)	Treatment Group (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Non Cueing	Key Words	2.09	1.97	.596	-3.08	7.26
Key Words	Key Phrases	3.75	1.88	.093	-.49	7.98
Key Phrases	Non Cueing	-5.84*	1.99	.014	-10.63	-1.04

* The mean difference is significant at the .05 level.

Appendix N: Simple Main Effects – Non-Cueing Treatment, Field Dependency, and Comprehension Test

Test of Homogeneity of Variance

Levene Statistic	*df1*	*df2*	*Sig.*
7.977	2	69	.001

One-way ANOVA: Non-Cueing Treatment and Field Dependency

Dependent Variable: Comprehension Test

	SS	*df*	*MS*	*F*	*Sig.*
Between Groups	402.518	2	201.259	11.677	.000
Within Groups	1189.260	69	17.236		
Total	1591.778	71			

Multiple Comparisons of the Means

Dependent Variable; Comprehension Test

Games-Howell

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-2.04	1.24	.123	-4.50	.43
FN	FI	-3.60*	1.18	.016	-.6.61	-.59
FI	FD	-5.63*	1.19	.000	-2.72	8.55

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent; FDI= Field dependence-independence

* The mean difference is significant at the .05 level.

Appendix O: Simple Main Effects – Non-Cueing Treatment, Field Dependency, and Total Test Scores

Test of Homogeneity of Variance

Levene Statistic	*df1*	*df2*	*Sig.*
5.257	2	69	.007

One-way ANOVA: Non-Cueing Treatment and Field Dependency

Dependent Variable: Total Test

	SS	*df*	*MS*	*F*	*Sig.*
Between Groups	1011.156	2	505.578	8.938	.000
Within Groups	3902.789	69	56.562		
Total	4913.944	71			

Multiple Comparisons of the Means

Dependent Variable: Total Test

Games-Howell

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-2.81	2.24	.357	-7.74	2.11
FN	FI	-6.02*	2.13	.028	-.11.49	-.54
FI	FD	8.83*	2.16	.000	3.76	13.90

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent; FDI= Field dependence-independence

* The mean difference is significant at the .05 level.

Appendix P: Simple Main Effects - Color-Highlighted-Keyword Treatment, Field Dependency, and Comprehension Test

Test of Homogeneity of Variance

Levene Statistic	*df1*	*df2*	*Sig.*
2.636	2	65	.079

One-way ANOVA: Color-Highlighted-Keyword Treatment and Field Dependency

Dependent Variable: Comprehension Test

	SS	*df*	*MS*	*F*	*Sig.*
Between Groups	165.875	2	82.938	4.422	.016
Within Groups	1219.125	65	18.756		
Total	1385.000	67			

Multiple Comparisons of the Means

Dependent Variable: Comprehension Test

Games-Howell

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-.90	1.50	.794	-4.33	2.52
FN	FI	-2.66	1.24	.150	-6.07	.75
FI	FD	3.56*	1.34	.005	.98	6.15

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent; FDI= Field dependence-independence

* The mean difference is significant at the .05 level.

Appendix Q: Simple Main Effects - Color-Highlighted-Keyword Treatment, Field Dependency, and Total Test Scores

Test of Homogeneity of Variance

Levene Statistic	*df1*	*df2*	*Sig.*
1.316	2	65	.275

One-way ANOVA: Color-Highlighted-Key-Phrase Treatment and Field Dependency
Dependent Variable: Total Test

	SS	*df*	*MS*	*F*	*Sig.*
Between Groups	502.032	2	251.016	4.455	.016
Within Groups	3662.247	65	56.342		
Total	4164.279	67			

Multiple Comparisons of the Means
Dependent Variable: Total Test
Games-Howell

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-1.55	2.59	.821	-7.77	4.66
FN	FI	-4.64	2.15	.086	-9.79	.52
FI	FD	6.19*	2.33	.026	.61	11.77

Note: FD = Field Dependent; FN = Field Neutral; FI = Field Independent; FDI= Field dependence-independence

* The mean difference is significant at the .05 level.