# COMPUTER LITERACY, COMPUTER ANXIETY,

# AND

# COGNITIVE STYLE:

# EFFECTS ON PERFORMANCE ON COMPUTERIZED TESTS

by

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# Preface

The rapid development of new computer technology and the advent of microcomputers has challenged conventional methods of instruction and education. What are the variables which affect an individual using computer-based instruction (CBI) or computer-based testing (CBT)? How do these variables affect performance relating to computer usage? These are some of the questions which led to this empirical investigation of computer literacy, computer anxiety, and cognitive style and the relationship to performance on a computerized test.

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# Table of Contents

Chapter

# List of Tables

# Chapter One

# The Problem

## Purpose of This Study

During the last two decades computer usage has penetrated almost every area of human enterprise. This emergence of a computerized society has created a need for research into the effects of computers on (a) how people learn, (b) how their learning can be evaluated, and (c) their emotional response to computers (Cambre & Cook, 1985; Maurer & Simonson, 1984).

It has been found that a person's knowledge of and experience with computers and his or her psychological perspective affect the variables most frequently associated with computer usage - computer literacy and computer anxiety (Allen, 1986; Cambre, 1985; Camp, 1987; Lee, 1986; Llabre, Clements, Fitzhugh, Lancelotta, Mazzagatti, & Quinones, 1987; Mahmood & Medewitz, 1989; Orr, 1988; Simonson, Maurer, Montag-Torardi, & Whitaker, 1987). Another major factor with considerable application to educational practice and computer instruction is cognitive style, specifically field independence/dependence (Canino & Cicchelli, 1988; Carrier, Davidson, Higson, & Williams, 1984; Witkin, Moore, Goodenough, & Cox, 1977). However, the relationships among these variables and their impact on computerized test performance has not been fully explored. The purpose of this paper was to examine whether computer literacy, computer anxiety, and cognitive style influence performance on a computerized test.

Overview

A study by Molnar (1978) found that the next great crisis in American education is computer literacy. Computer literacy was viewed as necessary for effective participation in contemporary society. The rapid development of computer technology has changed traditional methods used for instruction and testing (Hamby, 1986). Individuals using computer-assisted instruction may progress at their own pace, select paths of instruction, and interact directly with the computer. Individuals using computer-based testing are faced with basically two types of tests: (a) tests originally developed for paper/pencil administration which are transferred to computers with little or no revision; or (b) tests developed specifically for computer usage in which the student interacts directly with the computer. In the second type of test each interaction with the computer affects the direction of the next step. This interactive use of the computer more thoroughly employs the power of the computer as a thinking device. However, this evolution to interactive testing also requires students to use progressively complex computer skills as well as increasingly complex thinking skills (Orr, 1988).

The development, usage, and refinement of more complex computer skills is affected by: (a) an individual's measure of computer literacy (Simonson et al., 1987); (b) the level of computer anxiety (Lee, 1986; Llabre et al., 1987); and, (c) the individual's cognitive style (Canino & Cicchelli, 1988).

Researchers have found computer literacy to be an ambiguous term. It has been used interchangeably with computer experience (Bresnitz, Stettin, & Gabrielson, 1986; Jacobs, Byrd, & High, 1985). A survey by

Bresnitz et al. (1986) to measure computer literacy used the amount of experience (time of use) with computers as the basis for determining the level of computer literacy. In an attempt to define computer literacy, Simonson et al. (1987) examined many definitions of the term using three different approaches, none of which were equated to the time of computer usage/experience. Simonson's use of the term related to the operation and application of computer skills and to the ability to use computers effectively in today's society.

The theoretical use of computer anxiety as a valid psychological construct requires definition, methods of measurement, and correlation with other variables. Computer anxiety can be defined in terms related to anxiety in general and to computers in particular. Computer fear, computer phobia, and the resulting implications associated with computer usage are other manifestations of computer anxiety (Kramer & Polan, 1988; Mauer & Simonson, 1984). A study of learning characteristics in students using computer-related instruction found computer-related phobias to be a major issue, since phobias were found to be associated with negative attitudes (Paulanka, 1986).

Previous research has found computer anxiety to be a source of interference with performance on computerized tests (Lee, 1986). Failure to control for anxiety and familiarity with computers has caused inconsistency in findings of earlier studies of computerized testing (Llabre et al., 1987).

Individuals learn and process information in different ways. These modes of functioning, called cognitive styles, are disclosed in a consistent manner through an individual's perceptual and intellectual activities (Witkin, Moore, Oltman, Goodenough, Friedman, Owen, & Raskin, 1977). Cognitive styles affect an individual's academic choices, academic development, method of learning and teaching, and vocational preference (Messick, 1976; Witkin, Moore, Oltman, et al., 1977). One aspect of individual differences and cognitive style is the degree to which an individual is able to distinguish part of a field from the entire field. An individual with a field independent cognitive style perceives an object relatively independent of its surroundings. For an individual with a field dependent cognitive style, perception is dominated by the surrounding field (Witkin, Moore, Goodenough et al., 1977). A field dependent individual with a greater need for social recognition and approval may respond less positively to a computerized situation than a field independent individual who prefers to work independently (Canino and Cicchelli, 1988). In a computerized test, an individual's perception of computerized figures and ability to distinguish pertinent instructions quickly and accurately may affect one's performance on such a test (Jacobs, Byrd & High, 1985).

## The Problem

Varying degrees of computer literacy and levels of computer anxiety may influence an individual's performance on a computerized test. Individuals of equal aptitude and subject knowledge may perform at different levels on a computerized test due to levels of computer literacy and the presence of computer anxiety. Familiarity with such factors as the computer program in operation and the keyboard used with certain brands of computers may have an effect on test performance. Inexperience with keyboards and/or computers (e.g. which key to use to skip to the next item) may increase time needed to complete a test and increase levels of anxiety. Therefore, is the computerized test measuring the application of knowledge or the ability to interact efficiently with the computer? Will an individual whose cognitive style is more field independent be more efficient and accurate at scanning a computer screen than an individual who tends to be field dependent? In the interest of exploring the relationship between computer literacy, computer anxiety, cognitive style and performance on computerized tests, data was collected to answer the following research question.

## Research Question

What is the relative influence of computer literacy, computer anxiety, and cognitive style (field independence/dependence) on computerized test performance determined by (a) scores on the test, and (b) time required to complete the test?

## Definition of Terms

Computer literacy: "An understanding of computer characteristics, capabilities, and applications, as well as an ability to implement this knowledge in the skillful, productive use of computer applications suitable to individual roles in society" (Simonson et al., 1987, p. 233).

Computer anxiety: "Fear or apprehension felt by individuals when they use computers, or when they considered the possibility of computer utilization" (Simonson et al., 1987, p. 238).

Cognitive style: A mode of functioning "which we reveal throughout our perceptual and intellectual activities in a highly consistent and pervasive way" (Messick, 1976, p. 39).

Field independent: A way of processing information in which the individual gives greater credit to internal referents. Perception of an object is relatively independent of the surrounding field of reference.

Field dependent: A way of processing information in which the individual tends to rely on external referents as guides. Perception of an object is dominated by the surrounding field of reference (Messick, 1976; Witkin, Moore, Oltman et al., 1977).

## Summary

In Chapter I, the purpose of this study was presented, as well as an overview of the research, a statement of the problem, the research question, and a definition of terms. In Chapter II, the literature pertinent to the problem and to specific research questions is reviewed. The design of the study, procedures used, sample, instrumentation and an analysis of methods are presented in Chapter III. Chapter IV discusses the results pertaining to the research question. In Chapter V, a summary of the study, conclusion, and discussion of the findings are presented.

# Chapter Two

## The Review of the Literature

### Introduction

The dissemination of computer technology into every facet of life has necessitated changes in the methods used in education and training (Molnar, 1978). This rapid growth of the use of the computer in society invites inquiry into the cognitive and emotional impact of its development.

Existing research in this area deals with computer methods and the effectiveness of computer usage relating to computer-assisted instruction and computer-based testing. This research paper is a study of the effects on test performance of three variables related to computer usage: (a) computer literacy, (b) computer anxiety, and (c) the cognitive style of field independence/dependence. The major factors which influence individuals using a computer, their reactions to the computer, and the consequences of these factors on the effective use of computer-based testing were examined.

This review of the literature was organized into three areas. The first section analyzed an expression relatively new to research, "computer literacy." Computer literacy was defined using three different theoretical approaches and a definition arrived at by specialists in computing education. The second section of this chapter investigated another term relatively new to research, "computer anxiety." Computer anxiety was defined in terms pertaining to anxiety in general and to computers in particular. The third section of this chapter explored the learning characteristic of cognitive style, specifically field independence and field dependence, and its impact on an individual's ability to use a computer effectively. There is a review of all three sections at the end of the chapter.

## Computer Literacy

Computer literacy has become an ambiguous term. Its use in the literature varies. One study equates computer literacy to computer experience (Bresnitz et al., 1986). A survey by Bresnitz et al. (1986) of computer literacy used the amount of experience (time of use) with computers as the basis for determining the level of computer literacy.

Computer experience did not present the difficulties of definition associated with computer literacy. Computer experience has been defined in more quantitative terms. Koohang (1987) equated experience to length of time of computer usage. Computer experience was divided into 5 levels: (a) 1 week, (b) 1 week to 1 month, (c) 1 month to 6 months, (d) 6 months to 1 year, and (e) more than 1 year. Loyd and Gressard (1984) divided the kinds (nature) of computer experience into 4 levels: (a) observer only or use of computer games, (b) experience with word processors and data entry, (c) workshop or software introductions, and (d) programming and/or university level instruction. Other researchers sought to define computer experience in relation to different levels of usage. In a study of experience with and attitudes toward computers, 290 medical students and 200 clinical faculty were surveyed. Knapp, Miller, and Levine (1987) found: (a) 17% of the respondents had no prior computer experience; (b) 19% had computers at home; (c) 20% had some computer education; (d) 29% had used simple, complex, or packaged programs; (e) 34% had at least one college level computer course; and (f) 56% had used computers at work or school (responses possible in more than one category).

A survey of computer literacy (time of use) by Bresnitz et al. (1986) of 258 medical students revealed (a) 42% of the students had no computer experience prior to entering medical school, (b) 28% of the students had less than 1 year of experience, and (c) 30% had used computers for an average of 2 1/2 years prior to medical school. Bresnitz et al. (1986) cited a comparable study by G.W. Bracey (1982) at Duke University which produced similar results.

Past computer experience significantly affected performance on a computerized test (Lee, 1986). Lee also concluded that computerized testing may discriminate against individuals without prior computer experience. Individuals of equal ability in subject matter may not perform at the same level on a computerized test. In another study, it took longer for students in a course using computer-assisted instruction to complete the program than it took for students in a traditional lecture course (Waddell & Rinke, 1985). These results were contrary to expectations and may have been due to unfamiliarity with computers. A similar result was found by Jacobs et al. (1985); inexperience or difficulty with a keyboard and/or computer increased the time required to take a test.

Levels of computer experience have been found to be significantly related to attitudes toward computers. Individuals who have had computer instruction and/or programming applications had more positive attitudes toward computers (Koohang, 1987; Hines & Seidman, 1988). A more favorable response to methods of computer-assisted instruction was found as exposure to computers increased (Hamby, 1986). However, Knapp et al. (1987) found contrary results and stated that neither level of computer experience nor formal computer education was associated with attitudes.

Development of a computerized version of the Hidden Figures Test (Jacobs et al., 1985) sought to determine the extent of computer experience using the term computer literacy. However, a more precise definition of the term was researched in conjunction with the development of a standardized test of computer literacy and a computer anxiety index. Researchers used three different approaches to defining computer literacy: (a) related to programming skill and operation of computers; (b) restricted to general knowledge of and awareness of computers in social, educational, and vocational areas; and (c) ability to function effectively with computers in applying a "collection of skills, knowledge, understandings, values, and relationships that allow a person to function comfortably in a computer-oriented society" (Simonson et al., 1987, p. 232). However, use of the above three approaches makes it possible to classify an individual as computer literate in one situation and not literate in another situation. To further clarify the circumstance, a more succinct definition was sought. A group of six instructional computing specialists developed the following definition of computer literacy:

> Computer literacy was defined as an understanding of computer characteristics, capabilities, and applications, as well as an ability to implement this knowledge in the skillful, productive use of computer applications suitable to individual roles in society (Simonson et al., 1987, p. 233).

Computer Anxiety

Cambre and Cook (1985) summarized two major definitions by defining anxiety as a condition of arousal which follows the perception of a threat. This involves frantic feelings of being overwhelmed, disoriented, and/or confused. Freud believed that anxiety was an emotional state corresponding to fear (Gleitman, 1983). Anxiety has also been contrasted to fear, with anxiety occurring as a response to a general stimulus and fear occurring as a response to a specific stimulus. Anxiety has been described as a learned motive which is kindled by indefinite and unpredictable events (Ferguson, 1982). State anxiety refers to how an individual feels at a particular time in a particular situation. Trait anxiety refers to a stable disposition which illustrates how an individual usually acts in an anxiety-producing situation (Ferguson, 1982).

There has been a general agreement among researchers that computer anxiety is state anxiety (Cambre & Cook 1985). Computer anxiety has been defined in relation to a change in heart rate (Camp, 1987), blood pressure, and electro dermal response (Cambre & Cook 1985). Computer anxiety was also defined as "fear or apprehension felt by individuals when they use computers, or when they considered the possibility of computer utilization" (Simonson et al., 1987, p.238). Consequently, a person with computer anxiety would avoid computers and computer areas, exercise extreme caution when using computers, speak negatively regarding computers and their usage, and use computers for the shortest period of time necessary (Simonson et al., 1987).

Failure to control for anxiety and familiarity with computers has caused inconsistency in findings of earlier studies of computerized testing (Llabre et al., 1987). Previous research found computer anxiety to be a source of interference with computerized tests (Lee, 1986). A study by Johnson and Johnson (1981) stated that heightened computer anxiety decreased test performance for individuals relatively unfamiliar with computers. However, results to the contrary found that lower test performances were not the direct result of increased anxiety levels; no systematic relationship was found between anxiety and performance (Llabre et al., 1987). It has been found that inexperience and unfamiliarity with the computer cause high levels of anxiety. Some computer training (even if limited) prior to testing may be adequate to enhances test scores and lessen anxiety (Lee, 1986). In developing a computerized version of the Hidden Figures Test, researchers found that a computerized test may in fact be measuring computer anxiety and other variables, such as previous experience with a keyboard (Jacobs et al., 1985).

In a study analyzing the uses of interactive video in medical training, researchers found faculty who were "intimidated by" (computer fear, phobia, and/or anxiety) either video or computer usage (Kramer & Polan, 1988). Computerphobia has been defined as a resistance to and avoidance of computers, as well as fear, anxiety, or hostility toward computers (Mauer & Simonson, 1984). A study of learning characteristics in students using computer-related instruction found computer-related phobias to be a major issue, since phobias were found to be associated with negative attitudes (Paulanka, 1986). However, Kramer and Polan (1988) found that anxiety may be lessened by use of a computer, since a student uses the computer in private and does not have to deal with an actual teacher or with a real patient. While computer anxiety tends to lessen as familiarity with the computer increases, there is still the possibility of computer anxiety in individuals with computer experience when using an unfamiliar computer program (Cambre & Cook, 1985).

## Cognitive Style: Field Independence and Field Dependence

Cognitive style has been defined as the method used by an individual to perceive, think, and retain information (Hadfield & Maddux, 1988; Messick, 1976). In general, there are four characteristics of cognitive style:

1. Cognitive styles are associated with the pattern rather than the content of cognitive activity. The term refers to how an individual perceives, thinks, solves problems, learns, and relates to others. It refers to the individualized method one uses to process information.

2. Cognitive styles are far-reaching dimensions throughout the essential nature of an individual. This

characteristic carries through to one's personality in a holistic sense and is not a feature of cognition alone. This characteristic of cognitive style, particularly field independence and field dependence is important in relation to an educational setting.

3. While cognitive styles are not unchangeable, they have been found to be relatively stable over time. Ordinarily, it is possible to predict that an individual's style on a particular day will be the same in the near future and for years to come. This characteristic of stability makes determination of cognitive style, especially field independence/ dependence, effective for use in guidance and counseling.

4. Cognitive styles are bipolar, with each pole having adaptive value in designated situations and the possibility to be judged positively in relation to specified circumstances (Witkin, Moore, Goodenough et al., 1977).

It is important to distinguish cognitive styles from intelligence and other ability dimensions (field independence/dependence are processes, not content variables). This characteristic makes cognitive style a less threatening dimension to an individual. For example, it is easier to communicate information to an individual about one's tendency to be more field independent or field dependent than about one's IQ or abilities (Witkin, Moore, Goodenough et al., 1977).

Research has developed several methods of categorizing cognitive styles. Some examples include: active-reflective, concrete-abstract, spontaneous-systematic, internal-external, linear-creative (Hadfield & Maddux, 1988). The most comprehensive research in cognitive styles explores the dimension of field independence and field dependence (Haaken, 1988; Witkin, Moore, Goodenough et al., 1977). Field independence/dependence also has the most extensive application to educational concerns (Witkin, Moore, Goodenough et al., 1977).

Based on experiments in visual perception, field independence/dependence refers to an individual's ability to distinguish a stimulus from its embedding framework (Haaken, 1988). Field independence is a cognitive style which gives greater credit to internal referents for processing information than to the external referents characterized by field dependence

(Witkin, Moore, Oltman, et al., 1977). Field independent individuals tend to perceive items as separate from the background or field and experience their surroundings in a different manner. Field independent individuals function well independently and learn more efficiently when allowed to develop their own approaches to problem solving situations. In extensive research, Witkin found that persons who are more field independent: (a) are likely to restructure information and go beyond the information given; (b) prefer more solitary and impersonal situations; (c) are more concerned with principles and abstract ideas; (d) prefer study in science, math, engineering, architecture; (e) function autonomously in social situations; and (f) in a general population sample tend to be male. Field dependent individuals are less able to separate items from the surrounding field and perceive the environment in a more global way (Canino & Cicchelli, 1988). Witkin found field dependent individuals: (a) process information with referents available in the entire stimulus field; (b) are more interested in other persons; (c) show greater skill and sensitivity in social situations; (d) in choice of vocation prefer and excel in areas favoring interpersonal relations; and (e) in the general population tend to be female (Witkin, Moore, Oltman, et al., 1977).

Since the above research finds field independent persons have a greater ability to restructure information, an unstructured problem solving approach and a discovery method of learning would favor those who are field independent. A structured, step by step approach to handling information would meet the needs of the field dependent learner (Canino & Cicchelli, 1988). Adapting instruction to cognitive style through use of the computer is one way to produce a more ideal learning environment.

Summary

Computer literacy was defined relating to the nature (kinds) of computer experience. Some of the literature used computer experience and computer literacy interchangeably. This review of the literature suggests that a higher level of computer literacy increases performance on a computerized test. Anxiety was defined in psychological terms (state as well as trait) and in its specific relationship to computers and computer usage. The review of the literature suggests that a lower level of computer anxiety increases performance on a computerized test. Cognitive style was defined as it related to processing information. The category of cognitive style known as field independence and field dependence was examined. The review of the literature suggests that individuals who tend to be field independent perform more quickly and at a higher level on a computerized test than individuals who tend to be field dependent. Consequently, the purpose of this study is to examine the relative influence of computer literacy, computer anxiety, and cognitive style (field independence/ dependence) on computerized test performance as determined by (a) scores on the test, and (b) time required to complete the test.

# Chapter Three

# Design and Procedures

## Introduction

This research study was designed to examine the relative influence of computer literacy, computer anxiety, and cognitive style (field independence/ dependence) on computer-based test performance. Four instruments were used to collect data relating to the research question. In this chapter, the sample is described and the methods used are discussed. The chapter concludes with a brief summary.

## Subjects Participating in the Study

Third-year medical students (M-3's) (n=54) from a major midwestern medical college participated in the study. The sample included 71% males and 29% females ranging in age from 23 to 35 years old. During their psychiatry rotation, published, standardized tests were administered to determine levels of computer literacy, computer anxiety, and cognitive style; a computer experience survey was also used. The students were scheduled in the computer lab to take selected CBX cases. Complete results were missing for five students, and results on the Group Embedded Figures Test for a dyslexic student were not used. Thus, statistical data were analyzed with n = 48.

Instrumentation

Each student completed a series of materials including: (a) Standardized Test of Computer Literacy, Section #2; (b) Computer Experience Survey; (c) Computer Opinion Survey (Computer Anxiety Index); and, (d) Group Embedded Figures Test. At a later date, each student completed a CBX (computerized examination) case in the computer lab; this case simulated doctor-patient encounters and assessed patient management procedures. Performance on the CBX was measured by (a) the CBX test score and (b) TIME needed to complete the case.

Standardized Test of Computer Literacy (STCL). The STCL is a competency based test of general computer literacy. It is divided into three sections: (a) #1, computer systems; (b) #2, computer applications; and (c) #3, computer programming. Section #2 was selected for use in this study. This section measures general knowledge and skills in the use of computers, awareness of computer applications, and proficiency in discriminating among various computer languages and software packages. The STCL, Section #2, evaluates 25 achievement competencies in computer applications and is comprised of 28 multiple-choice questions. The range of scores is from 0 - 28, with the higher score reflecting a higher level of computer literacy. The standardized administration of the STCL allows 30 minutes for completion of each section (Montag, Simonson, & Maurer, 1984). Each section of the STCL may be scored and/or taken separately.

Normative data were based on 341 graduate and undergraduate students from six states. A Kuder-Richardson-20 reliability estimate of .87 was obtained for the total STCL. A pilot study (n=152) resulted in a KR-20 of .75 for Section #2 and .86 for the total STCL; this compares favorably to the normative data (Simonson et al, 1987).

Computer Experience Survey. Computer literacy and computer experience (time of use) have often been used interchangeably (Bresnitz et al., 1986). For this reason, data were collected using a computer experience survey in addition to the STCL. The Computer Experience Survey examined the students' experience with and cognizance of computers and computer applications. It consists of 13 survey questions, with choices ranging from 2 to 14 selections for each. Raw point values were assigned to each response; questions with a larger selection of responses were assigned a greater weight in the composite score. The highest maximum score (range 0-67) of 67 indicates extensive computer experience and knowledge (Orr, 1988).

For the scored items, the coefficient alpha for the Computer Experience Survey was .76. Professional computer programmers reviewed and revised items during development of the survey. The Computer Experience Survey correlated negatively ($r = -.58$; $p < .01$) with the CAIN. This negative correlation supports construct validity and implies that students with more computer experience are less likely to be computer anxious (Orr, 1988).

Computer Opinion Survey (Computer Anxiety Index). The Computer Opinion Survey is used to recognize students who exhibit anxious tendencies related to computer usage. This survey is also called the

Computer Anxiety Index (CAIN); the term opinion survey is used to decrease the potential for answer bias. The CAIN is an attitude survey consisting of 26 items which takes approximately ten minutes to complete (Montag et al., 1984). Possible scores on a Likert-type scale range from 26 to 156, with the higher score representing a higher level of anxiety.

Normative data were based on scores of 1943 high school and college students, trained computer users, and business sector users of computers from six states. The CAIN was found to have an internal consistency reliability estimate of .94 and a test/retest reliability estimate of .90 (Simonson et al., 1987).

Group Embedded Figures Test. The Group Embedded Figures Test (GEFT) is a perceptual test designed for the subject to locate a previously seen figure within a larger more complex figure. It is an adaptation of the original, individually administered Embedded Figures Test (EFT) and is used where larger numbers of subjects must be tested to determine field independence/ dependence. Administration of the test takes approximately 20 minutes. The GEFT is composed of three sections. The first section, a practice section, contains 7 very simple figures and is allotted two minutes to complete. Sections two and three each contain 9 more difficult figures (total = 18) and each section is allowed five minutes for completion. A trained scorer is provided a scoring key to score each item. All lines of the simple figure must be traced on the complex figure for an item to be counted as correct (Witkin, Oltman, Raskin, & Karp, 1971). Since the tendency to be more field independent or more field dependent is scored on a continuum, a score of 18 would mean the subject was very field independent. A score of 8, for example, would indicate a greater tendency to field dependence.

Normative data for the GEFT were drawn from 397 college students (155 men and 242 women). Correlation between parallel forms yielded a reliability estimate of .82 and compares favorably with the EFT. Validity of the GEFT was determined by using the parent measure, the EFT, as a criterion measure. The correlations, based on solution time, were -.82 for males and -.63 for females (r's should be negative since the tests are scored in reverse fashion) (Witkin, Oltman et al., 1971).

Computer-Based Examination (CBX). CBX refers to a computer-based examination developed by the National Board of Medical Examiners (NBME) in response to concern with lack of evaluation of clinical skills in practice. It simulates conditions of a doctor-patient situation in a hospital and/or office setting. The student, interacting with the computer, must manage a patient in an uncued, unprompted, interactive clinical simulation (Melnick & Clyman, 1988). The controlling element in the CBX is the forward movement of time (CBX allows only forward movement) by the student on the computer. No questions are asked and nothing is requested of the student during the CBX. Clinical material requiring the clarification of visual data is presented through the use of interactive videodisc. The simulations branch in response to the student's performance on the computer. It is this application which enables the CBX to respond realistically to various management strategies. Any sudden changes in the patient's condition or actions of other members of a medical team are conveyed to the student user. CBX may present information to the student, move time automatically, move the patient to a different location (e.g. from emergency room to intensive care unit, or from the hospital to the doctor's office), begin tests, procedures, or treatments. CBX records the sequence and timing of the student's actions. The quality of patient management is determined by a comparison with predefined patient management strategies and norm group performance. (Melnick & Clyman, 1988). The CBX is scored based on the number of actions taken by the student that are judged by the NBME to be benefits. Time was recorded in the number of minutes taken by the student to complete each case.

Normative data were collected on 200 first year medical students and 75 third year medical students using 14 CBX cases. Measurements of reliability and validity suggest CBX can be a useful measurement instrument (Melnick & Clyman, 1988).

## Analysis

Multiple linear regression analysis was used to assess the relative influence of computer literacy, computer anxiety, and the cognitive style of field independence/dependence (independent variables) on performance on a computerized test as determined by (a)

CBX scores on the test, and (b) TIME required to complete the test (dependent variables). Multiple regression determines what part of the prediction achieved can be attributed to the independent variables in diminishing amounts. To determine which independent variables together are good predictors of CBX or TIME, SPSSx selects a set of variables for inclusion based on statistical considerations (i.e. percent of variance explained by one variable that is not explained by any other variables) (Norusis, 1987). This method continues until the addition of other variables adds nothing much of significance to the data analysis (Ferguson, 1981). The independent variables of computer literacy, computer anxiety, and cognitive style (field independence/ dependence) form a linear composite that explains the degree of influence on the dependent variables, CBX and Time.

Summary

Fifty-four third year medical students participated in the study. Each student completed a series of four tests and/or surveys and a computer-based examination. Responses were then scored, entered into a data file, and analyzed using methods of multiple linear regression. The .05 significance level was employed in all statistical tests.

# Chapter Four

# Results of the Study

## Introduction

This chapter is divided into two major sections corresponding to the two dependent variables in the research question. The first section examines the relative influence of the independent variables, computer literacy, computer anxiety, and field independence/dependence, on CBX scores on a computerized test. The second section examines the relative influence of the independent variables on TIME required to complete a computerized test. Multiple regression tables are included. The chapter concludes with a brief summary.

## Results Concerning the Relative Influence of Computer Literacy, Computer Anxiety, and Cognitive Style (Field Independence/Dependence) on CBX Scores on a Computerized Test

The data were analyzed using methods of multiple regression. In the first multiple regression analysis, the total scores of all the independent variables were entered together in order to determine their relative influence on CBX scores. As seen in Table 1, the

Table 1

Multiple Regression of CBX Scores with Independent Variables

| Variable | Multiple R | R Square | R Square Change | F |
|---|---|---|---|---|
| GEFT | .36 | .13 | .13 | 6.88* |
| LIT | .40 | .16 | .03 | 4.36* |
| ANX | .43 | .18 | .02 | 3.30* |
| EXP | .47 | .23 | .05 | 3.12* |

* $p < .05$

CBX -- scores on computerized exam
GEFT -- Group Embedded Figures Test
LIT -- Standardized Test of Computer Literacy
ANX -- Computer Anxiety Index
EXP -- Computer Experience Survey

independent variables of cognitive style (field independence/dependence), computer literacy, computer anxiety, and computer experience accounted for 23 percent of the variance in CBX scores.

Field independence/dependence was found to have the greatest single influence on CBX scores, accounting for 13 percent of the variance ($p = .01$). This suggests that students who are field independent score higher on a computerized test than students who tend to be field dependent. These results support previous research which found that the cognitive style of field independence/dependence strongly influenced performance on computerized tasks (Canino & Cicchelli, 1988; Carrier, Davidson, Higson, & Williams, 1984). Thus, field independence/dependence can be considered a predictor of scores on a computerized examination.

The inclusion of computer literacy into the equation accounted for an increase of 3 percent of the variance. Field independence/dependence and computer literacy together accounted for 16 percent of variance of CBX scores ($p = .02$). These results support previous research which found that levels of computer literacy influenced performance on computerized tests (Lee, 1986). Enlarging the regression equation to include computer anxiety increased the degree of influence by another 2 percent. This supports previous research which found levels of computer anxiety to be a source of interference on computerized tests (Cambre & Cook, 1985; Jacobs et al., 1985; Johnson & Johnson, 1981). Field independence/dependence, computer literacy, and computer anxiety together accounted for 18 percent of the variance of CBX scores ($p = .03$). The addition of computer experience increased the degree of influence of the independent variables by another 5 percent. This supports previous research which found that levels of computer experience affected performance on a computerized test (Jacobs et al., 1985; Lee, 1986). Field independence/dependence, computer literacy, computer anxiety, and computer experience altogether formed a linear composite which explained 23 percent of the variance of CBX scores ($p = .02$).

A final analysis of CBX scores was conducted to assess the portion of variance unique to cognitive style and unique to the computer usage variables (computer literacy, computer anxiety, and computer experience). First, the computer usage variables in combination were forced into the regression equation and then cognitive style was entered. The additional increase in explained variance assessed the portion of the explained variance unique to cognitive style. Second, cognitive style was forced into the equation and then the computer usage variables were entered.

This analysis assessed the portion of the variance unique to the computer usage variables (see Table 2).

Table 2

For CBX: Portion of Variance Unique to Cognitive Style and Computer Usage Variables

| | Variance Accounted for | | |
|---|---|---|---|
| Variable | Entered First | Total | Unique |
| Computer Usage | .10 | .23 | .10 |
| Cognitive Style | .13 | .23 | .13 |

Results Concerning the Relative Influence of Computer Literacy, Computer Anxiety, and Cognitive Style (Field Independence/Dependence) on TIME required to complete a computerized test

The data were again analyzed using methods of multiple regression. In the second multiple regression analysis, the total scores of all the independent variables were entered together in order to determine their relative influence on the TIME required to complete a computerized test. As indicated in Table 3, the independent variables of computer anxiety, computer literacy, cognitive style (field independence/ dependence), and computer experience accounted for 20 percent of the variance in TIME required to complete a computerized examination.

Table 3
Multiple Regression of TIME
with Independent Variables

| Variable | Multiple R | R Square | R Square Change | F |
| --- | --- | --- | --- | --- |
| ANX | .39 | .15 | .15 | 8.37* |
| LIT | .40 | .16 | .01 | 4.19* |
| GEFT | .42 | .18 | .02 | 3.17* |
| EXP | .45 | .20 | .02 | 2.71* |

* $p < .05$

TIME -- time required to complete a computerized exam
ANX -- Computer Anxiety Index
LIT -- Standardized Test of Computer Literacy
GEFT -- Group Embedded Figures Test
EXP -- Computer Experience Survey

Computer anxiety was found to have the greatest single influence on TIME required to complete a computerized test, accounting for 15 percent of the variance ($p = .01$). This supports previous research which found computer anxiety to be a source of interference with performance on computerized tasks (Cambre & Cook, 1985; Jacobs et al., 1985; Johnson & Johnson, 1981; Lee, 1986). These results suggest that a computer anxious student will require more time to complete a computerized examination. Thus, levels of computer anxiety can be considered a predictor of the time required to complete a computerized test.

When computer literacy was added to the multiple regression equation, the degree of influence on TIME increased 1 percent. Computer anxiety and computer literacy together accounted for 16 percent of the variance in TIME ($p = .02$). These results support previous research which found that unfamiliarity with computers increased the time required to take a computerized test (Jacobs et al., 1985; Waddell & Rinke, 1985). Addition of the third independent variable, cognitive style (field independence/ dependence) increased the degree of influence on TIME by 2 percent. Computer anxiety, computer literacy, and cognitive style explained a total of 18 percent ($p = .03$) of the variance ($p = .03$). These results support prior research which found field independence/ dependence to affect performance on computerized tasks

(Canino & Cicchelli, 1988; Carrier et al., 1984). The entrance of computer experience into the equation accounted for an additional 2 percent of the variance. Past research also found levels of computer experience to influence the time required to complete computerized tasks (Jacobs et al., 1985; Lee, 1986; Waddell & Rinke, 1985). Altogether, computer anxiety, computer literacy, cognitive style (field independence/ dependence), and computer experience explain 20 percent of the variance in TIME required to complete a computerized test ($p = .04$). Thus, these independent variables formed a linear composite which explained 20 percent of the variance in TIME.

A final analysis for TIME was conducted to assess the portion of variance unique to cognitive style and unique to the computer usage variables (computer literacy, computer anxiety, and computer experience) (see Table 4). First, the computer usage variables in combination were forced into the regression equation and then cognitive style was entered. The additional increase in explained variance assessed the portion of the explained variance unique to cognitive style.

Table 4

For TIME: Portion of Variance Unique to Cognitive Style and Computer Usage Variables

| | Variance Accounted for | | |
| --- | --- | --- | --- |
| Variable | Entered First | Total | Unique |
| Computer Usage | .19 | .20 | .09 |
| Cognitive Style | .11 | .20 | .01 |

Second, cognitive style was forced into the equation and then the computer usage variables were entered. This analysis assessed the portion of the variance unique to the computer usage variables.

Table 5
Means, Standard Deviations, and Ranges for Independent Variables

| Variable | Mean | Std | Possible Range |
| --- | --- | --- | --- |
| GEFT (FI/D) | 15.06 | 2.58 | 0 - 18 |
| STCL (Literacy) | 16.81 | 5.30 | 0 - 28 |
| Experience | 15.60 | 7.96 | 0 - 67 |
| CAIN (Anxiety) | 122.90 | 19.35 | 26 - 156 |

## Summary

The results of the data analysis for this study were presented in this chapter. The findings were reported relating to each of the dependent variables, CBX scores and TIME required to complete a computerized test. These results indicate field independence/ dependence and computer anxiety have the greatest influence on performance (scores and time respectively) on a computerized test. These results indicate that an individual who is field independent scores higher and completes a test faster than an individual who is field dependent. Computer anxiety significantly influenced the time required to take a computerized test. In other words, individuals who are less computer anxious complete computerized tasks more rapidly than individuals who are more computer anxious. All of the independent variables significantly influenced CBX performance score and performance TIME relating to the computerized examination.

# Chapter Five

## Summary and Conclusions

### Summary

The rapid growth of computer technology has challenged traditional methods used in education and training. Research has shown that an individual's knowledge of, experience with, and psychological perspective relating to computers affect the variables most often associated with computer usage (Canino & Cicchelli, 1988; Llabre et al., 1987; Simonson et al., 1987; Orr, 1988). The purpose of this study was to explore the effects on computerized test performance of three variables related to computer usage: (a) computer literacy (and experience), (b) computer anxiety, and (c) the cognitive style of field independence/dependence.

In this study, published, standardized tests and questionnaires were administered to third-year medical students (n=54). These instruments measured levels of computer literacy and experience, computer anxiety, and preference for field independence/dependence. All students also completed a computerized examination as the criterion measure. General aptitude of the subjects was not compared to CBX scores. However, the computerized examination used was developed by the National Board of Medical Examiners and correlates significantly with scores from standardized tests of medical knowledge (Orr, 1988).

Statistical tests using multiple regression analysis were performed to determine the relative influence of computer literacy, computer anxiety, and cognitive style (field independence/ dependence on CBX score performance and on TIME required to complete the computerized exam.

## Conclusions

Research Question: What is the relative influence of computer literacy, computer anxiety, and cognitive style (field independence/dependence) on computerized test performance as determined by (a) scores on the test, and (b) time required to complete the test?

Field independence/dependence was found to make the largest unique contribution to CBX score performance for a computerized test. Computer literacy, computer anxiety, and computer experience explained the variance in CBX score in descending order. Computer anxiety was found to have the greatest single influence on TIME performance on a computerized test. Computer literacy, cognitive style (field independence/ dependence), and computer experience contributed to the variance in TIME in descending order. All of the independent variables contributed to the formation of a linear composite which explained the degree of performance relating to (a) CBX scores and (b) TIME required for test completion.

## Discussion

The results suggest that individuals who are field independent are likely to score higher and complete the task more quickly on a computerized test than individuals who are field dependent. Field independent persons have a greater ability to arrange information in a meaningful manner and are better able to adapt to the computer environment. This agrees with the findings of Witkin, Moore, Goodenough et al. (1977) that field independent individuals are more likely to spontaneously restructure the organization of the field on material which lacks it. The unsophisticated computer user approaches a computer and views information requiring a response. What is viewed on the computer screen must be conceptualized by the user by limiting the number of operations and organizing information in a logical manner, thus favoring field independent persons (Canino & Cicchelli, 1989). This perception must then be interpreted to keystrokes to manipulate the computer program. Since field dependent individuals do not adapt as easily to these changes in screen organization, they are more likely to have lower performance scores on computer-based tests and to take longer to complete a computerized task. This confirms studies which showed significant results regarding field independence/dependence and computer treatments (Canino & Cicchelli, 1989; Jacobs et al., 1985).

Research has shown that matching cognitive style to instructional materials is an important concern in educational research at this time. Many educators believe that students should be placed in programs that suit their cognitive style (Burger, 1985; Carrier et al., 1984). For example, field dependent students may be at a disadvantage in computer-based testing and instructional situations, due to an inability to focus on a major component and isolate it from the surrounding field. A poorly organized computer screen may confuse a field dependent student, resulting in frustration, confounding test results, and decreased reliability and validity of evaluation procedures. Screen arrangements should be designed for the field dependent student. Such a design incorporates a high degree of structure, uniform print style and color usage, consistency in location of information and prompts, and deletion of material not applicable to the present task. The student is more likely to benefit when teaching methods (via computer) and cognitive style are matched. The ever increasing growth of computer usage in education provides teachers and educators with a vehicle to match instruction to cognitive style through the use of carefully designed computer programs.

Computer anxiety was found to have a significant influence on time needed for completion of a computerized test. This supports previous research which has found computer anxiety to interfere with the speed of computerized tasks (Cambre & Cook, 1985;

Jacobs et al., 1988; Waddell & Rinke, 1985). Simonson et al. (1987) found computer anxiety to significantly affect scores on computerized tests. Although the forward movement of time is the controlling element in the CBX computer examinations, the examination itself is not time limited. In other words, the student is allowed as much time as necessary to complete the simulated case. Thus, anxiety did not contribute the largest degree of variance for CBX scores. However, on computerized tests which are time limited, the computer anxious student would be at a disadvantage and might not be able to complete the test in the allotted time; this would most likely result in a lower score. These results confirm further research which found computer anxiety to be a source of interference with computerized tests and research which found that failure to control for anxiety had caused inconsistency in findings of previous studies related to computerized testing (Lee, 1986; Llabre et al., 1987).

This study did not address the matter of gender differences which have been found in cognitive style related to field independence/dependence. This factor may limit the universal application of the study if differences occur between male and female. Further research needs to be carried out on how gender and perhaps other individual differences in cognitive style affect computer-assisted instruction and computer-based testing.

Additional research is needed to gain a clearer picture of where instructional sequences can be modified to address and meet the needs of the field dependent learner. An entire segment of student population may be at a disadvantage when poorly designed computer programs are geared to the field independent student and fail to meet the needs of the field dependent student. Researchers and educators have the ability and responsibility to make these determinations for use in schools, business, and industry.

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