Order Number 9215023

Individual differences in the use of CD ROM databases

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University of Hawaii, 1991

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INDIVIDUAL DIFFERENCES IN THE USE OF CD ROM DATABASES

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAI'I IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

COMMUNICATION AND INFORMATION SCIENCES

DECEMBER 1991

by

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Dissertation Committee:

Carol Tenopir, Chairperson
Gerald Lundeen
Wesley Peterson
Martha Crosby
Leon Jakobovits

Dedicated to

Sunaadh and KOKUA

ACKNOWLEDGEMENTS

It is almost always difficult to acknowledge all the people that help a doctoral candidate in her/his dissertation work. In my case, it is even more so, because of two main reasons. I entered the new Interdisciplinary Doctoral Program in Communication and Information Sciences at the University of Hawaii at Manoa, as a non-traditional foreign student from India. Firstlly, the program had no funding. This, combined with the exorbitant cost of living in Honolulu, made me almost decide to leave the program and go back to India at the end of the first year. But the International Educational Foundation, the philanthropic arm of the American Association of University Women (AAUW) granted me their coveted International Award of $10,000 during their Centennial Year, 1988-89. It could not have come at a better time. I would not be here to write these words, but for their timely award. My most sincere appreciation and thanks are due to AAUW.

Secondly, I met with an accident in Spring of 1989 and had to use a wheel chair and a pair of crutches. For the second time in two years, I was forced to think of quitting the program, because of the difficulty in commuting and coping with classes to be attended at the four corners of the university campus, not to mention the physical and emotional stress that I had to endure. Help came, this time in the form of my wonderful son, Bal Prasad (also: Sunaadh) and KOKUA, a quiet but selfless group of people providing needed service to the disabled students at UH. My son has provided me all the physical and emotional support throughout the last thirty months. I owe him my doctorate. He has been my greatest blessing. A big "Thank You" to the angels at KOKUA and Karen Murakami, in particular. I could not have kept up with all the deadlines and pressures of course work without your invaluable support.

Thanks are due to The H.W. Wilson Company for their generosity. True to their philosophy of helping academic pursuit wherever possible, they provided me three of their

CD ROM products, free of cost, for use in the experiment. Sigma Xi, the Scientific Research Society, chose me for their small but prestigious grant in January 1991. It helped me compensate the subjects participating in the study and paying other costs involved. "Thanks" to Sigma Xi, for the honor. Hardware could not be purchased due to paucity of funds. Thanks are due to the Dean, School of Library and Information Studies, who gave me permission to use the Wilson workstation in their microcomputer lab.

The ACRL/ISI Doctoral Dissertation Committee chose my dissertation proposal as the winner of their 1991 Dissertation Fellowship Award in July, 1991. I wish to record my appreciation to Dr. Durbin and his Committee, for the recognition. The SLIS Alumni Group granted me the Ralph Shaw Professional Award to enable me to go to Atlanta, Georgia and receive the ACRL/ISI Award in person.

This being a dissertation for the Interdisciplinary Ph.D. Program, my Dissertation Committee consisted of faculty from different departments/schools. Carol Tenopir, my Dissertation Committee Chair and Gerald Lundeen were from the School of Library and Information Science. Wesley Peterson and Martha Crosby were from the Information and Computer Sciences Department. Leon Jakobovits, the external member, was from the Psychology Department. The rich and diverse expertise each one of these members brought to this research study, made it a wonderful learning experience for me, in addition to enriching the value of the study itself.

Carol Tenopir had not only been an inspiration to me but provided unstinted academic support throughout. I am indebted to her for the many hours of fruitful discussion I have had with her. Gerald Lundeen, my academic advisor through my Master's and Doctoral Program, gave encouragement and scholarly advice whenever I approached him. Wesley Peterson gave me the confidence that I needed to complete this Interdisciplinary Program successfully. It was an honor to have been his student and to have had him on my committee. Martha Crosby, with her own seemingly inexhaustible energy and enthusiasm, challenged me to try new and difficult approaches to the research study and be as complete as possible. She provided the MBTI, KLSI and HIP Survey instruments for the study, and also wrote the codes for scoring the MBTI and HIP responses. Leon Jakobovits helped clarify many of the concepts that I had to deal with and provided guidance for the statistical analyses of the results of the study. Jan Stelovsky, of the Information and Computer Sciences Department, though not a member of my Dissertation Committee, provided invaluable support in recruiting subjects for the experiment, a very difficult task. He put me in touch with faculty who were interested in human-computer interaction studies involving students. I would like to specialy acknowledge his help. Thanks are also due to Ronald Flegal, Ricardo Trimillos and Richard Halverson for helping me recruit volunteers from their classes for the experiment.

There were many other friends who encouraged me throughout the four years that I have been in the program. Some have been very good friends and helped me at the personal level. In particular, I wish to thank Linda Wiig, Melissa Miller, Zatni Arbi, Dara Lee Howard and LeAnn Garrett.

I also hope that I have been able to live up to the expectations of all the faculty and friends who have helped me realize my dream. I also hope that this work would inspire others to take up from where I left off and continue the unending quest for understanding individual differences, so that , together, we can contribute to solving some of the problems encountered in human-computer interaction and information retrieval.

ABSTRACT

Individual differences in the use of technology, and computer-based systems in particular, have been studied by many researchers. The literature has seen contributions from the fields of computer science, communication, psychology, management information science and library & information science. Most of the work in the Information Retrieval (IR) area has, however, been related to the online database systems. Some have studied the effect of different training methods on users with varying cognitive traits, varying experiences, etc. On the other hand, complexity of use of different systems and system interfaces has been the focus of some studies. The proposed research would explore the effect of individual differences on performance of **novice** users of a new technology, i.e., **CD ROM database systems**, which are gaining popularity in academic libraries and elsewhere. In addition to extending the outcomes of previous findings, the proposed research would attempt to isolate variables that contribute to individual differences, by studying them in greater detail. The need to introduce variables hitherto ignored in IR context would also be examined.

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CHAPTER I

INTRODUCTION

1.1 Background

Patterns of information seeking behavior of patrons in libraries have been studied from various angles over the past two decades or more. In fact, one of the earliest classic studies on the information uses of scientists is credited to Voigt (1961), in Park's (1986) fairly exhaustive literature review on the topic of "Information Analyses". There are also other literature reviews, for example Ford (1973) and Daniels (1986); The former is from a conventional user/patron studies perspective, and the latter from a real inter-disciplinary point-of-view. The outcome of most of these studies, is however, a recognition of the fact that there is a definite difference in the use of information by different types of patrons.

A significant consequence of the revolutionary changes in information technology is the recognition, that (1) information is composed of complex structures and (2) human beings react to information in complex ways. The complexity of information and the organization of knowledge have become prime targets for theory building and research by information and library science researchers; the ways in which human beings interact with information has become the increased focus and concern, not only to librarians, but also to psychologists, Management Information Science (MIS) researchers and computer scientists, to name a few.

It was first demonstrated in 1954 that computers could be used for bibliographic searching. Ten years later, MEDLARS started providing the first large-scale batch service to the public. It took almost another decade for commercial vendors such as SDC ORBIT and Lockheed DIALOG to bring online searching to the tables of a variety of users in academic, special, government and public libraries (Bellardo, 1984). With the introduction of computers for information storage and retrieval in libraries, research shifted to a considerable extent to the use of technology by various types of users. As online information searches gained popularity, many other studies focussed on the use of technology in libraries and the reaction of users to such technology (Shera, 1967; Shinebourne, 1980; Brindle, 1981; Fenichel, 1981; Fine, 1984; Bellardo, 1985; Borgman, 1984, 1985, 1989; Woelfl, 1984; Trivison et al., 1986; Saracevic et al., 1988b).

These studies focussed mostly on the performance of online searches by librarians as compared to end-users, because the function of performing online searches was still the responsibility of these specially trained librarians, called intermediaries. According to a survey conducted in 1974 by Wanger et al.,. (1976), almost 85% of the users of ten major online retrieval services were librarian-intermediaries, who performed searches mostly on behalf of others. Five years later, it was found that online searching was still mostly performed by intermediaries rather than by end-users themselves, despite efforts to promote the latter (Meadow, 1979). This appears to have been because of two reasons: firstly, one needed to invest a lot of time and effort in learning to use the various online systems on which the databases were available (Bellardo, 1984; Borgman, 1984; Fenichel,1980, 1981; Mathews et al., 1983; Woelfl, 1984). Mathews et al. (1983) and Borgman (1984) found that very few users were willing to spend the time and effort required to learn the skills of online searching. Also, the interfaces and search strategies (for complex search problems) were not easy to learn. Many of these researchers found that the use of Boolean logic was not easily mastered by everyone. So, a confounding as well as an explanatory variable in user performance studies, was the system characteristics, i.e., the search software and its capabilities. Secondly, online searches were not cheap. In fact, one factor included in the study of performance of intermediaries was the cost per unit search, which was an indicator of the efficiency of the searcher.

Over the last ten years, some researchers studied the effect of experience on performance, while others studied patterns of use by different groups of people such as faculty members from specific academic disciplines or on a comparative basis; yet others researched the effect of different types of training on performance. Cognitive styles and personality traits, and more importantly, individual differences in performance which could be related to the different cognitive factors, have been studied by quite a few of these researchers, either directly or as an extension of their main study.

There is, however, substantial evidence in writings on information seeking behavior by many scholars in the field of information retrieval (IR) which suggests that most users of information would prefer to do their own searching for reasons of convenience, control and personal judgement. Relevance judgements have been talked and written about by countless practitioners and theorists. As a consequence of these studies and as a by-product of the tremendous advancements in microcomputer technology and memory devices, technological solutions to bringing the machines (and bibliographic databases) closer to end-users has been vigorously pursued in the last decade or so. Much as Bellardo surmised that the shift to direct end-user access is not a rapid one, and never likely to be complete (Bellardo, 1984; p.2), the first such possibilities, in the form of CD ROM databases on microcomputer workstations, became available in libraries in 1986, just two years after her writing.

1.2 Locus of the Study

Now, in the past six years, this new technology, i.e., the CD ROM (Compact Disc Read Only Memory), has revolutionized the way information can be accessed in libraries, particularly in university settings, where the majority of patrons are undergraduates (LePoer, 1989; Littlejohn, 1989; Steffey & Meyer, 1989). A great deal of effort has gone into minimizing the difficulties in interacting with the system by providing "user-friendly" or "easy-to-use" interfaces which help users search different databases on microcomputer-based systems. (David, 1989; Littlejohn, 1989; LePoer, 1989; Welsh, 1989). Evidence indicates that the current CD ROM interfaces have improved tremendously and are fairly easy to use, if some of the articles appearing in recent times are any indication. Writing on user success and satisfaction with CD ROM, Steffey and Meyer (1989) report of an overwhelming positive response, i.e., "The majority of the comments were of `Wow! This is fantastic!' nature"; Welsh (1989), found that 97% of the users of his library found CD ROMs easy to use; Littlejohn (1988) too found that most of the patrons found CD ROMs easy to use and were also mostly satisfied with their results. Two of the surveys (Balaraman, 1989a, 1989b) conducted at the Hamilton Library during Summer 1989 and Spring 1990, also indicated that over 90% of users find them easy to use. Difficulties introduced by system differences have also been minimized to some extent, by the use of a common search software across different databases.

CD ROM databases are different from the online databases. There is no anxiety about running up unbearable costs while searching on these systems. Nor is there the problem of frustration of making mistakes and having to redo costly searches or to look up help screens; by and large, function keys are mapped to provide screen-relevant directions for use anytime. Most of all, the "individual" searching the databases or doing the information retrieval (IR) is now different - it is the end-user himself/herself and not the intermediary, in a large majority of cases. In university libraries, it is mostly the student who is doing the searching.

Bellardo ((1984) listed four reasons why end-user searching will never be complete in the foreseeable future: (1) the typical user, being an occasional user does not need to access information systems on a regular basis and this does not warrant the time it takes to learn and maintain the necessary skills. (2) there is virtually no standardization among databases in terms of their search protocols and terminology, data format, etc. (3) There are too many of these databases and it is difficult to choose the right one, particularly if one does not know the contents of each, and, (4) Online searching is not an easy task - it is a complex cognitive activity, which is usually performed by well-educated, intelligent individuals who are trained specifically for the task and educated in the general theories of search strategy, computer logic, indexing languages, file organization and retrieval languages. Even these professionals need refresher courses and continuing education to update their skills and knowledge. An end-user cannot be expected to spend time and effort on attaining the same skills.

CD ROM has overcome many of these concerns. But, with the proliferation of CD ROM databases in university libraries, many faculty make searching these databases part of their class assignments and hence, students need to learn and use them. According to Tenopir and Neufang, (1991), over 1000 searches were done on CD ROM databases in a week in one university library, mostly by students. The second concern expressed by Bellardo is still a problem, though major vendors are trying to provide a common interface to the different databases produced by different agencies. Thus, in any research involving a system, system interface is either explicitly studied or has to be controlled.

Choosing the right database from a large number too, continues to be a problem, but by and large, specialized CD ROM databases are becoming available that can be searched for specific subject queries. Also, the general proliferation of microcomputers for various applications not only in university education but in secondary and even primary schools has removed much of the trauma of learning basic skills in the use of computers. Most students, when they enter a university for undergraduate education, seem to be already familiar with computers - quite a number of them have used computers for their homework and/or games. (All the 51 subjects in the current study had used computers before.) They do not need to spend too much time learning to use CD ROM databases; moreover, many of them have learned to use the OPAC (Online Public Access Catalog) for searching for books in the library (Tenopir, 1991). CD ROM interfaces present similar, though not the same type of interfaces. Most of the students are willing to perform their own searches with a minimum of instructions.

1.3 Justification for the Current Study and its Focus

1.3.1 Undergraduate Students as Subjects

Most of the earlier studies on individual differences either in the field of IR or MIS (Management Information Systems) used undergraduate students as surrogates for the professionals in their respective fields, because it was easier to get them to spare time for the studies. Rarely has research focussed on the students themselves, with the exception of students in computer science stream. However, with the dramatically changing scenario with the bulk of the responsibility of bibliographic searching is moving from librarians to undergraduate students, studies on user differences have to focus on these students.

This study, therefore, is focussed on undergraduate students. The subjects are undergraduate engineers, business majors and art/music/history majors to represent the three major academic disciplines, i.e., hard sciences, social sciences and humanities. They were recruited on a voluntary basis from the various departments at the University of Hawaii at Manoa.

1.3.2 CD ROM Databases

As has already been mentioned, most earlier IR studies were on online databases, commercial or public. There are, however, over 1000 titles available in CD format already and they are proliferating quickly (Nicholls, 1991). They are bound to be used more and more by the student population, as course assignments include using CD ROM databases to complete them. In fact, the more recent inclusion of audio, image and video on CDs is changing the scene even more dramatically. There is, however, no published research to date which focuses on end-users of CD ROM databases.

CD ROM systems are microcomputer-based workstations, mostly with in-built CD ROM drives. CD ROM databases from the same vendor, though produced by different agencies, generally come with a uniform search software; thus, searching different databases from the same vendor, does not pose any interface difference problems to the user. Most of these systems support Boolean search features, which are very common in bibliographic databases.

It may be worthwhile discussing some of the facts and figures of this publishing and distributing medium, just to get an idea of how dramatically it has expanded in a short span of six years. Paul Travis Nicholls of the School of Library and Information Science at the University of Western Ontario published comparative data on CD ROM titles over the past four years. His latest update appeared in the March 1991 issue of CD-ROM Professional. He reported that, as of mid-1990, there were a total of 1,025 commercially available database titles which could be identified as unique, listed in six standard directories to the CD ROM medium. (These directories are: The CD-ROM Directory 1990; CD-ROM Sourcedisc; CD-ROMs in Print 1990; Computer Readable Databases: A Directory and Sourcebook and Directory of Portable Databases.) Nicholls also extracted some titles from the "CD-ROM title announcements" section of CD-ROM EndUser, December 1989 to July 1990 and included them in his list of 1025 unique titles. Discussing the growth of databases in CD format, he observes,

> "The CD-ROM medium is actually in much better shape after six years than the online medium was at the same age." (Nicholls, 1991: p. 23)

The first CD ROM database was published in 1985 and by 1990, the number has risen dramatically to 1025. Almost half (46%) of all currently available CD ROMs are source databases (full-text, numeric, textual/numeric, computer software or desktop sounds). Twenty eight percent fell in the category comprised of directory type dealing with corporate information, who's who, special catalogs, etc. The traditional subject indexing and abstracting service databases (index type) form the remaining 26%. According to Nicholls' analysis, the overall proportion of indexes has been declining steadily since 1987 (48% to 26%), while that of source databases has risen (28% to 46%). This is a significant trend, which suggests that we are looking at a distinct medium that is now beginning to concentrate on what it does best.

Nicholls' study found that the breakdown of CD ROM titles by subject has remained basically stable over the past few years, although the total number of actual titles in each category has approximately doubled each year. Business, law and medicine, with a dominance of vertical markets, accounted for 30% of all titles and 56% among the social science titles. Science/technology titles formed 30% of the total number, while art/humanities contributed only 5%. The rest were considered general titles. Nicholls also discussed the updating patterns of these titles and noted that the trend is moving to infrequently updated source databases, such as full-text or numeric. Updating frequency is directly related to database type and subject. Only about 15% of all business, law and medicine databases are infrequently updated, in contrast to 71% of arts and humanities products which are infrequently updated.

Nicholls found that currently 87% of all CD ROM titles are designed to run on IBM/compatibles with just 7% for the Macintoshes and 6% for both. He noted that it is quite obvious that Macintoshes are ideally positioned to provide a platform for the multimedia CD ROM products that are expected to proliferate soon. It was also clearly pointed out by Rosen (1990) that Macintosh systems, with their in-built graphics and sound capabilities and the widespread Hypercard applications, serve as an excellent development tool for new multimedia applications. Real Multimedia applications would be products in which the various media would be more closely integrated and inter-related, with full motion color video or created in the CD-ROM XA, CD-I or DV-I formats. Rosen predicted that these new applications would more likely go straight to the consumer market, while the text-based CD ROM would continue to be the most widely used of the optical technologies in the information industry.

No further arguments should be needed to justify the choice of the system - CD ROM databases, as the locus of this study. If we are sitting on the brink of a revolution, it is worthwhile preparing ourselves to face it, rather than be swept away by it. Studying the future users of CD ROM systems would certainly help in preparing them to face the revolution as well as help shape the impact of the revolution in a smooth manner.

1.3.3 Choice of Databases

Three databases were selected for this study: Applied Science and Technology Index, Business Periodicals Index, and Humanities Index, corresponding to the three major subject disciplines from which students were recruited. All three databases are created by The H.W. Wilson Company and all these use the same Wilsearch search software. Thus, the system interface was controlled, eliminating problems encountered while testing subjects on different systems. The H.W. Wilson Company has been in the business of producing printed indexes and abstracts in a wide variety of subjects since the turn of the century. They entered the CD marketplace in 1987 and now have about 20 databases available in CD format. They target their products primarily to the high school and undergraduate level. This philosophy is reflected in the design of their search software; they have a special mode, called the Wilsearch mode, created for the end user student level. The Wilsearch mode was used in this study.

1.3.4 Choice of Variables

The experiment reported here studied variables that may contribute to individual differences in performance (See Chapter IV) of students on CD ROM databases. These were chosen either to confirm or extend earlier findings or to explore the need to introduce some new variables so far not considered by earlier researchers in IR studies. They are: age, sex, native language, visual ability, computer affinity, computer literacy, SAT (Scholastic aptitude Test - math and verbal) scores, learning style, personality types, human information processing modes, corrected vision, academic major and perceived usefulness. In one earlier study or another, all these have been found to contribute to the individual differences in performance of students on a variety of computer systems.

1.3.4.1 Academic Major

Academic major as an independent variable playing an intervening role between performance and other independent variables studied, first reported by Borgman (1984), has been extended to this scenario because of its high relevance to the locus of this study. One of the most important research questions being addressed here is whether students from different academic disciplines perform differently on CD ROM use.

1.3.4.2 Visual Ability

Studies in IR have not considered visual ability ("the ability to manipulate or transform the image of spatial patterns into other arrangements" - Sein, 1988: p. 92) as a variable which might affect one's ability to use computer systems. However, researchers in the field of education and management have used it to predict the ability to perform on computer systems (Vincente, 1986; Sein, 1988; Sein & Bostrom, 1989). Since this variable is already tested and found to affect performance of individuals in computer-related tasks, it is very likely to affect IR performance too. Therefore, visual ability is being introduced as an independent variable in this study for the first time in an IR context, to examine whether it affects searching on CD ROM databases. If indeed visual ability is found to be a predictor of performance on CD ROM databases, it needs to be included in future IR studies. The standardized VZ-2 test instrument from the Educational Testing Service (ETS) is used for this measure.

1.3.4.3 Human Information Processing

Another measure which has not attracted much attention in IR studies is human information processing style. It is fairly well accepted that most individuals exhibit preferred modes of information processing. Some people prefer *structured* assignments , focus on *verbal* recall of specific *facts* which they can sequence to form an *outline* as the basis for *logical* problem solving as opposed to those who prefer *open-ended* assignments where they can recall *spatial* material looking for *ideas* to show *relationships* that they can use to *summarize* as the basis for *intuitive* problem solving (Toggart & Torrance, 1988). Springer (1981) refers to this as left/right brain hemisphere dominance. But, it became the concern of behavioral and organizational sciences in recent times, mainly because of the non-uniform results of training programs designed for organizational employees. Chester Barnard (1938) called the two groups of mental processes logical and non-logical. Later research in management had studied this process and its effect on learning and performance of individuals (Taggart & Torrance, 1988). This study includes human information processing as an independent variable (See Chapter II) to examine whether a student's brain preference affects his/her performance. The standardized Human Information Processing Survey instrument published by the Scholastic Testing Service is used for this measure.

1.3.4.4 Perceived Usefulness

Perceived usefulness is again not a variable studied in IR research. It has, however, been widely researched in MIS area (Sein & Bostrom, 1989). Personal sense of perceived use may not have been of great importance in studies on intermediaries, but in the present context, where undergraduate students are the subjects, the importance of perceived usefulness (See Chapter IV) of CD ROM databases is expected to be significant. A questionnaire validated in the pilot study was used for this measure.

1.3.4.5 Computer Affinity and Computer Literacy

In most studies on individual differences particularly in IR area, both computer affinity ("liking" for working with computers) and computer literacy ("acquired skill" of working on computers) have been included as components of a overall measure such as technical aptitude, which also included math-related abilities, scores on quantitative tests, etc. In this study, they are being isolated in an exploratory attempt to see whether the two variables affect the performance of the subjects independently. This line of query was prompted by reports in literature (Griswold, 1985) and personal interviews with undergraduate students, that suggested that many of them enjoyed playing games on computers, but did not like to work with computers. A questionnaire validated in the pilot study was used for these two measures.

1.4 Important Differences & Potential Contribution of this Research

The research study described in the next four Chapters is an attempt to build on earlier studies, particularly in an IR context, while at the same time, borrowing from other related disciplines. It is also designed to overcome some of the shortcomings of earlier experimenters, by introducing new approaches in the choice and definition of variables.The factors which differentiate this study from earlier studies in IR are summarized below:

1. As has been discussed above, prior research was in the context of online information retrieval (IR) systems. The research reported here extends the studies to the new domain of CD ROM technology for information retrieval.

2. Most of the research reported so far, studied performance using a single system; in IR research, it was mostly a single database. Thus, the effect of the content of the system, i.e., the effect of the subject content of the database, was not considered to have any effect on the search performance of the user. If search performance was compared on two different databases, it was actually aimed at comparing the characteristics of the two systems (interface and strategies) on which the databases were available. This research, however, attempts to shed light on whether there is an interaction effect between the academic major of the searcher and the subject content of the database searched.

3. Visual ability has not been considered as a variable in most of the work in IR studies, though management science research has considered the issue (Sein, 1984; Sein & Bostrom, 1989). This research includes visual ability as a variable and studies the effects of the same on individual differences in the performance of users of CD ROM databases. This

is considered important, because CD ROM based systems have instructions and directions for the user on the screen. These are supposed to be easy for the user to look at and to visualize the outcome of following the instructions; thus, a high visual ability is likely to be an added advantage in using these systems.

4. Human information processing mode has also not been used in user studies in the IR area. Since this research is a study of undergraduate students, it is considered important and necessary to look at the information processing styles of students along with their other characteristics which are likely to contribute to individual differences.

5. Borgman as well as most of the researchers in the IR discipline, studied the ability to use computers and an individual's liking to use them, together as one factor, calling it "technical aptitude", "computer competency", "computer literacy", etc. A distinction is made between the two in this research; they are measured separately (using questionnaires) as "computer affinity" and "computer literacy". Their effect on (or correlation with) choice of academic major as well as performance is studied.

1.5 Main Research Questions Addressed

Every new study is prompted by one or more questions which are left unanswered by earlier studies. Most often, it happens that studies are designed with a goal of finding answers to those questions. This also makes those studies exploratory, by their very nature. The current research is one such. A few of the main questions which prompted this study are:

1. Does the academic major of students affect their performance on CD ROM databases?

2. Does perceived usefulness of a system affect performance on a system?

3. Is there a justification to include visual ability as a variable to be measured in research which purport to study individual differences of subjects in computer-related tasks, particularly undergraduate students?

4. Is there a need to isolate and study the effect of computer affinity on performance of subjects on computer systems as separate from that of computer literacy in such studies?

1.6 Organization of Text

Chapter II, LITERATURE REVIEW, covers the review of literature that have relevance to the current research and explains the development of the research design used in this study. Chapter III, RESEARCH DESIGN, describes the research design in detail. Chapter IV, EXPERIMENTAL PROCEDURE AND ANALYSIS explains the experimental procedure followed and the hypotheses tested. Chapter V, RESULTS AND DISCUSSION is a discussion of the results obtained and the conclusions based on the findings. Limitations of the study and implications for future research are also provided. Experimental materials such as questionnaires, search questions used as tasks, etc. are provided in the appendix.

CHAPTER II
LITERATURE REVIEW

2.1 The Approach

This dissertation study, though it draws upon the works of researchers from different fields, is conducted in the context of information retrieval. Thus, the emphasis is on the differences in the way students perform on tasks in the process of retrieving information using a recent and promising technology, i.e., CD ROM databases. The overall goal of the study is to determine whether earlier findings in an IR context on online systems hold for the CD ROM systems, and if not, whether future studies need to be designed differently. The study is also aimed at exploring the inclusion of some user characteristics which have not been considered in IR studies, but are found to have considerable influence on performance of users of computer systems in other fields of research. The following review of literature, therefore, discusses in depth, literature published in the field of information retrieval. Mention is made of relevant research in other fields, while a few studies from which the current study borrows heavily, are dealt with in detail.

2.2 Origins

Numerous studies in IR conducted over the past two decades have proven beyond doubt that there are considerable differences in the way individuals search on computerized databases as well as in the results they obtain. But it was Zweitzig (1977) who pointed out that user studies in librarianship are, with a few noteworthy exceptions, not about users, but studies of use. He stated that "the unit of analysis is generally away from the patron himself, to the utilities or *uses* that interaction with the library has provided." (Zweitzig, 1977, p.8).

Fine (1984), in an overview of behavioral research in librarianship observed that most of the research in this area can be classified into one of four major areas: (1) interest in organizational behavior and the application of principles from theories of management to the administration of libraries - studies that concern management styles and their effects, particularly with the introduction of technology; (2) study of the communication patterns of librarians, both verbal and non-verbal, which reflect their behavioral dimension; (3) interest that librarians have in themselves in the context of their professional lives; (4) studies of attitudes of different groups of users in two directions - (a) positive and negative responses to issues and processes and (b) comparing attitudes of different groups of users. Fine, however, pointed out that

> "Studies of uses and users, as they are conducted today and in the past, give us virtually no understanding of how people interact with information and with libraries" (Fine, 1984; p. 443).

It is that premise, i.e., the need to understand the psychology of the information user, that perhaps prompted some researchers such as Card (1983), Summers et al.,. (1983), Vigil (1983) and Borgman (1985) to examine individual differences in the use of libraries and in the technology for information access.

Fenichel (1979) provided a comprehensive review of studies of the online search process and summarized them in her later article (1981); these yielded results such as: (1) a small proportion of specific commands accounts for a large proportion of command use; (2) users of online databases could be grouped on the basis of process variables such as the number of commands used; (3) considerable variation in individual approaches to searching could be found even when the same system and the same database were used - similar variations had been reported between computer programmers, indexers, etc., where the intellectual processes involved were similar to those in online searching context; (4) New users often learned to perform simple searches after a brief period of training, though they did not utilize more sophisticated system features; (5) many experienced searchers did not perform as well as expected -there were obvious omissions and errors in their searches; (6) for both inexperienced and experienced searchers, the major problem was not with the mechanics of the system but with the search strategy; command language barrier, however, posed a problem for infrequent users; (7) even many experienced searchers preferred to perform only simple searches in most instances, not utilizing the interactive capability of the system; (8) the online search process was sensitive to factors associated with the institutional environment of the searcher such as the nature of the user groups, management policies and charging procedures that could influence the searcher by affecting his/her cost consciousness.

Fenichel made an attempt to identify measures that discriminate among users as early as in 1979, when she tested experienced and inexperienced searchers on the DIALOG system using ONTAP ERIC, the 1975 subset of the ERIC (Educational Resources Information Center) database. She classified the searchers into five groups as novices, moderately experienced searchers without ERIC experience, moderately experienced searchers with ERIC experience, very experienced searchers without ERIC experience and very experienced searchers with ERIC experience. Data were gathered on the education, online training, online experience, institutional setting, personal characteristics, and attitudes and opinions of the searchers. Performance measures were divided into process (e.g., number of commands used) and outcome variables (e.g., recall). Her results showed that, compared to experienced subjects, the novices performed surprisingly well, though as a group they were slower, made more errors and scored lower on most outcome measures. The important thing was that the differences were not as great as might be expected. However, the value of her pioneering work lay in the fact that she planned and executed a well thought out experiment which prompted many later researchers to extend behavioral studies to other variables such as educational background, institutional setting, learning styles, personality traits, intelligence factors, etc., in an effort to discover those behaviors associated with the process of bibliographic online searching that are correlated with success.

One of the recently published series of articles by Saracevic et al., (1988a, 1988b, 1988c), laid down the details of a study of information seeking and retrieving experiment under as real-life a situation as possible. The system used was DIALOG. Part I was a presentation of the background of the study and described the models, measures, methods, procedures and statistical analyses used; Part II was devoted to results related to users, questions and effectiveness measures and Part III presented the results related to searchers, searches and overlap studies. Thirty six searchers were tested on three cognitive tests - Remote Associates Test (RAT), Symbolic Reasoning Test (SRT) and Learning Style Inventory (LSI). (In fact this was the study conducted by Woelfl (1984) for her dissertation). Saracevic et al., expressed their frustration at the fact that the design of information retrieval systems were, by and large (with a very few exceptions), based on little more than common sense and interpretation of anecdotal evidence. They felt that the professional practice in IR domain would be on much more solid ground if they were confirmed or refuted, elaborated, cumulated and taught on the basis of scientific evidence (Saracevic et al., 1988a: p.161). Discussing a number of reviews published over a decade on this topic, they pointed out that all reviews, despite different backgrounds of the reviewers, concluded that research has been inadequate and that more research is needed.

> "The research in information seeking and retrieving is its infancy. It is still at an exploratory stage. ...The key to the future of information systems and searching processes (and by extension, of information science and artificial intelligence from where the systems and processes are emerging) lies not in increased sophistication of technology, but in increased understanding of human involvement with information". (Saracevic et al.,, 1988a: p. 162)

The current study was also designed with the same goal - to increase our understanding of human involvement with information, albeit in the context of a sophisticated information technology. But it also tried to address what some researchers called the problem of interfacing between end-user and large scale databases.

2.3 Study of Training Methods

In the mid-eighties, when studies on the variations in performance of IR systems was being conducted in different contexts and on different attributes of users, there was also a great enthusiasm to study the mental models of users which contributed to these variations. Further, the effect of different types of training provided to users which in the first place gave rise to the formation of different mental models by different individuals was studied by quite a few researchers, not only in the field of information retrieval, but in computer science and management science. Two such studies are reviewed here, mainly because they paved the path towards greater emphasis on individual differences rather than mental models, because of the weak effects of the latter on performance in many cases. The most frequently cited such studies are Borgman (1984a) in information retrieval and Sein (1988) in decision sciences. Both studied the effect of training on performance with computer systems by providing different types of training to two groups of students. In addition, the cognitive perspective in the man-machine interaction process was pursued by Borgman (1984), Halasz & Moran (1983), and other researchers. A majority of these researchers found an interaction between some form of conceptual training and the task performed.

Borgman (1984a, 1984b), examined the use of online catalogs in libraries. Her research was primarily aimed at taking a closer look at human abilities to use information systems based on the type of training they received. She trained undergraduate subjects on a prototype online catalog using two different training methods: (1) a conceptual approach that attempted to induce a mental model of the system, and (2) a procedural approach, or, step-by-step training, that replicated current methods of teaching similar systems. She found that those trained by the conceptual method performed better in complex tasks but the two groups performed equally well on simple tasks; however, some people had problems applying Boolean logic. Borgman (1984a; 1985) found that there were two major characteristics of the subjects involved which accounted for the differences in the test results which were not expected: (i) the dropouts from the benchmark tests were predominantly social science and humanities majors, while those passing the test were science and engineering majors; (ii) library use did not have any influence on performance in the tests. However, these two factors were not correlated. Borgman observed that "*the finding that ability to use an online catalog varies by academic majors suggests that some kinds of individual behavioral differences are operating. ... The use of computers in general and information systems in particular, requires a procedural mode of thinking.*" (Borgman, 1985, p. 244) This was in conformance with the earlier observations of Sheil (1981), who studied programmers and reviewed the literature on psychological study of programmers. Thus, it appears, that the style of thinking required for studying the sciences and engineering may be more appropriate for the use of computer-based information systems than that required for studying humanities and social science disciplines.

These findings indicate that training which helped users form some mental model of the system used, helped improve their performance. However, there was no conclusive evidence to decide that certain types of conceptual models were inherently superior to others. Sein (1988), based his dissertation work on these very premises and compared the effectiveness of two types of conceptual models - abstract and analogical - in aiding novice users form mental models of the filing capabilities of an electronic mail system. He looked at the influence of two individual difference variables, i.e., learning styles and visual ability, on performance. Subjects were students in management science courses, some of whom had had computer-related courses while others had not. Results of Sein's study indicated that although not statistically significant, the abstract model group performed better than the analogical model group. However, statistically significant results were obtained for the individual difference variables. High visual subjects performed better than low visual subjects. Abstract learners performed better than concrete learners; overall, convergers performed better than all other types of learners. Abstract learners benefited from the abstract model while concrete learners were severely hampered by it. Moreover, concrete learners performed better than abstract learners when provided with the analogical model: These findings, therefore, did not support any general superiority for either type of conceptual model. On the contrary, they suggested that the effectiveness of the conceptual model depended on individual characteristics such as visual ability and learning mode and the interaction of these with the conceptual model provided.

Reviewing past research on mental models in his dissertation, Sein observed,

> "What is less clear is whether certain types of conceptual models are inherently superior to others, and whether this advantage persists for different types of systems, programming languages and tasks." (Sein, 1988: p. xv)

Sein & Bostrom (1989) reporting on a later extensive study undertaken to investigate the puzzling display of weak effects of conceptual models in the literature, pointed out that a strong theoretical basis exists for the efficacy of conceptual models. Yet empirical evidence for strong effects of such conceptual models is scanty as well as ambiguous. They further identified (1) the effect of individual differences not being considered and (2) interactive effects of individual differences and conceptual models being ignored, as the two major factors that led to the above problem. It thus appears that there is no evidence to conclude that the type of training would be the deciding factor in user performance on systems. The research study reported here thus chose to examine the individual difference variables in greater detail.

Borgman (1984b), reviewed the research in the area of psychological research in human-computer interactions; she borrowed Moran's (1981) taxonomy of research in this area, which divided it into four approaches: experimental, features, factors and calculational. Of these, factors research consisted of studies that attempt to identify a patterns of psychological factors that are relevant to human behavior with computers. Among the theories applied in these studies are memory representation and retrieval (short-term memory, schemata, mental models, etc.), linguistic behavior, learning theories and various individual parameters.

2.4 Context of Research on Users in IR

Daniels (1986) provided one of the most comprehensive reviews of the literature in "cognitive models in information retrieval" from an interdisciplinary point of view. His analysis was aimed at suggesting how user models could be used to improve performance and acceptability in information retrieval systems. Following Borgman, he identified the types of cognitive models: (1) mental models in the man-machine interface context refer to the user's model of the system, whereas (2) conceptual models are those which are presented to the user, usually by the system designer, a trainer, etc.; and (3) user models, refer to the computer's model of the user and should probably also include the computer's model of the user's model of the system. There are different classifications of this third type - **user models**: (a) a model of a single, 'typical' or canonical user vs. a collection of models of individual users; (b) explicit models constructed by the user or specified by the system designer vs. models inferred or abstracted by the computer on the basis of the user's behavior; (c) models of long-term users vs. short-term users. Relevant to the present context is the first classification - canonical vs. collective model of user - Daniels also discussed the appropriateness of both in the context of information retrieval (IR) systems and concluded

> "... A standard, typical or ideal user probably does not exist in the IR situation; even within limited IR systems, for example, .. users come to the system from a variety of backgrounds, with varying levels of experience and states of knowledge" (Daniels, 1986; p. 289).

It appears that a collective model of groups of users is perhaps better suited to IR situations. But what are these groups and how are they to be determined? This is the problem which needs to be examined.

2.5 Individual Differences

In his review of psychological studies of programmers, Sheil (1981) demonstrated the need and importance of proper and sophisticated experimental techniques while studying the individual differences that account for differences in performance. However, individual differences or cognitive styles include individual preferences and abilities, which refer to basic aptitude. Studies conducted (Evans & Simkin, 1989), had included many variables that might be used to predict computer aptitude. An exhaustive list of variables by Fidel and Soergel (1983) illustrated the complexity of the context and processes in online searching - they listed over two hundred variables grouped into eight broad categories. Information seeking or retrieval models of many researchers used some of these variables or others, depending on the context in which the studies were conducted. Saracevic et al., (1988a) labelled them as need-oriented and problem-oriented schools of research.

But, whatever the context, most of the variables studied, whether in IR area or MIS, seem to have been selected based on little more than intuitive appeal; i.e., the nature of this stream of research has been mostly atheoretical, according to Sein (1988) and Sein and Bostrom (1989). Consequently, few attempts have been made to explain why these factors should be important even when they were found to be good explanatory variables (Sein, 1988).

In the field of education too, there had been only a limited interest in studying the differences in the attitudes about computers amongst students. Griswold (1985) compared attitudes of education and business majors in a study to find that the latter had more positive attitudes about computers than the former, but did not relate it to any individual differences variable. However, researchers on individual differences in the field of decision sciences identified at least two variables that have sound theoretical bases for influencing learning outcomes as visual ability and learning style (Sein, 1984; Sein & Bostrom, 1989). Learning Style had also been investigated extensively by Woelfl (1984), Logan and Woelfl (1986), Saracevic et al., (1988b) and later, by Borgman (1989) in IR studies.

2.5.1 Visual Ability

High visual ability had been studied by Vincent et al., (1986) in hierarchical file search; and by Sein (1988) and Sein & Bostrom (1989) while training novice users in computer systems. It had been hypothesized that novice learners with a low-visual ability can be expected to benefit most from a concrete, analogical, conceptual model, while abstract models hamper them; but high-visual subjects can be expected to benefit equally from either type of model. Sein & Bostrom indeed found these hypotheses did hold in their study. They also pointed out that while training a novice user on a system, it was not always easy to manipulate the system or the task performed. Most experiments were conducted on a fixed type of system interface and a certain type of task. So, what indeed contributed to the different levels of performance were the user characteristics, such as cognitive ability (e.g., visual ability), cognitive style (e.g., learning mode), motivational traits (e.g., perceived usefulness) and prior experience or familiarity.

Borgman (1989), though not studying this factor explicitly, observed in her concluding remarks, that people with high spatial skills may perform better in graphic or spatially oriented interfaces. She referred to an unpublished personal communication from Egan and Gomez, which found that providing spatial assistance in a text-editing interface was most effective for those with high spatial skills. The implications of these findings to interface design are bound to be significant. Sein (1988), discussing earlier studies on the topic, drew support for his own decision from findings which indicated that inductive reasoning and visual-spatial abilities can be strong determinants of the ability to draw proper analogies and points out that, "The variance in visual ability may explain why some of Borgman's (1984) subjects failed to benefit from the analogical model provided to them. It is possible that they did not have the required visual ability." (Sein, 1988: p. 93)

Thus, in this study, visual ability was introduced as a predictor of performance, to test whether indeed it has a role to play in an IR context.

2.5.2 Learning Style

According to Kolb's experiential theory of learning (Kolb, 1971), active experimenters have a learning mode that is dramatically opposed to reflective observers. His theory also put those with an abstract learning mode and concrete learning mode at the two ends of a spectrum, the former having the abilities to discover rules and structures inherent in abstract models, while the latter drew heavily on prior experiences. A combination of these two orthogonal continuums yielded four learning styles into which novice users of systems could be mapped. Kolb's theory and his instrument (KLSI) have been used by researchers in various fields. Woelfl (1984), studied individual differences in online search behavior of skilled MEDLINE searchers using the Kolb Learning Style Inventory (KLSI) extensively. She found her subjects clustered strongly in the "converger" type of LSI. However, a later study by Logan & Woelfl (1986) on library school graduate novice searchers yielded contrasting results; i.e., there were clusters in "divergence", "assimilator" and "accommodation" types with none in the "convergence" type. Woelfl also used the Remote Associates test (RAT), Symbolic Reasoning Test (SRT) and parts of Guilford's structure of the intellect model, as measures of verbal skill and mathematical reasoning respectively, the latter to be related to Boolean logic abilities. Contrary to expectations, the test scores were related to the search process and not the search outcome. SRT was the only measure related to both. Zuboff (1988) too, used KLSI in her study of factory workers who were learning to operate computer-based controllers.

Borgman (1989) and Sein (1988) also used learning style as a predictor of performance of subjects on their respective systems. Both did find statistically significant results. Borgman reported that the abstract/concrete dimension was correlated positively with academic major for her sample of undergraduate students from UCLA, with a tendency for engineering students to cluster in the converger (65%) category and for English majors to fall into the diverger group (42%). Sein found that subjects with abstract learning mode performed better than those with concrete learning mode; and those with a converger learning style performed better than those with other styles. Learning style inventory was used in this current study to test whether these findings hold for the undergraduate sample population at the University of Hawaii and in the context of CD ROM systems.

2.5.3 Personality Types

Evans & Simkin (1989), used the Myers-Briggs Type Indicator (MBTI) as measures of cognition, in their quest to find out "What best predicts computer proficiency?" This instrument classifies subjects into four contrasting pairs: (1) extroverted vs. introverted; (2) sensing versus intuitive; (3) thinking vs. feeling; and (4) judging vs. perceiving, for 16 possible types. It is reasonable to expect differences in individual behaviors of subjects belonging to these 16 types in performing tasks. In the field of IR, Brindle (1981) used a test similar to MBTI to study the personality characteristics of trained DIALOG searchers and found that all were "intuitive-perceptive" type (reported by Borgman, 1989). Bellardo (1984), who used MBTI to study library school students from six different universities with reference to their online search performance, did not find any significant results. Later, Borgman used MBTI in her more recent study (1989), and claimed that engineering students had personality types similar to that of programmers, as contrasted with English and psychology majors, and that the LSI and MBTI are valuable predictors of choice of major, explaining 43% of the variance (Borgman, 1989; p. 247).

Individual differences in the IR domain have often been accepted as being related to individual differences in other computing technologies. Egan (1988) provided a comprehensive coverage of these issues. He proposed that there is a need to be concerned about differences among individuals for three reasons: (1) the large differences in IR performances observed in the many studies conducted in the area; (2) the common personnel selection tests of the work place cannot be applied to computing tasks and (3) the possibility of accommodating user differences through improved design and training available today.

Bellardo (1984,1985), studied some attributes of online search intermediaries that relate to search outcome, in her study of library and information science graduate students in a first searching course. She tested them on two measures of creativity (based on self-report inventories) and one measure of personality in regard to masculinity, feminity and self-esteem (using the Interpersonal Disposition Inventory). She found only two combinations of traits, i.e., "artistic scholar" and "analytic individualist", accounted for a small but significant variance in search performance. Her findings also gave rise to doubts about high intelligence and other attributes cited by some writers in the field as necessary for high performance. Most importantly, she observed,

> "The notion that searching performance can be predicted by or is dependent upon certain cognitive or personality traits has thus become highly suspect". (Bellardo, 1984; p. 241)

Studies on programmers (Lyons, 1985; Sheil, 1981) have also been conducted by researchers in computer science and management science, using the MBTI. The clustering effect of programmer subjects into one type, i.e., the "judging" type, was observed in most studies; also, programmers were more likely to be introvert than extrovert.

2.5.4 Human Information Processing

Studies, particularly in the fields of psychology and artificial intelligence had tried to look at the ways human beings process information to explain the individual differences in performance of various tasks. Human resource development professionals in particular have been interested in research that could provide evidence of the different ways in which the left and right hemispheres of the human brain process information. According to Springer (1981) the right hemisphere is non-critical, while the left is always checking for "correctness", but all brain functions are important and should be valued. The two functions are complimentary, but for most of us, one of the two hemispheres is the dominant one in terms of our preferred mode of information processing. There are also degrees of dominance of the activities of the two hemispheres. Management professionals, particularly those involved in designing training programs, are concerned about the efficacy of training which is obviously affected by the different modes of information processing of the participants. Herrmann discussed the significance of left/right hemisphere differences for management in "The Creative Brain" (1981). His experience with the brain dominance concept at General Electric and other major corporations led him to observe that training programs good enough to bring about desired changes in the participants will be reflected in their brain dominance characteristics. Therefore one needed to measure human information processing style or mode as the basis for improving the design and delivery of the training activity (Taggart & Torrance, 1988).

In order to understand and apply these ideas, practitioners of training and development programs needed an instrument to survey the processing styles of individuals in his/her work place. Taggart and Torrance came up with a survey instrument called the Human Information Processing Survey (HIP Survey), copyrighted by HIP Systems. This instrument assesses an individual in terms of processing preference. They also developed a Strategy and Tactics Profile to accompany the HIP survey, which provides a description of a person's overall approach as well as his or her specific tactics in problem solving and decision making.

The HIP Survey measures the responses of individuals to a set of forty questions, to determine whether people are more left-brain oriented, right-brain oriented, or integrated. The instrument also had a fourth category for those who do not fall into these categories - they are said to fall in the mixed mode. These are perhaps more flexible than the left or right brain mode people.

In the field of information retrieval, there has been deep interest in the ways human beings seek and process information. The classic work of Taylor (1968), "Question Negotiation and Information Seeking in Libraries", had never stopped inspiring researchers to find answers to the questions he raised, such as, the difference between the visceral need and the expressed need, etc. Saracevic et al., (1988a), classified Taylor's school of thought as one revolving around the concept of information need and that of Belkin and others as problem oriented school, viewing the problem behind the question of the information seeker. Saracevic et al., observe that the problem oriented school has increasingly borrowed notions and approaches from cognitive science (Saracevic et al., 1988a: p. 163). However, there is no evidence that the HIP Survey instrument has been used in IR studies so far.

This study used the HIP Survey instrument since it was expected that the human information processing style would correlate with the personality types indicated by MBTI as well as predict learning styles provided by KLSI. The HIP instrument was also used to test whether the different brain preferences affected the performance of students on CD ROM databases as well their academic major.

2.6 Other Factors in User Studies in IR

Research on performance difference with computer-related tasks has brought to fore many other variables such as experience with computers or task domain, age, sex and technical aptitudes. The first variable, "experience" has been studied by Fenichel (1981) and Howard (1982) in the IR area. They found performance effects for both searching and database experience, with the best performance by those with experience in both. Many of the studies also found marginal to sizeable effects of age and sex on performance in IR contexts.

The last of these variables, technical aptitude was found to be an explanatory variable of individual differences by only a few researchers. Egan (1988) used the term for a cluster of factors including spatial and reasoning aptitudes and background (typically course work) in math and science. Spatial abilities was studied by Green et al., (1986), Sein (1988) and Sein & Bostrom (1989). Egan found that technical aptitude of subjects affected their learning ability, in an experiment designed to isolate learner characteristics that predict success. Sein and Bostrom tested spatial abilities using the VZ-2 test instrument from ETS (Educational Testing Service) to classify students as high/low visual. Green et al., (1986) studied reasoning ability in association with specifying database targets while Woelfl (1984) studied them as measures of mathematical reasoning.

2.7 Factors of Specific Interest to the Current Study

2.7.1 Academic Major

Academic discipline or choice of academic major has not been explicitly studied as a predictor of performance in most IR studies, perhaps because most of them were studies of intermediaries. These intermediaries were librarians, who performed online searches on commercial systems such as DIALOG, BRS, etc., after receiving special training on these systems. They normally performed searches on all subjects, irrespective of their own educational background. Thus, it was perhaps not considered very important to study this variable in IR settings. Two recent studies, one by Griswold (1985) and Borgman (1989) compared factors contributing to individual differences among students from different academic majors. Of the two, the more relevant research to the current study, was a recently published work by Borgman (1989). According to her, it was a study which was "prompted by unexpected findings" of prior research (Borgman, 1984a); the finding was that the performance on an information retrieval task in a controlled environment was heavily influenced by individual differences. More precisely, one demographic characteristic distinguished among those who passed and those who failed the benchmark test in her earlier study: those who failed were predominantly social science and humanities majors, while those who passed the test were science and engineering majors ($p<0.0001$). This finding that academic discipline was a factor in IR performance led her to search for the factors that might be related both to academic discipline and to retrieval aptitude. The link found between disciplines and information-seeking style suggested that personality characteristics, technical aptitudes, reasoning ability and other factors related to academic discipline might be appropriate to explore.

Borgman used a hypothetical model which suggested that both technical aptitudes and personality traits lead to choice of academic discipline and lead directly or indirectly (via academic orientation) to IR aptitude. Based on this model, she used academic orientation as an intervening variable to identify links to IR aptitude. Four test scores (RAT - Remote Associates Test, SRT - Spatial Reasoning Test, SAT - Scholastic Aptitudes Test - math and SAT -verbal) as well as course work in math and science at high school and undergraduate levels and GPA (Grade Point Average) scores at both levels were used as characteristics that would relate to technical aptitudes. She hypothesized that these characteristics would also be related to academic orientation, if they related to either IR or programming performance. Similarly, characteristics related to personality, as obtained from KLSI and MBTI were hypothesized as being related to the academic orientation if they were related to IR or programming performance. (Programming was considered on the grounds that it required some of the same technical and reasoning skills as did information retrieval, such as use of Boolean operators, keyword search, etc.)

Borgman's sample consisted of 64 undergraduate students from UCLA (aged 18-25), who were native speakers of English. One major was chosen to represent each of the three disciplinary orientations: engineering to represent science and technology, psychology for the social sciences, and English for the humanities. This was to minimize the variance within each group while maximizing the variance between groups.

Borgman's findings were: (1) Significant correlations exist between academic major and technical aptitudes; (2) Both SRT and the SAT math scores were correlated with major; neither RAT nor SAT verbal scores showed any significant correlation; also, contrary to expectation, engineering majors had the highest SAT verbal scores among the three groups; (3) Major was significantly and positively correlated with most of the measures of math and science course work; (4) SRT results were correlated with the SAT math scores, but the number of high school science courses was the only variable to which it was related.

As for the personality traits, the LSI abstract/concrete dimension was found to be correlated positively with major. Use of MBTI resulted in only one dimension (thinking/feeling) being related to choice of major. The extrovert/introvert and judging/perceptive dimension had weak correlations with the number of high school science courses taken, but with no other technical aptitudes. The other two dimensions correlated with several of the course work variables, with the thinking/feeling dimension the strongest. Though some consistency was found with earlier studies on programmers, there were contrasting findings with respect to heavy dominance of introverts among the engineering students. Not much clustering was found in two types (ISTJ, INTP) as in other studies, perhaps because of small sample size, but the engineering subjects were still most likely to cluster.

Borgman concluded that the clustering of subjects by major into groups based on technical aptitude, suggests that the effect of major on information retrieval performance in the earlier study (1984) may have been due to higher technical skills of the science and engineering majors. Prior experience on other computer tasks found to be a significant predictor of retrieval performance by other researchers may also suggest this result. She also found that the distinct clustering of engineering subjects have a pattern similar to that of the skilled MEDLINE searchers in Woelfl (1984) study, while the other subjects had a pattern that was almost the opposite. The engineering group also resembled the skilled DIALOG searchers of Brindle's study, falling in the intuitive/perceptive type. In combination, LSI and MBTI were found to be valuable predictors of choice of major, explaining 43% of the variance.

Borgman rightly observed that the findings of her later study had a number of implications for future research, such as designing an interface which does not need the use of Boolean logic for users with less technical aptitude. But, of greater importance to the current quest, was her recognition that people with high spatial skills may perform better in graphic or spatially oriented interfaces. Gomez and Egan (1986) conducted such a study with a text-editing interface, and found that providing spatial assistance was most effective for those with high spatial skills while it only confused those with low spatial skills. Sein and Bostrom (1989) confirmed these findings.

The most significant finding of Borgman's work, however, was the consistency of patterns among factors related to computing task performance, which lead her to conclude:

> "Individual performance differences are not random; they are sufficiently predictable that soon, they can be controlled, both through design and training. Future empirical research should seek (1) to isolate the human characteristics that lead to performance differences and (2) to isolate the interface factors with which they interact. This might help to generalize our understanding of user behavior with information systems." (Borgman, 1989; p.249).

The research reported here is aimed at the first of the two tasks Borgman lays in front of future researchers, i.e., to isolate the human characteristics that lead to performance differences.

2.7.2 Visual Ability

The current study being one of an interdisciplinary nature, as mentioned earlier, drew inspiration from other areas such as MIS where relevant research had been reported. One research study which used visual ability as a predictor of performance of students on computer systems and found statistically significant and theoretically important results was reported by Sein (1988) in the field of MIS. Sein examined a segment of the mental model formation process developed by him and Bostrom through a laboratory experiment. The experiment tested the effectiveness of two types of conceptual models (analogical and abstract) in aiding novice users form mental models of the filing capabilities of an electronic mail system. He also examined the role of three variables (learning style, learning mode, and visual ability), which contribute to individual differences. Though he did not find statistically significant results for the modes of learning, he found significant results for individual difference variables. In particular, high visual subjects performed better than low visual subjects. He also found that low visual subjects were hampered by the abstract model, but performed as well as high visual subjects when provided with the analogical model. His findings did not support a general superiority for either type of conceptual model. In fact, he concluded that the effectiveness of the conceptual model depended on individual characteristics such as visual ability and learning mode and the interaction between these variables and the provided conceptual model.

In a later article, Sein and Bostrom (1989) emphasized the importance and need for researchers to consider individual differences as important influences in the mental model formation process. Such studies, they believed, would go a long way in building a theory of human-computer interaction. In the current research, both visual ability and learning mode were studied along with other variables to test both for their influence on performance as well as on the choice of major by subjects.

2.7.3 Performance Measures

Right from the time of the famous Cranfield experiments in the mid-sixties, performance measures have been discussed and debated by many researchers including such pioneers as Salton & McGill and Salton, to Fenichel and Saracevic in the eighties. Whatever the focus of their studies, researchers in IR have used recall and precision as the standard measures of performance over the past 20 years. These measures are dependent on the relevance judgement by intermediaries or users, which again has been a debated issue. Relevance refers to the general (or, objective) appropriateness of an item retrieved to the query of a user which becomes pertinence when subjectively judged by the user himself/herself. Therefore, the judgement of this factor rests best with the user. Most studies used the following definitions for precision and recall and accepted relevance judgements of searcher-users.

Precision = Number of items retrieved and relevant /Total retrieved

Recall = Number of items retrieved and relevant /Total relevant in collection

(Salton & McGill 1983; p.164)

While it is easy to determine precision, it has always been difficult to measure recall, while using large databases, because it was never apparent how many items in the file were relevant to the question.

The measures of effectiveness and efficiency have also been used in IR studies to evaluate retrieval performance. Salton & McGill defined them as:

> "Effectiveness of an information system is the ability to furnish information services that the users need. On the other hand, the efficiency is a measure of the cost or the time necessary to perform a given set of tasks" (Salton & McGill 1983; p.158)

Most researchers measured these two factors separately. In many cases, they also judged the cost and time components of searches independent of each other.

Saracevic et al., (1988a) conducted extensive research in the field of IR over many years with a "collective aim of contributing to the formal characterization of the elements involved in information seeking and retrieving". Their studies, carried out with generous NSF and DIALOG grants appear to be, by far, the largest and most comprehensive effort in IR area in recent times. Saracevic et al., devoted the entire second phase of their study to making quantified observations on a number of variables used in the experiments and reported their results in a systematic manner (1988a).

> "Users and their questions are fundamental to all kinds of information systems, and human decisions and human-machine interactions are by far the most important variables in the processes dealing with searching for and retrieval of information. These statements are true to the point of being trite". (Saracevic et al., 1988a. p.162)

Saracevic et al., (1988a, 1988b, 1988c) used precision and recall as measures of effectiveness of searchers. They also measured efficiency in terms of the number of commands used during the search for a given question, the number of cycles completed (a cycle was defined as a set of commands progressing from selecting terms to typing results), the number of search terms used, the time used in preparation for searching and the connect time used. All these measures were studied independently for their effect on efficiency.

The conclusions arrived at by Saracevic et al., were presented entirely in terms of relevance, precision and recall odds, because, whatever was their focus, be it users, questions, searchers or searches, the only measures that they could use to compare them for inter- or intra-group consistency. While discussing the effect of cognitive traits of searchers on their performance, Saracevic et al., concluded that those who scored high on word association had increased relevance odds. As to learning styles, searchers who scored low on concrete experience as a learning mode had higher scores on all three measures of performance. Those who preferred abstractness over concreteness had a large increase in relevance and recall. Word Association abilities in searchers favored relevance odds and preference toward abstractness in thinking favored relevance and recall odds. It was also found that in searchers who had a high RAT score, relevance odds increased by 60%, while SAT scores had no significant relation with any of the three measures. Efficiency was measured not as one unit, but independently in terms of the five measured mentioned above. They found that higher number of cycles and lower number of search terms increased relevance; number of commands had no effect; lower preparation and total time increased relevance while online time had no effect. None of these had a significant effect on either precision or recall odds. (Saracevic et al., 1988c: p. 211).

Trivison (1986) reported the results of a preliminary study, which appeared to have been a precursor to the studies by Saracevic et al. She too discussed the performance measures efficiency and effectiveness in terms of relevance and recall. The performance comparison was, however, performed for every measure independently. None of the studies in IR field which examined searcher/user differences seemed to have looked at performance as one composite measure; everyone compared individual measures such as commands used, terms used, connect time, etc. independent of each other and studied their correlations with user/searcher characteristics separately.

The frustration of researchers in the field of information retrieval at not being able to come to a consensus on search outcome measures was most clearly expressed by Fenichel in 1981. She wrote,

> "All presently available measures of search outcome are imperfect and all evaluate different aspects of outcome. ...The problems of evaluating any aspect of an information retrieval system on the basis of such relevance judgements are well known. ...these measured were used because, given the current state-of-the-art, they are the best available." (Fenichel, 1981: p.28)

Looking back at all these studies and the great deal of theoretical work on the subject of performance measures, it appears that two important reasons, i.e.,

(1) professional image of an intermediary and (2) the economics of providing search services to patrons (efficacy of whole system was studied), could have been the reason for using these measures of relevance, recall, precision, time taken, cost-efficiency, etc. independently. In fact, recall and precision emerged as measures of evaluation of systems after the Cranfield studies. However, in the current study, which was of novice undergraduate students using a service generally provided free of cost in university libraries, it did not seem necessary to follow the established methods of treating performance measures. Instead, an attempt was made to calculate an overall normalized measure of performance by introducing a formula that took into account the logical correspondences between the four variables: 1) number of hits, 2) number of operators used, 3) number of search terms used and 4) the total time taken for searching and printing up to a maximum of fifteen records for each question. This procedure was tested and validated during the pilot study. This will be explained in detail in Chapter IV.

One important outcome of most of the user/searcher studies in online research is that there exists a definite and often wide variation in performance of individuals on these systems. In fact, Trivison et al., found that even inter-searcher recall was very low across the board and efficiency measures showed large variations between searchers. Searchers differed on every measure used and for every type of question (Trivison et al., 1986). There was one unusual finding, i.e., the time spent on the search had little or no correlation with recall or precision. She called it an interesting result. But, she concluded,

> "However, we probably were not prepared for the magnitude of the differences being reported here on both types of measures, effectiveness and efficiency. ... it seems that we know much less than we thought we knew about what is really going on in searching ... questions can be raised about the design of information systems and performance of people doing searching when confronted by the modern systems". (Trivison et al., 1986: p.348).

The locus of this study is precisely what Trivison called a modern information system, and this study is an attempts to address some of the questions about search performance of people confronted by it.

2.8 The Current Research

The current research design is heavily influenced by Borgman's study of individual differences (1989) and Sein's study of the effect of individual differences on the efficacy of analytical vs. analogical models (1988), since they both dealt directly with individual differences. However, it introduces some variables which previous studies did not include, i.e., human information processing, perceived usefulness and corrected vision. It also introduces a different manner of measuring technical aptitude by measuring students' liking for working with computers as "computer affinity", as different from their level of competency in using computers. The separation of affinity from literacy/competency used in this study is represented in Figure 2.1 as "Diffraction Effect", because this process divides a characteristic into two parts, one of which is a natural (affinity) trait of an individual and the other is an acquired (literacy or competency or skill) trait.

Figure 2.2 diagrammatically depicts the entire set of variables studied. The diagram also shows in bold type, the variables being introduced in IR context for the first time as contrasted with the variables that were adopted from Borgman and Sein. The full model proposed for the study with the links between the independent and dependent variables studied is described in detail in Chapter III.

Figure 2.1

Diffraction Effect in User Characteristic

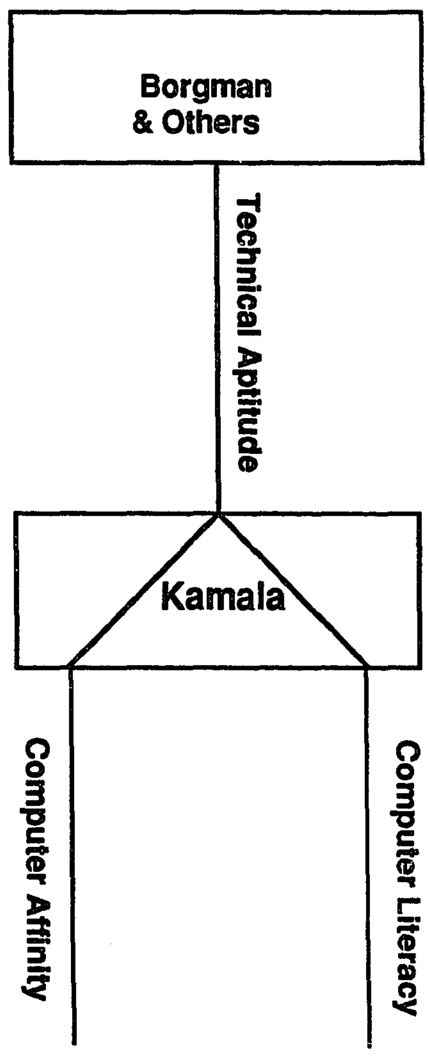
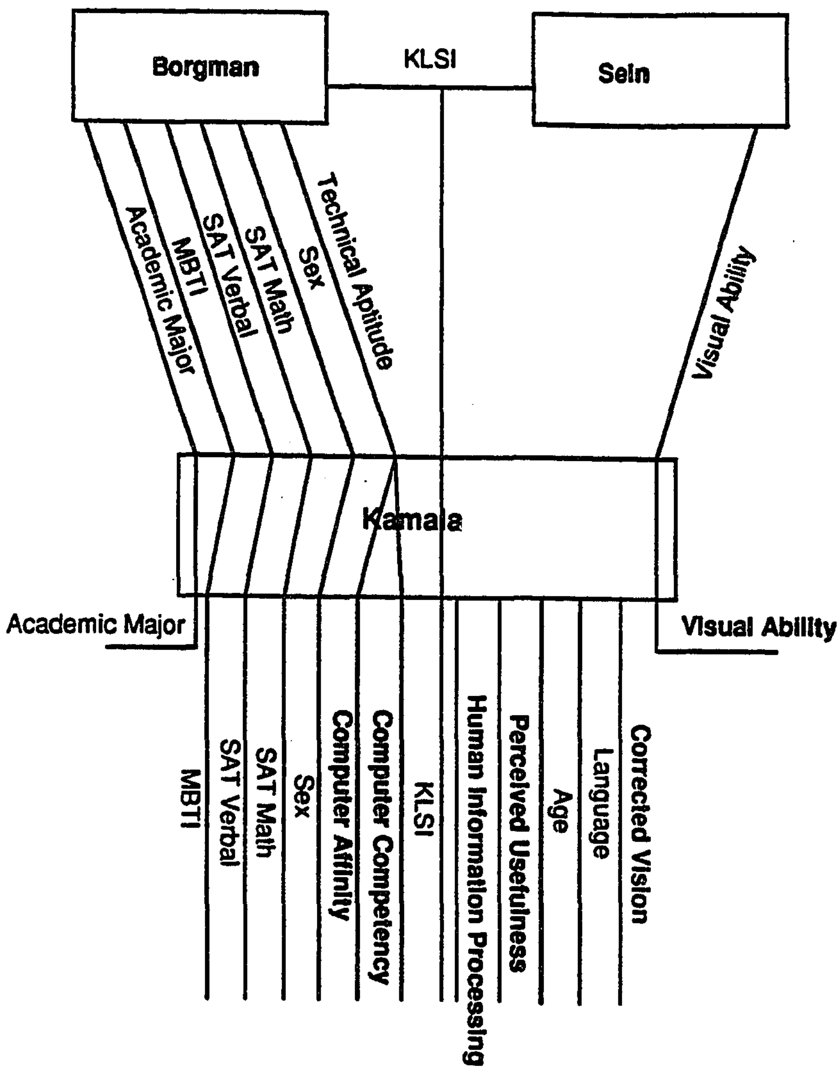


Figure 2.2

Variables Studied in the Research



CHAPTER III

THE RESEARCH DESIGN

3.1 Rationale

From the overview of literature discussed in Chapter II, it is clear that there are differences in the ability to use different information technologies by different groups of people. It is also clear that the findings of research in user behavior have great implications for libraries for designing tailor-made training for the different groups of patrons, as well as for database producers, both in providing user-friendly interfaces and retrieval software.

This research was designed to study individual differences in the use of CD ROM databases by **novice** undergraduate subjects. This study thus, did not concentrate on mental models or training methods, but on factors contributing to individual differences in the use of the CD ROM database systems.

3.2 System Used

The current study used three CD ROM databases produced and vended by The H.W. Wilson Company. They were Applied Science and Technology Index (AST), Business Periodicals Index (BPI) and Humanities Index (HI). A fourth database, MLA International Bibliography (MLA), was used in the Pilot Study. All databases with the latest version of the Wilsondisc search software were donated by The H.W. Wilson Company for the experiment. These databases were searched on a Wilson IBM-XT workstation, with an internal Amdek CD ROM drive. The workstation was itself a gift to the School of Library and Information Studies at the University of Hawaii at Manoa from the The H.W. Wilson Company.

3.3 Model Used

A hypothetical model of the user, the system and the performance which includes task as the fourth component, was used to study the effects of individual differences of users on their performance of the tasks. But it is also an extension of Borgman's model (1989) in the sense that the study examined whether the various factors that contribute to individual differences in user performance on CD ROM systems, also contributed to the choice of academic majors by the subjects. The models are diagrammatically presented as Figures 3.1 (Basic Model), and Figure 3.2 (Borgman's Model).

The model proposed in this study had all the four components of the basic model: System, User, Task and Performance. Each of these components has one or more characteristics. In most experiments, control is normally applied to one or two of these components, or, to the characteristics; then, the effects of the other characteristics on different components are studied. In the model proposed here, there is one characteristic of the system, i.e., the system content; two levels of tasks (simple & complex) and, fourteen characteristics of the user. The 14 user characteristics are the independent variables. The dependent variable is the performance which is determined using a combination of four measures: number of hits, time for search, number of terms used and the number of operators used.

In most of the earlier IR studies, experiments were performed on one single system. Hence, "system" meant the system interface and database search features; there has been no reference to the actual contents of the database. In this study, both the system interface and search features are controlled, by using one vendor's products. The third component of the system, hitherto not studied, i.e., the contents of the system (the academic area or subject covered by the database) becomes the system variable explicitly explored in this research.

Figure 3.1

Basic Model for an Experiment on a System

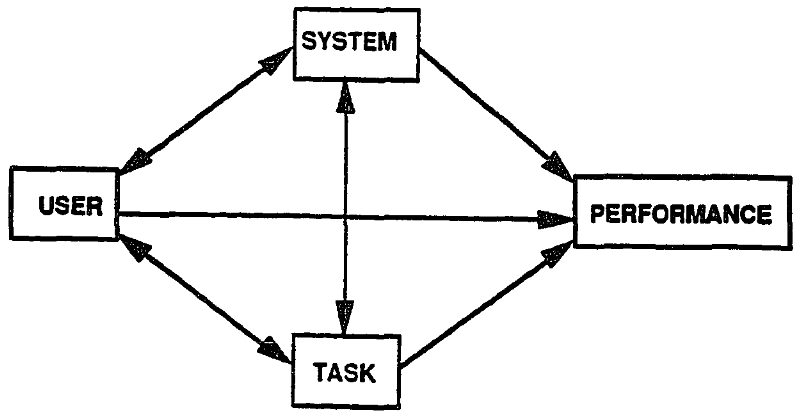
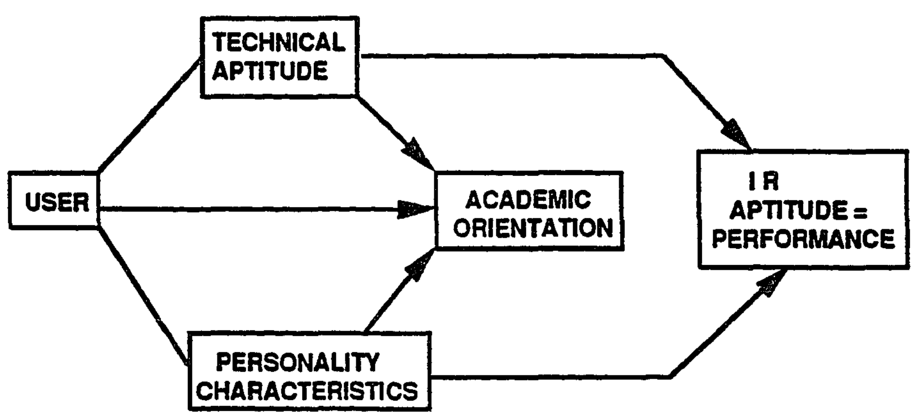


Figure 3.2

Borgman's Model



Christine L. Borgman

(Information Processing & Management :V. 25(3), 1989. p. 242)

The three CD ROM databases used (Applied Science & Technology Index, Business Periodicals Index and Humanities Index), each represented one of the three academic disciplines from which subjects were selected, i.e., science (or engineering), business management and humanities. Since the search software was controlled, the variable related to the system was the **System** (Database) **Content.**

Factors that were considered as influencing the individual performance of the subjects in the use of CD ROM systems, were age, sex, native language, academic major, corrected vision, visual ability, computer literacy, computer affinity, SAT math score, SAT verbal score, learning style, personality type human information processing mode and perceived usefulness of the system. The influence of some of these factors on the choice of academic major by the subjects was also studied, to confirm or extend Borgman's findings.

Visual Ability was measured using the standardized test VZ-2, from the Educational Testing Service (ETS). Personality types and information processing modes were determined by administering the two surveys MBTI (Myers-Briggs Type Indicator) and HIP (Human Information Processing) respectively. Learning style was measured by scoring the responses to a self-reporting survey, KLSI (Kolb's Learning Style Inventory). Two questionnaires were designed to obtain data on demographic variables as well as measures of computer literacy, computer affinity and perceived usefulness. All user characteristics were converted into categorical variables: depending on the distribution of subjects for each characteristic, they were categorized as "High" (above median) or "Low" (below median), in computer affinity, computer literacy, Visual Ability, SAT Math score, SAT Verbal score and performance factor. Perceived usefulness, sex, language, age, academic major and corrected vision were also categorical. Age was divided into two categories, with 18-22 being coded as "Traditional" and 23 and above as "Non-traditional".

3.4 Definition of Variables

3.4.1 Independent Variables

System

System Content: is defined as the academic discipline, which the contents of the CD ROM database pertains to. This was a categorical variable with 3 categories, i.e., Sciences, Humanities and Business.

Tasks

Task in this experiment is defined as the search performed by a user on a database. There were two levels of Task - simple and complex searches (2 categories). Simple tasks did not require the use of more than one search operator (AND). Complex task required more than one operator (AND, OR).

User Characteristics

Some of these are self-explanatory, by their very nature, i.e., age, sex, native language, corrected vision and academic major. Some are defined by the developers of the standardized instruments, i.e., sixteen personality types were defined by the Myers-Briggs Type Indicator (MBTI), four learning styles were mapped by the Kolb's Learning Style Inventory (KLSI) and four information processing modes were determined by the Human Information Processing Survey (HIP Survey). Apart from these, there were five other variables in this study, i.e, visual ability, computer affinity, computer literacy, SAT math and SAT verbal scores, all of which are continuous variables.

Two questionnaires were developed specifically for this study. Both these contain questions developed by the experimenter based on the observations made in earlier theoretical and philosophical studies and by looking at instruments used by other researchers for related purposes. They were validated in a pilot study conducted prior to the actual research study. In Questionnaire 1 (Appendix F), there were five direct questions, each with a five-point scale in Part I, to determine the degree of computer affinity of the student. Two control questions checked the validity of claims by subjects. Computer affinity was measured as the degree to which subjects enjoyed or liked to work with computers. Part II included four questions about the estimated length of computer use by subjects at work and at school, number of computer-related courses taken and number of computer systems used, as well as the number of computer related magazines read. Computer literacy was also measured on a five point scale, by evaluating the responses to these five computer literacy-related questions. Part III asked for information on the age, sex, native language, academic major, SAT Math and SAT Verbal scores.

Questionnaire 2 (Appendix J) used twelve questions to elicit the reaction of subjects to the nine tasks performed, ease of use of the system, and their perceived usefulness of the databases used. Perceived usefulness was defined as the database claimed to be "most useful" by the subject in response to questions in Questionnaire 2, which was administered after all the tasks were completed. Visual ability was again a continuous variable, measured by the answers of the subjects to the twenty paper folding pattern-based, visually-oriented questions in the VZ-2 test instrument.

The five continuous variables were later converted into categorical variables for the purposes of the analysis of the results of the study. They were all coded as dichotomous variables with "High" being above the median score and "Low" being below the median score for each variable. This divided the sample population into two halves - one below median and other, above.

Table 3.1

Independent Variables and Their Categories

Independent Variable	Categories	Measurement Tool
Visual Ability	2	Test instrument VZ-2
Learning Styles	5	Measured using KLSI Survey
Personality Types	16	Measured using MBTI Survey
Human Information Processing	4	Measured using HIP Survey
Academic Major	3	Questionnaire 1
Age	2	Questionnaire 1
Sex	2	Questionnaire 1
Native Language	2	Questionnaire 1
Computer Affinity	2	Questionnaire 1
Computer competency	2	Questionnaire 1
Corrected Vision	2	Questionnaire 1
SAT Math score (Claimed)	2	Questionnaire 1
SAT Verbal score (Claimed)	2	Questionnaire 1
Perceived Usefulness	2	Questionnaire 2

3.4.2 Dependent Variable

Performance was the only dependent variable. It was defined as the score for each task based on the number of hits, time for search, number of strategies used and the number of search terms used.

There were 6 Performance factors defined, corresponding to:

3 categories of System Content: Science, Business & Humanities

2 types of tasks: simple & complex.

This yields:

P(S)-S: Performance in Science databases - Simple task

P(S)-C: Performance in Science databases - Complex task

P(B)-S: Performance in Business databases - Simple task

P(B)-C: Performance in Business databases - Complex task

P(H)-S: Performance in Humanities databases - Simple task

P(H)-C: Performance in Humanities databases - Complex task

The value for the performance factor for the two levels is calculated differently:

1. Performance of Simple Task

= Sum of Performances on two simple tasks on the same database.

2. Performance of Complex Task

= Performance of one complex search on a database.

In addition,

3. Overall Performance

= Sum of Performances of all tasks in all the databases.

3.4.3 Control

No prior experience using CD ROM databases was permitted (**novice**).

The Research Design was:

3(System Content) X 2(Task Levels)

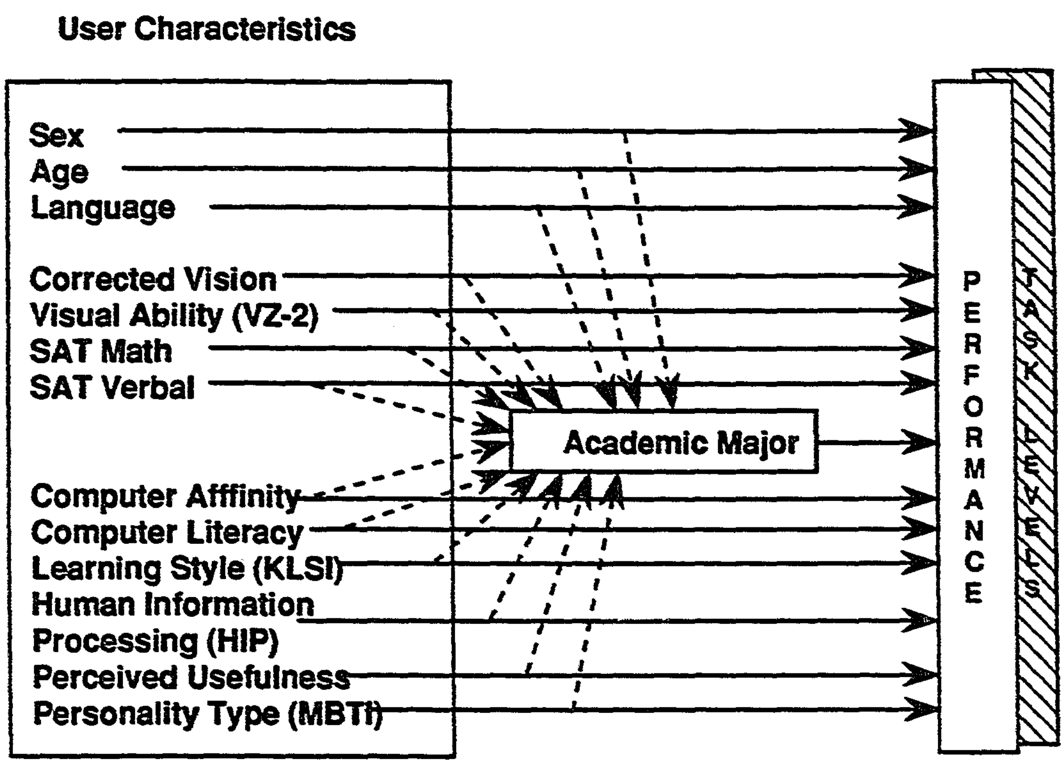
X 14(User Characteristics)

Here, System Content and Task were within-subject variables while the rest were between-subject variables.

This research design is depicted as a block diagram in Figure 3.3, labelled Proposed Research Design.

Figure 3.3

Proposed Research Design



CHAPTER IV

EXPERIMENTAL PROCEDURE AND ANALYSIS

4.1 Background

The conceptual research design for this study was most influenced by the work of Borgman (1989) and to a lesser degree, by that of Sein (1988). But, the inspiration and guidance required for the methodology and the systematic conduct of the experiment itself, were derived from Saracevic et al., (1988a), reviewed earlier in Chapter II. In their article, Saracevic et al.,.emphasized the increased importance of designing proper experiments to understand the human-machine interaction, which actually, is the key to better design.

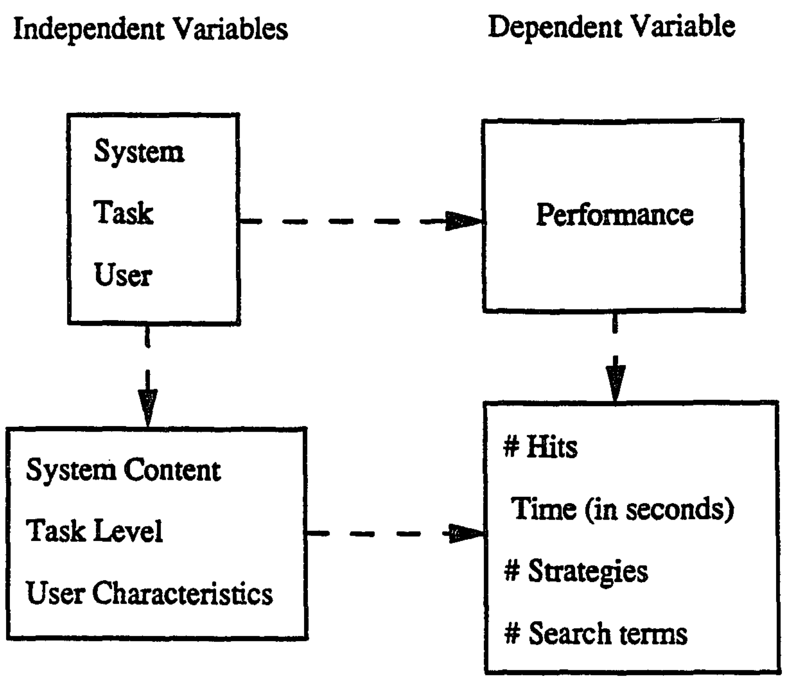
Saracevic et al.,. grouped their observations in five general classes of the entities involved: (1) User; (2) Question ; (3) Searcher; (4) Search and (5) Items retrieved. Thus, the user and searcher were two different entities in their research - i.e., the intermediaries were the ones who were conducting the searches and the effect of their cognitive traits, experience, etc. on search outcome was being tested. However, in the current study, these two entities were the main entities - the end-user, who himself/herself was the searcher and the search outcome, which is labeled "performance".

This research, therefore, studied the characteristics of the user and their effects on his/her performance on the system studied, i.e., CD ROM databases. It studied performance as one measure comprising four outcome measures of Saracevic et al., (number of commands used, number of search terms used, items retrieved (number of hits) and the total time taken for the task to be completed).

4.2 A Schematic Representation for Analysis

The following conceptual schema provided the framework for the analysis of the results. The translation of the conceptual schema to the practical one is described using downward arrows.

Both in the pilot study and the final study, every component comprising each of the independent variables was measured independently and its effect on the dependent variable, "performance" was studied.



The dependent variable, "performance" was calculated using a formula, which included the four measures of performance, i.e., number of hits, number of operators used, number of search terms used and the total time taken to complete the task. This formula is explained in detail in section 4.6.2.

4.3 General Description of the System

The Wilsondiscs came with the Wilson search software, which provides three levels of searching - Browse, Wilsearch and Wilsonline. Browse can be used for only one-term searches. Wilsonline is the most sophisticated of the three, requiring knowledge of the Wilson search commands. Wilsearch is at a level between the Browse and the Wilsonline modes - it uses a template screen which the user fills out to perform the search. This was designed to emulate the traditional manner of searching by users - i.e, by subject terms, by author or title, by journal name or even organization name and call number.

The Wilsearch interface (Figure 4.1) was chosen for the experiment because the producers intended it for use by students at high school and undergraduate levels. Entering subject terms in the three lines provided, or entering the name of the author or title words, or even journal names are automatically "AND"ed in Wilsearch mode. The word "any" must be used at the beginning of a line to indicate the "OR" operation, with the alternate terms (single terms, not phrases) entered one after the other following the "any". While using the operator "OR", phrases cannot be used because the software treats each word following "any" as an alternate concept. The "#" sign can be used as a symbol (wild card) for truncation, to take into account plurals of subject terms entered in singular form.

4.4 Pilot Study

As there was no exact research design to be emulated as a model, most of the procedures used in the experiment, including the administration of questionnaires designed by the researcher, had to be validated before use in the final study. Hence, a pilot study was designed and conducted prior to the final study.

4.4.1 Test Instruments

Two questionnaires were designed for this research. Questionnaire 1 (a slightly different version of Appendix F), consisting of three parts, and Questionnaire 2 (same as Appendix J, except for wording used for the ranking of responses) with 12 questions, as described in Chapter III.

Figure 4.1

Wilsearch Mode Search Screen

Enter your local search request for GSI <A>

Subject words:
2nd subject: <B>
3rd subject:

Author/name: <C>
Title words: <D>

Journal Name: <E>
Organization:
Dewey number:

<F> Press the END key when you have finished.

You do not need to fill out the entire screen. Use only those lines appropriate to your search request.

F1 = HELP | F2/ESC = Quit | End = End Input

(Wilsondisc Teaching Guide, 1991: p. IV-9)

In addition, four standardized test instruments were used - the KLSI (Kolb's Learning Style Inventory - Appendix A) self-reporting inventory, the MBTI (Myers-Briggs Type Indicator - Appendix B) survey , the VZ-2 (Visual Ability - Appendix C) Test and the HIP (Human Information Processing Survey - Appendix D) test were used to determine the different learning styles, personality types, visual abilities and preferred information processing modes respectively, of the subjects.

4.4.2 Subjects

Subjects for the pilot were recruited from the Psychology 100 class at the University of Hawaii at Manoa. As part of their course requirement, students enrolled in that course must volunteer as subjects for experiments conducted by graduate students or faculty in any of the departments of the University. Usually, they either receive two bonus points for their class work or receive monetary compensation. In this case, the faculty in charge of the class offered to give two points to the students who volunteered to take part in the pilot study. Psychology 100 is one of the core courses for all undergraduate study, and so, they were expected to be a heterogeneous group - coming from different academic disciplines. A total of seven students were recruited from this class, but unfortunately, the sample was lacking in one aspect - i.e., there were no students representing the hard sciences. This was partly because of the control used in the experiment - that the students must not have used CD ROM databases before (novice users). Four science students were later recruited from a math class and a science class. These four subjects were paid $5.00 as compensation for participating in the pilot study. The final sample consisted of eleven subjects, with 5 from the social sciences, 2 from humanities and 4 from the science/engineering branches. Four other humanities students who originally signed up to participate in the study either did not show up or called in sick. The subjects selected were novices in the use of CD ROM databases.

4.4.3 System

Three Wilsondisc CD ROM databases were used in the pilot study - Applied Science and Technology Index.(AST), Business Periodicals Index (BPI) and Modern Language Association Bibliography (MLA), representing the three major academic disciplines of science, social science and humanities.Two microcomputer workstations were used simultaneously, to suit the time slots preferred by the subjects who were volunteering to take part in the experiment.

4.4.4 Search Questions

The questions for the searches were chosen from over fifty real-life questions encountered in the two reference units at the Hamilton Library at the University of Hawaii at Manoa as well as from the samples provided in the Wilsondisc guides. The final nine questions were searched on the system by two experienced searchers - one faculty in the library school and the experimenter. One of the criteria in the choice of the questions was that they would not end up as lengthy searches. The other criteria were: simple searches were not to involve more than one Boolean operator and the complex search could have only up to two operators. In fact, in the final choice, the operator "NOT" was automatically eliminated, because the interface (Wilsearch) chosen does not support use of "NOT".

4.4.5 Experimental Procedure

The experiment was conducted in three phases.

Phase I

All subjects were asked to sign a consent form that they were participating as subjects in this research study voluntarily. Corrected vision of the subjects was determined using a standard eye chart. Next, subjects were asked to complete Questionnaire 1 to collect data on demographic variables and the subjects' level of computer literacy and computer affinity. VZ-2 test was then administered, followed by the self-reporting KLSI survey. Subjects were assured that the confidentiality of the data would be maintained.

Phase II

This was conducted in the computer lab of the School of Library and Information Studies at the University of Hawaii, where the Wilson workstations were located. At the beginning of this phase, all subjects were provided with the same type of training (bibliographic instruction) in the use of the databases, which involved demonstration on the system. The oral instructions and demonstration lasted fifteen minutes.

Subjects were asked to perform two simple searches and one complex search on each of the three databases, Applied Science and Technology Index (AST), Business Periodicals Index (BPI) and MLA Bibliography (MLA), one after the other. The questions were typed each on a separate sheet and given to the subject after each task was finished. The discs were changed after each set of two simple and one complex searches was completed on a databases by the subject, in the same order, i.e., AST first, BPI second and MLA third.

Subjects were asked to print out a maximum of fifteen records per search. The total time taken for each search was measured using a stop watch which was started when the student was handed the search question and stopped when the last hit was printed. No time limit was set for searching.

Phase III

There was a debriefing session at the end of the experiment. Any questions or clarifications were answered. Then, subjects were asked to complete Questionnaire 2, which would help determine the perceived usefulness of the systems and the user's reaction to the tasks performed, ease of use of the system, etc. Lastly, the MBTI and HIP surveys were administered, one after the other.

Students were also given the option to use the system to perform searches on topic of interest to them, or, needed for their class assignments/term papers. Some students chose to do so, and the experimenter helped them in their effort.

There were many important outcomes of the pilot study, the most important being the realization of the importance of pilot studies. The experimenter had underestimated the variations in the time required by different students for completing all the tasks This was compounded by the fact that one of the databases chosen, i.e., the MLA Bibliography was different from the other two with respect to data structure, which made it very slow compared to the other Wilsondiscs and made results difficult to compare. The search software was the same, but yet, it took longer to search on this database. Some search results were also different from what would be expected. Most of all, the system kept running for over forty five minutes for a search by one of the students, and the only way to stop it was to turn-off the machine.

There was also the problem of availability of the workstations - the laboratory in which the experiment was conducted was generally for the use of graduate students enrolled in the School of Library and Information Studies at the University of Hawaii at Manoa, and hence, this study had to be conducted mostly on week-ends when the workstations were not so heavily used. Using two workstations at the same time meant requisitioning the help of another person to monitor the time taken for each task by the student at the second workstation. Then there was the problem of switching discs between workstations. One student had to wait for the other to complete his/her tasks on a database, before the discs could be switched. This was more frustrating than envisaged, because of the different speeds of the two workstations - the Wilson Workstation was a much slower one (8088 machine) compared to the other, which was a 286 machine. It also gave rise to questions of validity of the measures of performance with regard to the order in which databases were searched and total time of search which had to be scaled down or up to compensate for different machine speeds. In addition, there were possibilities of non-uniform time measurements, because of two different people monitoring it, even though stop-clocks were used. The people who agreed to assist in the experiment were not trained for uniform judgements of the tasks performed and there were possibilities of errors creeping in.

There were some positive outcomes of the pilot study: (1) It proved that students do have varying degrees of visual ability and this was significantly correlated to the academic major. (2) There were subjects in all disciplines who showed high levels of computer affinity. (3) The academic major was more related to the level of computer literacy of the subject. (4) Students were too tired and even disinterested in the final stages compared to the initial phases of the experiment, because it took over two hours for most of them to comply with all the requirements of the study. Particularly, they showed reluctance to filling out the lengthy MBTI questionnaire which had 126 questions. A few of the students did not complete all the questions in the survey instruments and one refused to do so, because of the time involved. (5) Questionnaires 1 and 2 did measure the variables that they were intended to. (6) It was also observed that the use of even a single operator, be it "AND" or "OR" was not simple for all subjects. (7) Only a few subjects evinced much motivational trait.

4.5 Final Study

The final study was designed with care taken to eliminate, or, at least minimize as many of the problems encountered in the pilot study as possible.

4.5.1 System

Only one workstation was used - this eliminated the personal errors involved in two different people monitoring the time. It also eliminated the need to make adjustments for varying machine speeds. It certainly avoided frustrations caused by the waiting involved for one student while the other was still working on the next database on the second workstation. If there were any differences in performance introduced by the order in which the databases were searched, they were also totally avoided by having each subject perform the tasks on the three databases in the same order. Since there was only one copy of each of the three database available for the experiment, this made it impossible to use two workstations even if one could find two of the same speed.

One of the three databases, i.e., MLA Bibliography, was replaced by Humanities Index, because of the problems posed by the different data structure used in the production of MLA. Though marketed by The H.W. Wilson company to be used with their search software, it was not their product. Humanities Index, which covers a broad spectrum of the academic subjects included in humanities is a standard Wilson product, with identical data structures and indexing patterns as the other two databases (AST and BPI) used. Humanities Index also matched the academic interest of the subjects studied in the final experiment.

4.5.2 Subjects

The final experiment was also conducted by recruiting, on a voluntary basis, undergraduate students from the three differing academic majors (Engineering/Science, Business and Humanities). However, this time, the procedure for recruitment was changed to ensure higher motivation. The experimenter talked to faculty in different departments who were teaching writing intensive courses or courses which require using library sources for completing course assignments. She went to the classes and explained the relevance of the experiment being conducted for their course work and study. Yet, recruiting students for the study was the most difficult task of all. Most faculty were not interested in getting their students involved in an experiment, which would take two hours of the students' time. Also, because of the fact that the University of Hawaii libraries had introduced CD ROM databases almost two years ago, it was difficult to find undergraduate students who had not used the system before. It took the experimenter over a month to convince some faculty and students that the experiment would help them in their academic work.

Finally, three faculty - one each from engineering, humanities and business management, teaching upper division undergraduate level courses were found who, not only agreed to have their students participate in the experiment, but were enthusiastic enough to come and perform the experiment themselves. They also helped chose questions appropriate to the levels of students in their classes. Two of them requested that students be provided an hour extra to search an appropriate database for a class assignment after they completed the experiment. This provided a good motivation for students to participate in the study. In all, 26 subjects were recruited from the science/engineering area, 11 from the business management school and 14 from the arts and humanities stream.

4.5.3 Time Management

One factor which caused great concern in the pilot study and which needed definite attention was reducing the time which the students needed to spend at the site of the experiment. It was very difficult to keep the undergraduate students interested and involved in the tasks, if they were getting tired or loosing their patience. Time management was thus, a major task.

4.5.4 Test Instruments

The standardized test instruments KLSI (Appendix A), MBTI (Appendix B), VZ-2 (Appendix C) and HIP (Appendix D) were all used in the Main Study, but the manner in which they were administered was changed to make it less tedious for the students to comply with all the requirements of the study. Since the time taken to fill out the MBTI and HIP instruments were the longest, students were given the instruments to be completed at home, before coming to perform the experiment. This substantially reduced the time that they had to spend at the experiment site. It was found that this procedure worked very well. All subjects completed the two surveys, though a few did complain about the time spent on them.

A few minor modifications had to be made on Questionnaire 1 (Appendix F), to make it easier for students to complete. It was observed in the pilot study that most students did not read the instructions at the top of the questionnaire, which told them how to answer the questions where either a three or a five level ranking was involved and how a Yes/No answer required checking the appropriate box. The rankings were modified to explicitly read as "Least"/"Most" instead of 1-5. Similar modifications were made to Questionnaire 2 (Appendix J). These minor changes did help in reducing the time in filling out the questionnaires as it was not necessary for the students to ask for clarifications on how to indicate their responses, nor for the experimenter to check their entry while they were filling out the questionnaires. Overall, the time taken for the experiment was reduced considerably.

One more control question was added to the Part I of the Questionnaire 1 (Q1), to make sure the students' claims to computer affinity were valid, but nothing was added or deleted from Questionnaire 2 (Q2).

The experimenter also had to take into account the fact that the variations in the time taken by students for performing the tasks could be large. So, the Wilson workstation was reserved for time-slots of ninety minutes each, according to the preferred timing of students. These slots were anywhere from 9:00 am to 9:00 pm on working days, 9:00 am to 3:30 pm on Saturdays and 1:00 to 3:30 pm on Sundays. These timings had to be adhered to because of the hours when the computer lab was open for use. The final study spanned over a period of nine weeks with a break of two weeks between the first three weeks and last four weeks, because students could not spare time for participating in the experiment during their final examination period.

4.5.5 Search Questions

Since the pilot study showed that a search was not really "simple" if it required the even one use of operator "OR", questions were selected carefully. Single concept phrases were chosen for the simple searches. There were two simple tasks in each of the databases, neither requiring the use of the operator "OR". Complex tasks involved using the Boolean "OR". Wilsearch mode uses the Boolean "AND" as a default for terms/phrases entered in different lines on the template, or, typed consecutively on the same line (Figure 4.1).Thus, the complex searches involved use of both Boolean operators, "AND" and "OR".

Each of the nine questions (Appendix I - TASKS) was typed on a separate sheet, which also indicated the task number and which database it was on. Questions were given to the student one at a time by the experimenter.

4.5.6 Procedure

The Main experiment was conducted in three phases just as in the pilot study. Phase I began with the subject signing the Consent Form (Appendix H) after being told the need for the same. Corrected vision was tested using a standard eye chart which the subject was asked to read. Then the subject was asked to complete Questionnaire 1. Quite a few students needed help in answering the third question (types of computer systems used) in Part II, despite an example being provided, and they were helped as needed. After this, the subject was requested to take the visual ability test. The experimenter explained the purpose of the test and then VZ-2 test was administered. Lastly, the subject was asked to take the self-reporting learning styles inventory (KLSI) test. Phase I was conducted in the experimenter's office - no one else except the experimenter and the subject was present in the room during that time.

Phase II of the experiment was carried out in the online lab of the School of Library and Information Studies at UH, where the Wilson workstation is located in the lab. All subjects were tested on the same workstation, in the same room. Thus there were no variations in the environment. Phase II began with the experimenter explaining what CD ROM databases were and how they were being used in the libraries. The advantages of searching for information on computerized databases and the concept of Boolean operators "AND" and "OR", which made these systems more powerful to use, was explained using diagrams. The hardware used was described in brief. The Wilson software options as well as the choice for the Wilsearch mode were also explained (Appendix G).

A hands-on demonstration on the Applied Science and Technology Index followed the oral instructions. It consisted of a simple search and a complex search on a topic of common interest to most - "Rapid transit system in Hawaii". The search was demonstrated as a simple general search for just "rapid transit", and then "Hawaii" was added to show how the query could be modified to use the Boolean "AND" to get more specific information. It also showed the students how to go back and modify their searches. The use of the Boolean "OR" was demonstrated by changing the same query to look for information on rapid transit in Hawaii OR California OR Florida. The hits were viewed in all cases to show the student how they changed according to the changes made in the search strategy. The use of the wild card "#" for purposes of truncation, particularly to include plurals, was also explained with the help of the sample search guide provided by The H.W. Wilson Company. It was kept beside the workstation throughout the experiment and the student was told to use it if necessary. Students were also shown the three print requirements of the experiment - (1) the screen which provided the search results, i.e., the number of hits; (2) the actual hits themselves (up to a maximum of 15) and (3) the search template screen which showed the terms they used for the search. (1) and (3) involved the use of the "print Screen" key, while (2) required the use of the function key F6 for less than or equal to 15 hits and repeated use of the function key F4, when the number of hits exceeded 15. A short instruction sheet was also provided to the subjects (Appendix H). They were given plain paper to work with, if needed.

Subjects were asked to perform two simple searches and one complex search on each of the three databases, one after the other.The search questions were typed each on a separate sheet and given to the subject after each task was finished. The discs were changed in the same order, i.e., AST first, BPI second and HI third, after each set of two simple and one complex searches was completed on a database.

Subjects were asked to print out a maximum of fifteen records per search. The total time taken for each search was measured using a stop watch which was started when the student was handed the search question and stopped when the last hit was printed. No time limit was set for searching.

There was a debriefing session at the end of the experiment. Any questions or request for clarification were answered. Lastly, subjects were asked to complete the Questionnaire 2, which would determine the perceived usefulness of the systems and the user's reaction to the tasks performed, ease of use of the system, etc. A major change was introduced at this stage in Phase III of the experiment as explained earlier. The subjects just handed in the completed surveys for MBTI and HIP instead of filling them out at the end of the experiment. Every subject was thanked by the experimenter and paid $5.00 in cash as compensation for taking part in the experiment.

After completing the experiment, students were given the option to use the system to perform searches on topic of interest to them or needed for their class assignments/term papers. Most students chose to do so, and the experimenter helped them in their effort. It was a very satisfying and rewarding session for both the student and the experimenter. In all, 53 students signed up for the study and 51 actually completed all requirements of the experiment. Of the two who did not complete the experiment, one had a serious health problem and the other had to leave town for personal reasons.

4.6 Scoring Techniques

4.6.1 Independent Variables

Visual ability was measured by the VZ-2 test instrument and the scoring was done as per the scoring sheet provided in the ETS manual. There were 20 questions in all. Each correct score earned a point with a quarter of a point being taken off for every wrong answer. No points were taken off for unanswered questions.

Results of personality types (MBTI) and human information processing modes (HIP) were obtained by running the responses of the subjects to the survey against a computer program (See Acknowledgement: Dr. Martha Crosby). Learning Styles were determined from the responses provided by the subjects to the nine questions of the self-reporting KLSI survey. The raw scores were the sum of all the rank numbers given by the respondent in each of the four columns, CE, RO, AC and AE. Two combination scores were obtained by subtracting Concrete Experience from the Abstract Conceptualization score (AC-CE), and the Reflective Observation score from the Active Experimentation score (AE-RO). These scores plotted on a graph with (AE-RO) on the X axis and (AC-CE) on the Y axis placed the respondent in one of the four quadrants characterizing a person as to style of learning as: (1) converger (lower left); (2) diverger (upper right); (3) assimilator (lower right); or (4) accommodator (upper left). A person with a zero score on either axis was considered indeterminate.

Computer affinity was calculated by scoring each question in Part I of Questionnaire 1, on a five point scale. There were five questions and so the maximum score was 5. Similarly, computer literacy was calculated by scoring the five questions in Part II of the same questionnaire. The maximum score was 5 in this case too.

SAT Math and SAT Verbal scores were provided by the students themselves along with their age, sex, academic major and native language, in Part III of Questionnaire 1. Corrected vision (labelled as the variable "Sight") was recorded by the experimenter.

Perceived usefulness was recorded as the database ranked highest by the subject in Questionnaire 2.

4.6.2 Dependent Variable

The dependent variable, performance "P", was calculated using a formula. The term "Expert" used below is defined as the faculty, i.e., Dr. Carol Tenopir, who teaches the advanced online course to the graduate students at the School of Library and Information Studies at UH. The formula was developed as follows:

Let N(1) = Number of hits retrieved by the expert for a particular search

Let N(2) = Number of hits retrieved by the subject, for the same search

Then Normalized Number of hits = N = N(2)/N(1) if N(2) < N(1)

Else, N = 1 if N(2) >= N(1)

This normalization ensured that the score was always less than 1, for the number of hits, or, recall.

Let M = the number of search terms used

Let R = the number of operators used (AND, OR, #)

Let T = the total Time taken for the search (in minutes)

Then the dependent measure "performance" was given by:

P = (N * M * R)/ T.................................(K-1)

One of objectives of trying to devise a formula for measuring performance was to have some unit measure, which could be meaningfully standardized and applied to all searches, instead of trying to judge performance with reference to each of the outcome measures (components that go to make up the overall performance), as has been done so far. The logic on which the formula was devised was as follows: The total number of hits is more, if more alternate terms or concepts are searched. Thus, if a person used the "OR" operator once, s/he is most likely to retrieve more hits than when searching with only one term. There is a direct and positive relationship between the outcome of the search and the number of "OR" operators used, i.e., the number of hits increases as the number of this operators increases. Similarly, if a user used the "#" sign to include both singular and plural forms of the word used in searching, the likelihood of the number of hits increasing is higher. This also is a direct and positive relationship. So the performance factor was multiplied by the number of operators used, except for "AND" ("AND" got only one point per search). However, no points were taken off for using the operators wrongly, because this would automatically be accounted for in the number of hits.

The logic for having the number of terms used in the search in the numerator of the performance factor was to give credit to the student for coming up with terms to represent all the different concepts contained in the search question. Then again, inclusion of all correct concept terms would increase the relevance of the search results. This is a positive relationship. Hence, the subject received credit for using more relevant terms in the search. However, no points were taken off for using the wrong terms - the subject just received one point each for the right terms used.

The total number of hits itself had to be normalized because, a correct and specific search using "AND" would yield less number of hits, while a broad search performed without "AND"ing a second concept would yield a larger number of hits. Having the number of hits as it is in the numerator of a formula would not yield a true value for the performance. Hence, the total number of hits was divided by the maximum number of hits obtainable (as decided by the outcome, "N1" of the same search by two different experts), to yield the normalized number of hits. This was used in the formula, with the condition that a subject who scored higher than N1, still was given a value of 1 for the normalized number, (N) of hits (i.e., if N(2)/N(1) >= 1, then N= 1), while a subject scoring less than N1 received a value for N, which was a fraction equal to the value N(2)/N(1).

The total time was used in the denominator of the formula K-1, because the basic idea was to come up with a normalized unit factor, as a measure of performance. If a subject got equal to or more than 15 hits, s/he was bound to take longer to print the hits than someone who obtained only 4 or 5 hits. It would be more fair to compare the time taken per hit for each subject, and hence the normalized number of hits, "N" was divided by the total time taken. This also took into account another factor - the more number of search terms entered, the longer it took for the system to search for all of them; dividing by the total time taken normalized the time-component of the performance factor. The final factor arrived at yielded a measure for performance per unit hit per unit time.

The concepts of effectiveness and efficiency also were automatically included in the calculation of performance. Whereas effectiveness is generally correlated positively to the number of hits (recall), number of search concepts used and the number of operators (strategies) used, efficiency normally bears an inverse relationship to the time taken for a search by the user. These two concepts could be found to be implicit in the idea that the first three factors be used in the numerator and the last in the denominator of the formula for the performance factor. The formula may not be an exact one, but it provides the desired unit measure of performance sought in this study, while taking into account all the basic components and their relationships to each other, which are involved in such a measure.

The value for P was calculated for each subject for each search. Thus P-1 denoted the performance factor of a subject for task 1 (simple); P-2 denoted the performance factor for the subject for task 2 (simple) and P-3 was the performance factor for task 3 (complex) on the Science database (AST). Similarly, P-4, P-5 (simple) and P-6 (complex) were performance factors for tasks 4, 5 and 6 on the Business database (BPI) while P-7, P-8 (simple) and P-9 (complex) were performance factors of subjects for the Humanities database (HI), respectively.

This formula was validated during the analysis of the results of the pilot study and was found to hold with a qualitative assessment made of the subjects for about 85% of the cases. Different formulae were tried during the pilot study and the one which matched the qualitative judgement best was selected for the final study.

There were two simple and one complex tasks performed on each of the three databases. Thus, there were a total of nine tasks. The performance factors for the two simple tasks were added to yield one performance factor for simple tasks in a database, resulting in a total of six performance factors, i.e, two for each database.Thus P(S)-S denoted the performance of a subject for the Simple searches on the Science database (AST); P(S)-C denoted the performance of a subject for a complex search on the Science database (AST). Similarly, P(B)-S and P(B)-C and P(H)-S and P(H)-C stood for performance of subjects for the simple and complex searches on the Business database (BPI) and Humanities database (HI), respectively. These six performance factors for the 47 subjects (sorted by academic major) are listed in Table 4.1. Table 4.2 gives the range and standard deviation of five user characteristics and six performance factors, which are continuous variables.

4.7 Hypotheses

This research was designed to study the individual differences in the use of CD ROM databases by undergraduate students. Therefore, the major research question was: What is the effect of the various individual characteristics (measured by the instruments and questionnaires used in the study) on the performance (computed on the basis of the formula K-1) of subjects for the two levels of task on the system? The first set of 14 hypotheses address this research question.

Table 4.1

Performance Factors

Major	P(S)-S	P(S)-C	P(B)-S	P(B)-C	P(H)-S	P(H)-C
B	0.080	0.004	0.047	0.034	0.043	0.024
B	0.101	0.005	0.126	0.010	0.040	0.047
B	0.087	0.003	0.047	0.014	0.022	0.058
B	0.032	0.034	0.127	0.042	0.032	0.083
B	0.044	0.005	0.027	0.028	0.031	0.049
B	0.085	0.032	0.044	0.028	0.034	0.087
B	0.032	0.001	0.019	0.015	0.018	0.049
B	0.036	0.002	0.027	0.030	0.034	0.027
B	0.032	0.003	0.019	0.011	0.033	0.026
B	0.046	0.005	0.050	0.008	0.033	0.086
B	0.029	0.003	0.010	0.009	0.020	0.054
H	0.035	0.003	0.042	0.028	0.029	0.062
H	0.025	0.002	0.017	0.034	0.028	0.047
H	0.031	0.002	0.025	0.011	0.031	0.027
H	0.041	0.002	0.050	0.011	0.036	0.061
H	0.023	0.002	0.017	0.025	0.036	0.086
H	0.067	0.002	0.019	0.025	0.035	0.099
H	0.043	0.002	0.050	0.021	0.024	0.044
H	0.061	0.005	0.037	0.034	0.033	0.065
H	0.072	0.004	0.027	0.024	0.026	0.092
H	0.033	0.009	0.030	0.064	0.029	0.077
H	0.036	0.003	0.026	0.021	0.031	0.050
H	0.079	0.001	0.048	0.012	0.018	0.039
H	0.033	0.005	0.057	0.009	0.036	0.043

Table 4.1 (Continued)

Performance Factors

Major	P(S)-S	P(S)-C	P(B)-S	P(B)-C	P(H)-S	P(H)-C
S	0.078	0.064	0.100	0.060	0.033	0.124
S	0.046	0.004	0.026	0.022	0.035	0.047
S	0.029	0.043	0.040	0.030	0.042	0.048
S	0.060	0.002	0.032	0.029	0.027	0.047
S	0.029	0.002	0.049	0.025	0.031	0.096
S	0.031	0.003	0.021	0.011	0.034	0.028
S	0.029	0.005	0.022	0.028	0.033	0.048
S	0.032	0.004	0.048	0.032	0.022	0.046
S	0.034	0.004	0.016	0.050	0.027	0.078
S	0.054	0.015	0.028	0.019	0.039	0.071
S	0.025	0.003	0.091	0.008	0.020	0.021
S	0.022	0.006	0.095	0.031	0.031	0.087
S	0.044	0.006	0.039	0.020	0.031	0.016
S	0.031	0.004	0.069	0.036	0.031	0.066
S	0.032	0.004	0.018	0.012	0.034	0.090
S	0.025	0.004	0.031	0.028	0.023	0.074
S	0.098	0.004	0.135	0.028	0.037	0.116
S	0.048	0.004	0.044	0.059	0.034	0.094
S	0.040	0.002	0.021	0.044	0.036	0.070
S	0.030	0.003	0.037	0.030	0.033	0.108
S	0.034	0.005	0.041	0.037	0.024	0.064
S	0.053	0.005	0.107	0.087	0.033	0.099
S	0.043	0.003	0.042	0.032	0.031	0.102

Table 4.2

Continuous Variables

Variable	Minimum	Maximum	Range	Mean	Std. Dev.
Visual Ability	1.75	20	18.25	13.28	4.71
CompAffinity	1.25	5	3.75	3.23	0.67
CompLiteracy	0.75	5	4.25	2.85	0.84
SATMath (Claimed)	400	800	400	571.9	111.22
SATVerbal (Claimed)	320	700	380	490.24	103.96
Perf-S/S	0.02	0.1	0.08	0.05	0.02
Perf-S/C	0.001	0.06	0.06	0.01	0.01
Perf-B/S	0.01	0.14	0.12	0.05	0.03
Perf-B/C	0.01	0.09	0.08	0.03	0.02
Perf-H/S	0.02	0.04	0.02	0.03	0.01
Perf-H/C	0.02	0.12	0.11	0.06	0.03

There are 14 independent variables and six factors of one dependent variable, "performance". Therefore, there are 14 hypotheses, with six sub-hypotheses for each - i.e., the main hypotheses are common to the three simple [P(S)-S, P(B)-S, P(H)-S] and the three complex [P(S)-C, P(B)-C, P(H)-C] searches, and hence stated together in one hypothesis - for.example, $H1_0$ - a,b,c,d,e,f stands for the effect of the independent variable referred to in the hypothesis, on the six different performance factors; $H1_0$ - g referred to the effect of the same independent variable on the academic major. All hypotheses are stated in null form. There is no "g" sub-hypothesis for the academic major set, since academic major itself is the independent variable.

The research question regarding a subject's academic major having an effect on his/her performance in the use of CD ROM databases, if the academic major of the student is the same as the subject content of the database being searched, gave rise to the last two hypotheses, $H15_0$ and $H16_0$.

4.7.1 Effect of Individual Characteristics on Performances (a-f) and Academic Major (g)

$H1_0$ - a,b,c,d,e,f,g:

For both simple - P(S)-S, P(B)-S, P(H)-S, and complex - P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (**a-f**), and there will be no effect on the choice of academic major (**g**), of novice subjects in the use of CD ROM databases, based on their sex.

$H2_0$ - a,b,c,d,e,f,g:

For both simple -P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (**a-f**), and there will be no effect on the choice of academic major (**g**), of novice subjects in the use of CD ROM databases, based on their age.

$H3_0$ - a,b,c,d,e,f,g:

For both simple - P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on their native language.

$H4_0$ - a,b,c,d,e,f:

For both (simple - P(S)-S, P(B)-S, P(H)-S, and complex) -P(S)-C, P(B)-C, P(H)-C tasks, there will be no significant difference in the performance of novice subjects in the use of CD ROM databases, based on their academic major.

$H5_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on their corrected vision.

$H6_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on their Visual Ability, as measured by the VZ-2 test instrument.

$H7_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on their SAT Math scores.

$H8_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on their SAT Verbal scores.

$H9_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on the level of their computer affinity.

$H10_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on the level of their computer literacy.

$H11_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of CD ROM databases, based on their learning styles, as measured by the KLSI instrument.

$H12_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (a-f), and there will be no effect on the choice of academic major (g), of novice subjects in the use of

CD ROM databases, based on their preferred Human Information Processing styles, as measured by the HIP Survey instrument.

$H13_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (**a-f**), and there will be no effect on the choice of academic major (**g**), of novice subjects in the use of CD ROM databases, based on their perceived usefulness of the system.

$H14_0$ - a,b,c,d,e,f,g:

For both (simple P(S)-S, P(B)-S, P(H)-S, and complex -P(S)-C, P(B)-C, P(H)-C) tasks, there will be no significant difference in the performance (**a-f**), and there will be no effect on the choice of academic major (**g**), of novice subjects in the use of CD ROM databases, based on their Personality Types, as measured by the Myers-Briggs Type Indicator (MBTI).

4.7.2 Relation between Academic Major and System Content

$H15_0$:

There will be no significant difference in the performance of novice subjects in the use of CD ROM databases for information retrieval, for simple searches, across databases in different subject areas, based on their academic major.

$H16_0$:

There will be no significant difference in the performance of novice subjects in the use of CD ROM databases for information retrieval, for complex searches, across databases in different subject areas, based on their academic major.

4.8 Sample for Final Analysis

Though 51 subjects participated in the final study, four of them had to be dropped from the final analysis because data gathered for their performance could not be taken as realistic - three of them either hit the "return" key too fast for the machine to cope with or the printer jammed. Since the time measurement was made to an accuracy of one-hundredth of a second, even minor variations could distort the data. The fourth student, though currently enrolled as an undergraduate, had obtained another Bachelor's degree nine years ago. Since this study was aimed at the novice undergraduate level, it was not considered appropriate to include a graduated-undergraduate student whose behavior and interaction with the system was very different from that of other subjects, much as the subject was a novice as far as CD ROM databases was concerned. Thus, the final analysis included 47 subjects - 23 science or engineering majors, 11 business majors and 13 humanities majors.

4.9 Statistical Tests Used

As has been stated earlier, this study mainly looked at the effect of the 14 characteristics of the end-user on his/her performance on the CD ROM databases. Therefore, all 14 independent and 6 dependent variables, corresponding to the six performance factors, were converted into categorical variables. In addition, another performance variable, "Overall Performance " was calculated by adding all the six performances (i.e., Overall P = P(S)-S + P(B)-S + P(H)-S + P(S)-C + P(B)-C + P(H)-C). The effect of all the 14 independent variables on this Overall Performance was also studied. Continuous variables were converted into dichotomous categories corresponding to values above (High) and below (Low) the median value for each.

Chi-square test was conducted by pairing each of the 6 performances with the 14 independent variables, to test the hypothesis $H1_0$.- a,b,c,d,e,f to $H14_0$.- a,b,c,d,e,f. Chi-square test was also done by pairing the Overall P factor with the 14 independent variables, to compare the significance of the results with the six levels of performance. In order to test the universality of some earlier findings on contrasting types of personalities, Chi-square test was also run with the four MBTI contrasting types of E/I, N/S, T/F and J/P against all the 6 performance factors. Though not stated as an explicit hypothesis, a Chi-square analysis was performed with the response of subjects to the question as to which database they found easy to use. This was to check whether they found the same database as "easy" and as "useful" or, whether the responses to the two questions were different. Another set of Chi-square tests was performed by pairing academic major with the 13 other independent variables, to test the hypothesis $H1_0$ - g to $H3_0$ - g and $H8_0$ - g to $H14_0$ - g.

The average performance of subjects in each discipline was determined for each of the six task levels (two in each database) by running an ANOVA using a two-factor - unbalanced factorial model, for each of the performances. Because the sample size was not equal for all academic disciplines (23 science/engineering majors, 11 business majors and 13 humanities majors), the two-factor unbalanced model was used. Using this two-factor model also helped look at the effect of a second group variable, "sex", within the first group variable "academic major". These results and their implications are discussed in Chapter V.

CHAPTER V

RESULTS AND DISCUSSION

5.1 General Approach

As has been stated in the earlier chapter, there were two basic sets of analysis performed on the data gathered. One was the Chi-square and the other was the two-factor unbalanced ANOVA. The former was to determine whether there was any significant correlation between pairs of variables, both dependent and independent, and if so, what was the nature of the correlation. The latter test showed whether there was a main effect of either of the two grouping factors (X variables - sex and academic major) on the dependent variable (e.g., performance as Y variable) chosen, as well as to show the interaction effect of the two groups, if any. The choice of sex and academic major as grouping factors was based on the fact that past research (Bellardo, 1984; Borgman, 1989, Woelfl, 1984, etc.) had looked at these variables, but, the results have been conflicting. This study aimed at confirming or extending some of those findings, particularly that of Borgman (1989), because many of the variables studied by her were included in this study. ANOVA was also performed with some of the independent variables as Y variables, against the same X-group variables, to determine the effect of sex and academic major on these user characteristics. These were SAT Math scores, SAT Verbal scores, Computer Affinity, Computer Literacy and Visual Ability.

Table 5.1 lists the probability figures for all the 151 Chi-square tests conducted. Though the research design was only (3 x system content) x (2 x task levels) x (14 x user characteristics), i.e., 84, additional tests were performed, as will be explained later in this Chapter, either to confirm earlier findings or to look at the current results in a different perspective.

Table 5.1

Values for probability - Chi-square Tests

Y Variable-->	P(S)-S	P(S)-C	P(B)-S	P(B)-C	P(H)-S	P(H)-C	AcadMajor	Overall P
X Variable								
Sex	.0015	.5279	.9001	.8307	.2915	.9001	.0028	.1626
Age	.2146	.1481	.2989	.5394	.6797	.6797	.1787	.0618
Language	.5317	.8238	.6724	.1156	.6006	.6006	.0889	.7469
AcadMajor	.2781	.0796	.5616	.0684	.5616	.1075		.8315
Sight	.3430	.3636	.3224	.3430	.3224	.3018	.1879	.3430
Visual Ability	.3017	.0289	.6638	.6542	.3085	.8815	.0441	.8911
SAT Math	.6232	.0800	.0800	.6537	.8665	.1607	.2911	.0800
SAT Verbal	.8901	.8901	.2623	.1459	.0406	.8788	.1227	.2623
C-Affinity	.5945	.0070	.1081	.0144	.6763	.3115	.0359	.2096
C-Literacy	.8307	.5279	.0579	.3327	.4741	.9001	.0142	.7059
Learning Style	.5326	.4787	.1602	.6653	.0983	.1901	.2821	.2818
HIP Mode	.4491	.3440	.6606	.1069	.5199	.8598	.1190	.9106
E/I	.5602	.7160	.4231	.2337	.8463	.4231	.0579	.5602
N/S	.9793	.3299	.4231	.5259	.6793	.4231	.7811	.9793
T/F	.7980	.0743	.4745	.1216	.4745	.4745	.1086	.3037
J/P	.0642	.0050	.8463	.5602	.1035	.4231	.0448	.5602
Useful DB	.0626	.0986	.7787	.2616	.4982	.0381	.0001	.4774
Easy DB	.4335	.0384	.5549	.1291	.9036	.0201	.0040	.3510
MBTI	.2595	.1855	.6691	.0690	.4036	.3695	.3078	.6867

Though most behavioral studies accept only a probability figure of $p < .05$ as indicative of a significant effect, this study includes slightly higher values for p in the discussion which follows, because quite a few of the variables are being studied for the first time in an IR context, requiring that this research be exploratory and look for trends rather than definite predictions. Since the study tried to look at as many of the users' characteristics as possible, only results which were significant are discussed in detail. Borderline cases are mentioned briefly, as being indicative of trends. Table 5.2 lists the cases which are significant and those which show such a trend.

5.2 Results and Discussion

5.2.1 Hypothesis Relating to Performance

$H1_0$ - a,c,b,c,d,e,f:

These six relate to the effect of sex on the six performance factors, P(S)-S, P(S)-C, P(B)-S, P(B)-C, P(H)-S and P(H)-C. As can be seen from Table 5.1, only the null hypothesis $H1_0$ - a was rejected (p=.0015), while all the other five null hypotheses were upheld. This means that the performance of subjects on the simple task in the science database (AST), was the only one affected by the sex of the subject. In all there were 20 females and 27 males in the sample tested. 16 (80%) of the females performed well in the simple task on AST, compared to only 9 (33%) of the males. For all other tasks, sex did not show a significant effect. This result does not confirm earlier reports by many researchers in computer science, education, psychology, etc., who have found a primary effect of sex on computing performance and explained it by the greater likelihood of males having the technical aptitudes and more experience with math-related and computing tasks.

Table 5.2

Significant Effects

P(S)-S	Sex J/P Useful DB	p=.0015** p=.0642~ p=.0626~
P(S)-C	AcadMajor Visual Ability CompAffinity T/F J/P Easy DB	p=.0796~ p=.0289* p=.0070** p=.0743~ p=.0050** p=.0384*
P(B)-S	SAT Math CompLiteracy	p=.0800~ p=.0579~
P(B)-C	AcadMajor CompAffinity MBTI	p=.0684~ p=.0144* p=.0690~
P(H)-S	SAT Verbal	p=.0406*
P(H)-C	Useful DB Easy Db	p=.0381* p=.0201*
AcadMajor	Sex Visual Ability CompAffinity CompLiteracy E/I J/P Useful DB Easy Db	p=.0020** p=.0441* p=.0359* p=.0142* p=.0579~ p=.0448* p=.0001*** p=.0040**

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ~ $p \leq 0.08$

$H2_0$ - a,c,b,c,d,e,f:

This set of hypotheses related to the effect of age on the six performances studied. As Table 5.1 shows, none of the six was significantly affected by the age of the subjects, thus upholding all the six null hypothesis. It does not appear that the subjects would perform differently, if they were non-traditional students. However, this cannot be considered important because the range for the variable was itself not large (18-29) for the sample population. Green (1986) and Egan (1988) had found significant effect of age on performance with computer systems, but their range was far higher. Researchers in IR studies had not looked at this in an empirical study, partly because of the confounding effect of the interaction between age and experience of intermediaries, which was mostly the variable studied. Borgman had eliminated age as a variable in her studies by including 18-25 as one age group. This study, however, did group subjects as traditional (<=22) and non-traditional (>=23).

$H3_0$ - a,c,b,c,d,e,f:

There were only 5 non-English speaking students in the sample and no significant effect of the language on performance was found. All the six null hypotheses were upheld.

$H4_0$ - a,c,b,c,d,e,f:

The effect of academic major on performance was tested by this set of hypotheses. There was no significant effect on any of the six tasks. But, two of the six performances, i.e., P(S)-C, the complex task on AST, the science database and P(B)-C, the complex task on HI, showed borderline effect (p=.0796 and p=.0684) of academic major of the subject on performances of these two tasks. 70% of the science majors and 55% of business majors performed well in P(S)-C, while the figure for humanities majors was only 31%. Similarly, 69% of science majors performed well compared to 45% of business majors and 31% of humanities majors for the complex task on BPI. Again, 65% of science majors performed well compared to 46% of humanities majors for the complex task on HI. The business majors performed the poorest, with only 27% scoring "high". This confirms the hypothesis that though the choice of academic major may not affect performance of simple tasks, it is likely to affect the performance of complex tasks. But the fact that it is the science majors who appeared to have done well on both complex tasks, confirms Borgman's findings (1984a) of the effect of one academic major on performance - that science and engineering majors performed better than humanities and social science majors on information retrieval tasks.

$H5_0$ - a,c,b,c,d,e,f:

These six hypotheses looked for any effect that corrected vision of subjects may have on their performance. But as was found, it did not affect any of the performances and hence, all the six null hypotheses are upheld.

$H6_0$ - a,c,b,c,d,e,f:

These six hypothesis related to the effect of the visual ability of subjects (high/low) on their performance in the six tasks. It was found that visual ability significantly affected one of the performances, i.e, P(S)-C (p=.0289), the complex task on the science database, rejecting $H6_0$ - b. The remaining five null hypotheses in this set were upheld. 71% of the high visual subjects scored high on the performance, while only 39% among the low visuals scored high on performance. The importance of this is, however, that visual ability is a factor not to be neglected in IR studies. Sein (1988) did observe that Borgman's subjects who fared poorly in their performance on the online catalog used by her, may have been low visuals and hence, the difference. This study confirms Sein's observation. The complex task on AST was the first task requiring the use of "OR". High visual subjects (irrespective of their academic majors) seem to have been able to visualize the effect of using "OR" faster than those with low visual ability.

$H7_0$ - a,c,b,c,d,e,f:

SAT Math score has been studied as a predictor of performance on computer systems by many researchers, including Borgman (1989) and Evans & Simkin (1989). Borgman had studied SAT Math scores as one of the factors contributing to a overall variable, such as technical aptitude, and tested its correlation with performance. Direct effect of SAT Math scores, if any, as an independent variable by itself has not been reported. Most studies, however, reported strong correlation between SAT Math abilities and higher performance values. In this study, the effect of SAT Math scores on performance was examined through these six hypotheses. $H7_0$ - a, d, e and f were upheld. The two remaining cases, i.e., $H7_0$ - b and $H7_0$ - c, though rejected, could be considered borderline cases (p=.8 for both) indicative of an influence of SAT Math scores on performance of some tasks, primarily because there are many earlier findings to that effect. No definite conclusions can, however, be drawn based on the results of this study alone.

$H8_0$ - a,c,b,c,d,e,f:

These six hypotheses tested the effect of the levels of SAT Verbal scores on the performance of students in the simple and complex tasks. Only P(H)-S is affected (p=.0406) by the level of SAT Verbal scores, rejecting $H8_0$ - e. 70% of those who had a high SAT Verbal scored high on this, while only 38% of those who had low SAT Verbal scores performed well on the simple level tasks on the Humanities Index. The performance on the complex task on HI was, however, not influenced by SAT Verbal scores. This could be due to the fact that those whose verbal abilities were not high, perhaps, could not pick the correct search terms for one of the simple tasks ("Future of Judaism").

$H9_0$ - a,c,b,c,d,e,f: and $H10_0$ - a,c,b,c,d,e,f:

These two sets of hypotheses are discussed together, because of their significance when examined as a contrasting pair. As can be seen from Table 5.1, Computer literacy (p=.0579) had just a borderline effect, that too, in only one instance, i.e., P(B)-S, coming close to rejecting $H10_0$ - c. All the other five null hypotheses in that set were upheld. At the same time, computer affinity affected very significantly the P(S)-C (p=.007) and P(B)-C (p=.0144), rejecting the two null hypotheses $H10_0$ - b and $H10_0$ - d. The other null hypotheses were, however, upheld. But this does not take away the merit of the overall importance of this result - i.e., that it is necessary to isolate computer affinity and computer literacy as two variables and study their effect on performance independent of each other. Herein may lie the essential difference between one subject and the other - in the varying levels of computer affinity as opposed to their levels of computer literacy or proficiency. Looking at all computer-related variables as one factor such as technical aptitude (Borgman, 1989) may, therefore, not be sufficient to predict the performance of individuals on computer systems.

$H11_0$ - a,c,b,c,d,e,f:

Learning styles as determined by the KLSI survey have been found to be important predictors of performance on computer systems by many researchers (Woelfl, 1984; Borgman, 1989; Saracevic et al., 1988; Sein, 1988, etc.). These six hypotheses relate to the effect of these learning styles on the six performances of subjects in this study. Contrary to earlier findings, none of the performances was affected by the learning styles of the subjects. All null hypotheses were accepted. One possible reason for this outcome may, perhaps be, that learning styles do not affect all computer-related tasks equally or uniformly; their effect on performance in the context of CD ROM database searching may perhaps be minimal. Also, CD ROM interfaces are most likely simplified enough for most students to use, irrespective of their learning styles.

$H12_0$ - a,c,b,c,d,e,f:

Human information processing styles (coded as HIP Modes) have been found to affect learning skills by management training designers (Herrmann, 1981). Here the six Chi-square tests which tested the effect of HIP modes on performance did not produce any significant result, as can be gauged from the values for the probability in Table 5.1. All six null hypothesis remain accepted. However, it was interesting to note that in the case of P(B)-C, 100% of the Integrated type subjects performed high, while 50%, 46% and 44% of the Left, Mixed and Right modes respectively, performed well in the task. It is, however, difficult to make any conclusive remarks about the relevance of HIP modes in the IR situation, based on this small sample population study.

$H13_0$ - a,c,b,c,d,e,f:

Only one (f), of the six null hypotheses relating to the effect of perceived usefulness of the system on performance was rejected, while the other five (a.b.c, d & e) were upheld. The strongest effect was on P(H)-C (p=.0381), while that on P(S)-S was borderline (p=.0626). Only 33% of those who chose HI as the most useful database performed well on the complex task on HI, while 67% of those who chose AST as the most useful, scored high on P(H)-C. Only 23% of those who chose BPI as the most useful database performed high on the complex task on HI. As for P(S)-S, only 48% of those who chose AST as useful scored high on P(S)-S, while a high 77% of those who chose BPI as useful and a small 17% of those who chose HI as most useful, scored high on P(S)-S. This result confirms in part Griswold's (1985) observation that business majors possess a good attitude towards computers.

$H14_0$ - a,c,b,c,d,e,f:

This set of hypothesis tested the effect of the personality traits of subjects on their six performances. All the six null hypotheses were upheld. But one case, i.e., P(B)-C, showed a trend (p=.069) towards an effect. This means that the performance of subjects on the CD ROM systems was basically not affected by their differences in personality types. This result is rather contrary to many earlier findings. Borgman observed that personality types can be strong predictors of performance, but these results are more similar to Bellardo's (1984) results, who found no significant differences in performances on various tasks by personality traits. However, Borgman (1989) too did not find any clustering of subjects in any particular type in her study though other studies had found subjects to cluster into one or the other MBTI personality types. This study conforms to her findings in this respect, because there was no clustering of subjects in this study, in any of the 16 MBTI types.

Most researchers have also studied the four contrasting pairs E/I (Extroverts vs. Introverts), N/S (Intuitive vs.Sensing), T/F (Thinking vs. Feeling) and J/P (Judging vs. Perceiving) types of the MBTI personality types. Though not explicitly stated as hypotheses, this study also tested the effect of these contrasting pairs on the performance of subjects on the three databases. Only one contrasting pair showed a significant effect, i.e., the J/P dimension - P(S)-C with (p=.005), while P(S)-S with (p=.0642) showed a trend close to being significant. The only other dimension which showed a borderline effect, though not a strong one (p=.0743), was the T/F - this also affected the performance of the complex task in the science database, P(S)-C. These results are not in conformity with those of Borgman (1989) or Evans & Simkin (1989), who found the J/P dimension to have a weak relationship or no relationship with factors which predicted better performance levels, such as technical aptitude, science courses taken, etc. Surprisingly, neither the E/I nor the N/S dimensions had any effect on any of the performances, though many studies, including that of Borgman (1989) found the engineering subjects to belong to the Introvert group.

Another set of six hypotheses were similarly tested - to determine whether subjects performed well on databases which they perceived as being easy to use. Stated in the null form this hypothesis states that perceived ease of use would not have any effect on the performance. In two cases, however, there was a significant effect: P(S)-C (p=.0384) and P(H)-C (p=.0201). In the case of P(S)-C, 77% of those who said AST was the easiest database to use, actually scored high on this complex task, while only 33% of those who found BPI easy and 23% of those who found HI easy scored high on the same task. 50% of those who found both AST and HI easy to use also scored high, while 100% of those who found BPI and HI easy to use scored low on the task. On the contrary, none among those who selected BPI as easy to use, scored high on the complex task on HI, i.e, P(H)-C. 67% of those who claimed AST was the easy to use database scored high even on this task on Humanities Index, whereas only 23% among those who deemed HI easy to use, faired well on the task. However, 100% of all those who found both AST and HI easy scored high, while all those who found BPI and HI easy to use scored low (100%) on this task. This last result appears significant, because it is identical to the effect on P(S)-C. All those who found BPI and HI easy to use, scored low on both the complex tasks on the science and humanities databases. This result can be understood better when examined in conjunction with the effect (trend) of academic major on the performance factor for complex tasks as well as that of visual ability and computer affinity on academic major. Those who found only HI and BPI easy to use (and not AST) were either from business or humanities major, and, more likely to be "low visual" types. They also have less affinity towards computers, compared to others in their own academic stream and certainly less than those in the science major. It appears that , after all, factors that influence the choice of academic major do affect performance, thus making academic major an intervening variable. Moreover, business majors are found to fair poorly in two of the three complex tasks, while science majors did well on all complex tasks. This again resembles the trend observed by Borgman.

5.2.2 Hypothesis Relating to Academic Major

The set of hypothesis relating to the academic major of a subject being affected by the other 13 independent variables was stated as $H1_0$ - g to $H3_0$ - g and $H5_0$ - g to $H14_0$ - g, in Chapter IV. Table 5.1 shows the probability values obtained from Chi-square tests performed by pairing academic major with each of the 13 other variables studied.

Significant effect was found for sex (p=.0028), visual ability (p=.0441), computer affinity (p=.0359), computer literacy (p=.0142) and perceived usefulness (p=.0001). Thus, $H1_0$ - g, $H6_0$ - g, $H9_0$ - g, $H10_0$ - g and $H13_0$ - g were rejected, while the rest were upheld. In addition, one of the contrasting personality types, J/P (p=.0448), showed a significant effect, while E/I (p=.0579) proved to be a borderline trend. Ease of use (p=.0040) showed significant effect on performance, as was expected.

Sex has been found to be a predictor of academic major for a long time and this study confirmed it. 70% of males were science majors (19 out of 27), while only 15% were among each of the other two majors, i.e., business and humanities. This study showed that the majority of 45% (9 out of 20) of the females were from the humanities stream, with only 20% belonging to the science major. There was, however, a larger proportion of females to males (7:4) in the business major.

42 subjects claimed English to be their native language and 5 were non-English speakers. The effect of language though not significant, still showed some trend - 100% of humanities majors were native English speakers, while 91% of science majors and 73% of business majors were native English speakers. Non English speakers were almost evenly distributed between two majors - business (60%) and science (40%) with none in humanities. This is perhaps, not surprising.

One of the significant and at the same time, very important results, is the effect of visual ability on academic major (p=.0441). 67% of all the high visuals in the sample were science majors, with 17% in each of the other two majors. This research was designed to test the need for including visual ability as a predictor of academic major as well as performance on computer-related tasks. The results uphold the former proposition *in toto* , while supporting the latter only in one case, i.e., P(S)-C. Even this is important, because it points to the primary effect of visual ability on choice of academic major translates into its secondary effect on performance.

Yet other significant effects were of computer affinity and computer literacy on the academic major. 78 % of science majors showed high levels of computer affinity and computer literacy, while 45% of business majors and 36% of humanities majors also showed high levels of computer affinity. The corresponding value for computer literacy for humanities majors was slightly higher (38%). These results are not unexpected, but they show that computer affinity is not totally lacking in non-science majors. This result again shows the need to isolate these two variables in user studies.

The measure of perceived usefulness provided some unexpected results. While 100% of science majors said they found AST most useful, 91% of business majors said that they found BPI most useful, and only 46% of the humanities majors indicated HI as the most useful database. This may, perhaps, be due to the fact that the humanities majors actually came from diverse specialities such as art, history, music, etc. But, more surprising is the fact that 23% each of humanities majors indicated either AST or BPI as the most useful. About 9% of the business majors also said that they found AST most useful. This difference in perception of what is useful could be due to various factors, one of which being the courses that they might be currently enrolled in.

The effect of the Myers-Briggs personality type on academic major was not evident in the sample studied in this research. Nor was there any significant clustering effect. Though she did not find such clustering among any groups, Borgman felt that the engineering majors were still likely to cluster. Other studies such as that of Evans and Simkin (1989), Crosby and Peterson (1991) and Crosby and Stelovsky (1990) studied MBTI types specifically among computer science majors and this might well be the reason for their findings of significant effects of personality types on performance. It is most probable, that programmers fall at one extreme of the range of MBTI types even compared to other engineering and science majors. In this research, there were no computer science majors. The subjects who represented the science stream came from mechanical engineering, math, physics, oceanography, etc.

Surprisingly, this study also found that a higher clustering occurred among the humanities majors - 23% of these were grouped into the ISFJ type, followed by ESFJ and ISTJ with 15% share each. The largest science majors group was the ISTP (22%), with the INTJ, INTP and ISTJ all sharing an equal 13%. Business majors were the most mixed group - ENTJ, ESTJ, ESFJ, ISTJ and ISFJ all shared an equal 18% of all the business majors in the sample. However, what was more interesting was, perhaps, the total absence of a major in some groups - there were no science majors in ENTP, and INFJ; there were no humanities majors in ENTJ, INTJ, ISTP and ISFP, and there were no business majors in ENTP, INTJ, INTP, INFP, ISTP and ISFP. Thus INTJ, ISTP and ISFP were the types found only among science majors whereas INFJ was the prerogative of humanities majors.

Comparing these results with the four contrasting pairs of MBTI types, it was seen that 78% of science majors were introverts (confirming earlier findings), 64% of business majors were extroverts, and 62% of the humanities majors in this sample were introverts. This effect may be due to the fact that the sample consisted of quite a few art design majors, whose traits resembled those of engineering or science majors. Similar to Borgman (1989), this study did not find any sensing dominance in the S/F type. In fact, it was the only dimension which did not have an effect on the academic major in this study. The J/P dichotomy was fairly evident ($p=.0448$) from the study - 71% of all the perceiving types in the sample were from the science major, followed by 28% from humanities and only 6% from the business group. The thinking vs. feeling (T/F) dimension did not show a significant effect on the academic major, contrary to earlier findings (Borgman, 1989, Evans & Simkin, 1989). It was interesting to note that business majors resembled science majors closely in this dimension - 64% of business majors and 74% science majors were thinking types, while 62% among the humanities were feeling types.

The last of the chi-square tests was performed by pairing the overall performance with each of the independent variables. As seen from the Table 5.1, the only effect on overall performance was from the age, but even this was not significant ($p=.0618$).

5.2.3 System Content and Academic Major

The two hypotheses $H15_0$ and $H16_0$ were used to test the influence of the academic major (domain specific knowledge) of the subject and performance on simple and complex tasks respectively, on a database, based on the contents (academic area covered) of the database. For this, the average performance of the subjects from each academic major was calculated for each of the six tasks. Thus there were nine performance averages for the three simple tasks and nine performance averages for the three complex tasks. The study proposed that there will be no significant variation in the performances of the subjects on the three simple tasks [P(S)-S, P(B)-S and P(H)-S], between subjects from the three different academic disciplines, but the subjects would perform better on complex tasks [P(S)-C, P(B)-C and P(H)-C], in the database whose contents pertained to their academic majors. This is diagrammatically represented in Figure 5.1.

Figure 5.1

Expected Values

	Simple Tasks				Complex Tasks		
	S	**B**	**H**		**S**	**B**	**H**
P(S)-S	x1	x2	x3	**P(S)-C**	y1	y2	y3
P(B)-S	x4	x5	x6	**P(B)-C**	y4	y5	y6
P(H)-S	x7	x8	x9	**P(H)-C**	y7	y8	y9

The two hypotheses could be expressed in terms of the values x1-x9 and y1-y9, as follows:

$H15_0$:	x1=x2=x3	$H16_0$:	y1 > y2 and y3
	x4=x5=x6		y5 > y4 and y6
	x7=x8=x9		y9 > y7 and y8

Table 5.3 represents the actual values obtained for these variables in the study.

Table 5.3

Observed Values

	Simple Tasks				Complex Tasks		
	S	**B**	**H**		**S**	**B**	**H**
P(S)-S	.041	.055	.045	**P(S)-C**	.009	.009	.003
P(B)-S	.050	.049	.034	**P(B)-C**	.033	.021	.025
P(H)-S	.039	.039	.038	**P(H)-C**	.071	.054	.061

To interpret these results in a general perspective, one has to remember that what is being tested is the trend of effects and not the absolute values. Thus, one looks for orders of magnitude being the same for the values of the performance factors, to judge them as being equal. Thus, it can be seen that for simple tasks, the three conditions were met (within experimental errors), accepting $H15_0$. At the first glance, two of the three conditions appear to be defeated, for the complex tasks. If one looks at the absolute values, only part of the first one, i.e., $y1 > y3$ is met. However, the fact $y2 = y1$, still cannot be considered as totally rejecting the first condition. The last two conditions do not hold. Both y4 and y6 turn out to be > y5. Though y9 is > y8, it still is < y7, thus rejecting part of the condition. But, when one looks at the orders of magnitude of these values, they yield a different picture, which is similar to that of the simple tasks in two cases, i.e., P(B)-C and P(H)-C. However, in this scenario, the actual values of the performance factor P(S)-S show an important effect - the order of magnitude still being the same across majors, the variance in the values is far higher than in the other cases. The science and business majors scored three times as high as the humanities majors.

The hypothesis, $H16_0$ was proposed to test the correlation between the domain specific knowledge of a subject and his/her performance on a database pertaining to that academic domain. This means that, the lack of domain specific knowledge definitely affect humanities majors. The fact that science majors (who should have performed best in AST by the same token), did not do better than business majors, could be due to either of two reasons: (1) the order in which the databases were searched - AST was the first database that they were searching on, and, they were still learning the preliminary keystrokes and strategies; and, (2) science majors were more hesitant than the other two majors at the start of the experiment. Business majors were less hesitant than science majors and the combined effect of these two factors account for the equal performance of science and business majors in the first complex task. That the order in which the databases were searched was not rotated, to better test the effect of domain specific knowledge, is acknowledged here as a lacuna in this study. Thus, even though the hypothesis is not accepted in full, it provides some important results. Domain specific knowledge, particularly for science and technology database search, might still be a predictor of performance for complex tasks.

The sample size for the study was not only small, but skewed towards science majors. The business majors had the smallest representation. Yet, there were some results, worth taking note of - domain specific knowledge did not seem to affect simple tasks on the three databases. This is important. More research with bigger samples need to be carried out, to validate or refute the observations relating to the complex tasks. The fact that science majors seemed to perform better in almost all tasks (5 out of the 6) put together, is, however, in conformity with Borgman's findings. This also lends itself to the explanation one could find in the fact that high visual ability of the science majors could be a contributing factor in this phenomenon, as was found by Sein (1988) and Sein and Bostrom (1989).

5.2.4 Analysis of Variance

ANOVA tests were performed on six performance factors and five user characteristics, which were continuous variables. Two group factors chosen were academic major and sex. The two factor - unbalanced factorial model was used to perform the ANOVA, because of the distribution of subjects not being equal across academic majors. The sample population was also slightly skewed towards males (27 males and 20 females). Results of the twelve ANOVA tests are included as Tables 5.4 - a & b to Table 5.14 - a & b (Appendix K). These are sets of two tables each, with Table "a" showing the F-test results and the p-value, while Table "b" shows the distribution of the subjects within the two groups chosen along with the mean values of the Y variable for each cell.

Table 5.4 shows the results of ANOVA on the performance of simple task on AST. The measure of performance for ANOVA is continuous and hence represented as Perf-S/S, to differentiate it from P(S)-S, which was coded as a categorical variable. The same norm had been used for all the other performance measures used in ANOVA. As seen from Table 5.4 a, the effect of sex on performance is highly significant ($F(2,41) = 6.32$, $p = .016$), while academic major is not. But the interaction effect is significant, i.e., the likelihood of finding the effect of sex differently within academic majors is high ($F(2,41) = 3.97$, $p = .0265$). Table 5.4 b provides the incidence table, which shows that female subjects did perform better on this task than their male counterparts within the same academic major in two out of the three cases.

Table 5.5 a and b are the results of ANOVA for the performance on the complex task on AST. As can be seen, neither sex nor academic major had any significant effect, but the incidence table shows that females did as well as, or better than males in two cases.

Table 5.6 a and b show the ANOVA results for the performance of the simple task on BPI. Both sex and academic major show significant effect on performance ($F(2,41) = 6.85$, $p = .0124$ and $F(2,41) = 4.18$, $p = .0222$, respectively). The interaction effect is also significant ($F(2,41) = 3.83$, $p = .0299$) in this case. The incidence table shows that females performed twice (or more) as well as males in two of the three groups of academic majors. The case with the complex search (Table 5.7 a) on BPI is also not too dissimilar with respect to the effect of sex ($F(2,41) = 2.88$, $p = .0971$), while academic major ($F(2,41) = 5.88$, $p = .0057$) shows a pronounced effect on performance. Yet, the interaction effect is not significant. Table 5.7 b shows that in general, science majors performed better than others, but females out-performed males within the science major, while the effect was reversed within the humanities major. Both males and females from business major scored equally on the task.

Table 5.8 a shows that the effect of sex and academic major on the performance of the simple task on HI are both weak. The interaction effect of sex and academic major is also not significant. Table 5.8 b shows that all subjects (males and females) from all the three academic majors obtained equal scores. This could be attributed to the fact that the subjects had all performed six tasks already on the two other databases by the time they started on the simple tasks on HI. They were no longer novices in the use of the system and the simple tasks, perhaps, were too simple at this stage. The implications of this result is further discussed in the concluding section.

ANOVA results for the complex task on HI, however, present a slightly different effect. Table 5.9 a shows that the main effect of academic major on performance was significant ($F(2,41) = 3.85$, $p = .0293$), but that of sex was not. The interaction effect was also not significant. But, Table 5.9 b shows more interesting results - females out-did males again in two of the three academic groups, but the main difference is that in this case, it was the females from the humanities group performing better than the males on a task. Females also did far better than males among the science majors.

Table 5.10 a shows that academic major bears a very significant relation to visual ability ($F(2,41) = 4.28$, $p = .0205$). Sex did not have any significant effect on visual ability. But, this itself makes it all the more important. Table 5.10 b shows females in all three majors were not only more highly visual than males, but they were far more so within the science group (17.2 vs. 14.72). Science majors uniformly scored far higher scores in the visual ability test than subjects from the other two majors.

The effect of sex and academic major on the levels of computer affinity shown by subjects is also important though not significant. Table 5.11 a shows no significant effect of either of the two group factors - which means, that there are subjects (both males and females) in all disciplines who possess high affinity towards computers. Table 5.11 b shows the incidences - humanities majors exhibit almost the same level of affinity as science majors and the business majors are not too far behind.

Computer literacy is a measure of familiarity with computers, i.e., working with them. Perforce science majors and recently, business majors have to take courses which teach basic computer skills. Science and engineering students do have to work with computers for many of their core courses. So, the results of ANOVA are not surprising. Table 5.12 a shows that academic major affects computer literacy very significantly ($F(2,41) = 9.9$, $p = .0003$), while sex did not have any such significant effect. Nor was there an interaction effect. Table 5.12 b shows that even in levels of computer literacy, females scored higher both in business and science majors.

SAT Math scores have traditionally been considered predictors of academic major (Borgman, 1989). This test showed no such effect. Nor did sex have any effect on SAT Math abilities, as shown in Table 5.13 a. Again, Table 5.13 b reflects the same trend found between females and males in other characteristics - i.e, females in the business and science majors (in the latter, more definitely so) performed better than the males while males performed better than females among humanities majors.

The last of the ANOVA tested the effect of the two groups on SAT Verbal scores. Academic major showed (Table 5.14 a) a definite effect ($F(2,35) = 4.59$, $p = .017$) on SAT Verbal abilities, but sex did not. There was no interaction effect. Table 5.14 b shows, however, that the verbal abilities of science majors proved to be far higher than even those of humanities majors, contrary to common belief that science majors lack verbal skills. Borgman (1989) also had found similar trends. Here too, the female subjects scored higher both among the business and science majors, while males did better among the humanities group.

5.3 Conclusion

Over 150 Chi-square tests were performed in this study. Out of these, only 16 cases showed a significant effect, while less than 10 others proved to be borderline cases. These results (Figure 5.2) are not typical of IR studies - Borgman, Woelfl, Saracevic et al., etc. had found quite a few of the user characteristics to be predictors of performance. In particular, learning styles, personality types and SAT math and verbal abilities have been found to have significant effect in quite a few studies. The fact that this research did not find significant effects with these traditionally studied variables, but found definite influence with other variables introduced, is indicative of something.

There could be many explanations for the trend witnessed in this research - it could be that, as in the case of Bellardo (1984), the traditional predictions did not hold for the sample population studied; or, it could be that, in the 10 years since Bellardo, Woelfl, Borgman, etc., did their studies, online terminals have become so common in university settings, that students are no longer strangers to searching for information using the terminals - a fair familiarity with OPAC terminals, perhaps, overcomes even differences in learning styles, etc. This was somewhat evident in the current study, where almost all students had used the library online catalog sometime or the other; or, it could also (hopefully) be, that IR systems, CD ROM databases in particular, are becoming easier to use. Many of the reports of user surveys of CD ROMs discussed in Chapter I, as well as the personal experiences of this experimenter, confirm that they are indeed so. However, there was a more important phenomenon observed in this study. This relates to the teaching of Boolean logic to students. Bellardo and Borgman had both observed that Boolean logic was not easy for all students to learn. In fact, the first seed for this research was sown with Borgman's finding that the subjects who failed her benchmark test were social science and humanities majors and that was because they found it difficult to learn and apply Boolean logic. Contrary to her finding, this study found that all students did learn and use the two

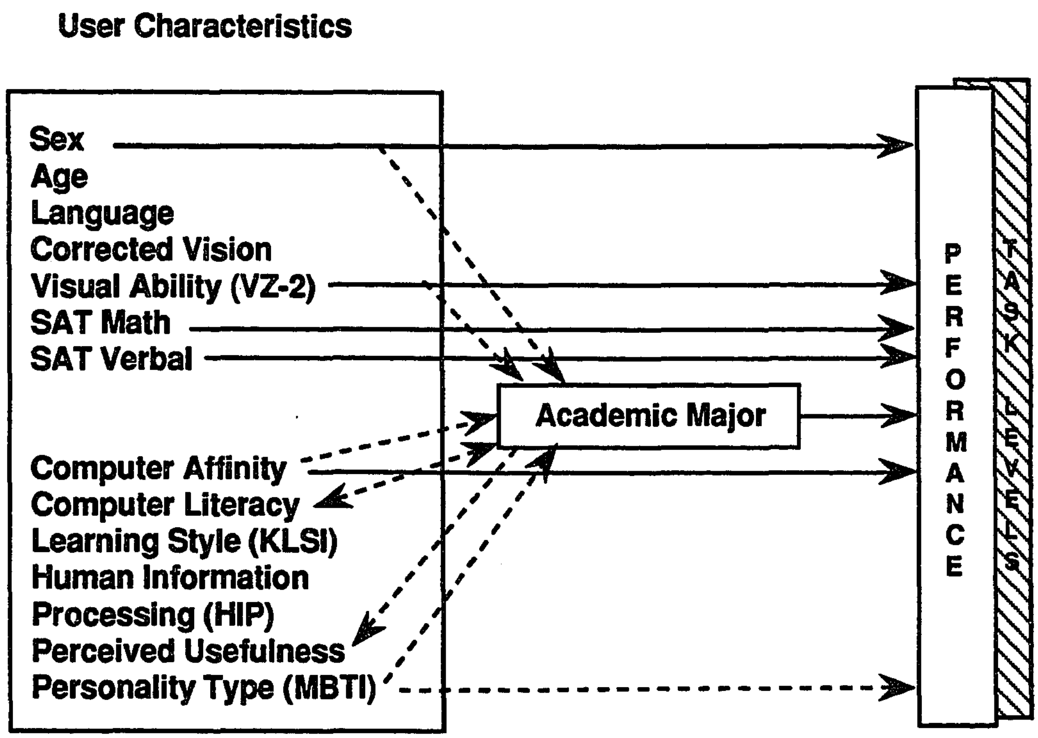
Boolean operators, "AND" and "OR", fairly easily. All of them received oral instruction and a demonstration which lasted about 15 minutes only, and yet, they all performed almost equally well by the end of the session.

A brief discussion of the interface (though controlled) used is in place at this juncture. Wilsearch, as was explained in Chapter III, was targeted towards the high school and undergraduate student level. It proved itself to be so in this experiment. In fact, some of the subjects did comment that this system was easier to use than the OPAC system, because they did not have to type in prefixes such as "AU", "TI", or, "Browse", or even "/w", etc., nor did they have to go through 4 or 5 screens,which asked them what mode they want to use, etc. The search template proved to be direct and easy to use, for almost all of the subjects. There was no ambiguity as to whether they were entering words which were subject words (terms) or title words.

However, it was not all smooth sailing throughout. Most students found it difficult to remember that they had to use "any" at the beginning of a line, when they needed to use "OR". They often typed in their terms with the word "or" in between the terms, ran their search and then realized that it did not work the way they wanted it to. They had to go back and modify their searches, twice in some cases, before they could get the "hang of it". This accounts for the low value of the performance factors for the first complex task [P(S)-S], which is a whole order of magnitude less than that for the other five tasks. The need to use the word "any" to indicate the use of the operator "OR" proved most vexing for all majors, some of whom wrote in the comments, "Why can't the system use plain English? - ex: OR instead of "any". It would have been far easier to use." The science majors had another cause for frustration - the need to go through two key strokes to print the hits - Wilsearch asks for confirmation before it prints, and understandably, subjects did not like to go through more than the minimum key strokes for any command. There was also an overall cause for the frustration of the subjects - by and large, most computer labs in the university

Figure 5.2

Observed Model



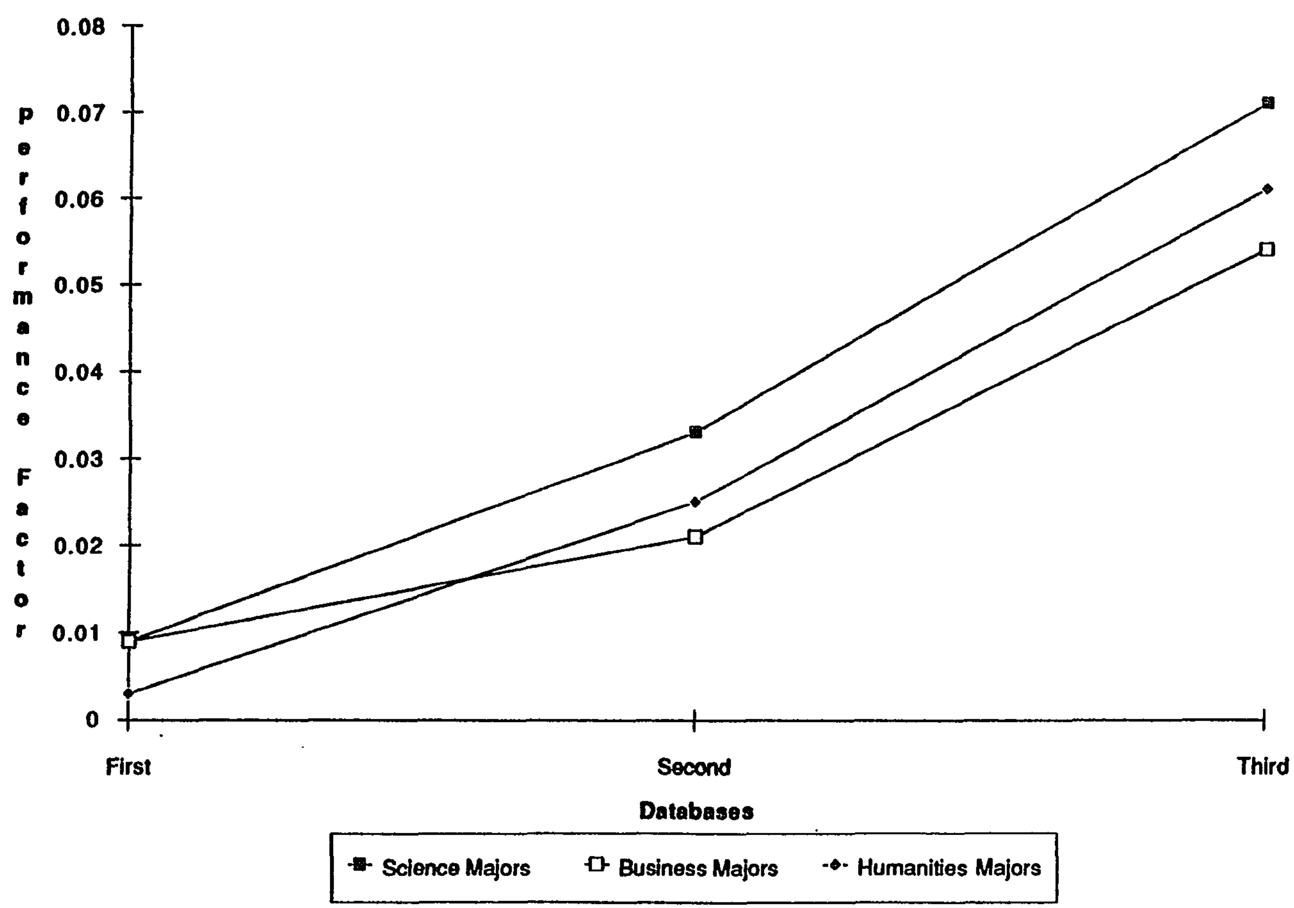
have equipped themselves with faster machines, and the Wilson workstation, an IBM-XT, proved to be too slow to be liked by the undergraduate subjects. Though The H.W.Wilson Company now provides search software for the faster line of machines, they still use the word "any" for "OR" in the Wilsearch mode, and it would alleviate the frustrations of many a student if they could adopt the natural language usage of "or", to indicate alternate concepts, or, for use of synonyms.

The above observation also led the experimenter to look at the improvement in performance of the subjects over the six tasks. Performance factors were within-subjects variables and Table 5.3 (Complex tasks) uses their average values, which in turn, become within-major variable in that context. The use of "OR" was required in all the complex tasks. The trend in the performance level for complex tasks is graphically presented in Figure 5.4. Looking at the performance trends for the complex tasks, it is easy to see that the pattern is identical for all three majors. The factors rose from a thousandth of a unit to hundredths between the first database and the second, and more than doubled for the third. The absolute values for the performance factors may be different for different majors, but the pattern across databases is the same for all the majors. All of them started slowly, but gained confidence as they performed one task after the other and did almost equally well in the third database. The comments made by the students in Questionnaire 2, made it clear that almost all the students had been able to get over their initial hesitancy and get on with the experiment very quickly. A number of them actually stayed after the experiment to perform their own searches and quite a few came back later to do some more searches. The overall reaction was extremely positive.

There was one other point brought out in the study - the humanities majors were more used to searching the OPAC, while the science majors used it less frequently. This was reflected in the results, too. Science majors, though performing the best in 5 out of the 6 tasks, still scored lower than business majors in the first task - it was, perhaps, because

Figure 5.4

Performance Trend



the science majors were the most hesitant to begin with, than the other two majors. But, once they learnt how to use the system, they did better than the other two majors. As one of the science subjects put it succintly, "Once you get the hang of it, it was easy." As for the business majors, they proved that they had a more positive attitude towards computers, as Griswold had found - they started well (and they were the least hesitant group) and scored better than the science majors in the first task and equalled them in the second (both in the first database); the science majors overtook them in the second database, after they had got "the hang of it".

The humanities majors too were more hesitant than business majors but better than science majors to begin with. Actually, the cause for their hesitation was two-fold - (1) unfamiliarity with CD ROMs and (2) the demonstration was done on the science database (AST). They were apprehensive that all the searches may be in a subject with which they were not familiar. Their hesitancy turned to excitement when they started searching on HI. In fact, the most enthusiastic comments came from this group, including profuse gratitude for giving them the opportunity to learn something which was so useful and "exciting", and, even personal compliments to the experimenter. However, these varying reactions across majors, yet similar patterns of progress within the groups of majors, proved that information retrieval is not so formidable a task for students if the systems can be simplified. Also, Boolean logic need not always prove to be a threat to learning.

However, this experiment did not take into account one factor, i.e., the order in which the three databases were searched, as mentioned earlier. If different majors had been asked to perform the tasks in an order which made them start with the database pertaining to their academic major, the results may have been different, though not necessarily so. The fact that the science majors performed better in most of the tasks (as has been found by Borgman and others, too), makes it difficult to predict how the subjects would have performed, had the order been changed. In all probability, the science majors might have done better than the business majors in the AST tasks, had they done it last, because of the experience gained with the first two databases. The same could be true for the other two majors. It would be worthwhile replicating the current study with the order of databases shuffled. The predictive abilities of domain specific knowledge could not be studied thoroughly in this research, because of this shortcoming.

The six ANOVA tests relating to performance of tasks showed that females performed either equal or better than males in 13 out of the 18 cases when each performance was viewed across groups by academic majors, and the females from science major out-did other females and science males in most cases. This trend witnessed here, particularly when viewed in conjunction with the five ANOVA results on individual characteristics (Table 5.10 to Table 5.14), is not in conformity with earlier findings. Female subjects in the business and science majors fared better than their male counterparts, while males did better than females among the humanities group in most cases, except in the complex task on HI. Tables 5.15 a and b affirms this pattern even for the total performance, which is the sum of all the six performance factors. However, the number of females in the science group was far less than males (4 out of 23), which makes it difficult to provide any definite conclusion. But the consistent pattern of better performance of females along with equal or higher levels of computer affinity and visual ability exhibited by females across academic groups, makes it difficult to ignore these results. The point made by this research is, perhaps, the same as that of some earlier theorists (Daniels, 1986) and experimenters (Saracevic et al, 1988) - i.e, research in end-user studies have to be continued and conducted in a systematic manner, so that sufficient empirical data is collected before definite user models can be built. Future research should, if possible, test the models found in this research with equal number of subjects in each major, and sex, within majors.

This study also shows that, while adopting some of the methods and models of traditional user studies, it is also necessary to concentrate on variables which might be more relevant to the new context in which studies are conducted, particularly if these variables have been omitted in earlier studies. This research at least succeeded in establishing the importance and hence, the need to include one such variable, i.e., visual ability, in end-user studies with computer systems in general and in IR research, in particular. It has also vindicated the isolation of the two factors, computer affinity vs. computer literacy, as predictors of performance and academic major. It appears that computer affinity is more of an individual difference than computer literacy - i.e., affinity is something innate to a person, while literacy is an acquired trait. Whether affinity can also be cultivated or increased is, perhaps, the subject for another research project. Suffice it to note that it is worthwhile studying these two factors as separate from each other. This finding, if confirmed by more empirical research, could mean a great deal to developers of interfaces and designers of training programs. This study also proved the need to take into account the differences in the levels of visual ability of end-users for better system interface design, and, of course, training procedures, in addition to accepting them as predictors of academic major and performance.

In a thought provoking article on the psychological study of programming, Sheil wrote that significance measures are not estimates of the *size* of an effect, but estimates as to *whether one occurred* at all (Sheil, 1981: p.115). If this study just managed to establish that an effect occurred with the few new directions it took, it was certainly worth it. Studies that follow can concern themselves with establishing the size of the effect. It is this experimenter's modest belief that this research has broken some new grounds, however small, which should serve as the site for others to explore further.

APPENDIX A

KLSI - Kolb's Learning Style Inventory

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APPENDIX B

MBTI - Myers-Briggs Type Indicator

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APPENDIX C

VZ-2 - Visual Ability Test
(Copyrighted Material - Not Reproduced)

APPENDIX D

HIP - Human Information Processing Survey

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APPENDIX E

Consent Form

CERTIFICATION

I certify that I have been given sufficient information about the project and that I herewith give my consent to participate in it. I certify that there has been no coercion and my participation is purely voluntary. I also agree to complete the full session of two hours as required by the experimenter, Kamala Balaraman.

Signature:

Date:

APPENDIX F

Questionnaire - 1

Please answer all the questions. Scales are 1 (low) to 5 (high); Yes/No responses need only a tick mark in one of the boxes.

Part I:

	AGREE Least..........>Strongly 1	2	3	4	5
1. Computers are fun					
2. Computers are easy to learn					
3. I like to spend more time using computers than anything else.					
4. I like to play video games (Video, Nintendo, etc.)					
5. I would buy a computer if I can afford one.					

6. I already have a computer at home	Yes		No	
7. I use a computer only when it is necessary to do so.	Yes		No	
8. I am learning to use computers only because it will help me to get a better job.	Yes		No	

Part II:

1 I have been working with computers for my course work for ______ years.

2 I have been at a job which requires working with computers for ______ years.

APPENDIX F (Continued)

Questionnaire 1

3. I have used different types of computers:

Yes		No	

List the type/s, including the library online catalog:
1.
2.
3.
4.

4. I have had computer-related courses:

Yes		No	

List the most recent ones:
1.
2.
3.
4.

5. I read computer magazines:

Yes		No	

List up to four:
1.
2.
3.
4.

Demographic Data:

Age: ____ Sex: ____ Native Language: __________

Academic Major:
....
If you have changed majors, please say from which to which:
....

SAT Scores:
Math: ....
Verbal: ....

Corrected Vision: ....
(Please do not fill this)

MAHALO!

APPENDIX G

Search Instructions (Oral and Demonstration)

Location: Microcomputer Lab, School of Library and Information Studies,

University of Hawaii at Manoa.

Matter presented below is of two types - that within ".." marks is oral and that within square brackets, i.e., [...] was demonstrated.

Experimenter: (to the Subject):

"This is the lab where we will be doing the experiment. As you see, this lab is equipped with microcomputers with CD ROM drives, either external or internal [point out]. One of them in fact has a "juke-box"- type of external drive, which can take up to 5 CD ROM discs".

[Take out one CD disc from the box and show it - let the student hold it. Ask them if they have seen anything similar to it. Some have seen the audio CD. Most had not seen any kind of CD].

"This is called the Compact Disc Read Only Memory - CD ROM. It is a type of optical disc. Just like magnetic discs, these discs store information, textual or numeric, and sometimes, images and sound. The recording is digital for all. A hard disk like the one here can hold up to 80 or 100 mbytes - one meg is 1 million. But this 4.5" thin shiny disk holds up to 600 mbytes, which is equal to about 250,000 pages of printed matter. This AST disc actually contains many volumes of indexes; as you can see, each disc covers a period of 6-10 years. Imagine having to go to the shelves, pulling out each volume and searching for information - how much time and effort would be involved in that manual process? This CD now enables you to search all those huge volumes at the same time, at this workstation, and that too, very fast. This is what you are here to try and do - does that sound exciting?

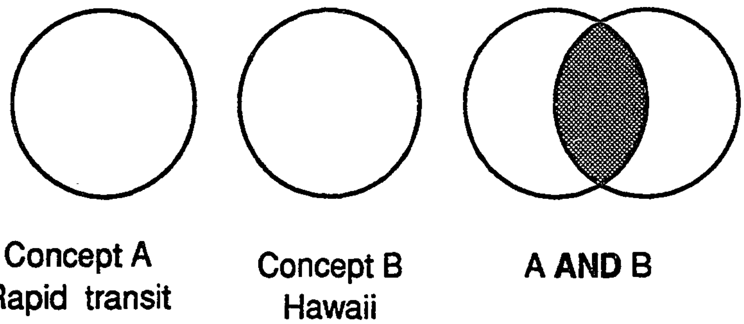
(Some subjects were nervous, because they did not know anything about CD ROMs, nor had they used computers much). There is nothing to be nervous about. I will be giving you a brief demonstration before you get on to the machine. So, relax and, try to follow closely what I do and say".

"All of you have at least seen and used a microcomputer. (All had). These are similar computers, but they have an extra device attached to them, which is called the CD drive or player - some of these drives are located in the slot previously used for a floppy drive, and in some cases they are located externally. These machine are referred to as workstations. Both Hamilton and Sinclair libraries have installed a number of these workstations in their reference units. We will be using this machine, which has been provided by The H.W. Wilson Company. There is a special software, called Wilsondisc software, which is loaded on this machine. This program is the one which makes it possible for us to search these CD ROM databases, also donated by the company for this experiment".

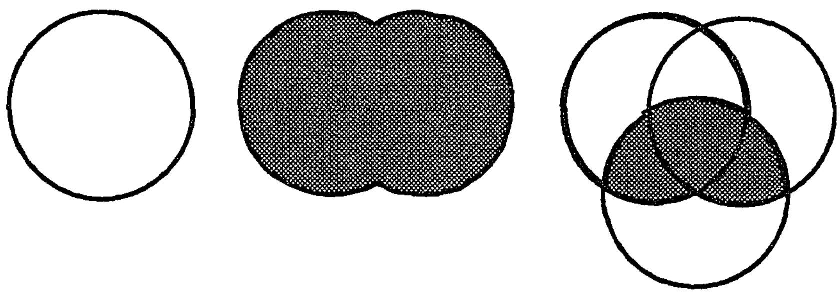
"I will now load this disc and show you how to search it for information. It is somewhat similar to searching the online catalog in the library. In general, all of us search the online catalog to look for the call numbers of books. We could search for a book by its full titles, or by some words in the title, or by its author, or by the subject of the book, when we don't know the author or title. When we search a library online catalog, we are searching a large database held in a mini computer, which contains the all the information concerning a book, called records, for all the books in the library. Here too, we will be searching large databases for similar information - the two main differences are that, (1) these databases contain information mostly on journal or magazine articles than on books, though books are also included, and (2) these articles and journals are not necessarily available in our library. But, by locating a reference on any of these CD ROM databases, we can go and search for the journals on the library catalog and find them if they are available in the library".

[Load AST and explain briefly the screens which show up]. "Wilsondiscs allow you to search them in three different modes. The Browse mode is too simple to do anything else except to search by one word or phrase. Wilsonline is too complicated for beginners to use - you need to know the special Wilson commands to use it. So, We are going to choose the Wilsearch mode from this Disc Search Menu. It is somewhat between the other two search modes in respect of its level of complexity (neither too simple nor too complicated). It is also aimed at students at the high school and undergraduate levels. [Get to the search template]. As you see, this screen is like a form - it asks you to merely fill up lines appropriate to your search. You do not need to fill the entire screen. When you do the experiment, one of the things I would like you to do is to read the instructions at the bottom of the screen - they tell you what you need to, or can do at that level. You know what a subject, an author, a title and a journal mean. Please ignore the last two lines - we will not be using them in this experiment".

"Before I start the demo, I want to show you some of the simple operators which are used in searching these systems. These are called Boolean operators. We will be using two of them - one is called the "AND" and the other "OR". Let us say we are looking for information on "Computer programs", as shown on this search guide.[Point out]. We have two basic concepts - "computer" and "programs". This is how the system will search for these concepts - first search for "computer" (A), then for "programs" (B), and lastly, combine the two, to find which article contains the topic "Computer programs" (A AND B). This can be diagrammatically shown like this:



As you see here, in the final result, the shaded portion of the last diagram has both computers and programs, while other parts have only one or the other. The process of combining different concepts in this manner to get the combined result uses the operator "AND". As you see, it is the only a portion of the three circles where they intersect each other is obtained as the result. Now let us see how to use "OR". As you know, many people refer to computer programs as "software". Software is thus an alternate term for programs. When we made the search for computer programs we may have missed the articles in which the author chose to use the term software. We can get all the information on our topic if we could search for ("programs" OR "software") and computers [show the example on the guide]. The diagram for the search will look like this: The second diagram has information either about "programs" or about "software" - the effect of choosing an alternate term for the same concept increases your output. Now see what happened when we combined the second diagram with the concept "computers" with the operator "AND". The shaded portion reduces in size.



Concept C
California

C OR B

(C OR B) AND A

Thus, when you "OR" a concept with another, you get more information, whereas with "AND", you get less information, because you are more specific in getting information on a topic which has all the concepts together in it. Please note that the operator "OR" is not used as it is, but implied by starting with the word "any" and following it with the terms programs and software. You do not need to type the operator "AND" either - it is implied whenever you use more than one term or lines. The demo will make the use of these operators clearer to you.

"Now let us do a search on some topic which interests all of us in Hawaii - "Rapid transit". How do we find information on this topic. First let us look for information on rapid transit systems in general. Let me also tell you that in this mode, you do not need to type "AND". It is the default - i.e., whether you type the subject terms on the same line (separated by spaces) or on consecutive lines, they are automatically "AND"ed. When you need to use "OR", you start the line with the word "any" - look at this demo guide [show the Wilsearch demo guide kept on the table] - you follow the word "any" with the terms which you want searched as alternate subjects, separated by spaces".

[Perform the search for information on "rapid transit" Explain the screen showing the number of hits found. Then show how to view the citations and print them Go back and modify the search to add Hawaii to the search, to make it more specific. Show how the number of citations reduce. Then go back and modify the search again to include "OR" - i.e., search for Rapid transit in Hawaii or California or Florida". Show how the number of citations increase again, because the specificity was reduced].

"You will need to print (1) the screen which shows the number of hits - use "shift + prt Screen" keys together to capture the screen. (2) print up to a maximum of 15 citations - if you get 15 or less than 15 hits, just use the function key F6 and all hits would be automatically printed; but, if you get more than 15 hits, you need to use the function key F4, individually for each hit, one at a time, fifteen times. Always read the instructions at the bottom of the screen or look at the guide, to find out which key to use. (3) Use the "esc" key to get back to the search screen and print it, using "shift + prt Screen" keys together again. You need to print this screen only after you finish printing your hits, because this search would be your final search, if you had modified the earlier ones".

"You will be performing three searches in each of these three databases Applied Science and Technology Index (AST), Business Periodicals Index and Humanities Index. I will give you the search questions one after the other. Now you may move to this chair and read these instructions. Relax, this experiment will not affect your grade in any class - my main interest is to study the differences in the way different students use this system, but I also want you to learn something which I am sure you will find useful for your own academic work".

[Give them the first 3 tasks to perform, one after the other. At the end of the third, switch the database to BPI. Give tasks 4, 5 and 6. Switch the disc to HI. Give tasks 7, 8 and 9. When the subject has finished all the tasks, thank him/her. Ask whether s/he wants to perform some search of his/her own; if yes, help in finding the information. If subject wants to know more about searching CD ROM databases, such as using word stems, etc., explain and demonstrate, as need be. [After the session, move back to the office to have the subject fill out the Questionnaire 2. Lastly, pay them $5/- and thank them once again].

APPENDIX H

Search Instructions (Written)

1. Please do feel free to write your search strategy on paper if you wish to. Else, you can do it directly on the screen.

2. Please feel free to ask the experimenter if you need clarification.

3. Please feel free to look at the search guide displayed if you wish to.

4. Go ahead and search for any other topic at the end of the session, i.e., when you have finished all the 9 tasks assigned.

APPENDIX I

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Applied Science & Technology Index (AST):

Task 1: Get me some articles on the maintenance of the Hubble space telescope.

Please ask for the next question when you are done.

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Applied Science & Technology Index (AST):

Task 2: Get information on the use of robots for the construction of space stations.

Please ask for the next question when you are done.

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Applied Science & Technology Index (AST):

Task 3: Find some articles about the combined application of lasers and machine vision

Please ask for the next question when you are done.

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Business Periodicals Index (BPI):

Task 4: Get information on IBM computer sales, reported in Electronic News.

Please ask for the next question when you are done.

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Business Periodicals Index (BPI):

Task 5: Find articles about Macintosh software for spreadsheets.

Please ask for the next question when you are done.

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Business Periodicals Index (BPI):

Task 6: Look for information on marketing by the giants Nike or Reebok in the shoe industry.

Please ask for the next question when you are done.

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Humanities Index (HI):

Task 7: Find all the books written by William Pfaff.

Please ask for the next question when you are done.

APPENDIX I (Continued)

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Humanities Index (HI):

Task 8: Get literature on the future of Judaism.

Please ask for the next question when you are done.

APPENDIX I (Continued)

TASKS

SEARCH QUESTION

Note: Do your searches and **print** up to a maximum of **15** records.

Humanities Index (HI):

Task 9: Find all information about the dances or music of American Indians.

This is the last question. Thank you!

APPENDIX J

Questionnaire 2

Please answer all the questions. Scales are 1 (low) to 3 (high); Yes/No responses need only a tick mark in one of the boxes.

1. Did you like

Task 1:	Yes		No	
Task 2:	Yes		No	
Task 3:	Yes		No	
Task 4:	Yes		No	
Task 5:	Yes		No	
Task 6:	Yes		No	
Task 7:	Yes		No	
Task 8:	Yes		No	
Task 9:	Yes		No	

2. Explain why you liked

Task 1:

Task 2:

Task 3:

Task 4:

Task 5:

Task 6:

Task 7:

Task 8:

Task 9:

3. Did you like

Appd. Sci. & Tech. Index:	Yes		No	
Humanities Index	Yes		No	
Business Periodicals Index:	Yes		No	

4. Explain why you liked

Appd. Sci. & Tech. Index:

Humanities Index:

Business Periodicals Index:

APPENDIX J (Continued)

Questionnaire 2

5. Would you like to use these again?

Yes		No	

6. If YES, please rank them in the order of most likely (3) to be used to the least likely (1)

	1	2	3
Appd. Sci. & Tech. Index:			
Humanities Index:			
Business Periodicals Index:			

7. If NO, please explain briefly why you do not like to use them again:
....
....

8. Which of the CD ROM databases did you find easy to use? Please rank them in the order of most easy (3) to the least easy (1)

	1	2	3
Appd. Sci. & Tech. Index:			
Humanities Index:			
Business Periodicals Index:			

9. If you did not find any database easy to use, please explain what you found difficult to do:
....
....

10. Do you think that any of these databases will be of use to you in the future?

Yes		No	

11. If YES, please rank them in the order of most useful (3) to the least useful (1)

	1	2	3
Appd. Sci. & Tech. Index:			
Humanities Index:			
Business Periodicals Index:			

12. If NO, please explain briefly why you think that they will be of no use to you:
....
....

Do you have any other comments?
....
....

Thank you for your cooperation!

APPENDIX K

ANOVA Tables

Table 5.4 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Perf-S/S

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	1.24E-3	6.21E-4	1.89	.1644
Sex (B)	1	2.08E-3	2.08E-3	6.32	.016
AB	2	2.61E-3	1.31E-3	3.97	.0265
Error	41	.01	3.29E-4		

There were no missing cells found.

Table 5.4 b

The AB Incidence table on Y1: Perf-S/S

	Sex:	M	F	Totals:
AcadMajor	B	4 .06	7 .05	11 .06
AcadMajor	H	4 .03	9 .05	13 .04
AcadMajor	S	19 .03	4 .07	23 .04
Totals:		27 .04	20 .06	47 .05

APPENDIX K (Continued)

ANOVA Tables

Table 5.5 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Perf-S/C

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	4.96E-4	2.48E-4	1.76	.1842
Sex (B)	1	7.54E-5	7.54E-5	.54	.4681
AB	2	3.93E-4	1.96E-4	1.4	.259
Error	41	.01	1.41E-4		

There were no missing cells found.

Table 5.5 b

The AB Incidence table on Y1: Perf-S/C

	Sex:	M	F	Totals:
AcadMajor	B	4 .01	7 .01	11 .01
AcadMajor	H	4 4.50E-3	9 2.67E-3	13 3.23E-3
AcadMajor	S	19 .01	4 .02	23 .01
Totals:		27 .01	20 .01	47 .01

APPENDIX K (Continued)

ANOVA Tables

Table 5.6 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Perf-B/S

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	.01	3.16E-3	4.18	.0222
Sex (B)	1	.01	.01	6.85	.0124
AB	2	.01	2.89E-3	3.83	.0299
Error	41	.03	7.55E-4		

There were no missing cells found.

Table 5.6 b

The AB Incidence table on Y1: Perf-B/S

	Sex:	M	F	Totals:
AcadMajor	B	4	7	11
		.03	.06	.05
	H	4	9	13
		.04	.03	.03
	S	19	4	23
		.04	.09	.05
Totals:		27	20	47
		.04	.05	.05

APPENDIX K (Continued)

ANOVA Tables

Table 5.7 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Perf-B/C

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	2.64E-3	1.32E-3	5.88	.0057
Sex (B)	1	6.47E-4	6.47E-4	2.88	.0971
AB	2	9.19E-4	4.59E-4	2.05	.1422
Error	41	.01	2.25E-4		

There were no missing cells found.

Table 5.7 b

The AB Incidence table on Y1: Perf-B/C

	Sex:	M	F	Totals:
AcadMajor	B	4 .02	7 .02	11 .02
AcadMajor	H	4 .03	9 .02	13 .02
AcadMajor	S	19 .03	4 .05	23 .03
Totals:		27 .03	20 .03	47 .03

APPENDIX K (Continued)

ANOVA Tables

Table 5.8 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Perf-H/S

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	3.81E-5	1.91E-5	.54	.5886
Sex (B)	1	9.31E-5	9.31E-5	2.62	.1131
AB	2	8.28E-5	4.14E-5	1.16	.3221
Error	41	1.46E-3	3.55E-5		

There were no missing cells found.

Table 5.8 b

The AB Incidence table on Y1: Perf-H/S

	Sex:	M	F	Totals:
AcadMajor	B	4 .03	7 .03	11 .03
	H	4 .03	9 .03	13 .03
	S	19 .03	4 .03	23 .03
Totals:		27 .03	20 .03	47 .03

APPENDIX K (Continued)

ANOVA Tables

Table 5.9 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Perf-H/C

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	.01	2.53E-3	3.85	.0293
Sex (B)	1	1.25E-3	1.25E-3	1.91	.1745
AB	2	2.84E-3	1.42E-3	2.17	.1273
Error	41	.03	6.56E-4		

There were no missing cells found.

Table 5.9 b

The AB Incidence table on Y1: Perf-H/C

	Sex:	M	F	Totals:
AcadMajor	B	4 .06	7 .05	11 .05
	H	4 .05	9 .07	13 .06
	S	19 .07	4 .1	23 .07
Totals:		27 .06	20 .07	47 .06

APPENDIX K (Continued)

ANOVA Tables

Table 5.10 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: VZ-2

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	172.92	86.46	4.28	.0205
Sex (B)	1	21.82	21.82	1.08	.3047
AB	2	7.58	3.79	.19	.8297
Error	41	828.16	20.2		

There were no missing cells found.

Table 5.10 b

The AB Incidence table on Y1: VZ-2

	Sex:	M	F	Totals:
AcadMajor	B	4	7	11
		10.56	12.68	11.91
	H	4	9	13
		10.94	11.22	11.13
	S	19	4	23
		14.72	17.12	15.14
Totals:		27	20	47
		13.55	12.91	13.28

APPENDIX K (Continued)

ANOVA Tables

Table 5.11 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: CompAffinity

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	1.85	.92	2.31	.1116
Sex (B)	1	.17	.17	.43	.5142
AB	2	.2	.1	.25	.7783
Error	41	16.37	.4		

There were no missing cells found.

Table 5.11 b

The AB Incidence table on Y1: CompAffinity

	Sex:	M	F	Totals:
AcadMajor	B	4 2.81	7 2.79	11 2.8
	H	4 3.19	9 3.14	13 3.15
	S	19 3.54	4 3.19	23 3.48
Totals:		27 3.38	20 3.03	47 3.23

APPENDIX K (Continued)

ANOVA Tables

Table 5.12 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: CompLiteracy

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	9.78	4.89	9.9	.0003
Sex (B)	1	.58	.58	1.18	.2842
AB	2	1.52	.76	1.54	.2262
Error	41	20.26	.49		

There were no missing cells found.

Table 5.12 b

The AB Incidence table on Y1: CompLiteracy

	Sex:	M	F	Totals:
AcadMajor	B	4 2.38	7 2.86	11 2.68
	H	4 2.44	9 2.11	13 2.21
	S	19 3.18	4 3.81	23 3.29
Totals:		27 2.95	20 2.71	47 2.85

APPENDIX K (Continued)

ANOVA Tables

Table 5.13 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: SATMath

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	25831.02	12915.51	1.05	.3612
Sex (B)	1	38.69	38.69	3.14E-3	.9556
AB	2	42001.28	21000.64	1.7	.1966
Error	35	431169.59	12319.13		

There were no missing cells found.

Table 5.13 b

The AB Incidence table on Y1: SATMath

AcadMajor	Sex:	M	F	Totals:
AcadMajor	B	3 530	7 567.57	10 556.3
AcadMajor	H	3 620	8 516.88	11 545
AcadMajor	S	16 580	4 652.5	20 594.5
Totals:		22 578.64	19 564.11	41 571.9

ANOVA Tables

Table 5.14 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: SATVerbal

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	85833.82	42916.91	4.59	.017
Sex (B)	1	7030.14	7030.14	.75	.3918
AB	2	21313.87	10656.94	1.14	.3315
Error	35	327300.6	9351.45		

There were no missing cells found.

Table 5.14 b

The AB Incidence table on Y1: SATVerbal

	Sex:	M	F	Totals:
AcadMajor	B	3	7	10
		363.33	465.71	435
	H	3	8	11
		490	451.25	461.82
	S	16	4	20
		527.5	557.5	533.5
Totals:		22	19	41
		500	478.95	490.24

APPENDIX K (Continued)

ANOVA Tables

Table 5.15 a

ANOVA Table for a 2-factor Analysis of Variance on Y1: Total P

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
AcadMajor (A)	2	.06	.03	8.11	.0011
Sex (B)	1	.04	.04	11	.0019
AB	2	.04	.02	5.34	.0087
Error	41	.14	3.52E-3		

There were no missing cells found.

Table 5.15 b

The AB Incidence table on Y1: Total P

	Sex:	M	F	Totals:
AcadMajor	B	4 .2	7 .23	11 .22
	H	4 .19	9 .2	13 .2
	S	19 .21	4 .37	23 .24
Totals:		27 .2	20 .24	47 .22

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