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On-line Catalogs:
Knowledge Structure and Subject Access

by

Kay A. Flowers

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE
MASTER OF ARTS

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Acknowledgments

My first thanks go to my advisor, Nancy J. Cooke, and to the other members of my committee: David Lane, Randi Martin, and Robert Dipboye.

I also acknowledge the help and support I have received from my colleagues at Fondren Library. I am particularly grateful to those colleagues, both at Fondren and elsewhere, who served as subjects in these studies. Jennifer Cargill, Sam Carrington, Edward Hayes, and Beth Shapiro were all generous with their encouragement.

Finally, I extend special thanks to my family and friends, particularly Gina Goff and Kerry Keck, for their support for this endeavor.
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Abstract

On-line Catalogs:
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by

Kay A. Flowers

On-line catalogs are replacing card catalogs in libraries. This paper reviews research covering the catalog's human-machine interface with emphasis on the difficulties of subject searching. Study 1 replicates previous findings that subject searching, though most often used, is the most problematic type of searching. In Study 2, the organization of the Library of Congress Subject Headings is compared with the knowledge structures of subject experts, subject novices, and librarians. Experts and novices in cognitive psychology differ from each other and from the subject heading structure, but librarians fall in between the two groups. The structures derived are used in Study 3 to predict the success of searching done by subject area novices and experts as well as by librarians. Experts in cognitive psychology find target books more easily than novices, but differences between librarians, subject experts, and subject novices are due to system experience, not subject expertise.
Introduction

The library catalog is the interface between users of libraries and the information libraries contain. For most of the 20th century, this function has been performed by a card catalog, a format that is now disappearing. In its place is the on-line catalog, a computer system offering on-line access to the catalog record of most (rarely all) of the books and journals in a library (Hildreth, 1985). Unlike the card catalog, which was largely standardized across the country and across types of libraries, on-line catalogs vary according to the system purchased or developed. This variability extends to the human-computer interface, the point at which the human searcher interacts with the computer database. The "human" portion is the searcher, potentially equipped with knowledge from using the system before, experience with the commands, and beliefs about how the system or other systems operate, as well as knowledge of one or more subject areas and cognitive abilities in organizing search strategies. The "computer" part of the interface is the portion seen and used by the searcher, including the terminal, the screen display, and the interactive command language, as well as the unseen element of how this interface works with the underlying database and its organization. If these elements do not work together productively, the searcher could finish a catalog search frustrated, having found nothing at all, less than what is available, or too much to effectively manipulate. Since more and more libraries have on-line catalogs and depend on them as sole access to their collections, the interface design has a direct effect on the productivity of scholars using those collections. Therefore, research is needed to understand the needs
and abilities of the user and the limitations of the interfaces so that better systems can be designed.

Whether on-line or "on paper," the catalog, a tool built by librarians to help patrons find needed materials, is very expensive to create and maintain, and its usefulness and effectiveness in both formats have been studied by many researchers. Lancaster (1977) and Markey (1980) review most of the research on card catalogs done between 1958 and 1979. Generally, these studies combined questionnaires and interviews in an attempt to find out what the patron was seeking, the information available to the patron before the search, the strategy used in the search, and whether or not the search was successful. Among the many findings from these studies are the following (selected from Lancaster, 1977, p. 69-72):

1. Few people ever remember complete bibliographic data, and often the data they do have is incorrect.
2. Most people remember titles better than authors.
3. People often remember key words in titles even when they do not remember exact titles.
4. People generally use authors for entry to the catalog before they use titles.
5. Most searches in the catalog are for known items (i.e., authors or titles).
6. Many known-item searches are, in fact, subject searches in which the user is using a known item only as an entry to a subject area.
7. Subject searches often fail because of failure to search for the right word or subject heading.
8. Subject headings are not specific enough to meet the needs of most users.

9. Subject searchers select individual items on the basis of date of publication more frequently than by name of author.

Lancaster, commenting on the reasons for studying catalogs, states

"it is likely that many of the present card and printed catalogs will someday be replaced by machine-readable catalogs capable of being searched through on-line terminals. To design effective on-line catalogs, more information is needed on how existing catalogs are being used, how successfully they are being used, and their major problems and limitations." (p. 19).

As computer-based catalogs were planned, many of these findings were incorporated in their design.

The first major computer-based catalogs, offered in the late 1970s, were originally inventory and processing systems. As might be inferred from this description, the public interfaces for these systems were afterthoughts. If the programmers asked anyone about the interface design issues, they asked librarians who were already accustomed to an older, technical interface. Therefore, the systems introduced to the public, since they were not originally meant for that purpose, were difficult for the public to use. Participants at a meeting held in 1980 (Divilbiss, 1980) to discuss the impact of public access to these systems spent as much time discussing hardware needs as they did discussing the design of the interface. Research in human-computer interaction was new and had not been applied to library systems. With this move of the catalog from cards to computer,
however, general research on database systems became relevant to the study of catalog use, performance, and satisfaction.

**Information Storage and Retrieval**

The study of information retrieval from paper indexes and abstracts predates databases, and databases (Date, 1990) existed before the on-line catalog. As computers moved into business, early systems were developed to offer access to the information in databases, most of it designed around records of employees, customer billing, inventory, etc. Retrieval was accomplished through query languages such as SQL (Structured Query Language) and QBE (Query by Example). An early review of query languages (Reisner, 1981) discusses human factors studies on these query languages and others. The studies were looking at "ease of use" as measured through tests of comprehension, query writing, retention, and productivity. The goal was to identify ways to minimize the time it took to learn a query language and to maximize the productivity of the person using the database.

Reisner (1990) updates her review of the research on query languages to include discussion of models of query writing, both conceptual and procedural. Though no research on models had been done by 1981, she reinterprets previous research to suggest how work in the area could contribute to the development of models. She goes on to describe current research that developed a three-state model of writing queries. Research in design and improvement of query languages found that changes based on errors reported in previous research did, in fact, result in improved performance by subjects. Finally, she discusses natural language queries and their comparison to query languages. In several studies, there are no
differences between the accuracy and number of valid queries in either query language or natural language.

Since these databases were often concerned with personnel records, inventory, etc., the data was structured and did not vary. For example, a salary of $50,000 can be expressed in few ways. In some cases, the databases had fields of fixed length, creating a rigid structure (e.g., no more than 10 letters for a last name). Once the format of the database was determined, this value did not vary. There were not multiple terms for the same department any more than there are multiple names for the same employee. Therefore, though a query could vary by format, according to the query language under study, the terms to be used in the query were the same.

Dumais (1990) also reviews the findings of research in query language as the first step in discussing text retrieval and new developments in indexing. The development of new systems for information storage and retrieval has not slowed since the introduction of the first systems, and research has followed these changes. Dumais (1990) discusses hypertext, artificial intelligence, and other new methods for information storage and retrieval, as well as some of the research evaluating these methods.

Among the more recent methods being examined for improving information retrieval is latent semantic indexing. In this method, a matrix of terms and associated documents is processed statistically to assess the latent semantic relationships between them. In this way, a semantic structure is built that goes beyond word occurrence in a document, thus offering the searcher more conceptual access. Research on retrieval using this method shows increases of 25% over comparable keyword searching (Dumais, 1990).
Menu systems are another method of retrieving data from structured databases, and they are particularly helpful in leading novice users through the organization of information. Research cited by Dumais (1990) discusses the problem of terms used in menus and the open question of menu length, as well as additional research in navigation issues. While menu systems are not often used in on-line catalogs, they are a central feature of the Gopher software developed at the University of Minnesota. This free software has become a popular tool for navigating network resources, the products of the "information superhighway." In some cases, menus can be several pages long for some types of information. Research on Gopher has just begun and should contribute to the overall area of menus for database access.

Keyword Searching

The central type of information retrieval relevant to on-line catalogs is keyword searching, a method first seen in citation databases. A major type of database, first available in the 1960s, reflected in the information science literature and discussed at length by Dumais (1990), the citation or bibliographic database was originally a byproduct of automated publishing systems. It is the on-line counterpart of printed indexes and abstracts--subject-based lists of references and abstracts of material published elsewhere. In their most common form, citation databases are indexed using terms from a controlled vocabulary as well as title and author, and they are searched on-line using a command-driven system combining these terms with Boolean operators (AND, OR, and NOT). Though controlled vocabularies attempt to standardize terms used for certain concepts, they are not completely successful. Both interindexer and intraindexer consistency ratings are low (Cooper, 1969). This finding means that most
of the time neither two indexers working independently nor the same indexer at different times will assign the same terms when indexing the same article using the same controlled vocabulary. Therefore, query writing in such a database is not just the correct use of the commands but the correct selection of terms as well. Research on these databases has also been reviewed by Borgman (1986c).

As the computer programs improved, indexing was extended to the free text of the abstracts in addition to the more restricted terms, and additional operators were added for adjacency of terms and co-occurrence of terms in the same field. These new searching techniques prompted research on the efficacy of the new forms of retrieval and the difficulty in learning them, particularly since there was an economic value to the information: many systems required paid intermediaries (librarians) who were trained to do keyword searching using the controlled vocabulary terms with Boolean operators, and the systems charged based on connect time and printed citations (Borgman, 1986c). The most common measures of search success used in these studies are "recall", representing the amount of information retrieved compared to the amount available, and "precision," representing the accuracy and relevancy of the material retrieved. In general, these terms are inversely related. A broad search could retrieve many citations (high recall) but have a low percentage of items relevant to the topic (low precision). On the other hand, a conservative search could produce a limited, if exact, bibliography but miss most of the information on the topic (low recall and high precision). Either type of search costs money for limited results.

The on-line catalog, as a special form of bibliographic database, shares some of the same problems as the citation databases described above.
The Library of Congress Subject Headings (LCSH), used to assign topics to books in the cataloging process, is not a strictly controlled vocabulary and is less exact than any such vocabulary currently in use. The problem of interrater consistency, or lack thereof, is also a concern. The result is that retrieval using authors and titles, which, though variable, use authorized formats and cross-references, is much more specific and successful than subject or topical searching.

Research on computer-based catalogs is, therefore, a subset of the broader field of information retrieval. Borgman (1986c) reviews much of the literature of on-line searching as it might apply to on-line catalog research. She found that many of the same user problems can be seen in both sets of research, but that the two areas are studying different populations: the information retrieval literature on citation databases concentrates on trained, expert librarians searching citation databases, while the on-line catalog literature concentrates on untrained, naive patrons searching the bibliographic database of a single library. Many problems are based on this difference in expertise. Individual differences such as personality differences are also sources of variance in success in information retrieval. Finally, the variability of features in the systems themselves are sources of the variability in search success. From this rich literature, specific problems with on-line catalogs have been identified, and many strategies have been used to study them.

Problems with On-line Catalogs

The user-system interface of an on-line catalog suffers from several observable problems associated with the difficulty of casual users searching on computers in a library environment. For example, users must extract information from the screen display of a bibliographic record. The ease
with which this information is extracted, whether it be call number, author, or title, varies with the amount of information on the display. Many catalogs may be difficult to use because their screens contain too much information (Crawford, 1987). Others may be frustrating to use because they employ a complex non-mnemonic command language or, alternatively, too many menus. Some catalogs require the construction of a search key instead of accepting a natural-language search string (i.e., they require the user to input "til/foundeart" instead of "t=foundation and earth" for a title search.) Virtually all catalogs presently available require the user to type in the information to be searched, a requirement which increases the likelihood of typographical errors and misspellings and the resulting failure and frustration. Although there have been systems which employed touch screen terminals without keyboards, this access method was found to be too slow for the catalog application due to complicated menu systems (Crawford, 1987). Though for the most part abandoned, increasing use of touch screens in public information kiosks could initiate a reevaluation of this technology.

The best example of the difficulty of using on-line catalogs is in the area of subject searching (Hildreth, 1989). As discussed above, most card catalog searches were "known-item searches," searches using an author or title to find a known item (Lancaster, 1977). Therefore, many on-line catalogs were designed to optimize the known-item search. Since on-line catalogs have become more familiar, however, statistics have shown that subject searches are more frequent and more desirable, though unfortunately more problematic (Matthews, Lawrence, & Ferguson, 1983). There are too many failures. First, the user has difficulty determining the appropriate terms for a search. The use of the Library of Congress
Subject Headings (LCSH) is often the source of this problem since it does not conform to the requirements of a controlled vocabulary. Searchers also do not understand the ways in which books are indexed, and they have difficulty implementing appropriate search strategies. Finally, in catalogs which lack full subject authority records (records which include the cross-references), users may enter incorrect terms and get no information, even though the catalog may have a great deal on the subject expressed in different terms.

Problems such as those described are still part of many catalog systems and have stimulated research into their causes and possible solutions. Four areas of research include (a) evaluating on-line catalog interfaces, both in general and in terms of specific catalogs, (b) identifying mental models of searchers, (c) identifying relevant individual differences, and (d) focusing on the subject searching process, the most problematic type of searching. Details of each of these areas of research are discussed in turn below.

Evaluations of On-line Catalogs

When studying human-computer interaction in on-line catalogs, several basic questions are usually asked.

1. Was a search successful? There are two parts to success, the first being the observed success, whether or not a user found a reasonable number of hits in response to a search request (recall and precision), and the second being the perceived success, whether or not the user found the desired information.

2. What proportion of the search failures were due to inadequacies of the collection and what proportion to
interface problems? A search could fail because the library failed to purchase the material. After eliminating these failures, those remaining are of central interest.

3. What factors differentiate successful from unsuccessful searches? For example, are there a large number of errors in command language, search string construction, or misspellings? Are there differences between users?

4. What proportion of errors are mechanical or part of the system design, and what proportion are the result of user failure, or the failure to formulate a search correctly? The former are definite candidates for change in the design. For example, if users consistently enter authors' names with the first name first, and the system accepts only last name first, perhaps a new step, which would automatically reverse author names when no hits were found, would solve the problem. User failures include, for example, using incorrect subject terms or not having enough information to perform a search (e.g., the author name "Smith" with no initials). Some of the latter types of failures can be corrected by making the system more intelligent.

5. Can errors be isolated and analyzed so that the system can be redesigned to prevent them? This question is relevant to studies on mental models such as Dickson (1984) and Borgman (1986b). If the user's mental model can be identified along with any of its
shortcomings, and if those shortcomings are
compensated for by the system, then the success rate of
the user should increase.

On-line catalogs have been studied from several perspectives, each
focusing on a different part of the problem.

The first major study of on-line catalog use, which exposed several
of the previously mentioned shortcomings and established base data for all
future studies, was conducted in 1982 under the direction of the Council on
Library Resources (Matthews et al., 1983; Ferguson, Kaske, Lawrence,
Matthews, & Zich, 1982). This study looked at users and non-users of on-
line catalogs. Questionnaires were used to reach 8,000 users and 4,000
non-users of 17 systems in 30 libraries. The questionnaire data were
supplemented by focused group interviews (Markey, 1983) and transaction
log analysis (Tolle, 1983), an analysis of the computer record of all
searches performed. The results indicated that users liked the on-line
catalogs and wanted additional terminals as well as additional information
in the database. (Many wanted journal article citations.) Users also
performed more subject searches than author or title searches, a finding
which contradicted all previous studies on card catalog use. The non-users,
while favorably disposed toward the on-line catalog, stated that they did not
use it because they had not had time to learn how. They went on to
estimate that it would take 15 to 30 minutes to learn how to use the catalog.
This finding raises questions in the area of training, since most non-users
felt it would not take long to learn but were unwilling to invest even that
short time period. This finding is similar to the "production paradox"
described by Carroll (1987), the paradox of users who wish to accomplish
something but will not take the time to learn how to do it more effectively.
As part of the same research initiative, Hildreth (1982) also looked at on-line catalogs, but he was more interested in the user interface. He compared 10 catalog systems, measuring the number of help screens, the placement of help, the command structure, screen layout, and other factors, and created a checklist of features for evaluation purposes. While his was a descriptive project, to document and assess the "state-of-the-art" in on-line catalogs, he makes it quite clear that the interfaces he was studying reflected a "successful confusion," but no real understanding of human-computer interaction (p. 37).

Since 1982, there have been several review articles, position papers, and some controlled studies of the use of on-line catalogs which tackle the interface directly. Janosky, Smith, and Hildreth (1986) examined first-time users of LCS, the on-line catalog for Ohio State University based on a circulation system developed locally. They gave subjects four questions, printed instructions, and a demonstration of on-line help, and then used verbal protocols and captured keystroke data for recording the interaction. They found that no subject was completely successful, with the rate of answering a question successfully ranging from 0% to 58% on the four questions. In looking at the errors generated as part of the search, they found that one misconception could result in a whole string of errors, a snowball effect leading to complete failure. While admitting the need for consistency in the interface, they point out that consistency with the user's mental model, the information and understanding the user brings to the interaction, is more important than consistency with the designer's conception of how the catalog does or should work. All subjects were novices, so no differences in performance, nor differences in mental models, could be analyzed on the basis of experience.
Mental Models and On-line Catalogs. The concept of a mental model of the man-machine interface, as explored by Janosky et al. (1986), is a useful concept in studying on-line catalogs (Borgman, 1984; Norman, 1983). A mental model is the user's concept of the system that is used to learn and understand the machine as well as to make predictions about its behavior. This construct has been investigated in user interactions with calculators (Young, 1981) and text editors (Douglas, 1983, as cited in Borgman, 1986b). As applied to on-line catalogs, a mental model would be the understanding or knowledge of the system or similar systems that the user brings to the catalog when performing a search. As used in this research, it is distinct from the conceptual model, the model developed by the system designer and built into the system. Borgman (1986b), starting from the hypothesis that a good mental model would improve searching success, trained subjects to use a prototype on-line catalog in two conditions: a theoretical condition which provided an analogy from which a mental model of the system could be developed, and a procedural condition which provided step-by-step instruction only. In the theoretical condition, she chose a card catalog analogy as the basis for a mental model of the on-line catalog. She found her training effects much smaller than expected, and they were limited to more complex searches where the theoretical group did better than the procedural group. On simple searches, both groups performed equally. This finding is similar to those in calculator studies: the effect is found for difficult or novel problems only (Halasz & Moran, 1983).

Dickson (1984), in analyzing transaction logs to determine user errors, found evidence that users were not using a card catalog metaphor when approaching the on-line catalog. Specifically, the searches that they
were performing could not be done in a card catalog (for example, searching for an author by entering the first name first). Dickson did not include survey data in her study, so the users' goals in their searches, as well as their perceptions of success or failure, are not available.

From the above, it is not clear what type of mental model, if any, is held by most searchers. In addition, it is not clear what type of conceptual model should be embodied in the design of on-line catalog retrieval systems. Answers to these two questions may contribute to understanding the origin of some errors and suggest possible ways of circumventing them. Crawford (1987) goes so far as to say "one task for designers may be to block this [card catalog] metaphor in such a way that patrons do not, under any circumstances, think of a patron access system as an 'on-line card catalog'" (p. 57). Yet, the research addressing these issues is incomplete. Borgman (1986b) used a prototype on-line catalog in a laboratory setting with novice users, an appropriate design for studying the training effects of mental models. However, her results offer no insight into the differences between expert and novice searchers and the mental models each brings to the search session. She also offers no insight into the models of actual systems. Dickson (1984) studied an existing system, but she looked at only the transaction log data, the computer's internal record of searches. Therefore, she could only infer mental models from error frequencies as determined by single unsuccessful searches. She had no measure of perceived success, search length, or search goal against which to judge her findings.

**Individual Differences.** Borgman (1986b; 1989) also raises questions regarding individual differences as a basis for differential success in using on-line catalogs. Specifically, 26% of her subjects failed to pass a
benchmark test, and those subjects were more likely to be humanities and social science majors. This finding contradicts Matthews et al. (1983) who found no significant individual difference other than amount of previous experience with the system. What makes Borgman's results interesting is that though humanities and social science majors may have less experience with computers (or did at that time), they are often the heaviest users of library resources. If, therefore, the heaviest users have the most trouble with the catalog interface, researchers in those areas may be hampered by poor user interface design.

Bates (1977) found that the ability to locate material in a specific area did not vary significantly according to the subject knowledge of the searcher. She compared library science graduate students with graduate students in psychology and economics in producing the one subject term for locating a book on a psychological or economic topic. Though predicting that graduate students searching in their specialty area would perform better than they did when searching in another field, she found that in fact they did slightly, though not significantly, worse. However, library science students, more familiar with the subject cataloging process, outperformed both groups, whether in their area or not. Therefore, success in subject searching may not vary according to one's knowledge or one's experience in the field but rather with one's understanding of the catalog.

**Subject Searching.** Subject searching, entering the catalog by way of a topic word or phrase, would seem the most useful type of searching to have available. In fact, most on-line catalogs have two ways to provide topical access: a subject search using the Library of Congress or other subject heading list and keyword searching with Boolean operators. However, as was
mentioned earlier, though subject searching in one form or other is now the most popular type of search, it is still the most problematic. These problems have led researchers to examine the existing methods and possible improvements.

Subject access is based on the **Library of Congress Subject Headings** (LCSH), a collection of subject headings and rules for their application which governs most cataloging done in the United States. Since this cataloging is shared through national bibliographic utilities which make catalog records available for a fee, these headings are the available subject access in virtually all on-line catalogs in the United States. Several limitations in the LCSH have been identified which could contribute to the problems inherent in subject searching. One of the most cited is the limitation in vocabulary. The subject headings are not "rich" enough to offer enough entry points for searchers (Bates, 1986; Chan, 1978). This problem is similar to the vocabulary problem described by Furnas, Landauer, Gomez, and Dumais (1987) where the variability in word usage for commands in a computer application makes success dependent on training. Another problem is finding the correct form of a subject heading. Lester (1989) examined ways to use the computer to enhance subject access by automatically creating plurals or singulars when the other form was entered, automatically truncating terms, inverting terms, etc. She found that limitations in the headings themselves could not be overcome with machine manipulation of the entry.

Bates (1986) analyzed the limitations of the subject cataloging process employed by the Library of Congress and found that it works against subject access by limiting the number of headings assigned to a work. First, the practice of whole document indexing means an item is cataloged as a whole, even if it is a collected work on many topics. Second, the principle of
uniform heading means there is only one heading for any description. Specific entry cataloging means each document is to be cataloged under the heading specific to the book and no other. In fact, catalogers are told that if they reach three headings, they should consider a broader heading. As a result of these practices, as of 1982, the average number of subject headings per book is 2.138, excluding the P classification, literature, which carries no subjects on fiction (Rather & Pietris, 1982).

Chen and Dhar (1990) looked at the entire process of subject searching by asking subjects to search for a topic of interest while thinking aloud. They found that misconceptions in searching could be grouped into a three-part taxonomy. Subject-area misconceptions are related to lack of subject-area expertise and include misinterpretation of terms, inappropriate level of specificity, and lack of knowledge of the amount of relevant work in an area. Classification-scheme misconceptions are related to the LCSH and include misinterpretation of subject headings, not understanding the indexing principles, and not consulting LCSH. The final category is system misconceptions, including misinterpretation of system messages and displays and not understanding the system capabilities.

**A Research Program**

The work reported here studies the problems in on-line catalog interfaces by focusing on one catalog in its current setting (see Appendix A). The results of a field study to identify current problems with the catalog are reported below as Study I. The problem of subject searching emerges as the most serious criticism of the current system.

Much of the research on subject searching has focused on the vocabulary of the subject headings list and ways to improve its richness. There have been fewer explorations of the problems inherent in the structure
of the LCSH, particularly as it relates to a particular subject area. In spite of advances in the field of information retrieval and thesaurus construction, the LCSH is not a controlled vocabulary. Unlike the PSYCLit Thesaurus, for example, there is no strict hierarchy that pulls it together and that leads a searcher through the vocabulary. When considering the difficulties of subject searching, one should consider that the LCSH can be thought of as a knowledge structure imposed on the record of knowledge. Therefore, questions of the level of subject expertise of the users of these headings are relevant to the success experienced by them. Knowledge structure has been shown to differentiate between novices and experts (Cooke & Schvaneveldt, 1987), and Chen and Dhar (1990) have shown that some errors are specifically related to subject-area expertise. Bates (1977), however, has shown that subject-area expertise may not affect success in searching on-line catalogs. Therefore, the structure of LCSH, a knowledge structure of its own, is the focus of the next studies in an attempt to clarify the role of subject expertise.

To explore this topic, two additional studies were conducted. Study 2 examines whether or not the structure of the LCSH in a particular subject area reflects the knowledge structures of subject experts or novices, the structure of librarians, or another structure entirely. In Study 3, the findings from Study 2 are examined to see if the knowledge structures of experts and novices predict success in using an on-line catalog with Library of Congress subject headings. In both studies, the area under consideration will be cognitive psychology since there is a supply of both experts and novices in this area. The questions to be examined include

1. What are the characteristics of the expert's knowledge representation?
2. How does this structure differ from that of novices? LCSH?
3. Can these structures be used to predict differential success using the on-line catalog?

Study 1

The first step was to replicate the findings of Matthew et al. (1983) on one specific catalog, the on-line catalog at Rice University. Therefore, users of the catalog were asked to fill out questionnaires on their use and satisfaction with the system. Since the focus of this research is the system itself, non-users of the catalog (those using the card catalog, for example) were not approached. In addition to the questionnaire, searching by some subjects was captured so that additional analysis could be done on what users actually do (as opposed to what they say they do). The goal of this experiment was to describe the use of one catalog at a particular time.

Method

Subjects

Subjects were selected from those using the central LIBRIS terminals in Fondren Library during the period March 15 to April 22, 1990 in two time periods: 1:00 PM to 6:00 PM (afternoon) and 6:00 PM to 10:00 PM (evening). These periods are associated with high reference traffic. Screen data (including information entered) and questionnaire data were collected from 20 subjects. An additional 30 subjects were given questionnaires only. Therefore, questionnaire data were collected from a total of 50 subjects. All subjects were invited to participate, and all participation was voluntary. Six of the 56 users approached (approximately 10%) refused to participate due to lack of time.
Materials and Equipment

A CompuAdd 386/25MHz running PROCOMM software with a color monitor was used to establish the search session and record screens and was set up in the room containing the central bank of LIBRIS terminals. At the time of this experiment, the regular LIBRIS terminals, Telex/Memorex 179s, had color screens and operated like the IBM 3270 family of terminals. The Telex and CompuAdd equipment differ in some minor ways. The most salient feature of the 3270 family is that they are fast as a result of the way they are connected to the central processor. The CompuAdd was connected in another manner, but the software communication rate was set at 9,600 bits per second to most closely approximate the speed of the Telex terminals. Another difference is that the information entered by the patron on a Telex terminal appears green, while the data entered on the CompuAdd appears blue, but the displays on the CompuAdd use the same colors as the Telexes. A few keys are different as well. On the Telex, a special <ENTER> key must be pressed for communication with the central computer. On the CompuAdd, the <Carriage Return> serves this function and is in a different place. Finally, for an unknown reason, the CompuAdd software echoes back the data entered after the <Carriage Return> is pressed. Therefore, for a brief moment (while the computer is performing the search) the search statement appears twice in the input line. None of the subjects commented on any of these differences.

The questionnaire (Appendix B) was adapted from the questionnaire used in the study by Matthews et al. (1983). It measures demographics, information brought to the search, and opinions of the catalog interface. It took between five and ten minutes to complete in a brief pilot study.
Procedures

Subjects were randomly selected from the regular users of the Rice catalog by using a random reminder beeper, an instrument which generates random signals at the rate of 5 beeps per hour. For the screen-capture group, when a signal was generated, the next user to enter the LIBRIS room and approach a terminal was asked to participate in a study of the catalog. These subjects then performed their search on the special terminal, and their screens were captured for later analysis. After their search, they were given a questionnaire. The sampling continued until data on 20 subjects was obtained. For the questionnaire-only group, when the signal was generated, the next user to leave a regular LIBRIS terminal was approached after completing a search. Both types of subjects were run at the same time. The difference between a screen-capture subject and a questionnaire-only subject was whether or not the special terminal was available for searching when the subject was approached. When all 20 screen-capture subjects had been completed, questionnaire-only subjects were run until a total of 30 additional subjects had completed the questionnaire.

Results

User Demographics

The subjects were primarily Rice University undergraduates. The "other" status category included undergraduates and graduate students from other colleges and universities, alumni, high school students, and people from the general community. The areas of interest were also broad, but most were in the sciences, social sciences, and humanities. There were no music majors or music interests represented. The "other" interest category
represented double interests: humanities/social sciences and English/pre-med. Tables covering the demographic and other data are in Appendix C.

These subjects were very experienced with computers and somewhat experienced with on-line catalogs. Seventy-eight percent said they use a computer weekly or daily. Another 16% use computers monthly, and 6% use them four times per year or less. There were no subjects who never used a computer. This finding is in strong contrast with the results of the 1982 study (Matthews et al., 1983). At that time, 50% of the aggregate sample, and 46% of the sample in ARL libraries never used a computer (Matthews et al., 1983). Therefore, the frequency of computer usage is so uniform that it does not account for significant variance on measures of satisfaction with the catalog, amount of material found, or general ratings of difficulty and power.

Fifty-eight percent of the subjects used the specific on-line catalog, LIBRIS, weekly or daily. An additional 24% used it monthly, and 12% used it 4 times per year. Only 6% (three subjects) had never used the catalog before the day on which the sample was taken, and of that three, two were in the "other," non-Rice status category. Also, this group has used catalogs elsewhere, with 42% reporting that they have used another on-line catalog system in the last year. The other catalogs included the University of Houston (12%), the Texas Medical Center Library (4%), Texas A&M (2%), plus 16 other catalogs, such as the University of Pennsylvania, Indiana University, University of Texas at Dallas as well as San Antonio, and Ohio State University. Several of these catalogs are based on the same software as the LIBRIS system. In fact, some subjects stated that they had learned to use LIBRIS by learning on a similar system first. Basically, then, this group demonstrated a lot of experience with
computers and on-line catalogs. The question of system expertise becomes more difficult to measure.

The purpose of the searches performed is related to the status of the searcher. Sixty-four percent of the searches were for information for a paper, not surprising since the period from mid-March to April is the time for writing term papers. An additional 20% wanted material for a class or course, 14% were doing unspecified research, 8% were doing research for publication, while another 6% were working on their dissertations. Finally, 18% were looking up material for a hobby or other recreational purpose.

Searching

The subjects were searching for books on a subject (60%), specific books (56%), books by a specific author (26%), or the availability of an item (22%). Only one person was checking publication information. Note that the subjects were told to check as many of the descriptions as applied to their research, and, consequently, these percentages are greater than 100%. Also, these percentages are similar to the 1982 breakdown (Matthews et al., 1983), and they reflect the continuing popularity of subject searching, a finding which was not predicted from the card catalog studies (Lancaster, 1977).

To achieve their goal, the subjects brought limited information to the catalog. Fifty percent brought a complete title, while another 50% brought a topic word. Thirty-six percent had a complete subject heading, and 32% had a complete author. Again, subjects were asked to choose all descriptions that applied to the information they had available; therefore, these percentages are also greater than 100%. However, if they are collapsed across type of information, 34 subjects, or 68%, brought subject information of some type to their search session.
The type of search used is available from the screen-capture data only; therefore, these totals represent only 20 of the 50 subjects described above. A "search" is defined as entering a command and search string; therefore, there are several searches per session. Given this definition, the 20 screen-capture subjects performed 88 searches: 16 author (18.18%), 16 title (18.18%), 46 subject (52.27%), and 10 keyword (11.36%). As is evident, subject searching is still the most popular type of search, although many of the subject searches were repeated attempts to find the same information. Of the 56 total searches by topic (subject plus keyword), 24 were first time searches, and 32 can be considered extensions of the same search. An extension of a search is one of three actions: adding or subtracting a term from the search string, changing the type of search (subject to keyword) with the same terms, or using new terms on the same recognizable topic. Keyword searching was introduced to the users in September, 1989, only eight months before this study was conducted, and few of the subjects used this method. Since keyword searching has the potential of being the most powerful subject searching method, this finding is revisited in Study 3.

Errors

To examine the question of what, if any, mental model is being used when approaching the catalog, the data captured on the microcomputer was examined. The errors made while searching fall into approximately four categories: problems with entering the correct search command, problems with navigating through the list of items found, problems with the appropriate search terms, and problems in stopping and starting over.

The problems with the search string include misspellings, abbreviation difficulties, problems associated with the information brought
to the catalog, or problems with typing. Some search strings, such as those for an author, were entered in the wrong order: a=samuel johnson. LIBRIS requires last name first, and so do card catalogs. Therefore, this example does not support a mental model based on the card catalog.

Another example was a patron searching for a journal title from an abbreviation: rad. eff. Though LIBRIS can be searched with truncated keywords, there are limits on how many truncated words are included in the search. Therefore, keyword searching and title searching were both ineffectual in this case. The user solved this problem by looking up the title in a book of abbreviations and then searching for the correct title, the way that this problem would have been solved with the card catalog. Since abbreviations are common in bibliographies, this is a serious problem.

The problems with navigation involved the commands "guide," "index," and "more." These commands are used to page through the information retrieved. The guide screen is the highest level, giving a general overview of the information retrieved. In the case of subject headings, guides can be many screens long (displaying up to 5,000 headings). Author/Title guides are always one screen in length in an effort to give an overview of all items retrieved. The index screen is the next level down in detail. It is an item-by-item list of the material retrieved, and is given by author or title, depending on the command originally issued. Subject indexes are by title only. "More" is used to page to the next screen of information, whether in a guide, an index, or moving from record to record.

There is some confusion on the part of the user as to which of these commands is appropriate. For example, one patron, given a short list of titles on a subject/title index screen, tried to issue the "more" command.
There were no more titles to be seen under that heading, so the patron was given the "Invalid Command Code" response. An additional problem arises from the fact that the system has no easy way to page backwards in a list. For example, if a user is on a list of 140 titles, and the current screen displays items 80-96, the only way to get to see items 54-79 is by issuing the command "i54," (for index, 54th line) or by starting over. Few patrons know this. None of the screen-capture patrons used this technique. For all these problems listed, however, the patrons in the screen-capture group issued 292 commands (i.e., m) for paging through retrieved material.

These problems with navigation are serious and are almost unique to the on-line catalog. The card catalog had guide cards, cards which stood above the rest and gave an indication of position in the sequence. However, there was no intermediate title list for scanning. Flipping through the cards was like issuing the "more" command and scanning the records. In the card catalog, however, users knew where they were and how to move back and forth between drawers, guides, and cards. In the on-line catalog the navigation is not so obvious.

Lack of a specific subject heading, coupled with a lack of cross-references, also caused problems. For example, one user made several attempts to find information on travel in specific areas, but travel is a subheading under a heading for the locale. Thus, the correct entry would be "Colorado--Description and Travel", not "Travel--Colorado." The subject headings in use in LIBRIS are identical to those used in the card catalog. However, people have trouble using them. Difficulties with subject headings may be the reason behind the high proportion of known-item searches done in card catalogs when compared with subject searches.
The subject search was more difficult and time consuming (walking between drawers), so they were not done. In the on-line environment, however, more subject searches are done. One possible reason for the increased popularity of subject searching is the time factor; a user is able to perform several unsuccessful subject searches in the time it would have taken to perform only one in the card catalog. However, the problems with the subject headings are more obvious in the on-line catalog. Even with these limitations, a card catalog mental model is not supported by the increased use of subject searching.

Some patrons had trouble starting searches or in starting over. Several seemed to believe that they had to go back to the opening screen to start a new search when in reality a search may be done from any screen. One patron began each search from the screen which explained how to do the search. Specifically, while doing an author search, the patron entered "a" and got the author search help screen, then entered the "a=" command with a search string. This sequence occurred three times, suggesting that the patron thought this procedure was necessary. There was no need to return to a starting point in a card catalog search, so the card catalog metaphor breaks down here as well. In fact, the return to a starting point is more reminiscent of a calculator being cleared before a new problem than of a catalog being searched.

The errors reported above are echoed in the responses from all the subjects to the open-ended questions provided on the questionnaire. Several subjects asked for easier subject searching or more headings. Others asked for a way to page or scroll backward in a long list. One called the system "unforgiving" of typographical errors. Therefore, the errors described appear to be important.
Attitudes Toward the Interface

In looking at general satisfaction with the catalog, 88% said they were very or somewhat satisfied with the result of their search. The question on amount of information found showed that 48% found all they were looking for or all they were looking for plus additional information. An additional 46% found some of what they were looking for. As might be expected, these two measures are related ($r(48)=.4696, \ p<.001$), with the predicted relation that the amount found affects user satisfaction.

A second area of interest involves the two general measures of difficulty and power. Eighty-six percent of all subjects rated the LIBRIS catalog easy to use (5, 6, or 7 on a seven-point scale where 1=difficult). Only one subject gave LIBRIS a "2" rating on the same scale, and no subjects rated it "1" or difficult. In terms of power, 70% of all subjects felt the system was powerful (1, 2, or 3 on a seven-point scale, 1=powerful). Again, no subject gave LIBRIS a "7," or inadequate power rating.

In seeking to explain these findings, a regression was performed using the four types of searches, author, title, subject, and keyword, and their ratings of difficulty on a scale of 1 (difficult) to 7 (easy). The measurement of overall difficulty was related to the difficulty of subject searching ($r(45)=.4648, \ p<.001$), suggesting that general problems with subject searching affect perceptions of the on-line catalog. More specifically, "selecting the right subject term" was the interface feature most frequently listed as difficult.
Discussion

Since the Matthews, et al. (1983) study, the users of on-line catalogs have changed in one major way: virtually all subjects use a computer on a weekly or daily basis. This experience with computers, as well as the large amount of experience with LIBRIS and other on-line catalogs, suggests that the group examined here was very experienced. The Rice University population may be more experienced since the Rice LIBRIS system had been in place four years before this study was conducted, and there are three other on-line systems in the city. Therefore, these findings may not generalize to the whole population, and additional research using first-year freshmen should be considered to see if expertise has any bearing on successful performance or user satisfaction.

Also, this study supported the importance of subject searching and the continuing problems experienced by users trying to perform subject searches. Related to this is the question of why users do not use keyword searching as an alternative to subject-heading searches.

Finally, this study supports the findings of the other studies reviewed in that the card catalog metaphor does not appear to be in use as a mental model for the operation of the catalog. Users entered first names first, searched mostly subjects, and started over from one point. No alternative model presents itself, though misconceptions exist which can lead to errors. For example, starting over from one point is a practice associated more with calculators. Navigation problems lead to errors in finding the correct screen. Subject searching is problematic, and misconceptions regarding search terms lead to errors and lack of satisfaction.
Study 2

Study 1 supported the importance of subject searching and the continuing problems experienced by users trying to perform subject searches. Most research on subject searching has emphasized the vocabulary of subject headings and less has been done on the structure of the LCSH and how this structure contributes to the subject searching problem. As mentioned earlier, LCSH can be viewed as a knowledge structure imposed on knowledge as stored in libraries. Because knowledge structures can differ by expertise and usage, it is legitimate to ask if the structure used by the Library of Congress, and the subject cataloging practices this structure imposes, are adequate to provide subject access to research collections used by both novices and experts in many fields.

Structure of Expertise

When looking at ways to elicit and represent knowledge structures from experts and novices in a field, several methods are used. The use of psychological scaling techniques like multidimensional scaling to reveal the underlying structure of proximity data is one approach. Another scaling method, which generates a network structure, is an algorithm called Pathfinder (Dearholt & Schvaneveldt, 1990). Pathfinder takes distance estimates and transforms them into a network pattern where each concept is a node and the links between the nodes represent associations between the concepts. The links are labeled with weights, and the network is non-spatial. This network acts as a representation of a knowledge structure. It has been used successfully to distinguish between novices and experts in several domains such as computer programming (Cooke & Schvaneveldt, 1987) and air-combat flight maneuvers (Schvaneveldt, Durso, Goldsmith, Breen, Cooke, Tucker, & DeMaio, 1985), and recently has been applied to the problem of
information retrieval (Fowler & Dearholt, 1990) and for describing
differences between experts in human-computer interaction (Gillan, Breedin,

Given previous findings that people differ in the ways they structure
knowledge according to their levels of expertise, this study examined how the
knowledge structures of experts and novices in a specific field differ from the
structure of the LCSH in that same field. The topic of Cognitive Psychology
was chosen as an area with available experts. Two methods, cluster analysis
and Pathfinder, were used to transform card sorting data into comparable
structures for novices, experts, and librarians. These derived structures
were, in turn, compared to the structure of LCSH as represented in the two
methods. Novices and experts should be significantly different in the ways in
which they structure knowledge as represented by terms in the field.
Librarians, on the other hand, as practitioners, should more closely resemble
the structure of the LCSH, a major tool for library retrieval.

Method

Subjects

Subjects were drawn from three different groups. Novices were
subjects currently taking Psychology 101, the introductory course, though
this task was not performed until after the subjects had completed the
cognitive psychology unit. Experts were graduate students who had taken a
graduate level course in cognitive psychology and who had chosen a specialty
in one of the areas of cognitive psychology. Finally, librarians were
volunteers from local and national libraries who perform original cataloging
or reference services, both tasks that require interaction with the subject
headings. To as great an extent possible, librarians that deal with the social
sciences were used. There were twenty subjects in each group.
Materials

A set of terms was created based on the *Library of Congress Subject Headings* (LCSH), 12th edition (Library of Congress, 1988). The terms did not reflect any of the relationships between headings.

In selecting the terms to use from the LCSH, three cognitive psychology textbooks, Ashcraft (1989), Best (1986), and Matlin (1989), were checked for terms from the field. Terms were extracted from the tables of contents of each book. To these terms were added words from the "New Terms" or "Key Terms" sections at the end of each chapter, plus the glossary if present (Matlin (1989) lacked a glossary). These three lists were then analyzed for common terms, and 71 terms, present in all three books, were selected to compare against the subject headings lists (Appendix D). The overlap of these various lists is shown in Table 1.

As is evident from the table, the questions of vocabulary raised by other researchers are relevant. There is less than a 50% vocabulary overlap between these textbooks in cognitive psychology. Though each book has more than 300 terms, and one over 400, only 71 are consistent across books. Therefore, vocabulary control is still an issue in the field, not just in the subject headings representing the field.

Each term selected was looked up in the LCSH. Of the 71 terms looked up in the headings lists, 22 were exact matches, 6 were present as cross-references, and 43 were not present at all. The large number of missing words is partially explained by the fact that some of the missing words are not topics, per se, and are too narrow for subject use; therefore, they would not appear in the subject heading lists. The 28 exact matches and cross-references were retained for use in this experiment. To increase the number of terms available, these 28 were supplemented by words present in
at least two of the books as well as the LCSH. This method resulted in 69 words selected.

The 69 selected words were tested for familiarity to novices. Twenty novices from the Introductory Psychology class were asked to rate their familiarity with the terms. All terms with a mean familiarity rating less than 3 (on a five-point scale) were dropped from the set of terms, producing a set of 52 terms. To this set, two terms were added back in: "feature detection theory," an example of a term not used in the subject headings, plus "phonemics," an example of a term which was not rated as familiar. These were used as tests of the selection criteria. If the term was not in the subject headings but in the textbooks, the question was where it would be placed in the structure. If words were not in the LCSH because they were not true topics, then such a term would sort under another, broader topic or would not be included in the clusters until the highest level. For the term not rated familiar, the question was whether familiarity would affect the ability of subjects to sort the terms. Therefore, 54 words were used in the final term set (Appendix D).
Table 1.

Books consulted, terms found, and percent overlap with other books.

<table>
<thead>
<tr>
<th>Book</th>
<th>Best</th>
<th>Matlin</th>
<th>Ashcraft</th>
<th>Intersection</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of terms</td>
<td>317</td>
<td>404</td>
<td>353</td>
<td>71</td>
</tr>
<tr>
<td>Percent overlap with at least one other book</td>
<td>47.6%</td>
<td>38.86%</td>
<td>48.72%</td>
<td></td>
</tr>
</tbody>
</table>
Procedure

The 54 terms were printed on slips of paper, and each subject was asked to sort them into piles according to his or her impression of how the concepts were related to one another and should be organized. The piles created could be as large or as small as necessary. The slips were randomly ordered for each subject, and the subjects were given up to one hour for the sorting task. Subjects were also given a set of blank slips of paper and encouraged to use them to create extra slips if they thought a term should be in more than one group. As an additional check on the vocabulary, subjects who thought a term incorrect were asked to add the correct term to the slip. The final pattern of organization was recorded.

Results

Quantitative Analyses

The organizational patterns from the card sorting task were analyzed in terms of conceptual closeness or proximity. For each concept pair, the number of subjects placing a pair in the same pile provided the number in a 54 x 54 matrix of the terms. A larger number indicated closer proximity (more subjects placing the pair in the same pile). This matrix was inverted and submitted to the Pathfinder algorithm to produce a network model of the knowledge structure for each group of subjects. The data were analyzed similarly using cluster analysis, producing clusters for each subject as well as a group cluster solution.

The knowledge structure of the LCSH was more difficult to represent. The LCSH terms do not lend themselves to cluster analysis. By using a presence/absence approach (if a term is present it is in a group), a basic matrix of "0s" and "1s" was built. However, any hierarchies in LCSH could not easily be reflected by clustering. Since the LCSH are not strictly
hierarchical, there was no simple algorithm to use. Several were tried (e.g., a value of "1" for a synonym, "2" for broader/narrower term, "3" for related term, etc.), but they did not produce a consistent pattern, mostly because the LCSH is not consistently hierarchical. The clusters did not adequately capture the structure present in the differing types of links.

The best example of this problem is the heading "Cognition." "Cognition" has several related terms, among which are "Perception" and "Thinking." However, there is another term, "Cognition in children," that does not share these related terms. Instead, it has narrower terms for "Human information processing in children," "Imagery (Psychology) in children," and "Perception in children." Neither "Human information processing" nor "Imagery," both legitimate subject headings, are related to the general term "Cognition." In a similar vein, "Cognition disorders" has as a narrower term "Memory, Disorders of," though "Memory," another legitimate heading, is not related to "Cognition."

Another problem with attempting to create a set of LCSH clusters comparable to the clusters of novices, experts, and librarians, is that the hierarchies of the novices and experts are in some ways products of the number of subjects. In other words, while one subject would have only two levels, two subjects would add levels and complexity, three would add more, etc. Therefore, using the presence/absence approach described earlier, it was impossible to produce a set of clusters for LCSH that had the same depth as those for the novices, experts, and librarians. In fact, additional effort was expended to be sure that these subject groups were the same size so that comparisons could be made.

As a result of these difficulties, a structure for the LCSH was directly constructed using the graphical features of KNOT (the Pathfinder software for the Macintosh). While the cluster analysis was subject to the number of
subjects present, the Pathfinder algorithm, tied to network relationships, was a more direct organizational tool. Using drawing tools provided in KNOT, a graphical representation of the LCSH was drawn by hand, thus avoiding the inconsistencies of hierarchies. This graphical representation was used for comparing the LCSH to the PFnets of the other groups (See Appendix E.)

**Within group consistency.** The first question examined was whether the clusters were consistent within groups. The consistencies of the clusters were first assessed by correlating the basic matrix of each subject against the matrix of every other subject. Experts are more consistent with each other than they are with novices or librarians (novices: $t(38)=3.782$, $p<.01$; librarians: $t(38)=3.0664$, $p<.05$). They are also significantly more consistent with each other than either the novices with novices or librarians with librarians (novices: $t(38)=3.534$, $p<.05$; librarians: $t(38)=2.6221$, $p<.05$). The other two groups are not significantly different from each other.

Each subject's matrix was then correlated with the group cluster solution for each group (Table 3). In cases where the subject was a member of the group producing the group cluster, the subject's cluster was compared with a group solution based on the other nineteen subjects. In this case, experts are more consistent with the expert cluster, showing a mean correlation of .4456, than they are with novices (mean correlation .3397, $t(38)=6.7386$, $p<.01$) or with librarians (mean correlation .3511, $t(38)=4.6786$, $p<.01$). The higher correlation of the experts (.4456) also suggests a higher degree of consistency among them. Novices are also more consistent with their group cluster than with the cluster of any other group (experts: $t(38)=5.8235$, $p<.01$; librarians: $t(38)=2.8704$, $p<.01$) as are librarians (novices: $t(38)=2.05$, $p<.05$; experts: $t(38)=3.7883$, $p<.01$). This
suggests that the subjects are more consistent with their respective group than with other groups.

Across group differences. The three correlations of the group cluster solution to the subjects in that group were then compared to each other to see if the groups were distinct. The experts are distinct from the librarians and the novices (librarians: \( t(38)=2.367, p<.05 \); novices: \( t(38)=3.2373, p<.01 \)). The librarians, however, are not distinct from the novices. Though the librarians were selected from among those who deal with the subject headings and are familiar with social sciences, they are by no means experts in cognitive psychology. Therefore, this finding is not surprising.

Correlation measures were also used to assess the similarities between the clusters. When the group clusters for novices, experts, and librarians are correlated, librarians appear more similar to novices than are experts (Table 4), thus supporting the lack of difference noted earlier. When the group clusters are compared to the basic cluster for LCSH, however, the librarians and the experts are the most similar to the LCSH.

To further assess the similarity between the subjects and the LCSH, the basic LCSH matrix was correlated with the basic matrix of each subject, and the mean correlation and standard deviation for each group is recorded in Table 5. Novices are significantly different from experts and librarians in their similarity to LCSH (experts: \( t_g(38)=5.7905, p<.01 \); librarians: \( t_g(38)=4.2556, p<.05 \)). Librarians and experts do not differ significantly on this measure. These results, with the results in Table 4, suggest that the librarians fall between the novices and experts in similarity to the LCSH.
Table 2.
**Mean (and standard deviation) correlations of sorting co-occurrence for all pairs of subjects**

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Experts</th>
<th>Librarians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novices</td>
<td>.1587</td>
<td>.1517</td>
<td>.1539</td>
</tr>
<tr>
<td></td>
<td>(.064)</td>
<td>(.071)</td>
<td>(.072)</td>
</tr>
<tr>
<td>Experts</td>
<td></td>
<td>.2315</td>
<td>.1645</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.0975)</td>
<td>(.084)</td>
</tr>
<tr>
<td>Librarians</td>
<td></td>
<td></td>
<td>.1746</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(.082)</td>
</tr>
</tbody>
</table>

Table 3.
**Mean (and standard deviation) correlations of each subject's sorting co-occurrence with the group cluster solution.**

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Experts</th>
<th>Librarians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novice Group</td>
<td>.3501</td>
<td>.3397</td>
<td>.3427</td>
</tr>
<tr>
<td></td>
<td>(.0732)</td>
<td>(.0935)</td>
<td>(.0915)</td>
</tr>
<tr>
<td>Expert Group</td>
<td>.2907</td>
<td>.4456</td>
<td>.3163</td>
</tr>
<tr>
<td></td>
<td>(.0788)</td>
<td>(.1087)</td>
<td>(.1020)</td>
</tr>
<tr>
<td>Librarian Group</td>
<td>.3280</td>
<td>.3511</td>
<td>.3682</td>
</tr>
<tr>
<td></td>
<td>(.0811)</td>
<td>(.0912)</td>
<td>(.0968)</td>
</tr>
</tbody>
</table>
Table 4.
Correlations of group clusters.

<table>
<thead>
<tr>
<th></th>
<th>Expert</th>
<th>Novice</th>
<th>LCSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Librarian</td>
<td>.6760</td>
<td>.7308</td>
<td>.3151</td>
</tr>
<tr>
<td>Expert</td>
<td></td>
<td>.6513</td>
<td>.2928</td>
</tr>
<tr>
<td>Novice</td>
<td></td>
<td></td>
<td>.2188</td>
</tr>
</tbody>
</table>

Table 5.
Mean correlations (and standard deviations) of all subjects against LC matrix

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Experts</th>
<th>Librarians</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCSH</td>
<td>.0987</td>
<td>.1521</td>
<td>.1486</td>
</tr>
<tr>
<td></td>
<td>(.0427)</td>
<td>(.0397)</td>
<td>(.0622)</td>
</tr>
</tbody>
</table>
Table 6.

*Similarities between PFnets*

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Experts</th>
<th>Librarians</th>
<th>LCSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novices</td>
<td>.2241</td>
<td>.1885</td>
<td>.1032</td>
<td></td>
</tr>
<tr>
<td>Experts</td>
<td></td>
<td>.2825</td>
<td>.1016</td>
<td></td>
</tr>
<tr>
<td>Librarians</td>
<td></td>
<td></td>
<td>.1077</td>
<td></td>
</tr>
</tbody>
</table>

Table 7:

*Means (and standard deviation) of number of groups used by subject in card sorting task*

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Experts</th>
<th>Librarians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td>10.5</td>
<td>9.3</td>
<td>8.7</td>
</tr>
<tr>
<td></td>
<td>(3.120)</td>
<td>(3.028)</td>
<td>(3.069)</td>
</tr>
</tbody>
</table>
The results from the cluster analysis and the Pathfinder algorithm differ in their measures of similarity. In Pathfinder, similarity is given by the C-measure, roughly the proportion of links in common between the two networks. Using this measure of similarity, the librarians were again more similar to the experts than to the novices (Table 6). In addition, the librarians were more similar to the subject headings than either experts or novices. Experts and novices were more similar to each other than either of them was to the subject headings. However, these measures of similarity are small and very close, and, therefore, they should be interpreted with caution.

Number of groups used in sorting task. Visual inspection of the clusters and Pathfinder networks (PFnets) (Appendix E) provides more indications of the differences between novices, experts, librarians, and the subject headings. First, while the clusters for librarians and experts both have 15 levels, the novices required 16 levels to cluster the 54 terms. The levels in the cluster are a general indication of how many piles were used in the sorting task. In general, the librarians used fewer piles for the card sorting task than the other subjects. Three librarians used only four topics to cover the 54 terms. Table 7 gives the mean number of groups used in the sorting task. However, only the difference between librarians and novices is significant ($t(38) = 1.9925, p<.05$).

Qualitative Analyses

In looking at the clusters produced, several similarities and differences are seen. The areas most similar involve language terms. All networks indicate close links between the same terms. In the clusters, this is the one area where a similar hierarchy is seen (Figures 1, 2 and 3). All the terms are close together, coming together by the fifth level (librarians), seventh level (novices), and eighth level (experts). Though the higher level for experts
might seem contradictory, examination of the words reveals that more terms are involved in this cluster than for novices or librarians, and they are added in a systematic fashion. Further, "grammar," "syntax," and "semantics" all come together at level two, compared to level seven for novices and level four for librarians. Another interesting note is the placement of "phonemics." This was the term rated unfamiliar by novices that was used in the sorting task as a test of that procedure. As is shown in the language clusters, though unfamiliar with the word, it is possible for novices to place the word in the correct area.

Several areas demonstrate differences between the four structures. For example, novices group "mnemonics" with "speech perception," not "memory." While the librarians also show a similar cluster for the language terms, they are confused by the term "surface structure," and they tie "speech perception" to "memory." "Pattern recognition" is also separated from "perception," and "mnemonics" from "memory." Though there is a definite "thinking/reasoning" group, it joins "cognition" at a high level, and it is separate from "cognitive psychology." Appendix E has the complete clusters for each group of subjects.

In general, the novice clusters come together at a higher level, indicating a lack of agreement. With the exception of the language cluster, they do not add terms systematically. This lack of agreement was seen when the basic matrix of each novice subject was compared against each other novice subject. Novices had an average intragroup correlation of .1587 compared to the average intragroup correlation of .2315 for experts (from Table 2). Experts, however, showed a greater range of variability, with correlations varying from .0055 to .5147 and a standard deviation of .0975 (versus .064 for novices).
Figure 1. Expert Language cluster.

aphasia
grammar
syntax
semantics
language
phonemics
linguistics
psycholinguistics
speech perception

Figure 2. Novice Language cluster.

grammar
language
linguistics
phonemics
psycholinguistics
semantics
syntax

Figure 3. Librarian Language cluster

grammar
syntax
language
linguistics
semantics
psycholinguistics
phonemics
In the Pathfinder networks, the novices and librarians are noted for chains of terms, whereas in the experts this structure is much less pronounced. A chain of terms is produced by terms that are connected with two links, one to the term before, and one to the term after. Most terms in the expert network have multiple links, thus producing more complicated networks of cycles (circles of terms) indicating the interrelatedness of terms. These cycles are also easily labeled, producing a "memory" network, a "perception" network, and a "language" network. In the novices and librarians, it is harder to interpret areas.

In Figures 4, 5, and 6, the "logic/reasoning" sections of experts, novices and librarians are compared. Note the cycle involving "insight" in the expert network. "Reasoning," "inference," "insight," and "logic" all have at least three links, thus causing the cycle in the middle. In the novice network (Figure 5) the terms have mostly two links. The exceptions are "insight" and "logic," but one of the links from "insight" is to "perception." usually another topic area. Another meaning of "perception," namely "insight, intuition or knowledge from perceiving" (American Heritage Dictionary, 1982) may be active in this network. The librarians (Figure 6) also have a network rich in multiple links. They too link "creativity" and "imagery" to "insight." However, they also throw in "feature detection theory" and "knowledge" as do the novices. "Feature detection theory" was the term not found in the LCSH but included in the sorting task. Its position in all three networks is linked to knowledge. However, it is actually a term from pattern recognition.

Figures 7, 8, and 9 show the network structure for memory for experts, novices, and LCSH. While "short-term memory," "working memory," and "memory" are linked in all networks, novices left out the term
"mnemonics." Experts show strong links to terms related to memory research such as "priming," reflected in the LCSH structure as well, and "interference," linked in the novice structure through the term "attention." Both novices and LCSH include "attention" in the close structure, but it is more removed for the experts. Also, all groups include the term "recognition," though novices link it additionally to "pattern recognition," probably on the basis of inclusion of the word.

**Discussion**

Structures for experts and novices in cognitive psychology were developed from the results of the knowledge elicitation. These structures are different from one another in how concepts are organized. The librarian structure is in between these two structures in terms of similarity. It has less within-group consistency than the expert structure (similar to the novices) and is most closely correlated with the novices. When librarian subjects are correlated with the LCSH matrix, their mean intergroup correlation is lower than that of experts, though higher than novices. However, in the similarities against the PFnet constructed for LCSH, librarians are more similar to the subject headings than experts.

These findings suggest that whereas experts and novices differ, the distinctions between novices and librarians and between experts and librarians are not so clear. Librarians fall in between the groups on all but one measure: similarity to LCSH. In this one case, they are more similar to the LCSH PFnet than either novices or experts. However, the differences are so low (one link in a network of 72) that they should be further investigated before any definite conclusions are drawn.
Figure 4:
Expert organization of logic/reasoning terms.
Figure 5:
Novice organization of logic/reasoning terms
Figure 6:
Librarians structure of logic/reasoning terms
Figure 7:
Expert organization of memory terms
Figure 8:
Novice organization of memory terms.

Figure 9:
LCSH organization of memory terms
Study 3

Study 3 used the knowledge structures derived in Study 2 to attempt to predict performance on subject searching tasks in the LIBRIS catalog system. The question asked is whether or not success in subject searching can be predicted from the searcher's knowledge structure in a particular set of terms. Specifically, can the knowledge structures be used to predict which searches should be difficult and which easy?

To answer these questions, a set of search problems was constructed based on the terms used in the card sorting tasks. The problems were in the form of abstracts of books held by the library and represented in the catalog (Bates, 1977). The subject headings on the books were limited to those from the list of terms generated for Study 2. Using these subject headings, the prediction was made whether or not the books would be difficult to find. If the subject headings present were linked or closely related in the knowledge structures of the subjects, the prediction was that the item would be easy to find. If the subject headings were not close to each other in the knowledge structure, then the prediction was that they would be more difficult to find. Therefore, this experiment contrasts the heading structure, as present in the headings chosen for the books, against the structure of novices and experts.

Method

Subjects

Subjects were drawn from the same three groups as above: novice students, expert graduate students, and librarians. The original sample of 20 librarians was pulled from across the country, and only local librarians were available for Study 3. This, coupled with a low number of cognitive graduate students in residence, resulted in unequal sample sizes: 6 librarians, 13
experts, and 21 novices. As described later, the novices were divided into two groups of 8 and 13.

Materials and Equipment

The equipment used was similar to that described in Study 1. A CompuAdd 486/66MHz running PROCOMM+ software was used to establish the search session and record screens. Since Study 1, the LIBRIS terminals have been replaced with CompuAdd microcomputers, so the differences between the two searching platforms were minimized. Some subjects found that the function keys did not work. Function keys are used for "Previous Record" and "Next Record" only. The keystroke equivalents were listed on the screen, and the data indicate that all subjects were able to work around this limitation. The PROCOMM software recorded an image of the screen every time the <Carriage Return> key was pressed, thus recording the search. This software does not record keystrokes; therefore, any backspaces were lost. The search strings actually sent to the computer were recorded. However, it was possible to type faster than the computer, and several experts managed to hang up the machine. The machine was set up in a private office instead of in the general terminal room, so subjects were able to search in comparative privacy and quiet.

The problem set was constructed similarly to Bates (1977). Using the terms from Study 2, a list of 1787 recent books in various areas of cognitive psychology was generated from PSYCLit. These books were searched on LIBRIS to see if they were owned and to check the subject headings assigned. Books that were owned and that had subject headings from the terms used were selected for use. While Bates (1977) limited her items to books with only one subject heading, multiple headings were accepted in this research. Books were selected where the subject headings were similar to the
knowledge structure of novices, similar to the knowledge structures of experts, and where the subject heading structure was different from both sets of subjects. Using this method, a group of 26 abstracts were coded as easy or difficult for novices and easy or difficult for experts. Though this coding lends itself to a 2x2 design, there was only one item that appeared hard for experts and easy for novices. Therefore, there were three main groups: easy experts, easy novices (EE/EN); easy experts, hard novices (EE/HN); and hard for both groups (HE/HN). The librarian structure was not considered because the central question was the success of novices and experts using the catalog, not librarians. The limited number of librarian subjects also made use of the librarian structures questionable.

The problem queries were presented in the form of the abstracts and tables of contents of the books. During a trial procedure, it became apparent that a subject would be unable to search for more than four items during the time allotted. Therefore, the abstracts were divided, with four abstracts used in the on-line portion of the experiment. An additional twelve abstracts were used in a paper and pencil session. (See Appendix G, H, and I for the abstracts used on-line).

Procedure

Each subject was given the four abstracts for the on-line task and asked to locate the book in question by formulating a search to execute in the catalog. The order in which the abstracts were searched was counterbalanced between subjects within each group. Subjects were asked to limit themselves to these subject and keyword searching methods and to avoid author and title searches. Of course, title words and authors are indexed in the keyword search. In fact, some subjects "cheated," looking for probable authors through the keyword search (e.g., k=newell, s=simon). To guarantee that all
items were searched, an arbitrary time limit of ten minutes was placed on each of the four on-line searches. A countdown timer was kept by the experimenter, but the actual time used was not recorded. The call number was provided as a means of checking for the correct item. If the subject found the item, she noted the author and title, informed the experimenter, and moved on to the next item.

After searching for four abstracts, the subjects were given the additional twelve abstracts and asked to make a list of terms or phrases they would use in order to find that item. They were also provided with the list of subject headings that had been used as search terms to locate the set of abstracts from which the twelve were taken. This list was the same set of 54 words used in the card sorting task (Appendix D). All of the abstracts provided were indexed by subject headings represented in that list. In one abstract, an additional subject heading, not found on the list, was also present. Because of the potential vocabulary problem, subjects were not limited to the list of subject headings provided. This section of the experiment took from 15 to 25 minutes to complete.

There are three limitations on this procedure. First, the ten-minute time limit was arbitrary and used for the convenience of the researcher, not as a variable. When this procedure was pre-tested with unlimited time, many novice subjects could not find some abstracts in as much as 30 minutes. It was clear a time limit was needed. Another problem with the time limit is that many subjects would not have continued searching that long. More than one subject commented that she would have "given up" if it had not been required for the task. In addition, when the equipment malfunctioned in any way, additional time was provided. For these reasons, the different times for each search were not recorded.
The second problem with this strategy was the inability to control completely for experience with the system. Introductory psychology students are often freshmen in their first semester; therefore, many are not familiar with the on-line catalog in use. While subjects were required to use only two search commands plus navigation commands, some did ask for help, and the help screens were used several times by both novices and experts. Because of the potential for system experience to confound the results, the year and major of the novices was recorded.

Finally, some subjects were better typists. While this observation may seem unimportant, in some cases success was affected by how many commands were entered and how quickly lists were scanned. This finding is reflected in how many commands were entered in successful and unsuccessful searches.

Results

Results of On-line Task

Number of books found. The base result was how many of the four books the subject found and whether this result was affected by the level of expertise of the subject (novice, expert, librarian) and/or the difficulty of the abstract. After a general discussion of findings, each of these effects will be discussed separately in the following sections. Tukey's test will be used for all pairwise comparisons. Since the Tukey test controls the experimentwise error rate, one-way analyses of variance were not done.

In Table 8, the average number of books found is given as a function of level of expertise. Although the results reflect the expected findings, the only significant difference as tested by the Tukey test occurs between novices and experts ($t_{53}(32)=4.6239, p<.01$). There are no significant differences between novices and librarians or librarians and experts.
These results imply that experts are better at locating materials in the catalog than are novices. However, it is possible that experience with the system is a more important factor than the difference in subject expertise. In Study 1, there were few subjects who had little or no experience with the online catalog, and research involving first-year freshmen was recommended. Therefore, in Study 3, the school year of the novices was recorded as a way to check for the effects of system experience. From this information, the novices were divided into two groups based on whether they were freshmen or not. This division resulted in a group of 13 freshmen novices and 8 novices that were sophomores or higher. As can be seen in Table 9, the freshmen novices (F Novices) performed much worse than the non-freshmen novices (NF Novices). Tests of the differences among the four means shown in Table 9 indicate that system experience affects the probability of finding the target book. Freshmen novices found significantly fewer books than any of the other three groups: non-freshmen novices ($t_{S}(19)=4.8507$, $p<.01$), librarians ($t_{S}(17)=3.7508$, $p<.05$), and experts ($t_{S}(24)=6.2782$, $p<.01$). The non-freshmen novices were not significantly different from either librarians or experts, nor were the librarians different from the experts.

Because the sample sizes of the four groups are very different (13, 8, 13, and 6) and two of the sample sizes are small, and because the performances of the NF novices and the librarians were very similar, these two groups were combined for the following analyses. The three groups thus produced were Freshmen Novices or F Novices (Novice System/Novice Subject, 13 subjects), System Experts, or S Experts (Expert System/Novice Subject, 14 subjects), and Experts (Expert System/Expert Subject, 13 subjects), three more equal groups. Where differential performance was
Table 8.
**Mean (and standard deviation) of number of abstracts found by group**

<table>
<thead>
<tr>
<th></th>
<th>Novices</th>
<th>Librarians</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number found</td>
<td>1.38</td>
<td>1.83</td>
<td>2.38</td>
</tr>
<tr>
<td></td>
<td>(.8048)</td>
<td>(.7528)</td>
<td>(.9608)</td>
</tr>
</tbody>
</table>

Table 9.
**Mean (and standard deviation) of number of abstracts found, novices divided.**

<table>
<thead>
<tr>
<th>Freshmen Novices</th>
<th>Non-Freshmen Novices</th>
<th>Librarians</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean number found</td>
<td>1.00</td>
<td>2.00</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td>(.5774)</td>
<td>(.7559)</td>
<td>(.7528)</td>
</tr>
</tbody>
</table>
shown, the two groups of the S Experts (librarians and non-freshmen novices) are shown in a sub-grouping.

A 3 x 4 analysis of variance was conducted using the three groups described with expertise as a between-subjects factor and abstract as a within-subjects factor. Both of the main effects were significant (subject expertise: \( F(2,37)=10.90, p<.001 \); abstract: \( F(3,111)=24.52, p<.0001 \)). In addition, there was an interaction of subject expertise and abstract (\( F(6,111)=2.77, p<.05 \)).

As can be seen in Table 10, the effect of expertise differed depending on the abstract, with Abstract 1 (EE/EN) found by 75% of the subjects, and Abstract 24 (HE/HN) found by only one subject. This interaction is depicted in Figure 10. An analysis of simple main effects revealed that abstract 20, proposed as hard for novices and easy for experts, was the primary source of the interaction (\( F(2,37)=13.43, p<.0001 \)). Freshmen novices did not find this abstract at all, while system experts and experts were able to locate it. Additional information on the nature of the abstracts and possible factors affecting the ease of searching will be discussed in a later section.
Table 10.

Number (and percent within group) of subjects finding each abstract.

<table>
<thead>
<tr>
<th>Abstract</th>
<th>EE/EN (1)</th>
<th>EE/HN (20)</th>
<th>HE/HN (6)</th>
<th>HE/HN (24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen Novices</td>
<td>9</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>69.23%</td>
<td></td>
<td>30.77%</td>
<td></td>
</tr>
<tr>
<td>System Experts</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>71.43%</td>
<td>57.14%</td>
<td>50.00%</td>
<td>7.14%</td>
</tr>
<tr>
<td>NF Novices</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>62.5%</td>
<td>75%</td>
<td>62.5%</td>
<td></td>
</tr>
<tr>
<td>Librarians</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>83.33%</td>
<td>33.33%</td>
<td>33.33%</td>
<td>16.67%</td>
</tr>
<tr>
<td>Experts</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>84.62%</td>
<td>76.92%</td>
<td>76.92%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>18</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>45.00%</td>
<td>52.50%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>
Figure 10.
Interaction of Subject Searching Success and Abstract

![Graph showing interaction between Subject Searching Success and Abstracts. The x-axis represents different abstracts labeled EE/EN (1), EE/HN (20), HE/HN(6), and HE/HN(24). The y-axis represents the number of subjects finding the abstract. The graph includes data for Freshmen Novices, System Experts, and Experts.]
Search behavior. Two of the groups in the analysis above were considered experienced with the system, and the effect of that experience can be seen in several ways. First, the effect of system experience can be seen in the number and type of searches performed, particularly the mix between keyword and subject searches. The freshmen novices were the most likely to use the subject search. Freshmen subjects performed 411 searches, of which 44.52% were subject searches. This was the highest percentage for the subject search. The system experts (including librarians and non-freshmen novices) performed 33.82% subject searches, with the novices performing 38.66% and the librarians performing 24.46%. The experts performed 27.37% subject searches. Table 12 shows the mean percentage of subject searches for each group. Freshmen novices use significantly more subject searches than either system experts or experts (system experts: \( t_s(25)=3.772, p<.05 \); experts: \( t_s(24)=5.9708, p<.01 \)). As would be expected, as experience with the system grows, and the use of subject searching decreases, the use of keyword searching grows.

Finally, as also illustrated in Table 11, the number of searches per subject per abstract decreases as expertise with the system increases. However, since those with more expertise found more items, they would have stopped searching earlier than those who did not, and thus would generate fewer searches. Therefore, these results should be interpreted with caution. Freshmen novices used significantly more searches per abstract than either system experts or experts (system experts: \( t_s(25)=4.29, p<.05 \); experts: \( t_s(24)=7.434, p<.01 \)). System experts also used significantly fewer searches per abstract than experts (\( t_s(25)=4.2597, p<.05 \)). Though the mean per abstract per subject appears different between the librarians and the non-freshmen novices, the difference is not significant.
Table 11:
Searches done by each group

<table>
<thead>
<tr>
<th>Group</th>
<th>Keyword</th>
<th>Subject</th>
<th>Total</th>
<th>Mean (Per Abstract, Per Subject)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>228</td>
<td>183</td>
<td>411</td>
<td>7.90</td>
</tr>
<tr>
<td>Novices</td>
<td>55.47%</td>
<td>44.53%</td>
<td></td>
<td>(3.28)</td>
</tr>
<tr>
<td>System</td>
<td>270</td>
<td>138</td>
<td>408</td>
<td>7.29</td>
</tr>
<tr>
<td>Experts</td>
<td>66.18%</td>
<td>33.82%</td>
<td></td>
<td>(3.53)</td>
</tr>
<tr>
<td>Librarians</td>
<td>105</td>
<td>34</td>
<td>139</td>
<td>5.79</td>
</tr>
<tr>
<td></td>
<td>74.54%</td>
<td>24.46%</td>
<td></td>
<td>(1.77)</td>
</tr>
<tr>
<td>NF Novices</td>
<td>165</td>
<td>104</td>
<td>269</td>
<td>8.41</td>
</tr>
<tr>
<td></td>
<td>61.34%</td>
<td>38.66%</td>
<td></td>
<td>(4.19)</td>
</tr>
<tr>
<td>Experts</td>
<td>260</td>
<td>98</td>
<td>358</td>
<td>6.88</td>
</tr>
<tr>
<td></td>
<td>72.63%</td>
<td>27.37%</td>
<td></td>
<td>(2.59)</td>
</tr>
</tbody>
</table>

Table 12.
Mean (and standard deviation) of Percentage of Subject Searches per Subject

<table>
<thead>
<tr>
<th></th>
<th>Freshmen Novices</th>
<th>System Experts</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Percentage</td>
<td>48.82%</td>
<td>33.46%</td>
<td>25.68%</td>
</tr>
<tr>
<td>(Standard Deviation)</td>
<td>(.3165)</td>
<td>(.2407)</td>
<td>(.1522)</td>
</tr>
</tbody>
</table>
A variable that changes with experience with the system is the number of "useless" searches (Table 13). As was mentioned in Study 1, many of the subject searches performed are actually re-searches for the same topic, just changed in some way. The reasons for changing the search string could be no hits, in which case another search is necessary, or too many hits. As shown in Figure 11, the number of records consulted rises with the number retrieved only to a certain point. After that, as the number of hits increases, fewer are consulted, and in large retrieval sets, none are consulted. Therefore, any search that produces no hits or too many hits (defined as more than 100 for this measure) is a "useless" search. That given, Table 13 shows how the number of useless searches changes with experience with the system. Novices had the most useless searches at 65%, while system experts had the fewest (52.70%).

Another interesting difference between these three groups was the number of times the target was present but missed. A missed target was defined as the item being present in an index actually displayed on the screen but not selected. The comparatively large number for the system experts suggests that while they were better searchers, they lacked the subject knowledge to recognize the item for which they were searching. The numbers of missed targets are given in Table 14.

Finally, in analyzing the screen capture data for searching behavior, many errors appeared. There were several spelling errors, but in every case the subject discovered the error and corrected it in the next screen. There were also navigation errors in that subjects would perform several steps when only one or two would have sufficed. Often subjects would back up and review items they had previously seen, in some cases reviewing an entire index twice in one session. There were also specific problems with keyword
and subject searching. Several subjects did not know the difference between these two types of search. They would try to combine subject terms using Boolean operators though the subject search expects exact matches on only one term. In the keyword search, there were also errors of logic. Some subjects appeared to want to broaden a search but would do so by adding terms with no specific operator. If no operator is specified, the system supplies the AND operator; therefore, rather than increasing the size of the return set, these additional terms actually reduced the list of hits. It is possible the subjects did not know the default operator; however, some of these errors were made by librarians who did know. The errors are summarized in Appendix F. In general, they replicate previous findings and are not the focus of this study.
Figure 11.
Items reviewed as a function of retrieval set size.
Table 13.
Number and percent of useless searches

<table>
<thead>
<tr>
<th></th>
<th>No hits</th>
<th>Too many hits</th>
<th>Total useless</th>
<th>Total Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen Novices</td>
<td>121</td>
<td>147</td>
<td>268</td>
<td>411</td>
</tr>
<tr>
<td></td>
<td>29.44%</td>
<td>35.77%</td>
<td>65.21%</td>
<td></td>
</tr>
<tr>
<td>System Experts</td>
<td>105</td>
<td>110</td>
<td>215</td>
<td>408</td>
</tr>
<tr>
<td></td>
<td>25.74%</td>
<td>26.96%</td>
<td>52.70%</td>
<td></td>
</tr>
<tr>
<td>NF Novices</td>
<td>83</td>
<td>77</td>
<td>160</td>
<td>269</td>
</tr>
<tr>
<td></td>
<td>30.86%</td>
<td>28.62%</td>
<td>59.48%</td>
<td></td>
</tr>
<tr>
<td>Librarians</td>
<td>22</td>
<td>33</td>
<td>55</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>15.83%</td>
<td>23.74%</td>
<td>39.57%</td>
<td></td>
</tr>
<tr>
<td>Experts</td>
<td>108</td>
<td>82</td>
<td>190</td>
<td>358</td>
</tr>
<tr>
<td></td>
<td>30.17%</td>
<td>22.91%</td>
<td>53.07%</td>
<td></td>
</tr>
</tbody>
</table>

Table 14.
Number of subjects not recognizing target.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Target Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experts</td>
<td>2</td>
</tr>
<tr>
<td>System Experts</td>
<td>6</td>
</tr>
<tr>
<td>Freshmen Novices</td>
<td>2</td>
</tr>
</tbody>
</table>
Abstract differences. The different abstracts also demonstrated differential success (Table 10, Figure 10). As selected, abstract 1 was easy (EE/EN), abstract 20 was hard for novices, (EE/HN), and abstracts 6 and 24 were hard for both (HE/HN). As shown in Table 10, these predictions had mixed success, and some of the factors involved will be discussed under the specific abstract. At this point, the predictions for 1 and 24 were supported. Since no difference between novices and experts was predicted, none was found. However, the prediction for 6 was not (see discussion below). Abstract 20 was mixed in that while 77% of the experts found it, so did 75% of the system experts, but none of the freshmen novices. Therefore, the prediction that abstract 20 would be easy for experts and hard for novices was supported. Factors affecting these predictions will be discussed by abstract.

Abstract number 1 (EE/EN) was universally the easiest of the four abstracts (75% of all subjects located it), while only one person, a librarian, found abstract number 24. When this finding is considered in light of the screen capture data several possibilities emerge. First of all, though all of these abstracts carried subject headings from the limited list used in Study 2, three of them had descriptive titles. In looking at the screen capture data, it is obvious that subjects were using words that appeared in the title to find material. For example, Abstract 6 (HE/HN) was the book Argument Structure by Jane Grimshaw. This book carries the subject headings "Grammar, Comparative and General -- Syntax," and "Semantics." However, (almost) every subject searched under the keywords "argument structure," both present in the title though not in the subject headings. In reviewing the abstract and table of contents provided, this is not hard to understand. It is clear that the book is about argument structure, and this phrase is repeated
many times in the table of contents. In this case, the book had an appropriately descriptive title that allowed it to be found by keyword. It was not impossible to find this book by subject. However, of the 18 subjects who located this item, only one, a freshman novice, found it through subject searching. Abstract 20 (EE/HN) also had a descriptive title. Those who found it used the keywords "symbolic processes," words from the title not present in the subject headings, thus making it easier to find than expected.

Some of the errors seen in the screen capture data relate to the actual terms used for searching the on-line catalog. Abstract 24 (HE/HN) is perhaps the most interesting. This abstract was predicted to be hard to find. The subject headings were "Human Information Processing" and "Thought and Thinking," two headings that novice and expert subjects failed to link directly in the PFnets in Study 2. These terms are linked directly by librarians, within three links in novices, and within two links in both expert and LCSH networks. While 37 of 40 subjects (92.5%) extracted the term "Information Processing" from the abstract (Table 15), none came up with the term "Thinking." Some used "Information Processing" as a subject heading (where it was cross-referenced to "Human Information Processing") and others as a keyword. Still others tried it both ways (hence the totals do not equal the number of subjects). However, only one subject, a librarian, was able to actually find the book. Another subject had the target on the screen but failed to locate it.

The reason for this failure is not the heading itself but the complications of a large catalog. With the general headings used by the Library of Congress, many books can have the same heading. One of the main problems demonstrated in the screen capture data was the problem of dealing with large return sets (as was shown in Figure 11). In this particular
abstract, most subjects had made the correct search but did not look at all the entries to find it. There were two common behaviors, both demonstrated on other abstracts as well. The first was to look at the first screen of the index only. In a keyword search, the index is arranged in reverse chronological order and alphabetical within year. Therefore, limiting the search to the first screen only means the subject was looking at the most recent books under that heading. In the case of Abstract 24, published in 1989, that search was not sufficient. The second behavior was to try to narrow the search using other terms. Abstract 24 is not rich in terms. No one considered "Thought and Thinking" as a possible term for use with this heading. In fact, the most experienced librarian stated that the book was cataloged incorrectly because "Thought and Thinking" is too broad for the subject matter of the book.

Because of this lack of terms, any attempt to limit the search removed the target from the result set. The only way to find this book was to page through a long index. Since the call number did not include a date, even this clue was not available.

Table 16 demonstrates the number of hits returned for different searches using "Information Processing." While some subjects did page through complete retrieval sets, none was longer than 45 hits. In longer indexes, the subjects were selective in what they displayed on the screen. In the case of 2201 hits, the system will not display beyond 500, and the target occurs after that point. Therefore, the last four searches are the only ones that would work. The librarian who located the item used the last search. From this example, the size of the retrieval set appears to be a major hurdle in locating material by subject.
Table 15.
Use of heading "Information Processing" by groups.

<table>
<thead>
<tr>
<th></th>
<th>Used Heading</th>
<th>Subject Searches</th>
<th>Keyword Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen Novices</td>
<td>11</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>System Experts</td>
<td>14</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>NF Novices</td>
<td>8</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Librarians</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Experts</td>
<td>12</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 16.
Retrieval sets of "Information Processing"

<table>
<thead>
<tr>
<th>Type of search</th>
<th>Retrieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>k=information processing</td>
<td>2201</td>
</tr>
<tr>
<td>k=information adj processing</td>
<td>577</td>
</tr>
<tr>
<td>k=human information processing</td>
<td>196</td>
</tr>
<tr>
<td>s=human information processing</td>
<td>154</td>
</tr>
<tr>
<td>k=(information adj processing).su.</td>
<td>149</td>
</tr>
</tbody>
</table>
Paper and Pencil Task

The continuing vocabulary problem was illustrated in the results from Part 2 of Study 3. In this section, subjects were asked to list terms that would describe the abstracts so that they could be located again. Since the subjects could not get feedback from the system on their choice of terms, they tended to list more than they would have used searching. These findings were reviewed with two questions in mind: would the subject have found the item, and how many terms did she think necessary to describe the document. Most subjects used more terms than the LCSH. As an additional measure, the descriptors from PSYCLit were also compared to the words used by the subjects. Though these provided more terms than LCSH, the subjects were still extracting more words than either indexing scheme. In part 2, the two groups of novices were combined into one group of 21 since system experience was no longer relevant to the task.

Successful search. In answer to the first question, the results of the abstract task were checked to see how often an LCSH heading was provided. The results for novices are in Table 17, followed by Tables 18 and 19 for experts and librarians respectively.

The columns giving the percent that would match LC and PL are the percentage of terms from LCSH and PSYCLit that were matched. The lower number for PSYCLit reflects the fact that PSYCLit generally provides more terms than LCSH. Therefore, subjects having a mean number of two PSYCLit terms might have only 25% of the terms available while those having only one LCSH term might have 100% of the available terms.
Table 17.

Novices: Mean terms used and match with LCSH and PSYCLit

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Mean Terms</th>
<th>% match w/LC</th>
<th>% match w/PL</th>
<th>% would find LC</th>
<th>% would find PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.238</td>
<td>71.43%</td>
<td>28.57%</td>
<td>90.48%</td>
<td>95.24%</td>
</tr>
<tr>
<td>3</td>
<td>3.762</td>
<td>16.67%</td>
<td>21.43%</td>
<td>33.33%</td>
<td>85.71%</td>
</tr>
<tr>
<td>4</td>
<td>3.571</td>
<td>58.73%</td>
<td>37.30%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5</td>
<td>3.81</td>
<td>35.71%</td>
<td>27.89%</td>
<td>85.71%</td>
<td>85.71%</td>
</tr>
<tr>
<td>7</td>
<td>4.048</td>
<td>22.22%</td>
<td>15.87%</td>
<td>52.38%</td>
<td>76.19%</td>
</tr>
<tr>
<td>11</td>
<td>4.143</td>
<td>40.48%</td>
<td>26.79%</td>
<td>76.19%</td>
<td>100.00%</td>
</tr>
<tr>
<td>12</td>
<td>3.286</td>
<td>45.24%</td>
<td>21.77%</td>
<td>76.19%</td>
<td>80.95%</td>
</tr>
<tr>
<td>13</td>
<td>4.714</td>
<td>44.44%</td>
<td>35.24%</td>
<td>85.71%</td>
<td>85.71%</td>
</tr>
<tr>
<td>16</td>
<td>3.571</td>
<td>37.25%</td>
<td>17.65%</td>
<td>71.43%</td>
<td>66.67%</td>
</tr>
<tr>
<td>19</td>
<td>2.667</td>
<td>31.75%</td>
<td>18.37%</td>
<td>95.24%</td>
<td>95.24%</td>
</tr>
<tr>
<td>21</td>
<td>2.429</td>
<td>52.38%</td>
<td>20.24%</td>
<td>52.38%</td>
<td>61.90%</td>
</tr>
<tr>
<td>26</td>
<td>3.524</td>
<td>38.10%</td>
<td>24.49%</td>
<td>90.48%</td>
<td>90.48%</td>
</tr>
<tr>
<td>Means</td>
<td>3.5636</td>
<td>41.20%</td>
<td>24.63%</td>
<td>75.79%</td>
<td>85.32%</td>
</tr>
</tbody>
</table>
Table 18.

**Experts: Mean terms used and match with LCSH and PSYCLit**

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Mean Terms</th>
<th>% match w/LC</th>
<th>% match w/PL</th>
<th>% would find LC</th>
<th>% would find PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3.077</td>
<td>84.62%</td>
<td>24.18%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3</td>
<td>3.231</td>
<td>0.00%</td>
<td>16.67%</td>
<td>0.00%</td>
<td>84.62%</td>
</tr>
<tr>
<td>4</td>
<td>3.846</td>
<td>51.28%</td>
<td>38.46%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5</td>
<td>4.077</td>
<td>34.62%</td>
<td>28.57%</td>
<td>92.31%</td>
<td>92.31%</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>25.64%</td>
<td>21.37%</td>
<td>53.85%</td>
<td>84.62%</td>
</tr>
<tr>
<td>11</td>
<td>4.538</td>
<td>65.38%</td>
<td>31.73%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>12</td>
<td>2.615</td>
<td>57.69%</td>
<td>18.68%</td>
<td>92.31%</td>
<td>92.31%</td>
</tr>
<tr>
<td>13</td>
<td>4.231</td>
<td>46.15%</td>
<td>38.46%</td>
<td>76.92%</td>
<td>76.92%</td>
</tr>
<tr>
<td>16</td>
<td>3.231</td>
<td>20.51%</td>
<td>28.85%</td>
<td>53.85%</td>
<td>76.92%</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>38.46%</td>
<td>20.88%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>21</td>
<td>3.462</td>
<td>76.92%</td>
<td>30.77%</td>
<td>76.92%</td>
<td>92.31%</td>
</tr>
<tr>
<td>26</td>
<td>3.846</td>
<td>43.59%</td>
<td>24.18%</td>
<td>84.62%</td>
<td>92.31%</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>3.6795</strong></td>
<td><strong>45.41%</strong></td>
<td><strong>26.90%</strong></td>
<td><strong>77.56%</strong></td>
<td><strong>91.03%</strong></td>
</tr>
</tbody>
</table>
Table 19.

**Librarians: Mean terms used and match with LCSH and PSYCLit**

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Mean Terms</th>
<th>% match w/LC</th>
<th>% match w/PL</th>
<th>% would find LC</th>
<th>% would find PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.167</td>
<td>66.67%</td>
<td>26.67%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3</td>
<td>2.333</td>
<td>16.67%</td>
<td>19.44%</td>
<td>33.33%</td>
<td>100.00%</td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
<td>55.56%</td>
<td>30.56%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5</td>
<td>3.167</td>
<td>45.83%</td>
<td>28.57%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>7</td>
<td>3.167</td>
<td>22.22%</td>
<td>16.67%</td>
<td>66.67%</td>
<td>83.33%</td>
</tr>
<tr>
<td>11</td>
<td>2.667</td>
<td>50.00%</td>
<td>22.92%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>12</td>
<td>1.833</td>
<td>66.67%</td>
<td>21.43%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>13</td>
<td>2.333</td>
<td>55.56%</td>
<td>33.33%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>16</td>
<td>2.5</td>
<td>55.56%</td>
<td>29.17%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>19</td>
<td>2</td>
<td>33.33%</td>
<td>14.29%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>21</td>
<td>2.167</td>
<td>100.00%</td>
<td>29.17%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>26</td>
<td>2.667</td>
<td>44.44%</td>
<td>21.43%</td>
<td>83.33%</td>
<td>100.00%</td>
</tr>
<tr>
<td><strong>Means</strong></td>
<td><strong>2.45842</strong></td>
<td><strong>51.04%</strong></td>
<td><strong>24.47%</strong></td>
<td><strong>90.28%</strong></td>
<td><strong>98.61%</strong></td>
</tr>
</tbody>
</table>
The measure of whether or not the item would be found in LCSH or PSYCLit reflects the number of subjects who had at least one heading that would have given them a chance to locate the item in the catalog or database. As is evident, the percentage is much higher for librarians than for experts, and experts are higher than novices. Also, the chance of finding something in PSYCLit is higher than in LCSH because the chance of having a PSYCLit term was higher than LCSH, though the percentage overlap was lower (there were more terms to choose from).

**Number of terms used.** Tables 17, 18, and 19 also give the mean number of terms used for each abstract. The mean across abstracts was 3.56 for novices, 3.68 for experts, and 2.46 for librarians. The low number for librarians reflects subject cataloging practice since the task presented was very similar to cataloging a book: the librarian has the title, table of contents, and abstract and must come up with appropriate headings. Since the Library of Congress does not encourage many headings, librarians did not choose many terms.

Abstract 16, *Mental Imagery* by Mark Rollins, offers one example of how additional terms were assigned to the abstracts. The Library of Congress assigned three headings: Imagery (Psychology), Cognition, and Cognitive Science. PSYCLit added the terms "Philosophies" and "Perception." In addition, PSYCLit uses the term "Cognitive Processes" to describe what is usually encompassed by "Cognition" in the LCSH, thus providing a total of six descriptors. Table 20 shows how many subjects included the LCSH headings as given. No subject had all three headings. At most, two headings were present in the lists given. Table 21 shows the number of additional different words and the mean number of words per subject. The librarians extracted only three additional words that were not
part of the subject headings, while experts and novices supplied 15 more and 20 more words respectively.

The low number of headings provided by librarians is again a reflection of the subject cataloging rules of the Library of Congress. A book should not have more than approximately three headings. If a cataloger finds that more than three headings are needed, she is encouraged to consider giving the book a broader heading that encompasses the headings previously assigned.
Table 20.
Subjects using correct subject terms.

<table>
<thead>
<tr>
<th></th>
<th>Imagery</th>
<th>Cognition</th>
<th>Cognitive Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Librarians</td>
<td>6</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Experts</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Novices</td>
<td>10</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 21
Number of additional words used by subjects

<table>
<thead>
<tr>
<th></th>
<th>Additional Words</th>
<th>Mean Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Librarians</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Experts</td>
<td>15</td>
<td>3.23</td>
</tr>
<tr>
<td>Novices</td>
<td>20</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Abstract differences. Finally, the abstracts were also coded for whether they would be easy or difficult for novices and experts. It was more difficult to interpret the abstract data in this fashion. In general, the percent of subject heading overlap was used as an indication of whether or not the terms were present. Table 22 indicates the success of the EE/EN group of abstracts. For each abstract, the percent is the mean percentage of subject terms that were generated. In other words, if a group generated an average of two subject heading terms and four were present, then they generated an average of 50% of the subject terms. Using this indication, the EE/EN abstracts were somewhat easy. Experts had higher percentages than novices, but both groups had almost a 50% or greater chance of finding the items.

Tables 23 provides the same information for the easy expert, hard novice (EE/HN) group. There were more books that fell in this category, but findings are not conclusive. Only abstract 26 shows a large difference between the ability of the two groups to generate the terms.

Table 24 gives information on the HE/HN group. Abstract 3 was definitely in this category, but abstract 2 was not, and abstract 16 may be a candidate for the hard-to-find Hard Expert/Easy Novice group. Again, the predictions were not supported.
Table 22:
EE/EN abstracts and success in LCSH

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Experts</th>
<th>Novices</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>65.38%</td>
<td>40.48%</td>
</tr>
<tr>
<td>13</td>
<td>46.15%</td>
<td>44.44%</td>
</tr>
<tr>
<td>21</td>
<td>76.92%</td>
<td>52.38%</td>
</tr>
</tbody>
</table>

Table 23:
EF/HN abstracts and success in LCSH

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Experts</th>
<th>Novices</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>51.28%</td>
<td>58.73%</td>
</tr>
<tr>
<td>7</td>
<td>25.64%</td>
<td>22.22%</td>
</tr>
<tr>
<td>12</td>
<td>57.69%</td>
<td>45.24%</td>
</tr>
<tr>
<td>19</td>
<td>38.46%</td>
<td>31.75%</td>
</tr>
<tr>
<td>26</td>
<td>65.5%</td>
<td>38.10%</td>
</tr>
</tbody>
</table>

Table 24:
HE/HN abstracts and success in LCSH

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Experts</th>
<th>Novices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>56.41%</td>
<td>71.43%</td>
</tr>
<tr>
<td>3</td>
<td>0%</td>
<td>16.67%</td>
</tr>
<tr>
<td>16</td>
<td>12.31%</td>
<td>37.25%</td>
</tr>
</tbody>
</table>
Discussion

The ability to predict searching performance based on knowledge structure was only partially supported in this research.

First, the effect of the heading structure was diluted by the importance of system experience. Experts are better at searching the on-line catalog in a particular area, but they are relying on words other than the subject headings for locating material. In some cases, the words are present in the subject headings, but often they are in the title. While there is an indication that subject experts are better searchers than either novices or librarians, additional research controlling system and vocabulary effects will be needed before definite recommendations can be made.

In the samples used in this research, materials were located due to title keywords rather than subjects, and the lack of the vocabulary can not be ignored. In fact, the item with the poorest title, that required good subject headings for access, was not located. One reason for the failure, however, was the difficulty in navigating large result sets. The researcher does not want to wade through large indexes of items, and "large" in this experiment was anything over 50 items. With a poor vocabulary, and many items under general subjects, this limitation greatly reduces the value of topical searching in the catalog.

The lack of vocabulary was also evident in the additional terms used by subjects when searching the catalog and when describing abstracts of material. Though subjects did cover some of the headings assigned by the Library of Congress, they provided additional words that enhanced the chances of retrieval. Even the additional descriptors provided by PSYCLit did not cover all the words desired by the experts in this experiment.
Several extensions to this research could be made to further tease apart the effects of system experience and subject expertise in the success and failure of subject searching in an on-line catalog. In performing the analysis on system experience, the groups available were three cells of a 2x2 design. Therefore, the first extension should be a similar project to fill the missing cell: pairing freshmen in Introductory Psychology (system novice/subject novice group) against first-year cognitive students, or against cognitive students from another university with another system (system novice/subject expert group). This arrangement would be a better division of subject novices and experts with equal system inexperience. In addition, subject experts with more experience with this system, both here and at other libraries where it is installed, could be paired with seniors in Introductory Psychology. In general, the groups were not divided sharply enough for real effects to emerge.

Another extension would be to change the nature of the task. Rather than search for books that are known to exist in the catalog, the subject could be given a general question, like a paper topic, and asked to find the five best books on that topic. The differences in terms used would better reflect subject expertise, yet the task would be more familiar to novice subjects.

Finally, searching the on-line catalog using LIBRIS should be compared to searching other catalogs using other database retrieval strategies. For example, retrieval using relevance feedback and term weighting should be compared to traditional keyword searching with Boolean operators. While some research in this area has been done, most of it involves full text databases with richer vocabularies. With the limited vocabulary of the catalog, would the relevance feedback produce better results? Since this retrieval method lists retrieval sets in order from most relevant to least, the
tendency of the searcher to ignore all but the first screen might still result in success if the software is able to locate the most relevant material.

General Discussion

Study 1, while a replication of previous research, supported those findings in the case of a specific catalog and specific environment. The catalog was considered useful and powerful, and most subjects were satisfied with their searches. However, subject searching and finding the correct subject term were features often listed as difficult. The difficulty of subject searching was the only variable significantly correlated with system difficulty.

Study 2 demonstrated that knowledge structures can be used to between novices and experts, but librarians fall between these two groups. Findings suggest that the LCSH may reflect the knowledge structure of librarians more closely than the knowledge structure of the experts in the field; however, this finding is weak and should be reexamined in other subject areas with more control for subject expertise.

Study 3 showed that while experts are better at locating target books than novices and librarians, the differences may stem from system experience more than subject-based experience. Nevertheless, differences in subject knowledge affected the ability to select the correct material and choose appropriate terms. Most subjects were reluctant to look at large result sets (n>50). Therefore, systems that increase the precision of searching are needed.

At this point, there are still many questions to be answered about the difficulties of subject searching; however, some suggestions for improvements can be made. The least likely and most global suggestion is the redesign of the Library of Congress Subject Headings to more accurately
reflect the vocabulary and structure of experts in the different subject areas. To do this, the audience for the subject headings must be identified so the product serves that audience, not just librarians. Another possibility is the enrichment of the bibliographic record through the inclusion of abstracts and tables of contents, a service now provided by some bibliographic record vendors. The research described here demonstrated that subjects could extract the correct vocabulary and formulate searches based on the abstracts and tables of contents. Such an enrichment would enhance the chances of success in keyword searching. Another possibility is adding relevance feedback to traditional keyword/Boolean searching. If items are listed from most relevant to least, based on the search, the chances of the searcher finding her target would be greatly increased. With the addition of abstracts and tables of contents, relevance feedback and term weighting would work together to make a more efficient search engine that would work harder for the user and reduce the amount of time spent in navigation.

Finally, interfaces could be designed to be configurable for different levels of expertise. Bates (1989) has suggested that such a front-end could "wrap around the subject headings" with a larger vocabulary as well as more structure. An interface which could be tailored by an individual to assist in subject searching at various levels of subject expertise would be the best solution.

The studies presented sought to establish the role of the subject heading structure in the success and failure of subject searching. Additional study is needed to further explore how researchers search the catalog for unknown material and to evaluate suggestions for improving subject-based retrieval. Such findings should be incorporated into new interfaces to be studied. With such an iterative approach, computer catalog
interfaces will change with our understanding of the user, her misconceptions, and her goals. As catalogs move beyond the book collection of the local institution to global networks, the ability to find material by subject becomes even more crucial to academic research. Research depends more and more on machine-readable data, and the interfaces of catalogs and other retrieval systems will become central to the success or failure of the academic enterprise.
References


Hildreth, C.R. (1989). Intelligent interfaces and retrieval methods for subject searching in bibliographic retrieval systems (Advances in


Appendix A.

The system under consideration is the NOTIS system, developed by Northwestern University, marketed by NOTIS Systems, Inc., and installed at Rice University's Fondren Library. This system is now installed in over 150 libraries in North and South America, including 46 of the largest libraries in the United States (as measured by membership in the Association of Research Libraries). NOTIS has gone through several releases since it was studied in 1982 (Matthews et al., 1983), and the current system implementation offers keyword searching with Boolean operators, a recent modification.

NOTIS was installed at Rice University in 1985-1986. LIBRIS, the on-line catalog module, became available to the public in May of 1986; therefore, all undergraduates as of spring 1990 have known no other catalog at Rice. Keyword search became available in September 1989. The card catalog has been closed since January 1986 making the on-line system the only source for recent materials. Thus, all patrons are encouraged to use the on-line system, and the card catalog has been removed to a remote part of the library.

The interface used by the NOTIS system is textual in nature, offering one command line on which to enter commands and search strings. At the time of the field study, the bibliographic record appeared as a card image; in other words, the various parts of the record were not labeled and were indented as they are on a catalog card. The exception to this arrangement was that the call number appeared at the bottom of the record, not at the top as in most card catalogs. Since the field study, a new interface for NOTIS
has provided a labeled screen and a slightly different command structure. Study 3 used this new interface. Neither of these changes, however, affect subject searching. One change which will affect subject searching is the inclusion of cross-references in the index screens. A searcher can now see the alternative forms of a heading without looking them up in the LCSH books.
Appendix B.

Questionnaire

Study 1
LIBRIS Questionnaire

Thank you for participating in this study. All your answers are confidential.

Information about you as a user. Unless otherwise indicated, please check only one answer:

I am

- Rice Undergraduate student
- Rice Graduate student
- Rice Faculty member
- Rice staff member
- Other: please explain

Prior to this visit, I have used or accessed this catalog (check all that apply)

- on site (in the library) only
- through a modern
- through a DTI
- through the network
- not applicable

The one category which best describes my academic area, or area of personal research, is

- Architecture
- Arts and Humanities
- Business/Management
- Engineering
- Music
- Physical/Biological Sciences
- Social Sciences
- Other: please explain

In this past year, I used other library computer systems or catalogs at (check all that apply)

- University of Houston
  (all campuses)
- Houston Academy of Medicine
  (Jones Library in Medical Center)
- Texas A&M
- Other: please list location(s)

I use a computer other than the library's computer catalog

- daily
- weekly
- monthly
- about four times a year
- about once a year
- never before today

I learned how to use this computer catalog (check all that apply)

- from a friend
- from the library staff
- using printed instructions
- using the instructions on the screen
- by myself, with no help
- Other: please explain

I use this computer catalog

- daily
- weekly
- monthly
- about four times a year
- about once a year
- never before today
Now, we need some information about how you did your search. Unless indicated, please check one answer:

I came to search the computer with the following information (check all that apply):

___ a complete author's name
___ part of an author's name
___ a complete title
___ part of a title
___ a topic word or words
___ a complete subject heading
___ Other; please explain

-----------------------------
-----------------------------
-----------------------------

By searching the computer catalog, I was hoping to find (check all that apply)

___ a specific book, journal or magazine
___ books, journals or magazines on a specific subject
___ books by a specific author
___ information such as publishers, dates, spellings of names
___ whether or not a book was available for my use
___ Other; please explain

-----------------------------
-----------------------------
-----------------------------

By doing this computer search, I found

___ everything I was looking for,
___ plus more useful information
___ all that I was looking for
___ some of what I was looking for
___ nothing I was looking for

In relation to what I was looking for, this computer search was

___ very satisfactory
___ somewhat satisfactory
___ somewhat unsatisfactory
___ very unsatisfactory

--------------------
--------------------
--------------------

In general, I think this system is:

(please circle your answer)

1----2----3----4----5----6----7

difficult  easy

--------------------
--------------------
--------------------

I need this information for

___ class or course reading
___ course paper or report
___ thesis or dissertation
___ writing for publication
___ teaching or planning a course
___ research
___ keeping up on a topic or subject
___ hobby, personal interest, or recreation
___ Other; please explain

-----------------------------
-----------------------------
-----------------------------

powerful  inadequate power

1----2----3----4----5----6----7
This part of the questionnaire asks your opinion of how this library computer catalog works. Please rate the following statements on a scale of 1 (difficult) to 7 (easy) based on your experience with this system. Please circle the number that corresponds with your answer, or "N/A" if not applicable to your experience.

<table>
<thead>
<tr>
<th>Difficult</th>
<th>Easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A computer search by title is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>A computer search by author is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>A computer search by subject is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>A computer search by keyword is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Remembering commands in the middle of the search is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Choosing the correct subject term is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Reading through multiple screens is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>If I retrieve more than I need, narrowing the search is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Understanding explanations on the screen is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Using a one letter code for the search command (such as a=) is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Understanding abbreviations on the screen (such as illus.) is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Locating call numbers on the screen is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Searching with an abbreviation of a name or word is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Using logical terms like &quot;and,&quot; &quot;or,&quot; or &quot;not&quot; is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Remembering the exact sequence or order of commands is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Understanding the initial instructions on the screen is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Reading the display for a single book is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Reading the display for a single journal is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Reading the list that shows more than a single book or journal is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Interrupting or stopping the display of information is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Typing in exact spelling, initials, spaces and hyphens is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Understanding the order in which items are displayed is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Using commands like &quot;g&quot; (for guide) and &quot;i&quot; (for index) while searching is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Correcting mistakes is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Getting help from the system is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Learning to use LIBRIS is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Understanding the help screens is</td>
<td>1-6-7 N/A</td>
</tr>
<tr>
<td>Relearning the system after occasional use is</td>
<td>1-6-7 N/A</td>
</tr>
</tbody>
</table>
On these questions, the scale is 1 (Strongly Disagree) to 7 (Strongly Agree). Circle the number corresponding to your answer.

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displayed messages are too long</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>Selecting from a list of choices takes too much time</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>The rate at which the computer responds is too slow</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>I often have to wait for a terminal to be available</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>If I make an error, I understand why</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>The screen displays are too cluttered</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>I have trouble remembering and using commands</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>I must get help frequently</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>I feel competent and knowledgeable about the system commands</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>Instructions are consistent</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
<tr>
<td>The screen displays are difficult to read</td>
<td>1 - - - - 2 - - - - 3 - - - - 4 - - - - 5 - - - - 6 - - - - 7</td>
</tr>
</tbody>
</table>

If you could change one thing in the LIBRIS on-line catalog system, what would it be?

Do you have any other comments about the LIBRIS system or this study?

Thank you for your participation!
Appendix C.

Tables from Study 1
Table 1. **Subject Demographics**

<table>
<thead>
<tr>
<th></th>
<th>Questionnaire Only</th>
<th>Screen-capture Data and Questionnaire</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent</td>
<td>N</td>
</tr>
<tr>
<td><strong>Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>15</td>
<td>30</td>
<td>11</td>
</tr>
<tr>
<td>Graduate</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Faculty</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Staff</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td><strong>Interest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Architecture</td>
<td>4</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Humanities</td>
<td>7</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Business/Mana</td>
<td>4</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Engineering</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Music</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sciences</td>
<td>5</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Social Sci.</td>
<td>7</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 2. *Information need by status of searcher*

*All questionnaires*

<table>
<thead>
<tr>
<th></th>
<th>Undergraduate</th>
<th>Graduate</th>
<th>Faculty</th>
<th>Staff</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course or class reading</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Course Paper or Report</td>
<td>16</td>
<td>2</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Thesis/ Dissertation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Writing for publication</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Teaching</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>3</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Keeping up</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Recreation/Hobby</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Table 3. **Errors and frequencies: Screen-capture Data only**  
**Collapsed across 13 subjects making errors**

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigation</td>
<td>10</td>
</tr>
<tr>
<td>Search string</td>
<td>27</td>
</tr>
<tr>
<td>Search term</td>
<td>12</td>
</tr>
<tr>
<td>Starting over</td>
<td>11</td>
</tr>
</tbody>
</table>

Subjects with no errors: 7 (of 20)
Table 4. **General Ratings of Catalog from Questionnaire**

<table>
<thead>
<tr>
<th>Satisfaction</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very satisfied</td>
<td>29</td>
<td>58</td>
</tr>
<tr>
<td>Somewhat satisfied</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Somewhat dissatisfied</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Very dissatisfied</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Amount of information found**

<table>
<thead>
<tr>
<th>Amount of information</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Everything looking for plus</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>All looking for</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Some of what looking for</td>
<td>23</td>
<td>46</td>
</tr>
<tr>
<td>None of what looking for</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

General rating of difficulty  
(1=Difficult, 7=Easy)  
Mean=5.5 (N=50)

General rating of power  
(1=Powerful, 7=Inadequate power)  
Mean=2.94 (N=50)
Appendix D.

Words used in Study 2
<table>
<thead>
<tr>
<th>The 71 matching words</th>
</tr>
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<tbody>
<tr>
<td>algorithm</td>
</tr>
<tr>
<td>artificial intelligence</td>
</tr>
<tr>
<td>attention</td>
</tr>
<tr>
<td>automatic processing</td>
</tr>
<tr>
<td>availability heuristic</td>
</tr>
<tr>
<td>bottom-up processing</td>
</tr>
<tr>
<td>chunking</td>
</tr>
<tr>
<td>cognition</td>
</tr>
<tr>
<td>cognitive psychology</td>
</tr>
<tr>
<td>computer simulation</td>
</tr>
<tr>
<td>concept formation</td>
</tr>
<tr>
<td>conceptually-driven</td>
</tr>
<tr>
<td>processes</td>
</tr>
<tr>
<td>conditional reasoning</td>
</tr>
<tr>
<td>context</td>
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<tr>
<td>data-driven processes</td>
</tr>
<tr>
<td>declarative knowledge</td>
</tr>
<tr>
<td>deep structure</td>
</tr>
<tr>
<td>depth of processing</td>
</tr>
<tr>
<td>ecological validity</td>
</tr>
<tr>
<td>elaborative rehearsal</td>
</tr>
<tr>
<td>encoding</td>
</tr>
<tr>
<td>encoding specificity</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Words used in sorting task

algorithm  language
analogy     linguistics
aphasia     logic
artificial intelligence memory
attention mnemonics
categorization paired association learning

perception

phonemics
priming
problem solving

proposition

psycholinguistics
reasoning
recognition
representation
selective attention
semantics
short-term memory

speech perception
strategy

structuralism
surface structure
syntax

thinking
working memory
Appendix E.
Clusters and PFnets
Study 2
Librarian Clusters
Novice PathFinder Network
LCSH PathFinder Network
Appendix F.

Errors from Screen Capture Data

<table>
<thead>
<tr>
<th>Category</th>
<th>Freshman Novices</th>
<th>System Experts</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Misspelling</td>
<td>21</td>
<td>20</td>
<td>11</td>
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<tr>
<td>Machine Misspelling</td>
<td>1</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Command Syntax</td>
<td>15</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Boolean in Subject</td>
<td>5</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Stop Words</td>
<td>8</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Logic</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Navigation</td>
<td>7</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>
Appendix G.
Abstracts Used in Study 3
Complete PSYCLit Entry
How do people make deductions? The orthodox answer is that they follow formal rules of inference. The authors repudiate this theory. They argue that people reason by building a model of the state of affairs, formulating a conclusion based on this model, and searching for alternative models that refute it. Formal rules work syntactically; mental models work semantically. The theories therefore make different predictions about the difficulty of deductions. The book reports experiments that compared these predictions in the main domains of deduction: propositional reasoning, relational reasoning, and quantificational reasoning. In each domain, the results corroborated the model theory and ran counter to the rule theories. // The authors relate their findings to problems in artificial intelligence, linguistics, and anthropology. They describe computer programs based on the model theory, including one that solves a major problem in the design of electronic circuits. Finally, they show how the theory resolves a long-standing controversy about rationality.
Models for connectives
Conditionals
  The model theory of the meaning of conditionals
  Deduction with conditionals
Reasoning about relations
  Two-dimensional spatial deductions
  Alternative rule theories for spatial deductions
One quantifier at a time: The psychology of syllogisms
  The causes of difficulty in syllogistic reasoning
  Formal rules for syllogistic reasoning
  Mental models for syllogistic reasoning
Many quantifiers: Reasoning with multiple quantification
  The differences between rules and models
Meta-deduction
  Meta-cognitive deduction
Deduction, non-monotonic reasoning, and parsimonious conclusions:
  How to write a reasoning program
  The combination of valid and non-monotonic reasoning
Beyond deduction: Thinking, rationality, and models
  The critique of mental models
AN: AUTHORED-BOOK 91-032011-000
TI: Argument structure.
AU: Grimshaw,-Jane
IN: Brandeis U, Professor of Linguistics & Cognitive Science, Waltham, MA, US
PY: 1990
SE: Linguistic inquiry monographs, 18.
IS: 0-262-07125-8 (hardcover)
LA: English
AT: M2; Interdisciplinary: Graduate/Professional
UD: 9203
DE: GRAMMAR-; THEORY-FORMULATION; SYNTAX-;
SEMANTICS-
CC: 2720; 27
PO: Human
CR: (from the jacket) "Argument Structure" is a contribution to linguistics at the interface between lexical syntax and lexical semantics. It will be of interest not only to linguists who focus on the nature and form of linguistic representations but also to psychologists who study the acquisition and use of language. It formulates an original and highly predictive theory of argument structure that accounts for a large number of syntactic phenomena. The main analytical focus is on passives, nominals, psychological predicates, and the theory of external arguments. /// In the course of "Argument Structure" Jane Grimshaw suggests that, contrary to the prevailing view, argument structure is in fact structured; it encodes prominence relations among arguments that reflect both their thematic and their aspectual properties. The prominence relations support a new theory of external arguments with far-reaching consequences for the syntactic behavior of predicates and the nature of cross-categorical variation in argument structure.
TC: (Abbreviated)
Acknowledgments
Principles of argument-structure representation
The structure of argument structure
Structured argument structure: The thematic dimension
Theta-marking and the structure of a-structure
Structured argument structure: The aspectual dimension
Consequences of thematic and aspectual prominence for linking
External arguments and a-structure prominence
Theta role labels
Nominalization
Ambiguity in the nominal system
Nominals and event structure
The lexical representation of nominals
Compounds and argument structure
Theta-marking properties of argument-taking nominals
Complements and modifiers
The argument structure of nominals and passives
Suppressed positions and argument adjuncts
External arguments and suppression
More evidence for suppression
Argument adjuncts in passives and nominals
Argument, adjunct, or argument adjunct?
Argument structure and anaphora
Reflexive cliticization
Local anaphora and thematic-hierarchy effects
Long-distance anaphora and prominence
AN: EDITED-BOOK  91-151011-000
AU: Hoffman,-Robert-R.  (Ed); Palermo,-David-S.  (Ed)
IN: Adelphi U, Garden City, NY, US
PY: 1991
IS: 0-8058-0903-1 (hardcover); 0-8058-0904-X (paperback)
LA: English
CH: 26 chapters selected from 27
AT: P2; Psychology: Graduate/Professional
DT: 4200: Conference Presentation
UD: 9201
CF: This volume stems from a conference held at the University of South Florida, Jan 16-17, 1987, entitled "Speaking, Reading, Thinking, and Development: The Accomplishments and Goals of Modern Research." Some chapters reflect actual conference presentations, while other chapters differ from the original presentations.
DE: COGNITIVE-PSYCHOLOGY; COGNITIVE-PROCESSES; TEACHING--; COGNITION--; VERBAL-COMPREHENSION; SPEECH- PERCEPTION; MOTOR-SKILLS; PERCEPTION--; COGNITIVE- DEVELOPMENT
CC: 2340; 23
PO: Human
CR: (from the preface) The present volume perhaps represents a further step in the maturation of cognitive psychology... If anything, this volume represents the arrival of "applied cognitive psychology." Like the previous "Cognition and the Symbolic Process" volumes, this book is "directed toward those who are engrossed in the problems of cognition and the symbolic processes" (Weimer & Palermo, 1974, xi), with the goal of laying out current theoretical and methodological issues, and new directions for research and applications. In addition, this volume is also intended to capture the overall "state of the art" by describing recent research methods and results in many of the areas of experimental psychology, including language, learning, memory, speech perception, semantics, motor skills, visual perception, problem solving, and individual differences.
TC:
  Preface
  Dedication
  A letter to James J. Jenkins
  Photograph of J. J. Jenkins
  I. Perspectives
Introduction / Robert R. Hoffman and David S. Palermo

001- <<SEE CHAPTER>> Retrospections on the study of memory and cognition / David L. Horton

002- <<SEE CHAPTER>> Direct perception and other forms of knowing / Ulric Neisser

II. Speech perception

003- <<SEE CHAPTER>> Modularity and the effects of experience / Alvin M. Liberman and Ignatius G. Mattingly

004- <<SEE CHAPTER>> A note on linguistic nativism / Michael Studdert-Kennedy

005- <<SEE CHAPTER>> Auditory enhancement in speech perception and phonology / Randy L. Diehl, Keith R. Kluender, Margaret A. Walsh and Ellen M. Parker

III. Language comprehension

006- <<SEE CHAPTER>> Holistic models of word recognition / Neal F. Johnson

007- <<SEE CHAPTER>> Syntactic modularity in sentence comprehension / Charles Clifton, Jr.

008- <<SEE CHAPTER>> Global and local context effects in sentence processing / Donald J. Foss and Shari R. Speer

009- <<SEE CHAPTER>> The complexity of reading / Philip B. Gough

IV. Cognition and motivation

010- <<SEE CHAPTER>> Cognition, motivation, and emotion: Ideology revisited / William N. Dember

011- <<SEE CHAPTER>> Metaphor and context in the language of emotion / Robert R. Hoffman, John E. Waggoner and David S. Palermo

012- <<SEE CHAPTER>> Fog cat fog / Haj Ross

V. The development of knowledge and problem-solving skills

013- <<SEE CHAPTER>> Children's theories vs. scientific theories: Differences in reasoning or differences in knowledge? / William F. Brewer and Ala Samarapungavan

014- <<SEE CHAPTER>> Cognitive physics and event perception: Two approaches to the assessment of people's knowledge of physics / John B. Pittenger

015- <<SEE CHAPTER>> Mathematical cognition: Accomplishments and challenges in research / James G. Greeno

016- <<SEE CHAPTER>> Understanding memory access / Jeffery Franks, John Bransford, Kevin Brailey and Scot Purdon

VI. Pedagogy

017- <<SEE CHAPTER>> The aesthetic basis of pedagogy / David Premack

018- <<SEE CHAPTER>> Pragmatic skills and the acquisition of linguistic competence / Judith A. Becker
019- <<SEE CHAPTER>> Educating for applications: Possibilities and paradoxes / James J. Jenkins
VII. Perception and motor skills
020- <<SEE CHAPTER>> Light and mind: Understanding the structure of film / Robert N. Kraft
021- <<SEE CHAPTER>> Ecological units of analysis and baseball's "illusions" / Claudia Carello and M. T. Turvey
022- <<SEE CHAPTER>> The role of attractors in the self-organization of intentional systems / Peter N. Kugler, Robert E. Shaw, Kim J. Vicente and Jeffrey Kinsella-Shaw
023- <<SEE CHAPTER>> Perception and representation in the development of mobility / Herbert L. Pick, Jr. and Karl S. Rosengren
VIII. Applications of cognitive psychology
024- <<SEE CHAPTER>> An eventful approach to studying mental retardation / Penelope H. Brooks and James Van Haneghan
025- <<SEE CHAPTER>> An ecological framework for ergonomic research and design / Leonard S. Mark, Marvin J. Dainoff, Robert Moritz and David Vogle
026- <<SEE CHAPTER>> Methodological problems in applied cognition and perception research: Theoretical implications / Rik Warren
Author index
Subject index
AN: AUTHORED-BOOK 89-146001-000
TI: Models of thought, Vol. 2.
AU: Simon,-Herbert-A.
PY: 1989
IS: 0-300-04230-2 (hardcover, Vol. 2); 0-300-02347-2 (hardcover, Vol. 1)
LA: English
AT: P2; Psychology; Graduate/Professional
UD: 9203
DE: COGNITIVE-PROCESSES; MODELS-; INFORMATION-THEORY; COMPREHENSION-; PROBLEM-SOLVING; THINKING-; CONCEPT-FORMATION
CC: 2340; 23
PO: Human
CR: (from the cover) In this book, Simon discusses developments in the information-processing revolution in cognitive psychology that have occurred over the last ten years. /// The volume brings together papers by Simon that focus on human performance of relatively complex tasks and on the architecture of the information-processing system that performs them.... Of particular interest in this new volume are discussions on the following topics: an improved model of short-term memory capacity based on experiments with Chinese language materials, a review of the evidence supporting the EPAM model of learning and recognition, a theory of learning from examples and its application to secondary-school mathematics learning, studies of differences between expert and novice performance in problem solving, computer simulations of scientific discovery, a theory of the role of imagery in problem solving, and an information-processing explanation of Gestalt phenomena.
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Otto Selz and information-processing psychology (1981)
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Modeling semantic memory: Effects of presenting semantic information in different modalities (1977) / with Steven Rosenberg
From words to equations: Meaning and representation in algebra word problems (1977) / with Dan A. Hinsley and John R. Hayes
The information-processing explanation of Gestalt phenomena (1987)
Index of names
Index of subjects
Appendix H.

Abstracts used in Study 3

As seen by subjects.
Examples given are from the searching experiment.
Abstracts used for the paper and pen section were in the same style.
Abstract

CR: (from the cover) How do people make deductions? The orthodox answer is that they follow formal rules of inference. The authors repudiate this theory. They argue that people reason by building a model of the state of affairs, formulating a conclusion based on this model, and searching for alternative models that refute it. Formal rules work syntactically; mental models work semantically. The theories therefore make different predictions about the difficulty of deductions. The book reports experiments that compared these predictions in the main domains of deduction: propositional reasoning, relational reasoning, and quantificational reasoning. In each domain, the results corroborated the model theory and ran counter to the rule theories. // The authors relate their findings to problems in artificial intelligence, linguistics, and anthropology. They describe computer programs based on the model theory, including one that solves a major problem in the design of electronic circuits. Finally, they show how the theory resolves a long-standing controversy about rationality.

TC: (Abbreviated)

Prologue
Acknowledgments
The logic of deduction
The concept of logical form
The cognitive science of deduction
Deduction: A theory at the computational level
Formal rules: A theory at the algorithmic level
Content-specific rules: A second theory at the algorithmic level
Mental models: A third theory at the algorithmic level
Reasoning with propositions
Models for connectives
Conditionals
The model theory of the meaning of conditionals
Deduction with conditionals
Reasoning about relations
Two-dimensional spatial deductions
Alternative rule theories for spatial deductions
One quantifier at a time: The psychology of syllogisms
The causes of difficulty in syllogistic reasoning
Formal rules for syllogistic reasoning
Mental models for syllogistic reasoning
Many quantifiers: Reasoning with multiple quantification
The differences between rules and models
Meta-deduction
Meta-cognitive deduction
Deduction, non-monotonic reasoning, and parsimonious conclusions:
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  The combination of valid and non-monotonic reasoning
Beyond deduction: Thinking, rationality, and models
  The critique of mental models
References
Author index
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CR: (from the jacket) "..." is a contribution to linguistics at the interface between lexical syntax and lexical semantics. It will be of interest not only to linguists who focus on the nature and form of linguistic representations but also to psychologists who study the acquisition and use of language. It formulates an original and highly predictive theory of argument structure that accounts for a large number of syntactic phenomena. The main analytical focus is on passives, nominals, psychological predicates, and the theory of external arguments. // In the course of "..." X suggests that, contrary to the prevailing view, argument structure is in fact structured; it encodes prominence relations among arguments that reflect both their thematic and their aspeccual properties. The prominence relations support a new theory of external arguments with far-reaching consequences for the syntactic behavior of predicates and the nature of cross-categorical variation in argument structure.

TC: (Abbreviated)

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Structured argument structure: The thematic dimension
Theta-marking and the structure of a-structure
Structured argument structure: The aspeccual dimension
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External arguments and a-structure prominence
Theta role labels
Nominalization
Ambiguity in the nominal system
Nominals and event structure
The lexical representation of nominals
Compounds and argument structure
Theta-marking properties of argument-taking nominals
Complements and modifiers
The argument structure of nominals and passives
Suppressed positions and argument adjuncts
External arguments and suppression
More evidence for suppression
Argument adjuncts in passives and nominals
Argument, adjunct, or argument adjunct?
Argument structure and anaphora
Reflexive cliticization
Local anaphora and thematic-hierarchy effects
Long-distance anaphora and prominence
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TC:

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A letter to James J. Jenkins
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I. Perspectives
   Introduction / Robert R. Hoffman and David S. Palermo 001-
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Dorothea P. Simon
A tale of two protocols (1979) / with Dorothea P. Simon
Expert and novice performance in solving physics problems (1980)
   / with Jill H. Larkin, John McDermott and Dorothea P. Simon
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   Rosenberg
From words to equations: Meaning and representation in algebra
   word problems (1977) / with Dan A. Hinsley and John R. Hayes
The information-processing explanation of Gestalt phenomena
   (1987)
Appendix I.

Items as cataloged and available on LIBRIS
Abstract 1

Search Request: K=REASONING.SU. AND PSYCHOLOGY.SU. 

Rice University
BOOK - Record 5 of 46 Entries Found

Author: Johnson-Laird, P. N. (Philip Nicholas), 1936-

Title: Deduction / P.N. Johnson-Laird, Ruth M.J. Byrne.


Description: xii, 243 p. : ill. ; 24 cm.

Notes: Includes bibliographical references (p. 217-331) and index.

Subjects: Reasoning (Psychology) 
Thought and thinking.
Logic.

Other names: Byrne, Ruth M. J.

START over Brief view <F6> FORWARD page
HELP INDEX <F6> NEXT record
OTHER options <F5> PREVIOUS record

NEXT COMMAND: start

Abstract 6

Search Request: K=ARGUMENT ADJ STRUCTURE 

Rice University
BOOK - Record 5 of 6 Entries Found

Author: Grimshaw, Jane B. (Jane Barbara), 1951-

Title: Argument structure / Jane Grimshaw.


Description: x, 202 p. : 24 cm.

Series: Linguistic inquiry monographs ; 18

Notes: Includes bibliographical references (p. <175>-197)

Subjects: Grammar, Comparative and general--Syntax.
Semantics.

LOCATION: CALL NUMBER STATUS:
MAIN STACKS P295 .G68 1990 Not checked out

START over Brief view <F6> NEXT record
HELP INDEX <F5> PREVIOUS record
OTHER options

NEXT COMMAND: start
Abstract 20

Search Request: K=Cognition and 1991
BOOK - Record 23 of 98 Entries Found

Title: Cognition and the symbolic processes : applied and ecological perspectives / edited by Robert R. Hoffman, David S. Palermo.

Description: xvii, 545 p. : ill. ; 24 cm.

Notes: Includes papers presented at the conference "Speaking, Reading, Thinking, and Development" held at the University of South Florida, Jan. 16-17, 1987. Includes bibliographical references and index.

Subjects: Cognition.
Psycholinguistics.
Perception.

Abstract 24

Search Request: K=Information processing simon thinki
BOOK - Record 1 of 1 Entry Found

Author: Simon, Herbert Alexander, 1916-

Title: Models of thought / Herbert A. Simon.

Description: 2 v. : ill. ; 26 cm.

Notes: Includes bibliographical references and index.

Subjects: Human information processing.
Thought and thinking.

LOCATION: MAIN STACKS CALL NUMBER STATUS:
BF455 .S525 Enter HOL 1 for holdings

STArt over HELP OTHER options
HOLDings BRIef view

NEXT COMMAND: