

**Supporting ease-of-use and user control:  
Desired features and structure of Web-based online IR systems**

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## ABSTRACT

The emergence of Web-based IR systems calls for the need to support ease-of-use as well as user control. This study attempts to investigate users' perceptions of ease-of-use versus user control, and desired functionalities as well as desired interface structure of online IR systems in supporting both ease-of-use and user control. Forty subjects who had an opportunity to learn and use five online databases participated in the study. Multiple methods were employed to collect data. The qualitative and quantitative analysis of the data show that users consider both ease-of-use and user control are essential for effective retrieval. The results are discussed within the context of a model of optimal support for ease-of-use and user control, particularly, emphasizing on the balance between system role and user involvement in achieving various IR sub-tasks.

**Keywords:** ease-of-use, user control, online information retrieval systems, interactive information retrieval, system role and user involvement.

## **1. Introduction**

The Internet has introduced the concept and capability of information retrieval to millions of users. There is an increasing growth in databases, producers, vendors, records and searches. From 1975 through 1999, the number of databases has grown from 301 to 11,681, the number of producers has increased from 200 to 3,674, the number of vendors has enlarged from 105 to 2,454, the number of records available have grown from 52 million records to 12.86 billion records, and searches have grown from 1974 approximately 750,000 to 90 million searches in 1998 (Williams, 2000). The trend in information retrieval (IR) system design is to design for end-users rather than the once targeted professional intermediaries.

Almost every online database system has its Web version. Web-based online systems open a new avenue for end users to retrieve information. However, the inherent interactive nature of Web-based online systems is double-sided. On the one hand, they are intuitive and easy to use; on the other hand, they are less efficient to control. From users' perspectives, they preferred the ease-of-use of variety of functions of Web interfaces, but they were also concerned that they might lose the control in this new environment (Xie & Cool, 2000). At the same time, not all functions of Web interfaces are easy to use. One of the most important characteristics of the Web-based interfaces is, as noted above, that they are interactive, and as such they provide a wider range of possibilities for searchers, which might bring greater complexity and require increased effort. Searchers want both greater user control and greater ease-of-use. They don't want one without the other.

In order to provide searchers with ease-of-use systems and at the same time allow searchers to have a certain degree of control, we need to first understand users' perceptions of ease-of-use versus user control in searching Web-based online databases. To be more specific, we need to answer the following questions:

- 1) What are users' perceptions of ease-of-use versus control in searching Web-based online databases?
- 2) What are the desired features and functionalities that support ease-of-use as well as user control?
- 3) What are the desired interface structures that support both ease-of-use and user control?

## **2. Literature Review**

The nature of information retrieval is interaction. Information retrieval involves an interactive exchange between a user and an information retrieval system (Ingwersen, 1992; Belkin, 1993; Saracevic, 1996). Information seeking is also a form of problem solving. It is pretty straightforward to search for a fact or known-item, but it takes considerable time and cognitive effort to search for a subject area (Marchionini, 1992).

Ease-of-use has been considered an important criterion for selection of information retrieval system (Lancaster, 1979; Krichmar, 1981). Designing interactive systems is not just a matter of making them easy to use; it is a matter of balancing ease against other factors, such as power and security (Thimbleby, 1990), ease-of-use and usefulness (Hartson, 1998). When ease-of-use is

perceived as important, user control is also considered essential for efficient retrieval (Bates, 1990, Xie & Cool, 2000).

In recent years researchers and designer started to realize the importance of ease-of-use as well as user control of IR systems. When Vickery and Vickery (1993) criticized the over-elaborated existing interfaces, they called for the need to design simple systems that allow flexible dialogue between user and the system. Hendry and Harper (1997) proposed the creation of an informal information-seeking environment to reduce the problem of over-determined information system. After examining a sample of interactive IR systems over time, Savage-Knepshield and Belkin (1999) concluded that greater emphasis has been placed on end-user ease-of-use. Direct manipulation and natural-language interaction with GUIs has served to increased the ease-of-use of IR user interfaces. At the same time, designers have increased the level of support afforded to interaction in IR as well as the level of control provided to the user, however, they mostly focus on query iteration and reformulation.

Although both users and designers emphasize ease-of-use in the design of IR systems, there is no simple agreement as what constitutes “ease-of-use”. According to Thimbleby (1990), although making systems easy to use is, self-evidently, a good idea and has caught on as a popular slogan, the idea is simple-minded. In reality, ease-of-use is a complex and interesting concept involving various tradeoffs. If a computer system is sufficiently powerful to be easy to use, this implies it is also sufficiently complex to confuse its users. Or if it is made easy to use, it becomes increasingly trivial, and may ultimately be easy to use only to do nothing worth doing. Miller (1971) identified several criteria that can be used to measure ease-of-use: the length of learning time, the number of errors, and exasperation responses. Other researchers proposed similar measurable attributes for ease-of-use, such as learnability, speed of user tasks performance, user error rates, and subjective user satisfaction (Hix and Hartson, 1993; Shneiderman, 1998). However, there are no standard or commonly agreed measures for ease-of-use.

Another issue related to ease-of-use and user control is which/who does what in information retrieval process. According to Hix and Hartson (1993), because use of an interactive system is a matter of cooperative task performance between the user and the system, there are times when decisions must be made about which/who does what. For many features, there will be both a user task and an associated system function. Some jobs will be allocated to the user only; these are the manual tasks. Some jobs will be allocated to the system only; these are the automated functions. Bates (1990) wrote a very provocative piece in which she asked a very important question for the design of an IR system, “what capabilities should we design for the system, and what capabilities should we enable the searcher to exercise?” She argued that IR systems should support searcher control and system retrieval power. However, after evaluating the early Text Retrieval Conferences (TREC) Interactive Track results, Beaulieu, Robertson and Rasmussen (1996) found that it is not an easy task to design the system so that searchers involvements can improve the search performance.

The discussion of ease-of-use and user control is worthless without the discussion of user tasks. Task analysis which include how the task and sub-tasks are performed are essential for interface design (Diaper, 1989; Hackos & Redish, 1998). While perceived ease-of-use is an important factor in determining the use of information systems, a good interface alone does not make an

information system easy to use. Mathieson & Keil (1998) noted the perceived ease-of-use is affected by the fit between task and technology. An information system that allows a user perform a task more effectively will be perceived as easier to use, and a system that does not allow the user to achieve their goal will be perceived as difficult to use, even if they have comparable interfaces.

In addition to recognition and definition of a problem, Marchionini (1995) defined a sequence of tasks for information seeking, including: selection of information source, query formulation, search execution, result examination, information extraction, information search reflection, iteration, and completion. Xie and Cool (2000) further identified five sub-tasks that users have to achieve in order to accomplish their search tasks in the online environment: databases selection, query formulation, query reformulation, results organization and display and results delivery. This study builds on the classification of these five sub-tasks.

### **3. Methodology**

Forty students who took the class “Electronic Information Retrieval Systems” in spring 2001 were recruited for the study. The advantages of this sample selection are: 1) These students are representatives of future information professionals, and will be the main users of variety of online systems. 2) All of the participants have prior experience utilizing Web search engines but had no or very little experience searching online databases. 3) These students were provided with the opportunity to access multiple online systems in this class. 4) In-depth data could be collected within a period of four months through multiple methods as part of the class requirements. Participants searched DIALOG Web, Lexis-Nexis Web, FirstSearch Web, Dow Jones Interactive, and Ovid Web. The systems picked for this study are not an exhaustive sample of online services, but rather a representative group of most frequently used and highly respected systems (Williams, 2000). Their search experiences of these online systems were recorded through the semester.

In order to investigate the research problem and research questions, data collection involved three steps: 1) data collected before participants started their searches on any online system; 2) data collected when participants searched each individual online systems, and 3) data collected when participants searched and compared multiple online systems. Multiple methods were used to collect the data: open-ended pre-questionnaires, open-ended post-questionnaires, diaries, transaction logs and a self-administered report.

Before they learned how to search each individual online system, each participant first completed a self-administered *pre-questionnaire* that asked about 1) his/her demographic characteristics, 2) his/her searching experiences with a variety of IR systems, and 3) his/her perceptions of what constitutes ease-of-use versus user control.

For each of the system, participants received instructions/lectures about how to use it. Each subject then was asked to perform searches on eight topics. Participants were instructed to keep *diaries* to record their comments regarding the design of the interface in terms of its ease-of-use and user control as a whole. They were required to record “their perceptions of ease-of-use and user control of each individual feature and functionality” used to achieve the following sub-

tasks: 1) database selection, 2) search strategy formulation, 3) search strategy reformulation, 4) help mechanisms access, 5) results organization and evaluation, and 6) results delivery. At the same time, they were also required to capture their search sessions from beginning to the end (*transaction logs*) which include database(s) selected, queries used, problems encountered, help systems used, results organized and displayed, results delivered, etc. After finishing their searches, participants were asked to fill in the *post-questionnaire* based on their diaries and transaction logs.

At the end of semester, data were collected based on multiple system comparison. After searching for his/her own information problem by using all the five systems, participants were asked to rate (using a five-point scale: 1 = not at all, 2 = a little, 3 = some, 4 = some more and 5 = extremely) the five online systems and their associated features and functionalities in terms of their levels of ease-of-use and user control on the following areas: 1) database selection, 2) search strategy formulation, 3) search strategy reformulation, 4) help mechanisms, 5) results organization and evaluation, 6) results delivery, and 7) overall evaluation. Open-ended *reports* were administered to participants, who were asked to identify their desired interface structures, desired features and functionalities for a Web-based online database system to support both ease-of-use and user control, and how ease-of-use versus user control plays a role in their preferences for one type of interface over another. Most important, participants were instructed to elaborate upon their reasons, and to give examples to support their arguments.

In order to collect data covering different tasks users generally perform, participants finally were asked to conduct three searches: 1) for a known item, 2) for specific information, and 3) for information on a subject. Participants were randomly assigned three systems to search for information. They were asked to record the search process as well as their comments for all three searches. For this paper, the author used comments extracted from the real search process.

Of the forty participants in this study, 50% were female and 50% were male. Most of them self-rated themselves as having pretty good computer skills: intermediate (47.5%), advanced (25%) and expert (10%), with only 7.5% rating themselves as beginners. Table 1 presents subjects' frequency use of online and other information retrieval systems before this study. For each type of IR system presented in Table 1, participants were asked to indicate, on a 1-5 scale, in which 1=never use, 2=rarely use, 3= occasionally use, 4=often use, 5=use daily. According to Table 1, while participants have some experience with different types of search engines and online public access catalogues (from  $\bar{x}$  =2.7 to  $\bar{x}$  =3.75), they rarely use online databases (from  $\bar{x}$  =1.13 to  $\bar{x}$  =1.38).

Table 1. Subjects' frequency of use IR systems

Type of application	Mean	Type of application	Mean
Directories (e.g. Yahoo)	3.73	Dialog Web	1.23
Search Engines	3.75	Dow Jones Interactive	1.35
Meta-search engines (e.g. Meta-crawler)	2.70	FirstSearch Web	1.20
Specialized search engines (on one area)	2.58	Lexis-Nexis Web	1.38
Natural Language search engines (e.g. Ask Jeeves)	2.50	Mapit Web	1.25
Library Catalogue	3.03	Ovid Web	1.13

The results of this study were analyzed using quantitative as well as qualitative methods. The quantitative analysis focused on the descriptive statistical analysis of the data. The qualitative analysis was based on Strauss & Corbin's grounded theory (1990) utilizing content analysis (open coding); the development of taxonomies of perceived ease-of-use and user control, desired features and functionalities, and desired interface structure; and derivation of a model of optimal support for both ease-of-use and user control. Table 2 presents the detailed data analysis plan.

Table 2. Data analysis plan

Research Question	Data Collection	Data Analysis
Perceptions of ease-of-use and user control	Pre-questionnaire Open-ended report	content analysis taxonomy of ease-of-use taxonomy of user control
Desired functionalities	Diary transaction log post-questionnaire open-ended report	content analysis taxonomy of desired functionalities descriptive analysis
Desired interface structure	Diary transaction log post-questionnaire open-ended report	content analysis taxonomy of desired interface structure descriptive analysis

#### 4. Results

In this section, the author tries to summarize the answers to the three research questions that were raised in the first section: 1) perceptions of ease-of-use and user control; 2) in supporting ease-of-use and user control, desired features and functionalities for database selection, query formulation, query reformulation, help mechanism access, results organization and evaluation, and results delivery; 3) desired interface structures in supporting ease-of-use and user control.

## **4.1 Perceptions of ease-of-use and user control**

As discussed in the literature review, there is no standard definition for ease-of-use and user control. In order to design effective IR systems for end users, designers need to first understand users' perceptions of ease-of-use and user control. In this study, participants were asked to report their perceptions in three areas: 1) ease-of-use, 2) user control and 3) the importance of ease-of-use and user control as separate and combined aspects in their use of IR systems.

### **4.1.1 Perceptions of ease-of-use**

After data analysis, the results show that ease-of-use are considered as: an intuitive system that is easy to learn, an easy to navigate structure that incorporates many options for users to choose, and an IR system that supports efficient information retrieval.

To most of users, an intuitive system is the precondition for its ease-of-use. One subject provided his version of ease-of-use: "intuitiveness, no complicated or unique rules powering searching, easy to understand interface." Other subjects defined ease-of-use as, "retrieving information without confusion," "there are few instructions to read before beginning to use system," "how straightforward each feature is," etc. Participants stated that an intuitive system should "allow users to have the ability to understand the system and understand how to use and perform the functions of the system easily." An intuitive system normally is also easy to learn. Participants' understanding of ease-of-use "lean toward systems that have obvious ways of searching and do not take too much time to learn," explained by one of the subjects. Echoed by another one, "Is the interface easy to figure out even if it's your first time?"

To many users, ease-of-use requires an IR system to have a structure that is easy to navigate. Most participants pointed out that it is essential to have a system structure that is easy to navigate. Just as one subject wrote, "ease-of-use requires 'simple' or less precise but easier to navigate structure." "The ability to navigate through all the data the system is provided is ease-of-use," another one added. To be more specific, "the layout of the interface needs to be easy to use. It should be easy to see where I was going and what I was doing," commented by one subject. One related characteristic of an IR system for ease-of-use is providing more options for users to choose. For example, as one subject commented, "First Search's interface gave me five options to query reformulation, all of which I found to be very necessary in ease-of-use. If only all of these online databases gave me these options, I would be the happiest user alive."

Ease-of-use is highly correlated to efficient information retrieval by many users, that is how much time they must spend to retrieve information. They expect "the search has to be fast." One subject illustrated in a quantitative way, "3 clicks & I am seeing the information, I want to use." Another one described one bad example of database selection, "I really don't like this system. It takes me a lot of time to choose databases because I have to click into so many steps to select the databases and the databases selection is so complicated. It is not easy to use and learn."

### **4.1.2 Perceptions of user control**

User control was considered as: incorporation of many options, especially more options for query formulation and the ability to construct a precise query, the ability to understand an IR system with the assistance of help mechanism, the ability to manipulate the search environment

with different levels of flexibility, and the incorporation of user feedback for IR system improvement.

Interestingly, “many options” is also considered as one important element of user control. A subject well summarized it, “User control gives users options in their search.” Here are two quotes from the participants regarding two systems that users have more control: “Lexis-Nexis has good user control because of the three different search modes in the query formulation. The three different search modes provide good control over how you want to search for information.” “Dialog offers numerous ways to narrow down the search with connectors, proximity operators, prefixes, suffixes, truncation. Dialog may be more difficult to learn in the beginning, but the tradeoff is the user has more control and may get far more results than other systems.” More options for search modes and the ways that queries can be formulated are essential for user control. In addition to more options for query formulation, user control also indicates that users are able to construct more precise queries based on their understanding of the system.

According to subjects, “construct a specific query to the search topic” or “the ability to create an exact query” is user control. To most of the subjects, user control is to “maintain control over the search process.” But more importantly, “only if the user understands the system’s structure.” In another words, “the user can navigate through the system with some level of understanding.” Understanding the system refers to “having an understating of advanced searches, Boolean phrases, proximity searches, and truncated searches, etc.,” explained by one subject. Users can never expect themselves to fully understand an IR system without the help of the help mechanisms, and that is why on-screen explanations are also key elements of user control. Another subject points out, “the on screen explanations provided by Lexis-Nexis, Ovid, and FirstSearch are also helpful to a novice user and gives them a greater sense of control”

“Manipulation” was emerged as a synonym for “user control” in this study. Manipulation is not limited to query formulation, and it is more related to “a user’s ability to control and manipulate the environment to his/her advantages and efficiency,” or “the ability to customize the system to match user preferences.” In addition to overall manipulation, users also need specific manipulation, such as “you can restrict the dates of news articles or where you can search a particular a magazine,” or “user control means that the user can select layout # of hits displayed, order displayed, etc.” Flexibility determines the level of user control. One participant pointed out clearly, “the system that offers the greatest flexibility will lead to more user control.” Another one described in his words, “User control is my own control of what I want to do, at any given moment on the system.” To be more specific, another one added, “The ability to make a broad search or a narrow one at your own will.”

Incorporation of user feedback is another requirement for user control. Users are not satisfied just conducting searches; instead, they like to be involved in the design and improvement of online IR systems. One subject claimed, “I won’t feel I am in control unless I know that my suggestions can be incorporated into the system.” One representative comment is “the most important aspect of user controls is that the designer of an online search system welcomes feedback from users and will actually try to incorporate the most popular suggestions into any revisions of the system. When a user sees that his/her idea was used. It is the best feeling of user control one can have!”

### **4.1.3 Perception of the importance of ease-of-use versus user control**

Participants were asked to rate the importance of ease-of-use, user control and both ease-of-user and user control to their use of IR systems on a 1-5 scale, in which 1=not at all, 2= a little, 3=some, 4=some more and 5= a great deal. The results show that participants consider both ease-of-use and user control essential for their use of online databases. The mean scores for the importance of ease-of-use, user control, and both ease-of-use and user control respectively are 4.1, 4.07 and 4.36.

More than 60% of the participants prefer both ease-of-use and user control over just ease-of-use or user control because they supplement to each other. One subject points out, “because without one that other is pointless.” The typical reason for the choice is that users want to take great advantage of the system physically as well as psychologically. Here are the explanations from participants: “I prefer both because this makes the search process easier and more efficient;” “Both are important to me to reduce user stress and motivates continues use.” Specifically, “I prefer both because I didn’t want it to be confusing to use, but I like to be able to be specific so I can find what I want;” “This way you can control how your search is being preformed and you can perform a search without too much training.”

Users’ understanding of ease-of-use and user control is also related to user experience. According to the participants, novice user desire greater ease-of-use, but experienced users desire more user control. One subject’s criterion for ease-of-use is “how easy a system is for even an inexperienced user to use easily.” As to user control, another subject stressed the importance that “a system allows advanced users to manipulate interface.” Another interesting perception is that ease-of-use should be judged by the system’s target user group as one participant wrote, “Ease-of-use in general terms means how easy the database is to use by the target user group.”

To summarize users’ perceptions of ease-of-use and user control, it seems that ease-of-use concentrates on the requirements for the design of IR systems to be easy to use while user control focuses on how users and IR systems can be integrated together and the requirements for the design of IR systems to assist users exercising their power.

### **4.2 Desired features and functionalities supporting ease-of-use and user control**

In order to find relevant information effectively, end-users need to interact with online information retrieval systems in the search process. The search task can be divided into the following five sub-tasks as suggest by the previous researchers (Xie, 1998, Xie & Cool 2000): database selection, query formulation, query reformulation, results organization and evaluation, and results delivery. Since it is also important for users to access help mechanisms from time to time in the search process, the author also includes help mechanism access as one of the sub-tasks.

It is essential to examine how the existing online systems facilitate users achieving each of the sub-tasks easily as well as efficiently. Moreover, this study tries to shed some light on what users would like online systems to do for them and what users would like online systems let them do themselves.

This section reports the results of post-questionnaire and open-ended reports, which embed information of user diaries and transaction logs. Participants were asked to rate different features in terms of their levels of ease-of-use, user control and overall general use in supporting users' accomplishment of the following sub-tasks: 1) database selection, 2) search strategy formulation, 3) search strategy reformulation, 4) help mechanisms, 5) results organization and evaluation, and 6) results delivery. The ratings were done by using a five-point scale: 1 = not at all, 2 = a little, 3 = some, 4 = some more and 5 = extremely. The rated features were identified from all the five online systems, but not every system has all the features. In the post-questionnaire and open-ended reports, subjects also provide reasons and examples of their evaluation of features and functionalities regarding ease-of-use and user control.

#### 4.2.1 Database selection

Database selection plays an important role in achieving the overall search task. "Good beginning is half done" well applies to the selection of relevant databases. It is crucial to find relevant databases efficiently. However, the proliferation of databases has produced not only a wealth of potential sources, but considerable confusion as well. The quality of features of database selection relates users' satisfaction with the online system. Just as one subject commented, "I have found that my satisfaction with a system increases when the selection databases is easy and quick." At the same time, many subjects express their fear for database selection. One typical comment is, "This task can sometimes be painful. I found that I disliked this part of searching process the most. Selecting databases is a very tedious task."

Table 3 Evaluation of database selection features

Database selection features	General use	Ease-of-use	User control
Single database	3.47	3.92	3.61
Group database	3.94	3.97	3.58
Alphabetical list	3.44	3.51	3.58
Subject/topic list	3.80	3.86	3.71
Favorites/saved databases	3.40	3.60	3.66
Search for databases	3.61	3.42	3.44
Source information	3.64	3.69	3.61

Table 3 presents the mean score of each database selection feature available in online database systems in terms of its support for general use, ease-of-use and user control. For ease-of-use, users prefer the ability to choose a group database ( $\bar{x} = 3.97$ ), a single database ( $\bar{x} = 3.92$ ) or choose a database(s) from a subject topic/list ( $\bar{x} = 3.86$ ). For most of the subjects, as suggested by one subject, "single database +group database is simple and easy to use." Main reasons for the preferences are, according to the subjects, first, "easy to identify databases according to my topic/subject"; second, "group database—you can find the right topic for the proper database"; third, "being able to choose group databases gives you the option to search several databases";

finally, users “found group database the most effective. It seemed to be the most likely to produce the most results.”

However, ease-of-use should not compromise user control. While “group database” was ranked high for ease-of-use ( $\bar{x}=3.97$ ), it was not rated high for user control ( $\bar{x}=3.58$ ). It is not enough for users to choose “group database”. Users want to also be able to remove or add individual database as they wish. “One thing I really like about Dialog is you can remove individual databases if you have chosen to search a group of databases compiled by Dialog. Other systems would force you to pick all of your databases one by one instead of excluding one from a convenient list,” commented by one subject. “Single database” selection and “subject/topic list” also has the same problem, high for ease-of-use but low for user control.

The ability to “search for databases” ( $\bar{x}=3.88$ ) and the ability to use their saved databases in “favorites” ( $\bar{x}=3.66$ ) are the preferred choices for user control. “Search for a databases so you can make sure you have correct database,” one subject explained his reason. Many subjects agreed with him, “search for databases” helps them to find most pertinent databases. However, Many participants thought some of the “search for databases” features (e.g. DIALINDEX in Dialog) were not easy to use. Users like the opportunity to save the databases that they have used. Reasons for preferring “favorite” are that “they provide information on my topic” and “it saves time”. More importantly, as one subject pointed out, “The interface (DJ) also allows the user to save the list of databases searched, to allow more control over the search process.”

Interface transparency is also required by users for both ease-of-use and user control. They would like to make sense of the organization of databases. One example of the complaint is “these (databases in Lexis-Nexis) are not that easy to use because you really have to know where your subject would fit in, and this system does not allow a very good interface for browsing and for source information. In addition, they need descriptive of database names. Although users praised the ease-of-use of “i” button which provides information about a database, but users want more. For example, “Ovid’s databases aren’t broken down into separate groups or categories (at least that I could find); there’s a listing of databases, but many of these titles aren’t descriptive of their contents, so often you must click on the information button and check each one individually. Because there are so many you probably won’t check them all, and could easily miss one that’s very important to your search. It’s also irritating on how you choose between the “one database” and “many databases” screen in Ovid...it’s not real evident as a selection.”

One dilemma related to ease-of-use and user control of database selection is number of databases available in an online retrieval system. Generally speaking, more databases covered in an online system indicate more coverage, but it is also more difficult for users to find relevant databases. While more database coverage might mean more difficult to use, it does add extra weight for user control. One subject claimed, “Having the necessary databases available is a very important option. Your search is limited when the number of databases available is small.” But another one pointed out, “more databases available, more difficult for database selection.”

### **Query Formulation**

To end users, query formulation is never an easy job. Formulating a query equals problem articulation. It is a challenge for users to convert their unspecified information problem into a

statement that contains a couple of terms with operators. The new emergent Web-based online databases have offered new alternatives comparing to traditional command based online databases.

Table 4 Evaluation of query formulation features

Query Formulation Features	General use	Ease-of-use	User control
Multiple search modes	3.72	3.77	3.80
Run saved searches	3.63	3.66	3.60
Browse	3.42	3.67	3.60
Types of search/field search	4.03	4.00	4.11
Tools, e.g. index terms	3.75	3.75	3.86
Search tips	3.50	3.58	3.50
examples	3.79	3.91	3.76

Table 4 presents the mean score of the perceived usefulness of each query formulation feature available in online database systems in terms of general use, ease-of-use and user control. “Types of search/field search” ( $\bar{x} = 4$ ), “examples” ( $\bar{x} = 3.91$ ) and “multiple search modes” ( $\bar{x} = 3.77$ ) were ranked as top features for ease-of-use. Almost every subject commented on the helpfulness of the “example” feature. “Examples” offer users visual information about query formulation, and make it easy for them to formulate queries. Just as one user praised, “I always like the examples. I am a visual learner and like being able to see how to do things.” Users also recognized the usefulness of “examples” especially when they had problems in formulating queries, one user wrote, “Examples –really helps to formulate search especially if having problems.” In addition, this feature helps users to understand the system. Another user stressed, “I like examples + search tips because this helps when you don’t know something about a system.” Many subjects praised the ease-of-use of the “types of search/field search” option. One subject said, I really like to be able to search different fields just by checking off boxes.” Agreed by another one, “the ability to use a form or tables to select the field rather than have to remember the abbreviation for its use in the query is much easier.”

“Types of search/field search” ( $\bar{x} = 4.11$ ), “tools” ( $\bar{x} = 3.86$ ) and “multiple search modes” ( $\bar{x} = 3.8$ ) were the top features desired for user control. “Types of search/field search” was regarded highly because “it can help narrow down or have an overall view of results.” Another reason for users’ preference of this feature is “the degree of control with a specific query is helpful.” Some subjects used this feature when they don’t know what to do, for example, “I liked to browse features when I wasn’t sure what I was looking for but rather just looking to see what was out there.” “Tools” was praised for its user control ( $\bar{x} = 3.86$ ), but criticized for its ease-of-use ( $\bar{x} = 3.75$ ). Just as one subject commented, “the ‘tools’ is a good idea, but they are not very descriptive about what each of the selections such as ‘tree’ or ‘permuted index’ are.” Another one gave an example, “mapping is a powerful feature that could be much more straightforward if a message were added to describe its functions.”

Flexibility was perceived as the product of the availability of “multiple search modes”. One subject stated, “you can use quick search for easier search and power search for more thorough search.” Users can choose different search modes based on their information need, just as one subject commented, “I like a choice of search modes, because they allow me to choose based on my search needs. More importantly, ‘search mode’ allows me to pick the mode that fit me best.” One subject summarized, “Search modes — allows users to choose search modes which give the user needed control.”

However, not all the search modes were welcomed by all subjects. Different subjects have different opinions towards the search modes. For example, while most of the subjects praised user control of command mode of Dialog that assists them efficiently constructing their queries, many of them complained about its difficulty of use because they had to strictly follow the syntax of the commands to formulate their queries.

### Query Reformulation

Query formulation, and especially query reformulation are considered as the most difficult tasks that users face in interactive information retrieval process. (Efthimiadis, 1996; Belkin, et al, 2001). It is not easy for users to construct their initial queries to precisely represent their information needs; therefore, they have to adjust their queries manually or with the assistance of IR systems. For users, the process of query reformulation is the process of understanding their information needs and further representing their needs.

Table 5. Evaluation of query reformulation features

Query Reformulation features	General use	Ease-of-use	User control
Search history	4.14	4.11	4.11
Edit/revise search	3.89	4.03	4.03
Limit search	3.97	3.80	3.86
Hyperlinks in results	3.88	4.09	3.88
Find related info. in other database/search modes	3.78	4.06	3.72

Table 5 presents the mean score of each feature for query reformulation available in online database systems in terms of its support for general use, ease-of-use and user control. “Search history” was rated as the best feature for ease-of-use ( $\bar{x} = 4.11$ ) as well as user control ( $\bar{x} = 4.11$ ). Search history made the search easier by “reusing better queries.” Search history was praised most for providing an opportunity for users to track down the search process and reformulate their queries. Here are some quotes, “Search history – hands down the most effective way to quickly reform queries see how results were arrived at, evaluate search strategies, etc.” “It allows the user to look back on the searches you have been working on to help gauge oneself.” “Search history” was perceived as one feature that helps users to correct errors, and not repeat what has done. One subject wrote, “The feature I like the most is the search history. I could always go back to see what I did wrong or what I did right.” “You know what you’ve done so you didn’t have to do it again,” another one added. In one word, a subject well summarized, “search history makes reformulation fast and easy.”

The “Edit/revise search” function was rated highly for both ease-of-use ( $\bar{x} = 4.03$ ) and user control ( $\bar{x} = 4.03$ ). Users stated it provided the ability to edit a mistake or to refine their queries. It also enabled them to easily review or rerun their original query without trouble. FirstSearch was praised highly by many subjects in offering multiple options for search revision. One subject applauded FirstSearch, “FirstSearch was by far the best at query reformulation, such features as refine, find related, expand, limit and the popular search history make the design very efficient.” This opinion was echoed by another participant, who said, “the one I liked best was FirstSearch. The ability to refine your search was helpful, more so, being able to expand the search, i.e., show authors, subject headings, limit by author, year, and document types was ideal. Being able to check search history, which allowed you to check your query and refine it as needed. All these helped me make it the best choice for me in this area.” At the same time, Lexis-Nexis and Dow Jones Interactive was criticized for their lack of options for query reformulation.

While many features for query reformulation were perceived to support both ease-of-use and user control, “hyperlinks” and “Find related info. in other database/search modes” were described as providing more ease-of-use than user control. The “Hyperlinks” option was highly praised for its ease-of-use. One typical comment, “Hyperlinks lets you move right to other by same author, journal, etc. in one click.” “Hyperlinks” can “further explore the information if you would like.” “Find related info. in other database/search modes” was rated highly for ease-of-use ( $x=4.06$ ). One subject described the benefit of this feature, “a really nice feature in both Ovid and FirstSearch is that a user can change databases within a query and does not have to reconstruct the query after the change of databases.” Users liked more about that they could use the same query when they change to another search mode since the format of the query is automatically customized for the new search mode. One subject discussed how he learned from this feature, “I liked how my query would come through on each search mode and in the proper format without having to do it myself. It did serve as a guideline and learning tool that assisted me in figuring out the various operators and how to use them in a query when conducting a search.” However, this feature may cause users lose control of the search process, especially when they don’t want to carry the same query to the new database or another search mode.

### **Help Mechanism Access**

Help mechanism plays an essential role in assisting users to effectively retrieve information. In the information retrieval process, users need to consult various help mechanisms when they encounter problems. The design of the help mechanism greatly impacts a users’ perception of ease-of-use and user control of an IR system. A good help mechanism needs to contain different forms of help features. One subject summarized what a help mechanism should contain, “a combination of on screen explanation, clearly marked help buttons, and examples is necessary to provide users of all levels of optimum utilization of an online IR system.”

Table 6 Evaluation of help mechanism features

Help features	General use	Ease-of-use	User control
On screen explanations	3.74	3.91	3.69
General Help	3.57	3.51	3.57
Tips	3.37	3.51	3.43
How this works	3.54	3.61	3.59
Examples	3.89	3.97	3.83
Source information	3.94	3.83	3.77
Tutorial	3.00	3.12	3.12

Table 6 presents the mean score of perceived usefulness of different help features available in online database systems in terms of their general use, ease-of-use and user control. “Examples” again was ranked the highest for both ease-of-use ( $\bar{x}=3.97$ ) and user control ( $\bar{x}=3.83$ ). Since it is discussed in detail in “query formulation”, here emphasis is placed on other help features.

As to ease-of-use, “on screen explanation” ( $\bar{x}=3.91$ ) was ranked as the top one for its quick and easy access, and its context sensitivity. Users like this feature because, as one subject put it, “it is right there and I don’t have to look for them.” More importantly, it “shows you right away what it means, covers how it works.” One subject stated, “usually exactly what I need the help.” In addition to its convenience, it was also applauded for its context sensitivity. Another one spoke highly of this feature, “context sensitive pop-up window is extremely useful.” As “on screen explanation” is predetermined, users don’t have too much control about its content, and that is the reason that it was not rated high for user control ( $\bar{x}=3.69$ ).

It is a difficult task to choose the right databases. “Source information” provides an opportunity for users to know about the content of databases before choosing relevant databases; therefore it is really an effective feature for user control ( $\bar{x}=3.77$ ). Here are the reasons that subjects select source information as their favorite help mechanism: “Source information gives you options to review databases before you select it.” “It allows users to tell if a database might be what you need to search in or not.” At the same time, it is quite easy to access “source information” by clicking an “I”(“I” stands for information) button.

Users do apply “least effort” principle in using IR system. One subject confessed, “I rarely used the help mechanisms, I don’t know why I didn’t, but I would usually play round with the system to figure out how to use it before I would even think about using the help mechanism.” That is why “tutorial” was rated the lowest for both ease-of-use ( $\bar{x}=3.12$ ) and user control ( $\bar{x}=3.12$ ). “General help” has mixed reviews for its ease-of-use ( $\bar{x}=3.51$ ) and user control ( $\bar{x}=3.57$ ). Users liked context-sensitive help that some of the systems provided. Many subjects complained about the non context-sensitive help. Here is one example, “when I accessed help, it was not context-sensitive. I had to select from a list of help topics or perform a search to find the appropriate information.” In addition to non context-sensitive help, the major problem with the “general help” revealed by this study is it is very difficult for users to first identify their problems. Second, it is very hard to navigate the help to find the right information. One subject told her story, “It took me some time to navigate into help. Then I tried to figure out how to label my problem and where I needed to go in order to find the right help information. When I

finally did arrive at the correct help topic, I found the results were not helpful at all.” Another one expressed his frustration, “Dialog’s help was one that was hard to navigate, so instead of trying hard to find the information that may have made the system easy to use, instead, made it more frustration.”

### Results Organization and Evaluation

As to results organization and evaluation, users were mainly concerned with how an IR system can assist them in effectively evaluating results. Many users spent more time evaluating results than searching for information. In order for an IR system to support users in effectively evaluating results, it is important that it has mechanisms that support users in: 1) organizing their search results in different approaches; 2) displaying results in different formats, and more importantly, 3) connecting user queries to the display of search results to assist users in effective retrieval.

Table 7 Evaluation of features for results organization and evaluation

Database Selection features	General use	Ease-of-use	User control
Sort by date	3.94	3.97	3.86
Sort by relevance	4.08	4.00	4.00
Citation	3.83	3.94	3.83
KWIC	4.44	4.25	4.28
Full	4.00	3.94	3.86
Custom view	3.68	3.68	3.82

Table 7 presents the mean score of each feature for results organization and evaluation available in online database systems in terms of its perceived usefulness for general use, ease-of-use and user control. “Key word in context (KWIC)” was ranked the highest for ease-of-use ( $\bar{x}=4.25$ ), user control ( $\bar{x}=4.28$ ) and general use ( $\bar{x}=4.44$ ). In general KWIC was preferred because “it makes it easy to review articles for relevancy.” To be more specific, “it is especially good for searching for specific information.” Quick evaluation is another reason that users like this feature, just as one subject answered the question regarding which feature he/she likes the best: “The KWIC of course because at a glance I could tell if the result was relevant or not.”

“Sort by relevance” is another highly preferred feature for ease-of-use ( $\bar{x}=4$ ), user control ( $\bar{x}=4$ ) and general use ( $\bar{x}=4.08$ ). It is mainly preferred because, as one subject explained in her report, “you do not have to sort — already done for you.” “Sort by relevance” was considered more useful than “sort by date” since most users care more about the relevance than the date of an item. The only problem with the “sort by relevance” feature is that the results are not always ranked by relevance from a user’s point of view. Moreover, users have no idea how the “sort by relevance” actually works which makes it difficult to trust the sorted results. One subject described this problem, “I noticed that even though I asked the results be presented by relevance, but that wasn’t always the case. The problem is that I don’t know how the system determines the relevance.”

In general users complained about the difficulty of using command mode of Dialog Web, but they did like the control they have for results organization and evaluation. One subject

commented, “It lets you sort the results by author, journal name, publication year and title. It lets you see the free, short, medium, long full, KWIC format of articles. This is a very good feature because everyone may be looking for something a little different and you can pick the way that best suits your purpose.” However, it is lack of the feature - “sort by relevance”. One subject argued, “Dialog does not give users the option to sort by relevance. This limitation may affect the success of some searches. I don’t like to wade through several documents that happen to be more recent to get to the documents that may be more relevant.”

### Results Delivery

Results delivery is the final step towards the information seeking process. The main concern of this sub-task is how to effectively deliver the results in a format that is acceptable to users, and more importantly, with retrieved items delivered in their original style, preferably with information that would allow users to know how the results were received. That means the final delivery should allow the inclusion of the statement of the search history.

Table 8 Evaluation of results delivery

Database Selection features	General use	Ease-of-use	User control
Email	3.53	3.71	3.76
Download	3.56	3.68	3.68
Print	3.64	4.09	3.91
Clean copy	3.85	3.64	3.91
With search history	3.97	4.00	4.00

Table 8 presents the mean score of each feature for results delivery available in online database systems in terms of its perceived usefulness for general use, ease-of-use and user control. There is not so much problem with results delivery in both ease-of-use and user control. Users want to keep record of the process of how they obtain the related information. Just as search history is highly preferred for query reformulation, it is also one of the favorite features for results delivery regarding ease-of-use ( $\bar{x}=4$ ), user control ( $\bar{x}=4$ ) and general use ( $\bar{x}=3.97$ ). Users liked “print” and “email” for different situations. According to subjects, while print is more for personal use and “get it right away”, “email is great for a work group environment” and “you can save and read it later.” Many users cherished the opportunity they can choose to print a clean copy as a way of user control ( $\bar{x}=3.91$ ). Just as one subject commented, “to have a copy without all the extraneous data that is included on the screen is most convenient for use.” “I, however, do not like it when you cannot print a ‘clean’ copy of the article that you would like to use,” echoed by another one.

### 4.3 Desired structure supporting ease-of-use and user control

Overall interface structure of an online IR system is the key element of the system. Search structure plays an important role in its overall structure. Online systems in general employ two types of search structures: “multiple search modes” which offers variety of search modes and “multiple search forms” which offers different search forms for different subject search. Online

systems with “multiple search modes” have different formats. Some of them differentiate command and non-command search, such as Dialog Web’s “command search”, “guided search”, and “browse a list”. Some of them focus on basic and advanced search, such as Lexis-Nexis Web’s “Quick Search”, “Power search”, “search forms” and FirstSearch’s “Basic”, “Advanced” “Expert” and “Browse Index.” Ovid Web offers different field search, such as author search, journal search, and title search in addition to basic and advanced search. Different from the rest of online systems, Dow Jones Interactive provides different search forms for different types of searches. It contains newsstand, publication library, Web center, company & industry center. Each has its own unique search form. Table 9 presents the means scores for ease-of-use, user control and general use of two different search structures. It seems that different structures of online systems do not have much impact on their perceived ease-of-use and user control because the mean score for each column is pretty close.

The integration of different functionalities of an online IR system also constitutes its structure. Table 10 presents each of the online system in terms of its ease-of-use, user control and general use. With all the five online systems, Ovid was regarded as the top one for both ease-of-use ( $\bar{x}=4$ ) and user control ( $\bar{x}=3.77$ ). One subject explained the reason, “Ovid—it’s the most intuitive but it still allows a lot of user control.” Users have different perceptions of Dialog, especially its command search. Dialog was ranked the lowest for ease-of-use ( $\bar{x}=2.81$ ), but pretty high for user control ( $\bar{x}=3.6$ ). On one hand, Dialog’s command search was praised for its user control, “I prefer Dialog even though it is more difficult to learn. I feel that it gives the user more control.” On the other hand, some users criticized its difficulty of use, “Dialog. I dislike the tedious task of command line searches.” Overall, users think “Dialog—most query formulation control & most comprehensive in terms of databases. Ovid—best user interface.” FirstSearch is in the middle, just as one subject commented, “I like FirstSearch. But it’s not as powerful as Dialog. However, it is more easy to use.” None of the system can be named as ideal. One option is to combine several systems and take advantage of benefits of each of the system. Here is one typical example, “In my ideal information retrieval system the beginner or quick search model would be like the advanced model in FirstSearch. The model for every specific queries would like the command mode in Dialog, but I would include in this mode some of the icons present in OVID that would expedite the query formulation process.”

Table 9 Evaluation of desired search structures

Types of Structure	General use	Ease-of-use	User control
Multiple search modes	3.58	3.69	3.60
Multiple search forms	3.56	3.42	3.51

Table 10 Evaluation of desired systems

Types of Systems	General use	Ease-of-use	User control
Dialog Web	3.14	2.81	3.60
Dow Jones Interactive	3.60	3.69	3.60
Lexis-Nexis Web	3.24	3.14	3.32
Ovid Web	3.69	4.00	3.77
FirstSearch Web	3.83	3.89	3.72

To most users, a good structure has to satisfy the following requirements: first, the interface should be intuitive to users. Second, the interface should have some similarities to the systems they are used to. Third, the interface should have a clear interface, especially a clear start screen. Most important, fourth, the interface should allow users to customize and personalize their own interfaces.

“Inviting users” is the basic requirement for an interface. One subject made the statement, “Overall, the interface should be made to look inviting to users, with terminology that bluntly states what it is, with form search, power search, and quick, or simple search. The interface should have no intimidating parts to it, or the majority of the users, no matter how amazing they are, will not use that part.” If an interface does not satisfy this requirement, it will lose its users.

In general users learn to use a new system by associating the new system to the systems they knew before. They would like to have an easy transition from systems they are familiar with to systems that are new to them. The best way to facilitate users to use online systems is to offer some similarities, especially the similarity in the structure. One subject discussed his experience of using the online systems, “I found online systems like Nexis, Dow Jones, and FirstSearch are more inviting. Their interface designs are similar to Hotbot search engine. The similarities to search engines provide a familiar interface with only a few commands to learn. When the user is able to identify the similarities between two different kinds of systems, the transition between the two is easy.” Another one added her opinion, “The three systems Dow Jones, Ovid, FirstSearch were similar to Web search engines or library OPACs. Most people who do extensive research using online information retrieval systems would have used either a Web search engine or an OPAC system. This creates a mental model that will enable you to use it from memory.”

Users’ preference of a system is highly related to the design of the main screen of the system. A clear first page offers users an easy start as well as psychologically assurance. In addition, a good first page also guides users in their search process. When users were asked to provide reasons for their choices of best structures, more than half the subjects mention “a clear main screen”. Here are some representative quotes. One subject commented on Ovid, “This system starts off with a bang. As soon as you login the place is a list of all databases. Before each database is the now famous red “i” which gives the user information about the database. You can choose up to five databases to search through at once. I love the fact that this is all presented to the user at the first screen.” Another one commented on Dow Jones Interactive, “I especially liked how once you were logged in to Dow Jones that everything was, for the most part, laid out for you. Your options were right in front of you, clearly describing where you can go. For me this eliminated questions of what I needed to do next.” Another subject commented on FirstSearch, “The main screen of FirstSearch looks fairly plain but the drop-down boxes contain all the pertinent information.”

Customization and personalization for different levels of users is another requirement for a desired structure. Users prefer to have their personalized online IR systems that allow them to configure how to choose database, how to formulate and reformulate queries, how to organize and display results, and how to deliver the final results. They want to be able to customize the default functionalities, and furthermore, still be able to change them when necessary. One subject well summarized it, “my desired structure needs to enable me customizing the system. I

would like to personalize the system to my preference in the overall search process.” At the same time, users also want IR systems to hide customization functions so novice users have ease of mind and are not confused by the complexity of the system. Just as one subject put it, “A good structure should allow users from different levels feel at ease, and also can act on it.”

As discussed before, users prefer a combination of ease-of-use and user control. They prefer online systems that offer multiple search modes ranging from novice to advanced, so all levels of users can find their ways of searching. One user well presented her idea, “There are two choices: basic or advanced in Ovid. This feature provides all types of users with simplicity and control.” Not all the people agree on the same criteria for the desired structure. There are different opinions of what constitutes a best structure. While most users dislike Dialog for its difficulty of use, some users like it because of more user control. For example, one user commented, “Though some find the query formulation and database selection process difficult in Dialog, I overall find it the best-structured system because though difficult, these options provide the best coverage and most selections.”

## **Discussion**

In order to design an ideal online IR system to support both ease-of-use and user control, we need to extend the discussion of the three research questions raised before. As discussed in the literature review, there is no standard definition for ease-of-use and user control. The results of this study highlight important requirements for system design from users’ perspective. Participants of this study, which are characterized as novice users of online databases but experienced users of Web search engines, do have agreements on ease-of-use and user control. While ease-of-use requires an intuitive system that is easy to learn, easy to navigate, and supporting efficient information retrieval, user control requires a customizable system that can be understood, manipulated, and incorporated with many options and user feedback. The perceptions of ease-of-use and user control do not seem to be in conflict if we can make a customizable system being intuitive. While ease-of-use requires the system design to focus on empowering the system, user control requires the system design to concentrate on empowering users. We cannot consider one thing without the other since many of the problems with online IR systems are caused by focusing only on one aspect.

The discussion of desired structures, desired features and functionalities to support both ease-of-use and user control can be best represented into the discussion of the model of optimal support for ease-of-use and user control presented in Figure 1. This model illustrates: 1) desired features for ease-of-use and user control and their relationships, 2) desired functionalities in supporting ease-of-use and user control, 3) desired structure in supporting ease-of-use and user control, 4) the system role and user involvement in supporting ease-of-use and user control, and 5) the requirements for ease-of-use and user control in each of the IR sub-tasks.

A good feature needs to support ease-of-use as well as use control, and cannot have one without another. According to the results, current features and functionalities of existing online IR system aren’t perfect, and they have different problems. To make things more complicated, a feature’s ease-of-use and user control are interrelated. Four types of relationships can be identified from the data: 1) independent, 2) conditional, 3) supplemented, and 4) contrary. In

independent relationships, features with ease-of-use have no impact on user control, and vice versa. For example, “on screen explanation” was liked by users for ease-of-use, but it has no obvious positive or negative impact on user control. In conditional relationships, features with ease-of-use cannot be successful without user control, and vice versa. For example, in database selection, while “group database” was ranked high for its ease-of-use, users also expect to be able to remove or add individual databases within the group. “Tools” are very useful for users to formulate and reformulate queries, at the same time, “tools require several interactions which are not easy enough for users to use. The same finding also occurred in Sutcliffe, Ennis and Watkinson’s (2000) study of end-user information searching Medline. In query formulation, users liked the “types of search/field search” for user control, at the same time, they also complained about too many fields make it difficult for them effectively make their choices. In supplemented relationships, a feature’s ease-of-use and user control are responsible for different part of a sub-task. For example, in query reformulation, “search history” was regarded highly for its ease-of-use in accessing previous queries as well as for its usefulness (user control) in tracking down the search process. In contrary relationships, features for ease-of-use can be the problem for user control, and vice versa. For example, command mode in Dialog is preferred for user control, but disliked for its difficulty of use. Also “search for databases” is praised for user control, but cause more confusion for its complexity of use in some of the IR systems.

According to Krichamr (1981), frustration with only one or two important features of one system could easily lead to negative attitude toward the entire system. It is important to establish positive relationship between ease-of-use and user control of a feature. Among the four types of relationships, researchers need to focus on the conditional, supplemented, and contrary relationships. More features for supplemented relationship are wanted since users can take advantage of one feature for both ease-of-use and user control. Features for conditional relationship needs to be improved to make sure these features satisfy both requirements for ease-of-use and user control. Otherwise, these features still have major problems. Features for contrary relationship need to be paid more attention. It is important to convert this relationship to one of the other three so these features will not cause any negative impact to either ease-of-use or user control. Therefore, the overall perception of an IR system can be improved.

When we discuss ease-of-use and user control, we have to discuss the system involvement and user role. Information retrieval is interactive, and interaction requires both the user and the system play different roles in performing different tasks (Beaulieu, 2000). Ease-of-use can be achieved by system design, but user control needs the collaboration of system and user involvement. Bates (1990) called for the need to delegate clear responsibilities for system and user involvements. While Bates focused on the discussion of both the user and system involvements from different levels of search activities, the author tries to associate the system and the user involvement with ease-of-use and user control in the context of achieving sub-tasks of the search process. In order to achieve each of the sub-tasks, IR systems and users need to collaborate together. For example, Livonen and Sonnenwald (1998) found that users’ term selections came from six sources: controlled vocabularies, documents and the domain, the practice of indexing, clients’ search requests, databases, and the searchers’ own search experience. It is too much burden for users to select terms from all six resources, and at the same time it is impossible for any IR system to provide terms from all the resources either. It can only been done by both the user and the system involvement. According to Dunlop, Johnson and

Reid (1998), evaluation of information retrieval systems need to focus on two layers: evaluating the underlying system effectiveness and the overall ability of the system to aid users. The overall ability to aid users should not stop at making the system easy to use, but, more importantly, the system should extend the users' ability to exert control.

In terms of system functionalities, in database selection, systems needs to provide different ways for users to view or find all the relevant databases that are available when users need to make judgments about relevance of the available databases. In query formulation, the system needs to expand the users knowledge frame work, and further provide terms, field searches and examples of searches when users need to make decisions about search strategies, terms used, relationships of the terms and any field searches. In query reformulation, the system needs to keep track of the search process to assist users in reformulating their queries when users need to evaluate the search process and identify problems, and finally make a decision about how to reformulate their queries. In results organization and evaluation, the system needs to organize and display the results in different ways to assist evaluation when users need to effectively evaluate results. In results delivery, the system needs to offer more options for results delivery with different styles. In using help mechanisms, the system needs to offer various types of easy to access, context-sensitive and well-organized help mechanisms when users need to define and categorize the problem encountered and further make decision about how to apply the information obtained from the help mechanisms to solve the problem. In order to create an ideal online IR system, user involvement needs to focus on how to make conceptual judgments and decisions, and system role needs to work on how to extend users' knowledge structure and assist them make various types of decisions.

One issue related to system involvement and user role is that not all sub-tasks are equal in terms of its requirement for ease-of-use and user control. User involvement is essential and cannot be missing from any tasks and sub-tasks since only users themselves know their overall search tasks and how these can be changed according to the circumstances. Some sub-tasks require more user control while the others require less. That all depends how much cognitive activity a user has to engage in in achieving these tasks. Extending previous research regarding greater control needed in database selection (Belkin, et al., 1996; Koenemann, 1996; Park, 2000), this study indicates that users need to engage in more cognitive activities in database selection, query formulation and query reformulation. It takes great cognitive effort for users to convert their ambiguous information need to a query. It takes the same or more effort for users to identify appropriate databases that might contain information to meet their information need. In addition, relevant articles on a particular topic are scattered in a large number of databases, and the most useful databases may only account for very little of the relevant literature (Hood & Wilson, 2001). That makes the processing of finding relevant databases even more difficult. Users want user control in database selection, query formulation and query reformulation, moreover, they need online systems to support their decision-making by expanding their knowledge base and search capabilities which are yet to be done in the current online systems. It is important to incorporate system features to allow users to exercise control. In results organization and evaluation, system involvement and user involvement concentrate on different aspect of the task. The design should focus on the organization of results in order to assist effective evaluation. Within all the sub tasks, results delivery is the task that requires the least user control since there is not much cognitive activity that users have to go through. In order to improve the existing

features, more options for the customization of results and delivery methods are needed. More important, search records, which contain how the results are generated, should be attached.

Generally speaking, the more a system requires cognition, the more difficult it is to use. Users rather take the path of least cognitive resistance than using effective functionalities of IR systems (Sutcliffe, Ennis and Watkinson, 2000). However, users prefer an interface design that requires a relatively low cognitive load, and the same time, can result in high user satisfaction. (Hu, Ma, & Chau, 1999). Therefore, it is essential to balance the relationship between user control and ease-of-use in designing features for these sub-tasks.

A desired structure cannot be considered as just a simple interface structure. In order to design a good structure, we have to take a couple of things into consideration. In order to support both ease-of-use and user control, the challenge is how to design an online IR system that is intuitive, and that users can customize and personalize the system based on their knowledge and skills.

One way to overcome the challenge is to empower systems as well as empower users. That is to design an IR system to facilitate interactions between users and the system. Therefore users and IR systems become partners. Based on the evaluation of the interactive systems in TREC, Beaulieu, Robertson and Rasmussen (1996) found that most of interactive IR system design focus on interaction in search formulation and query expansion. To facilitate interactions, an IR system design needs to go beyond query formulation. First, it needs to be intuitive and look inviting, so users feel comfortable to participate in the interaction. Second, an IR system needs to build connections to enable users to associate their knowledge of other IR systems they work before to the new system to prepare them for the interaction. Third, an IR system needs to support interactions at different sub-tasks and between sub-tasks. By obtaining information about users' retrieval skills, search tasks and subtasks, and their understanding of the system, a flexible template can be designed to guide users through the retrieval process. Fourth, the design should also enhance the role that users play in the information retrieval process by expanding users' knowledge base, and further supports users in making decision in the search process. As Bates (1990) points out, system involvement should not limit to explain the mechanics of a command, but should suggest links between the human conceptual process and system capabilities that aid the user in carrying out his/her desired activity. Fifth, as the integration of all the functionalities of an online IR system constitute its overall structure, all the functionalities and features should be designed to support both ease-of-use and user control. Based on results of this study, users' dislike of one feature affects their overall evaluation of an IR system. In another word, every feature makes a difference. Sixth, a multi-dimensional help mechanism, which should contain variety of context-sensitive help aids, from examples to error explanations, needs to be implemented into the system to assist users understanding the system and asking questions in the retrieval process. The design of an interface structure goes beyond the interface itself. Bates (in press) developed the Cascade model that describes several design layers, which have to be taken into account in the processing system implementation. Design decisions at each layer have a cascading impact on subsequent layers, therefore, the information content, its database structure, and retrievable elements are essential for effective information retrieval. In one word, we need to take the cascades of interactions into the consideration in order to design a desired interface structure.

## **Conclusion**

Users consider both ease-of-use and user control essential for effective retrieval. It is important to design online IR systems to incorporate desired functionalities and structure to support ease-of-use as well as user control. While ease-of-use mostly can be achieved by system design, user control can only be accomplished by the collaboration between the design of the system and the user involvement. No information retrieval task can be done without users' cognitive involvement, but a good online IR system can extend human knowledge structure and link human conceptual process to system capability.

The model of optimal support for ease-of-use and user control illustrates the essential components for the design. Empowering the system as well as its users is a key approach to achieve the goal of supporting both ease-of-use and user control. To be more specific, the design of an IR system should implement a structure into the system that makes the information retrieval process into an interactive process. Designers need to develop a dynamic interface that incorporates user-adaptable mechanism. Customization and personalization may result in greater user control. At the same time, the dynamic interface should not sacrifice its simplicity and consistency for ease-of-use.

In designing online IR systems, researchers need also take account of user tasks. Different tasks and different subtasks have different requirements for ease-of-use and user control, depending on the requirement for users' cognitive involvement. Designers need to pay special attention to how to aid users in accomplishing subtasks, such as database selection, query formulation and query reformulation. Although this study did require participants to search for three types of tasks: subject search, specific information search and known item search, it did not further analyze the different requirements for ease of use and user control among the three tasks because of the limitation of the data.

Participants of this study can be characterized as novice users of online IR systems but experienced users of Web search engines. The results of this study mainly reflect perceptions of this type of user. One thing was noticed in the data is that users do have some different requirements for desired functionalities and structure. Some users want more control than others while everyone wants ease-of-use. Some users' requirements for ease-of-use and user control do change in the course of their interactions with the system and in the course of learning different systems. They need more control when they have more understanding of IR systems and when their retrieval skills get better.

Further research need to focus on how to incorporate ease-of-use and user control in IR system design to support different types of information retrieval tasks, support different types of users, support the change of requirements for ease-of-use and user control over the course of information retrieval process, and support users in using different types of IR systems.

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