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.
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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 3674, the number of vendors has expanded from 105 to 2454, the number of records available have grown from 52 million records to 12.86 billion records, and searches have grown from approximately 750,000 in 1974 to 90 million searches in 1998 (Williams,

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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 the users' perspective, they prefer the ease-of-use of a variety of functions of Web interfaces, but they are also concerned that they might lose the control in this new environment (Xie & Cool, 2000). Simultaneously, 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 an increased effort. Searchers want both greater user control and greater ease-of-use. They do not 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 (Belkin, 1993; Ingwersen, 1992; Saracevic, 1996). Information seeking is also a form of problem solving. Ease-of-use has been considered an important criterion for selection of information retrieval system (Krichmar, 1981; Lancaster, 1979). 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 an 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 graphic user interfaces has served to increased the ease-of-use of 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 worth doing nothing. 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 task performance, user error rates, and subjective user satisfaction (Hix & 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. 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.

The discussion of ease-of-use and user control is worthless without the discussion of user tasks. 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 and Keil (1998) noted the perceived ease-of-use is affected by the fit between task and technology. An information system that allows a user to perform a task more effectively will be perceived as easier to use, and a system that does not allow the user to achieve his/her 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 in an electronic environment, including: the selection of information source, query formulation, search execution, result examination, information extraction, information search reflection, iteration, and completion. Xie and Cool (2000) further identified six sub-tasks that users have to achieve in order to accomplish their search tasks in searching online databases: databases selection, query formulation, query reformulation, help mechanism access, results organization and display, and results delivery. This study builds on the classification of these six sub-tasks.

3. Methodology

Forty students who took the class "Electronic Information Retrieval Systems" in spring 2001 were recruited for the study. In-depth data were 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 (Tenopir, 2001; Williams, 2000). Their search experiences of these online systems were recorded through out 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 of the online systems; (2) data collected when participants searched each individual online system, 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 self-administered reports.

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 systems, participants received standard instructions/lectures about the background of the vendors, and how to use features and functionalities that are designed to achieve all of the sub-tasks. However, to minimize the influence of the training, the lectures did not discuss any of the systems in terms of their ease-of-use and user control. Each subject then was asked to perform searches on seven 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.

In order to minimize the impact of the order of the systems that participants learned to use, at the end of semester, data were also 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 uses in a general sense, their levels of ease-of-use, and their levels of user control in achieving all the sub-tasks. The taxonomies of structures/features of the five online systems for the six sub-tasks were summarized and presented to the participants as long as the structure/feature existed in at least one of the online systems. 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 that users generally perform, participants finally were asked to conduct three searches: for a known item, for specific information, and

Table 1
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

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. Participants were surveyed about their frequent use of different types of IR systems before this study. They were asked to indicate their uses of different types of IR systems, on a 1–5 scale, in which 1 = never use, 2 = rarely use, 3 = occasionally use, 4 = often use, 5 = use daily. According to the results, while participants are frequent users of Web search engines ($\bar{x} = 3.75$) and online public access catalogues ($\bar{x} = 3.03$), they rarely use online databases (from $\bar{x} = 1.13$ to $\bar{x} = 1.38$). This selected group minimizes the potential influence that participants might bring different experiences of online systems to the study.

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 and Corbin's grounded theory (1990) utilizing content analysis (open coding), which is the process of breaking down, examining, comparing, conceptualizing, and categorizing. Based on the pre-questionnaire, post-questionnaire and open-ended report, open coding was used to develop taxonomies of perceived ease-of-use and user control, desired features and functionalities, desired interface structure, and derivation of a model of optimal support for both ease-of-use and user control. Table 1 presents the detailed data analysis plan.

4. Results

In this section, the author summarizes the answers to the three research questions that were raised in the first section.

4.1. Perceptions of ease-of-use and user control

4.1.1. Perceptions of ease-of-use

The participants considered ease-of-use 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 a pre-condition 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," 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[s] toward systems that have obvious ways of searching and do not take too much time to learn," explained by one of the subjects.

To many users, ease-of-use requires an IR system to have a structure that is easy to navigate. Just as one subject wrote, "ease-of-use requires 'simple' or less precise but easier to navigate structure." Another one added, "the ability to navigate through all the data (that a) system is provided is ease-of-use." 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, "FirstSearch'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. There are two aspects to efficiency, fast response time and efficient use of a user's time. Participants' expectation is "the search has to be fast." One subject illustrated in a quantitative way, "three clicks and I am seeing the information, I want to use." Another one described one bad example of database selection, "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 mechanisms, 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 for user control. A subject summarized well, "user control gives users options in their search." Here are two quotes from the participants regarding two systems in which 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.

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.'' Users can never expect themselves to fully understand an IR system without the help of the help mechanisms. Another subject pointed out, ''the on-screen explanations provided by Lexis-Nexis, Ovid, and FirstSearch are also helpful to novice users 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.'' 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 magazine,'' 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.''

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 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-use and user control to their uses 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 considered 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 preferred both ease-of-use and user control over just ease-of-use or user control because they supplement to each other. One subject explained, ''because without one the 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 more 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 continuous use.''

Users' understanding of ease-of-use and user control is also related to user experience. According to the participants, novice users 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 the 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 six sub-tasks as suggested by the previous researchers (Xie, 1998; Xie & Cool, 2000): database selection, query formulation, query reformulation, help mechanism access, 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. Tables 2–8 present participants' evaluation of each feature available in online database systems in terms of its support for ease-of-use, user control, and its use in a general sense.

4.2.1. Database selection

Database selection plays an important role in achieving the overall search task. "Good beginning is half done" 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 to users' satisfaction with the online system. At the same time, many subjects expressed 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 2 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" ($\bar{x} = 3.97$), which contains several databases with common characteristics, 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, "single database + group database is simple and easy to use." According to the subjects, main reasons for the preferences are: first, "easy to identify databases according to my topic/subject;" second, "being able to choose group databases

Table 2
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

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 rated high for ease-of-use ($\bar{x} = 3.97$), it was not 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 complied 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," which organizes the databases by subject areas, also have the same problem.

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 the correct database," one subject explained his reason. Many subjects agreed with him, "search for databases" helps them to find most pertinent databases. However, 62% of the 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 "it allows more control over the search process" and "it saves time".

4.2.2. 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 formalized statement, and further convert the statement into a compromised need that contains a couple of terms with operators (Wildemuth, Cogdill, & Friedman, 1999). The new emergent Web-based online databases have offered new alternatives compared to traditional command based online databases.

Table 3 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"($\bar{x} = 4$), which provides different fields for users to search, "examples"($\bar{x} = 3.91$), which offers examples of query formulation, and "multiple search modes" ($\bar{x} = 3.77$), which allows users to search in basic, advanced or form modes, were rated as top features for ease-of-use. Almost every subject commented on the helpfulness of the "examples" feature. This feature offers users visual information about query formulation, and makes it easy

Table 3
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

for them to formulate queries. 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 because this helps when you do not know something about a system." Many subjects also praised the ease-of-use of the "types of search/field search" option. Here is one typical comment, "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" ($\bar{x} = 3.86$), which enables users to search for documents in the specific indexing structures of the current databases, such as the vocabulary Tree, Thesaurus, and others, 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 did not know what to do, for example, " I liked to browse features when I was not 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."

Flexibility was perceived as the product of the availability of "multiple search modes". 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 fits me best." However, not all the search modes were welcomed by all subjects. While 80% of the subjects praised the user control of the command mode of Dialog that assisted them in efficiently constructing their queries, 64% of them complained about its difficulty of use because they had to strictly follow the syntax of the commands to formulate their queries.

4.2.3. Query reformulation

Query formulation, and especially query reformulation are considered as the most difficult tasks that users face in interactive information retrieval process (Belkin et al., 2001; Efthimiadis, 1996). 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 4 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," which enables users to have an overview of their queries used for the search, and also allows them to combine their used queries, 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. Just as one subject states, "search history—hands down the most effective way to quickly reform queries, see how results were arrived at, evaluate search strategies, etc." Furthermore, "search history" was perceived as one feature

Table 4
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 information in other database/search modes	3.78	4.06	3.72

that helps users correct errors, and not repeat what has been done. In one word, "search history makes reformulation fast and easy."

The "edit/revise search" function was rated high for both ease-of-use ($\bar{x} = 4.03$) and user control ($\bar{x} = 4.03$). Users stated it provided them 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 comment was echoed by many of the subjects. 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," which allows users to search more information by clicking the hyperlinks provided by the systems, and "Find related information in other database/search modes," which enables users to change from one database/search mode to another by using the same query, 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." "Find related information 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 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 do not want to carry the same query to the new database or another search mode.

4.2.4. 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 on 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.

Table 5
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 5 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 rated 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" ($\bar{x} = 3.91$), which provides brief information about features right on the screen, was rated 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 do not have to look for them." More importantly, it "shows you right away what it means, covers how it works." 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 pre-determined, users do not 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," which presents information about databases in different ways such as an 'I' button, 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 is the typical reason that subjects select it as their favorite help mechanism: "Source information gives you options to review databases before you select it." At the same time, it is quite easy to access "source information" by clicking an "I" ("I" stands for information) button.

Overall users do apply "least effort" principle in using IR system. One subject confessed, "I rarely used the help mechanisms, I do not know why I did not, 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 ($\bar{x} = 3.57$). Forty-one percent of the 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 the 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."

4.2.5. Results organization and evaluation

As to results organization and evaluation, users are mainly concerned with how an IR system can assist them in effectively evaluating results. Many users spend 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 evaluation.

Table 6 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)," which displays the portions of the document containing search terms and each search term is highlighted and includes several words surrounding it to give users context, was rated 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," which organizes the results based on 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, that was not always the case. The problem is that I do not know how the system determines the relevance."

In general, subjects 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 does lack the feature—"sort by relevance." Although

Table 6
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
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

subjects had questions about what determines the relevance, they would like to have this kind of feature which could help them obtain relevant results.

4.2.6. 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 are received.

Table 7 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. Participants wanted to keep a record of the process of how they obtained 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 ($\bar{x} = 3.97$). They 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.''

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,'' and ''Search Forms,'' and FirstSearch's ''Basic,'' ''Advanced,'' ''Expert,'' and ''Browse Index.'' Ovid Web offers different field searches, such as author search, journal search, and title search in additional to basic and advanced search. Different from the rest of the online systems, Dow Jones Interactive provides different search forms for different types of searches. It contains ''Newsstand,'' ''Publication Library,'' ''Web Center,'' and ''Company & Industry Center.'' Each has its own unique search form. Table 8 presents the

Table 8
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

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 user control but more impact on ease-of-use. "Multiple search forms" ($\bar{x} = 3.42$) was considered much easier to use than "multiple search modes" ($\bar{x} = 3.69$)" because it only has one search mode.

The integration of different functionalities of an online IR system also constitutes its structure. Table 9 presents each of the online system in terms of its ease-of-use, user control and general use. With all of 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 is the most intuitive, but it still allows a lot of user control." Users have different perceptions of Dialog, especially its command search. Dialog was rated 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 easier 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.

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 using. 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. Almost 100% of the subjects identified this requirement for a good 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

Table 9
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 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. Seventy-two percent of the subjects 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, "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. Sixty-five percent of the subjects recognized the importance of the design of the main screen of a system. A clear first page offers users an easy start as well as psychological 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 mentioned "a clear main screen." 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." 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 are additional requirements for a desired structure. Customization and personalization refer to the ability that a user has to change the default features for different sub-tasks, make some features visible or invisible, and make non-structural changes of interfaces (e.g. color, font size, order, etc.). Although not everyone desires to customize and personalize online systems now, 55% of the participants prefer to have their personalized online IR systems that allow them to configure the most efficient ways to choose database, formulate and reformulate queries, organize and display results, and deliver the final results. 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 to 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. Not all the participants agree on the same criteria for the desired structure. There are different opinions of what constitutes a best structure. While most users disliked Dialog for its difficulty of use, some users liked 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, the options provide the best coverage and most selections.''

5. 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. This study sheds some lights to the myth of ease-of-use and user control. The results of this study highlight important requirements for system design from the 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 concepts of ease-of-use and user control do sometimes overlap. For example, participants of this study considered ''more options'' as an essential element for both ease-of-use and user control. While they liked the opportunities to find at least one option that works for them for ease-of-use, they also preferred the possibility for them to choose any options for user control. More important, the two concepts also depend on each other. More than half of the participants thought ease-of-use and user control were part of an entity, and it would be worth nothing without the other. The perceptions of ease-of-use and user control do not seem to be in conflict if we can make a customizable system 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.

At the same time, ease-of-use and user control are not universal concepts, and they depend on some of the contextual factors. These contextual factors can be summarized as different user groups, different information seeking tasks and sub-task, and different computer programs or systems. Novice and experienced users have different perceptions and demands for ease-of-use and user control. For example, while novice users care more about ease-of-use, experienced users demand more user control. In achieving different tasks and sub-tasks, they also have different requirement for ease-of-use and user control that is highlighted in the discussion of the second research question. Finally, users have high expectation of ease-of-use and user control on IR systems that support more cognitive process than word-processing programs that support more routine tasks.

Ease-of-use and user control, for the most part, are subjective perceptions from users' perspective. This study not only investigates the general perception of the two concepts, but also further explores the participants' evaluation of different features/structures in terms of how they facilitate them in achieving different sub-tasks. That helps greatly to clarify and enrich the concepts of ease-of-use and user control.

The discussion of the rest of the research questions can be best represented into the discussion of the model of optimal support for ease-of-use and user control presented in Fig. 1. This model

System Role

Desired Structure
Intuitive and inviting system;   Share similarities with other IR systems;
Have a clean start interface;   Customization and personalization;

IR Sub-tasks	Desired features for Ease of Use	Desired Functionalities	Desired features for User Control	
Database selection	**Group database selection** / **Single database** / **Subject/topic list**	Provide different ways that users can view, understand and find relevant databases	<u>Search for relevant databases</u> / Favorites/saved databases	Make judgments about relevance of databases available
Query formulation	*Types of search/field search* / Examples / *Multiple search modes*	Expand users' own knowledge structure	*Types of search/field search* / **Tools** / *Multiple search modes* / <u>command</u>	Make decisions about search strategies and queries
Query reformulation	*Search history* / *Edit/revise search* / **Hyperlinks**	Keep track of the search process	*Search history* / *Edit/revise search*	Evaluate the search process
Results display and evaluation	*KWIC* / **Sort by relevance**	Organize results to assist effective evaluation	*KWIC* / **Sort commands**	Effectively evaluate results
Results delivery	*With search history* / *More options for delivery*	More options for results delivery with different styles	*With search history* / *More options for delivery*	Be able to choose different options
Help mechanism	*Examples* / **on screen explanation**	Variety of easy to access, context sensitive help mechanisms	*Examples* / Source information	Make decision about how to define the problem, and how to use the help to solve the problem

Types of relationships for desired features
Independent-------- regular   Conditional------ **bold**
Supplemented ----*italics*   Contrary ------<u>underline</u>
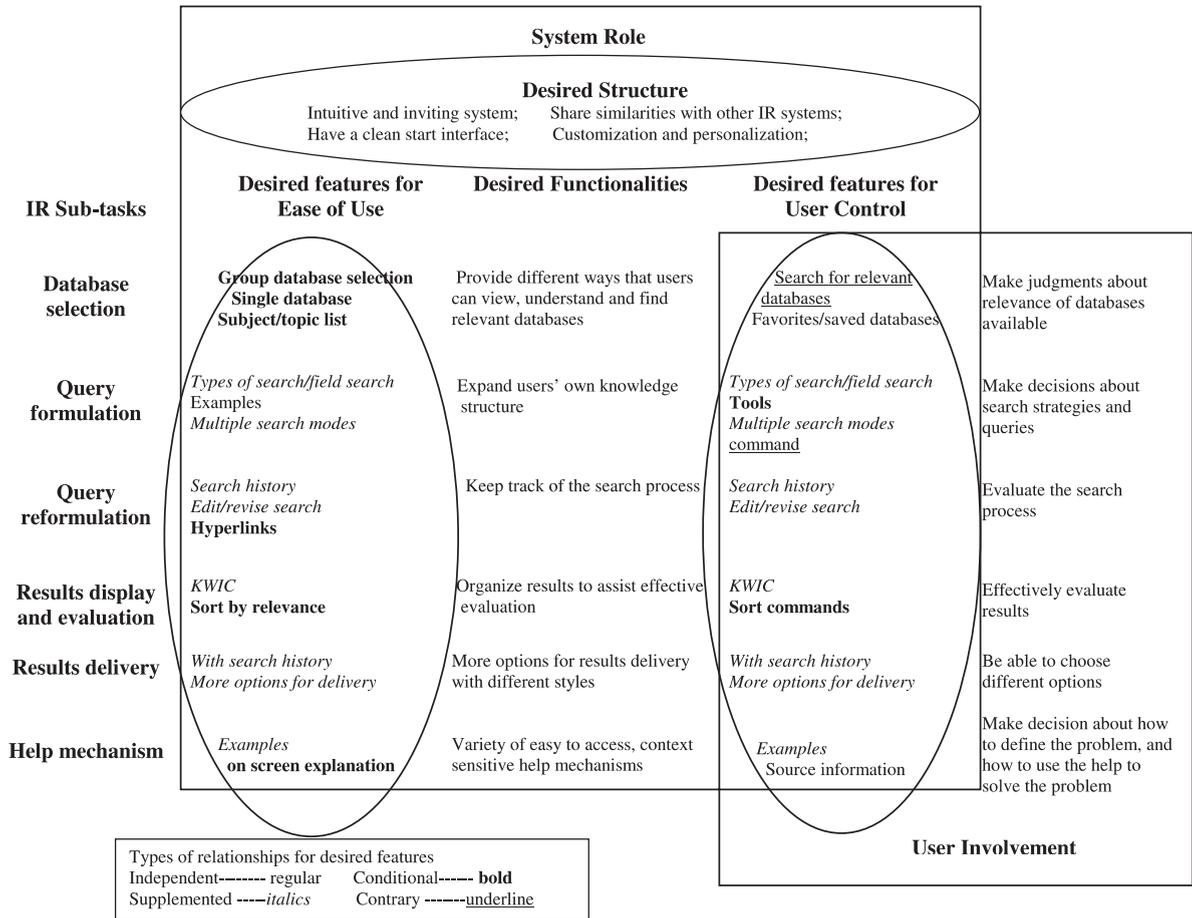
User Involvement

Fig. 1. Model of optimal support for ease of use and user control.

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 user control, and cannot have one without another. According to the results, current features and functionalities of existing online IR systems are not perfect, and they have different problems. To make things more complicated, a feature's ease-of-use and user control are interrelated and impact each other. Four types of relationships emerged based on the problems identified from participants' evaluations of features: (1) independent, (2) conditional, (3) supplemented, and (4) contrary. These relationships arise from both the nature of the features and the problems in the current design of features. In independent relationships, features with ease-of-use have no impact on user control, and vice versa. For example, "source information" 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, "group database" was rated high for its ease-of-use, but this feature in some of the online systems does not allow users to remove or add individual databases within the group. The "tools" feature is very useful for users to formulate and reformulate queries, at the same time, "tools" contains more complicated structure, and requires several interactions which are not easy enough for users to use. The same finding also occurred in Sutcliffe, Ennis, and Watkinson (2000) study of end-user information searching of 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 parts 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 was preferred for user control, but disliked for its difficulty of use because of the variety and flexibility of the command structure. Also "search for databases" was praised for user control, but caused more confusion for its complexity of use in some of the online systems. These relationships were identified from the qualitative analysis, and further statistical analysis would support the relationships better.

According to Krichmar (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 a 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. In order to design features to support both ease-of-use and user control, researchers need to improve the current features by solving the identified problems, and especially pay more attention to the features that inherently have complicated structure. Consequently, 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. 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 framework, 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 to 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 their requirements 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 to achieve these tasks. Extending previous research regarding greater control needed in database selection (Belkin, Cool, Koenemann, Ng, & Park, 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. 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 aspects 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.

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 et al., 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. 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 designs 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 enough to participate in the interaction. Second, an IR system needs to build connections to enable users to associate their knowledge of other IR systems that they have used before to the new system, and 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 sub-tasks, 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 decisions in the search process. As Bates (1990) pointed 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 in understanding the system and asking questions in the retrieval process. The design of an interface structure goes beyond the interface itself. Bates (2002) developed the Cascade model that describes several design layers, which have to be taken into account in the process of 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 consideration in order to design a desired interface structure.

6. 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 a greater user control. At the same time, the dynamic interface should not sacrifice its simplicity and consistency for user control.

In designing online IR systems, researchers also need to take user tasks into account. Different tasks and different sub-tasks 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 sub-tasks, such as database selection, query formulation, and query reformulation. Although this study did require participants to search for three different types of tasks, 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 participants do have some different requirements for desired functionalities and structure. Some of them want more control than others while everyone wants ease-of-use. Some participants' 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.

Acknowledgements

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