Comparison of Contributing Factors in System Affective Response in a Boolean and Hypertext Bibliographic Database Environment

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The present study compares factors of searcher affective response to two bibliographic retrieval systems. One system relied on hypertext linking to facilitate searching, the other a traditional Boolean approach. Eighty-five participants were randomly assigned to either system to perform four search tasks. Data collected from study participants were analyzed using factor analysis to determine underlying factors in searcher response to each system. General attitudes were positive for both systems. Negative attitudes were correlated to searchers' experiences with specific features of each system. Findings of the study have implications for the design of bibliographic retrieval systems and for searcher training.

Introduction

Several methods exist today to permit searching of structured database environments, such as bibliographic databases. Traditionally, a Boolean approach or variant thereof, has been used to allow a searcher to view a subset of the database that contains documents or document surrogates that may be relevant to the searcher's information needs. Queries may be modified based on an initial perusal of retrieved documents or their surrogates, to provide additional relevant items or to further limit the number of items retrieved. Many of today's commercial retrieval systems still rely on such an approach. However, other methods have been developed and may be used for structured database environments.

Searching hypertext-based information retrieval systems is a novel experience for many people. Hypertext-based systems offer an al-

ternative to Boolean-based IR systems; specifically, they offer associative links between discrete units of information. When used with a database of structured bibliographic records, these links can be identical to traditional bibliographic links (such as "see references" or controlled vocabulary terms) or they can be non-linear semantic links. These non-linear links are the hypertext model's unique contribution to information retrieval and provide one means of overcoming one of the major limitations of Boolean-based systems.

Only anecdotal information is available that describes searchers' affective response. The study described here was undertaken to explore this area. Specifically, this study's objective was to determine if any differences existed in searcher affective response to a hypertext-based bibliographic retrieval system and a comparable Boolean-based system, each using the same database. Although not a performance measure, searcher affective response could play an important role in how an IR system is used, and therefore the outcome of search tasks. Findings of the study have implications for bibliographic retrieval systems design, where searcher conceptualizations may be instrumental in deciding on system design features. Results may also have applications for how searchers may be trained to use information retrieval systems.

Previous Studies

The study of user behavior with traditional Boolean-based information retrieval systems has been a staple of IR research literature for many years. Theories have been developed to better explain the search process. Bates (1989) developed a "berrypicking" model of information retrieval in which the retrieval process is likened to the process of searching for isolated berries scattered in a forest. To facilitate this approach, browsing, citation searching and area scanning are among several techniques suggested for inclusion in online retrieval systems. In another study, Jacobson (1991) relied on the communication theory of "sense-making" to describe the search processes of novice searchers in a multi-file, full-text database environment.

With the recent popularity of hypermedia-based retrieval systems, user studies focusing on how hypertext systems are used have also

been undertaken. The majority of these studies have utilized databases that consisted of full-text documents. Tague-Sutcliffe and Toms (1995) used transaction log analysis to evaluate novice searcher behavior with a hypertext, full-text database of proceedings and decisions of court cases. They found that: searchers were more successful when they used the system's indexes rather than search commands; repeated internal browsing negatively affected recall; content summaries did not assist searchers in distinguishing between relevant and non-relevant text, and ; available on-screen help was inadequate. Similarly, Marchionini et al. (1991) examined the effects of search and subject expertise on searching in a HyperCard stack dealing with hypertext, employing both novices and experts in the process of online searching and hypertext. The authors found that search specialists exhibited a more varied approach to searching than the subject specialists and that subject and search experts outperformed novices in retrieval performance.

In one of the few user studies that utilized a structured bibliographic database in a hypertext environment, Borgman et al. (1990; 1991) examined children's use of a hypertext-based card catalog. The authors found that children were able to search a hypertext-based card catalog without prior instruction. Further, they observed that the children were able to search as effectively using a Boolean-based catalog. The children liked the hypertext-based and Boolean-based systems equally, but the hypertext-based catalog was liked more consistently across all age and gender groups. Another study which utilized hypertext-based interfaces with bibliographic databases include Nelson (1991), who reported on the use of a hypertext-based IR system for an online public access catalog which employed a browsing option as a means of replacing Boolean operators to reduce the size of retrieved sets.

More recently, Dimitroff and Wolfram have investigated the applicability of hypertext-based bibliographic retrieval systems in a series of studies. Initially, the authors investigated the feasibility of the design of such a system, called HyperLynx (Dimitroff and Wolfram 1993) and searcher affective response to the system (Dimitroff and Wolfram 1995). The authors found that the design of a small database system was at least feasible, and that novice and experienced

searchers reacted favorably to the hypertext approach. However, the lack of Boolean search capabilities to help focus search strategies was frustrating for experienced searchers accustomed to Boolean search features. In subsequent investigations the authors studied the effect of linkage structure on searcher performance and attitudes (Dimitroff, Wolfram and Volz 1996; Wolfram, Volz and Dimitroff 1996; Wolfram and Dimitroff 1997) and performed a direct comparison of searcher performance using a comparable Boolean-based system (Wolfram and Dimitroff, submitted). The authors concluded that the addition of inter-record linkages based on key words from titles and abstracts did not significantly improve search outcomes in most circumstances. From a performance perspective, the Boolean-based system provided superior retrieval performance, particularly in search situations where a large number of relevant records existed in the database.

The present study represents the final phase of the HyperLynx project. Searcher affective response for the HyperLynx and Boolean-based systems was studied to determine if significant differences existed in how searchers perceived each system. With knowledge of performance and searcher attitudes, recommendations can be made for the design of bibliographic database systems that incorporate hypertext linkages.

The Search Systems

The HyperLynx system was developed using Asymetrix ToolBook, an authoring package with a flexible and powerful application development environment. The system contains approximately 3,000 records from the NTIS database dealing with library and information science. Pre-coordinate or non-Boolean searches can be carried out on several fields. Access to records is initiated through indexes on vital record fields including authors, descriptors, and complete titles. A user may browse an index by indicating the first letter of the term to browse, then scroll through the list of terms until a desirable term is found; or the user may enter a search term which, if it exists in the index, is found and highlighted. The number of postings associated with the search term (except for the complete title index, which consists of unique entries) is indicated beside the

term. Once in the database, searchers are able to browse along different dimensions by using author and descriptor linkages on a record page or by returning to the different indexes for new terms to use. For authors and descriptors, access is gained from an index to the first record in a circular list of linkages if more than one document is available under the search term. Searchers may navigate to each record containing the term, the last record being linked to the first record in the list, thereby permitting circular traversal of common instances within the records.

By linking records with the same author, a possibly important connection is established since authors will often produce more than one work in a subject area, or may produce other works, which could also be relevant to the searcher query. Searchers may at any time traverse to other linked records via linkages associated with co-authors and descriptors or go back to any index for the selection of other search terms. The main advantages of the design were its simplicity, requiring no familiarity with Boolean operators and flexible browsing, which permitted searchers to explore several avenues within each record.

The Boolean retrieval system, containing the same database as the HyperLynx system, was developed using InMagic DB/Textworks for Windows. This system provides searchers with traditional Boolean search operations and nested searching capabilities on both the author field and descriptor field in addition to full title searching. Only rudimentary knowledge of search command syntax was necessary since searchers need only enter search terms manually or from a searchable index, and searches were able to select the desired Boolean operation from a selection box. The record page interface for both systems was designed to provide the same "look and feel" when browsing the database contents.

Methodology

Eighty-five subjects were recruited from the student body and staff of the School of Library and Information Science at the University of Wisconsin-Milwaukee. Subjects were briefly interviewed regarding their experiences searching electronic information retrieval sys-

tems and their knowledge and/or experience with Boolean and hypertext-based systems. Subjects were randomly assigned to either the HyperLynx system or the Boolean system.

After a brief orientation to the system assigned, subjects were given four search questions for which they were asked to find relevant records using the assigned system. The first search topic, representing a practice question, asked that they find a known item document by author. They were also asked to conduct three subject searches: one with a small relevance retrieval set (4 records), one a medium set (23 records) of relevant items, and one a large retrieval set (50 records). The subject search topics required the use of more than one descriptor for optimal retrieval. In addition, the search topic with a large relevant retrieval set necessitated non-sequential exploration of records. An electronic log was created for each subject that automatically recorded several process variables. Usage and performance outcomes of these data have been dealt with in detail elsewhere (Wolfram and Dimitroff, submitted). Upon completion of the search tasks, subjects were asked eleven closed-ended questions designed to determine their affective response to the assigned system. Questions were based on those used by Dalrymple and Zweizig (1992) in a study comparing affective response to an online catalog and traditional card catalog (see Table 1). Subjects were asked to use a 10-point scale (1 = disagree, 10 = agree) to respond to each statement.

T-tests and factor analysis were used to analyze the participant responses on the survey instrument. Factor analysis serves as a useful tool in categorizing searcher responses. The aim of factor analysis is to summarize the interrelationships among the variables in a concise but accurate manner as an aid in conceptualization (Gorsuch 1983). Complex data sets with many variables can be simplified by identifying underlying factors that may suggest relationships between groups of variables (Losee and Worley 1993, 194). Factor analysis provides both qualitative and quantitative distinctions and was used in this study as means of describing "operational representatives" (or factors) underlying the complete set of searcher affective variables. The exploratory use of factor analysis described by Gorsuch (1983, 4) as a means of giving rise to future

theory and research was used by Dalrymple and Zweizig (1992) in their study of searchers of library catalogs. They suggest that constructs derived from factor analysis be used in combination with other measures to provide a more complete and accurate picture of the process of information retrieval. In this study, the researchers used factor analysis in order to clarify, corroborate, or enrich results of the search process and outcome analysis.

Findings and Discussion

T-tests were tabulated initially to determine if there were any significant differences in searcher response to each system. A significant difference was found for only one variable ($p < 0.02$). In response to the statement "The information system was frustrating to use", subjects who had searched the Boolean system were more likely to agree with this statement (mean 6.91) than those who had searched the hypertext system (mean 5.65). This finding may be reflective of the more rigid search environment of the Boolean-based system. Boolean-based systems can be much more unforgiving of searcher error since input must be exact. One of the much-touted benefits of a hypertext-based interface is the flexibility provided the searcher to explore the database contents. This flexibility may have resulted in significantly less frustration on the part of the subjects. With only one variable showing a statistically different mean, further investigation of the differences in subjects' experiences with the two systems was needed. Exploratory factor analysis provided some clarification in the analysis of subjects' reported responses.

The data analysis for each system was computed using the factor routine in SPSS. The principal components method was selected to extract the factors. Initially, a non-orthogonal rotation of the factors (oblimin) was used for both systems, which takes into account potential correlations between factors. Due to the low correlations between the factors for the hypertext system (i.e. less than | 0.2 |), the analysis was rerun for the hypertext system using an orthogonal rotation (varimax). Tables 2 and 3 display the results of the two factor analyses.

Table 1. Mean Affective Ratings: Boolean and Hypertext Systems

Question	Variable Name	Mean Response* Boolean System	Mean Response* Hypertext System
The HyperLynx system was easier to use than I expected.	EASIER	6.24	5.49
The HyperLynx system was fun to use.	FUN	5.56	5.75
The HyperLynx system was frustrating to use.	FRUS	6.91**	5.65**
The HyperLynx system was easy to use.	EASY	5.94	5.2
When searching for records, finding search terms was difficult.	FTERM	6.29	5.96
The HyperLynx system is confusing to use.	CONFUS	5.21	5.98
Compared to other IR systems, I made more mistakes using the HyperLynx system.	MISTAKE	5.94	6.14
I found the linkage structure of the HyperLynx system difficult to picture in my mind.	DATPIC	5.24	5.57
I found navigating through the HyperLynx system overwhelming.	OVRWLM	3.5	4.16
Were there too few access points to use in identifying relevant documents?	FEWACC	5.88	5.18
Were there too many access points to use in identifying relevant documents?	MNYACC	4.65	4.45

* Rating scale = 1 (disagree) - 10 (agree).
** Difference is significant, $p < 0.02$.

Factor Solution: Boolean System

The analysis for the Boolean system resulted in three factors. The first factor, explaining 42.4% of the variance, includes variables that reflect subjects' attitudes toward usage features. These variables included: frustration, difficulty in finding appropriate search terms, increased mistakes, difficulty picturing the database structure, and too few access points. All of the attitudes of the subjects' on these variables were negative and all were interpreted as relating to the subjects' difficulties in using the system. In other words, the subjects' *reactions* to having difficulty with the mechanics of searching. This factor was called "usage features."

The second factor, explaining 15.8% of the variance, consists of variables related to searchers' more general reactions to the system as a whole and these were all negative reactions. This factor was labeled the "overall negative" factor. The variables loading to this second factor include: confusing, overwhelming, and too many access points. These three variables all describe broadly applicable reactions to the system. Note that these all resulted in negative correlations. Given the wording of the questions, the subjects' reactions are, in fact, positive (e.g., navigating was not overwhelming and there were not too many access points). Note, too, that while MNYACC may appear to be similar to FEWACC in terms of specificity of the problem, the MNYACC variable is assumed to reflect subjects' reaction to an excess of potential options or the subjects' inability to deal with the many access options. Both scenarios might be logically grouped with searchers' confusion and feeling of being overwhelmed by too many options, for example.

The third factor, explaining 10.6 percent of the variance, includes general positive attitudes. This factor includes the variables easier to search than expected, fun to use, and easy to use. This factor was called "overall positive."

These results show that the negative reactions of subjects are the result of relatively specific problems. For instance, selecting appropriate search terms, a feature that allows little flexibility or forgiveness in a Boolean-based system. Too few access points, too, could be the cause of the same kind of negative response: the limitations of having to input the database-specific search term could result in negative reactions.

Table 2. Factor Solution (Oblimin): Boolean System

Variable	Factor 1	Factor 2	Factor 3
FRUS	0.62		
FTERM	0.76		
MISTAKE	0.48		
DATPIC	0.68		
FEWACC	0.69		
CONFUS		-0.53	
OVRWLM		-0.80	
MNYACC		-0.97	
EASIER			0.83
FUN			0.85
EASY			0.87
Percent of Variance Explained	**42.4**	**15.8**	**10.6**
Cumulative Percent	**42.4**	**58.3**	**68.8**

Factor Solution: Hypertext System

The second solution used the data from subjects assigned to the hypertext system and also resulted in the emergence of three factors. The first factor, accounting for 32.9% of the variance, is similar to the Boolean system solution's "attitude toward usage features" factor. Variables include: frustration in finding appropriate search terms, confusing to use, increased mistakes, difficulty picturing the structure of the database, feeling overwhelmed by the options, and too many access points. These variables describe negative reactions to relatively specific usage features and are very similar to the responses reported by Boolean system subjects' first factor.

The hypertext system subjects' second factor accounts for 21.5 percent of the variance. This factor contains several variables that reflect searchers' attitudes toward positive, general variables: the system was easier to use than expected, was fun to, use, was easy to use, and was not frustrating to use. This factor was also called "overall positive."

The third hypertext factor, accounting for 11.4 percent of variance, was called "database structure." It consisted of the following three

variables: too few access points, too many access points, and difficulty in picturing the structure of the database. The last two variables also loaded into the first factor ("attitude toward usage features").

Table 3. Factor Solution (Varimax): Hypertext System

Variable	Factor 1	Factor 2	Factor 3
FTERM	.53		
CONFUS	.79		
MISTAKE	.77		
DATPIC	.52		.55
OVRWLM	.76		
MNYACC	.68		-.51
EASIER		.83	
FUN		.84	
FRUS		-.80	
EASY		.72	
FEWACC			.86
Percent of Variance Explained	32.9	21.5	11.4
Cumulative Percent	32.9	54.4	65.9

Because the results do not, in themselves, offer any hard evidence in support of any theory, care must be taken in interpretation. Factor analysis can, however, help in interpreting a variety of variables by clustering them. In looking at affective response to two information retrieval system models it was useful to see how factor analysis went beyond examination of a group of unique variables to examination of the underlying dimensionality of the subjects' reactions through identifying composite factors. Since, in both cases, roughly two-thirds of the variance may be explained by the resultant factors, other influences unaccounted for by the factors may also play a role to a lesser degree.

What was revealed here was that both system models resulted in positive reactions to each system in general, overall terms. Clustered negative responses related to searchers' experiences with specific usage features, such as finding appropriate search terms. These results may inform system designers or those involved with user training to focus on specifics: those features that, no matter what the underlying model, compromise a search query or are not "for-

givable" by the system (e.g., mapping variant spellings to system acceptable search terms). Underlying structure and, surprisingly, the wealth of additional search options available in the hypertext model, did not positively or negatively influence searcher reactions.

Given that the two systems were designed to appear as similar as possible and that the structured bibliographic records were identical in both systems, it was a bit surprising to find that the database structure emerged as a factor in the hypertext system group. The findings show subjects reacted negatively to variables that clustered together which relate to the structure of a hypertext-based system. The earlier performance study comparing the two systems (Wolfram and Dimitroff, submitted) revealed that for queries resulting in a large number of relevant items, the Boolean system out-performed the hypertext system, which may explain why searchers reacted negatively to some of the hypertext structure. Systems designers might note that while the screen layout may make the search processes appear similar, with different underlying models searchers still perceive database structure features differently. Searcher affective response can be an influential determinant in how effectively an information retrieval system is used. Based on the findings of the present study, the authors conclude that the underlying structure does affect how searchers view the system, despite similar interfaces, which can influence search outcomes. Therefore, designers should not simply focus on the interface alone when trying to improve IR system usability.

Conclusions

The present study attempted to ascertain primary constructs that describe searcher affective response to a Boolean-based and hypertext-based bibliographic retrieval system using factor analysis. Although the use of factor analysis does not unambiguously support a given theory, it can suggest areas for further exploration or examination. The clustered variables in this study suggest that system interface designers as well as trainers should concentrate on what might appear to be relatively superficial, mechanical search features. With or without an understanding of the concepts associated with electronic information retrieval, searchers' frustration can be avoided by insuring that these mechanical features are as clear and under-

standable as possible. This study also suggests that the generally positive feelings the subjects had toward both models did not carry over to the search features. This may, however, be explained by the study population: the subjects all were affiliated with an LIS program, therefore they may have had a more sophisticated understanding than a typical information retrieval system user of the concepts required for successful searching. Their negative responses were not related to the search process overall but rather those features that tend to change from system to system and from interface to interface. Even the most experienced searcher can empathize with the frustrations that come from inconsistent commands.

Additional research examining a broader range of searchers with more varied search experiences is needed to provide broader generalizations. When used in conjunction with user-based performance research, searcher affective response can provide valuable insight into the overall effectiveness of an information retrieval system.

Acknowledgments

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