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Full Text Search Strategies and Modifications: The Role of the Searcher and the Role of the System

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Abstract: Full texts of magazine and journal articles are searched by end users through many online systems. Advice to end users on how to search full text abounds and there is a growing body of research that examines full text retrieval results. However, commercially available online systems build little of this advice or help with strategy into their software. In examining how eleven academic end users searched the Magazine ASAP full text database on DIALOG, we found a variety of modifications were made to improve precision or recall. Most searchers had an acceptable number of retrieved documents in mind and made modifications to reach that. Searching is an affective, cognitive, and sensorimotor process with much interaction between the searcher and the system. Today's systems do little to assist the searcher and many improvements could be made.

1. INTRODUCTION

Much of the research on retrieval performance of full text databases uses a highly controlled search environment in a research article or single domain database. Professional searchers develop queries, search the database, modify or alter the search strategy as an independent variable, judge relevance, and analyze the results. (1)

This type of study has the advantages that it controls extraneous variables, produces quantifiable results, and can be undertaken by a single researcher. The main disadvantage is that it does not directly involve end users--the primary target group for full text databases. It provides no information on how an end user interacts with a full text database and system and how that system helps (or hinders) their quest for relevant documents.

With a grant from the Council on Library Resources we studied how academic end users as they searched full text magazine articles on Magazine ASAP[TM] online via DIALOG. We recorded their searches, reactions, and interactions with the system. This provided us with a wealth of data on the different ways end users used full text online magazines, their search strategies, strategy modification, their successes or failures, and their interactions with the system.

In a presentation at the ASIS annual meeting last year we examined the variety of uses made of the database, including full document retrieval, partial document retrieval, fact answering, browsing, etc. (2) This paper focuses on the searchers' interaction with the system, when and why they made modifications, affective, cognitive, and sensorimotor behavior involved in searching, and how online systems can be improved to facilitate end user searching of magazines online.
2. **METHODOLOGY**

Eleven subjects participated, including undergraduates, graduate students, and faculty. Each participant was taught basic DIALOG search commands and had the content of the Magazine ASAP (MASAP) database described to them. After a training session and online practice time, each participant was allowed to search up to five hours online on any topic they chose. These five hours were scheduled at each subject's convenience during the course of one semester. A lab monitor was present at each session to help if needed with the mechanics of searching, but was instructed not to guide search strategy. The interactions between lab monitors and searchers in a sense shows times the online system failed to provide adequate support functions for these novice users.

Data was gathered in three ways: 1) pre- and post-interviews recorded the participant's opinions about full text databases, 2) every search session was downloaded and printed out later for analysis, and 3) all search sessions were audiotaped. Participants were taught to "think-aloud" as they searched so we could record their spontaneous reactions and more reasoned relevance judgments as they searched. Ericsson & Simon pioneered this approach and demonstrated that it provides objective descriptions of what one perceives oneself to be doing while engaged in a problem solving activity.(3) Belkin used concurrent verbalizations of database searchers to develop software for human-computer interaction in end-user retrieval systems.(4)

3. **ANALYSIS OF MODIFICATIONS**

Modifications are more interesting than initial search strategies in this study of inexperienced searchers because initial strategies were greatly influenced by what was taught in the training sessions. The searchers had to be taught that linking concepts with a Boolean AND will retrieve more documents than with the (S) paragraph operator or (nN) near word operator, but when to use each to broaden or narrow a search was left to them. Searchers were given a list of DIALOG commands and MASAP field codes.

We suggested in the training session that initial strategies link concepts with the (S) paragraph operator (as recommended in the MASAP and DIALOG manuals.) After that initial search statement, searchers took different modification paths, in part depending on their results.

3.1 **Modifications to Increase Recall**

If the initial statement retrieved zero documents, only rarely did a searcher immediately assume there were no documents. Most were more or less tenacious, often trying a variety of modifications until they got something. Although we did not study personality, our impression was that the number of modifications told us more about the searcher's basic personality than anything else. One particularly negative and pessimistic searcher gave up after only a few modifications if her initial strategy retrieved nothing (and she rarely asked the lab monitor for help, usually not following the advice even when she did ask.) Other, more positive searchers tried a variety of modifications, seeming to believe that the database would yield some relevant information if they could only find the right combination of commands.

Only in a few instances did those searchers who used a broadening of modifications think to add synonyms or to change their initial search words. Even the few times they added synonyms they used only one or two (e.g., tourist policy or tourist development) and no one searcher routinely used the Boolean OR operator or changed words to search a given topic. Most did use truncation to find variations in word stems. DIALOG has no automatic word variant features other than truncation and

3.2 **Modifications to Increase Relevance**

If the initial statement retrieved 40 or more documents, searchers were asked how they perceived the relevance of the results. A second set of searches was done to evaluate the extent to which the searcher could modify their search strategy to retrieve more relevant documents. Searchers were given a broad range of topics to search on, and were allowed to use all the databases available to them. Their searches were recorded and later transcribed for analysis.

A few key words were highlighted, and searchers were asked to explain why they had chosen to use them. Their explanations were transcribed and later transcribed for analysis.

**Data Reduction**

The data was then analyzed to determine which modifications were most effective in increasing recall and relevance. The results were then interpreted to provide recommendations for improving search strategies.
no context-sensitive help messages that suggest alternate strategies.

3.2 Modifications to Increase Precision

If the number of documents retrieved after the initial search statement was perceived to be too many, most searchers used narrowing strategies. Although no one expressed exactly what number was "too many", everyone seemed to have an intuitive feeling of what would be a reasonable and acceptable number. One searcher who retrieved 40 articles in one search said "Forty. Oh, that's good. That's a good number. It's not too big and it's not too small." Another searcher called 31 hits "only 31" but exclaimed "oh that's a lot" when a subsequent search retrieved 169. Perhaps they were assuming there would be false drops with large numbers of documents or that the level-of-effort to view so many would be too great even if many would be relevant. They did not express how they arrived at a threshold number.

A second reason for making modifications to narrow the search was to improve precision after viewing some documents and judging many to be false drops. Although we did not calculate precision rates because searchers did not always view all documents retrieved, a large number of false drops occurred in many searches. Search strategy modifications to restrict retrieval at first often followed the same pattern (e.g., (5)--(10N)--(5N)--(3N) or starting with AND.) One searcher in particular consistently followed this formula, never really catching on to why she kept getting some of the same false drops in each search.

After exhausting the free text possibilities some searchers gave up and viewed titles or citations and KWIC portions of just the first few documents. Some looked for other ways to improve precision, most often finding help with value-added fields. Searchers variously used the MASAP fields for geographic name, controlled-vocabulary descriptors, special features, and SIC codes.

One searcher was getting many false drops in a search about robots used in the hotel industry because many articles described robotic conferences held in specific hotels. She needed to search the concept of "hotel industry", not merely the word "hotel". While viewing her initial search results she noticed that SIC codes were added to some records and before her next search session she went to the library to find appropriate SIC codes for the hotel industry. Even though her SIC code search was very broad (she added no other qualifying terms) she was extremely satisfied with the results.

Another searcher discovered the descriptor field while viewing false drops and asked how she could see and search descriptors for the topic "dance". She did many subsequent searches on dance in different countries, each time restricting the dance concept to the descriptor field. She did not look up additional descriptors or broader or narrower terms, even when her searches were repeatedly unsatisfactory. When a later free text search turned up a document with several relevant paragraphs that had been missed with the descriptor search, the searcher attributed the miss to indexer error rather than understanding that indexers index at the level of specificity of the whole document.

4. REASONS FOR FALSE DROPS

Examining false drops helps to provide insights into the unique characteristics of a multi-title magazine article database that adversely affects precision. False drops occurred routinely for the causes listed in Table 1.

As expected, the peculiarities of language caused the most false drops. Some were trivial (e.g., the word stem Fund retrieving fundamental) that the system could have solved if the searcher had been more knowledgeable. Another common cause was words near to each other but unrelated; sometimes these were in separate sentences or paragraphs, sometimes they were not.
Others causes were more complex having to do with the figurative or idiomatic language that is often used in non-scholarly literature. In a search on Japanese dance, one article was retrieved that spoke of the "Japanese forced to dance to the tune of. . .", another poetically described leaves dancing while Japanese lanterns swayed.

With these figurative false drops, the search terms almost always occurred a single time. Term frequency counts would eliminate many of these. In addition, certain types of articles or magazines could be predicted to contain such language. Magazine ASAP includes some fiction and poetry in popular reading magazines. Categorization of articles and magazines would help the searcher eliminate these.

Such categories are supported by other false drops noted by searchers. At least two searchers noted that false drops came from calendars of events; others didn't like interviews, press conferences, short news articles, etc. If the searcher could have excluded these categories (or included only the types they wanted) many useless articles would be eliminated. When an recurring type is noted, it would be nice to tell the system to exclude types "like this one".

Often the causes of false drops in magazine articles can only be solved with some kind of vocabulary control. Multi-meaning words like Indians and China cause many false drops. Controlled vocabulary descriptors solve the problem if full documents are desired and were found useful by those searchers who caught on to the idea. Automatic thesauri would be more useful. Linguistic analysis of texts would add even more value, but is of course difficult to achieve. Although automated natural language understanding is not yet realistic, Salton has suggested that limited linguistic processing for specific applications might be useful and successful. Finding processes for resolving a certain type of ambiguity might be one such application.(5)

5. SEARCHER BEHAVIOR AND INTERACTION

5.1 Three Behavioral Domains in Online Searching

Online searching is conceptualized as task behavior occurring along three interrelated domains.(6) The affective domain (A) involves the user's goals, needs, and purposes. From the perspective of behavioral psychology, goal or purpose is seen as the exertion of motivational effort towards satisfaction of the goal. The cognitive domain (C) involves the user's knowledge and decisions. Behaviorally, this is viewed as the execution of symbolic sequences in problem solving. The sensorimotor domain (S) involves the user's sensory input and motor output. This includes reading, scanning, and keyboarding.

At any given moment while searching, these three behavioral domains act together as an integral unit, just as in the body, the circulatory, respiratory, and nervous systems act as an integrated unit. Each sensorimotor act (S) is an outward response to the searcher's inner affective behavior (A), and is mediated through the searcher's cognitive behavior (C). For example, when a searcher turns on the KWIC option, each keystroke (S) is a sensory-motor response to the user's goal, which is the affective behavior of wanting (A) excerpts of full-text documents through the cognitive behavior of deciding (C) to opt for the set KWIC option. Or, when an end user types /DE (S) it is a sensorimotor response to the affective behavior of hoping (A) to obtain a retrieval set of indexed documents, by invoking the person's cognitive behavior of knowing (C) the Descriptor field limitor. In this paper we focus on features of searchers' affective behavior. For emphasis, affective words are underlined throughout this section.

In the online searching environment affective reactions to system constraints can cause an end user to abandon a search. Resistance to following instructions causes errors. End users feel insecure, especially in the beginning stages when they demand information and reassurance. The analysis of the affective behavior of searchers shows that full text searching is an emotionally dynamic affair, with momentary Mapping aff designed to

5.2 Titling

Analytic affective reactions ar searcher res on the sce.

(1) "I'd like. . .
This is visit states has t rapid scrollth

(2) "I wish. . .
This is clea achieve the displayed. I continuous involvement

The t retrievals ar categorize speech act retrieval and is positive e use the title second exta records scr to read the naming this L could see system disp.

5.3 Affec

The in the onll transcript a transcripts envromenter retrievals, t the self. sample of t for each aff expresses JN=Time w she rejects magazine. The affect expectatior
momentary ups and downs, involving a range of feelings from insecurity to elation. Mapping affective online search behavior helps identify ways in which systems can be designed to be more responsive to the actual experiences of end users.

5.2 Titling Affective Speech Acts

Analysis of the transcripts of the search sessions identified several kinds of affective reactions that accompanied the search steps. In broadest terms, affective reactions are bi-polar: either positive or negative; either on or off. For example, a searcher reacts positively to a specific retrieval by commenting while reading a record on the screen:

(1) "I'd like to have about three examples, and this one is excellent." This is visibly a positive affective reaction, showing that one of the searcher's goal states has been reached. Or, a searcher reacts negatively to the system's manner of rapid scrolling while attempting to read records on the screen:

(2) "I wish I could see them, they go off the screen faster than I'm reading them." This is clearly a negative affective reaction, showing that the searcher has failed to achieve the goal state of wanting to immediately review the records as they are displayed. In a given search session the interplay of positive and negative reactions is continuous and spontaneous, reflecting the dynamic nature of a searcher's involvement with the search environment.

The transcript is a sequential record of the person's dynamic interplay with the retrievals and with the system itself. In order to analyze this dynamic, it is necessary to categorize the statements (reactions) in the transcript using the methodology of speech act analysis. (7) In example (1) above, the searcher is looking at a particular retrieval and is estimating its value in relation to the searcher's purpose, and this value is positive since the person uses the word "excellent" in commenting on it. We could use the title APPROVING PROGRESS for this positive affective speech act. In the second example, the searcher is looking at the results of a Type command as the records scroll quickly by, and is expressing a desire to stop the flow enough to be able to read the results. We could use the title PROTESTING A SYSTEM FEATURE in naming this negative affective speech act, since the searcher's use of the words "I wish I could see them..." indicates that the searcher feels helpless in changing the way the system displays the results.

5.3 Affective Reactions to Objects in the Full Text Online Environment

The searcher's affective reactions are always directed to an identifiable object in the online environment. The searcher's affective reactions as indexed by the transcript are given TITLES by the speech act analyst, as exemplified above. In the transcripts of this study we identified five objects of affective reactions in the online environment. These were reactions to: retrievals, search strategy, the system (hardware/software), the human monitor, and the self. The affective speech acts were grouped according to the object type. A sample of these are presented in Table 2. A transcript segment and its context is given for each affective speech act. In the first speech act directed to retrievals, the searcher expresses incredulity at the number of retrievals in the set she created by ANDing JN=Time with an author name. This may be labeled REJECTING REALITY because she rejects the evidence that this author could have written 66 articles for Time magazine. Thus, she doubts the reality of the numerical value shown on the screen. The affect in the speech act is the searcher's incredulity that is based on an expectation that was not met. The searcher apparently expected a small number of
6. SUGGESTIONS FOR SYSTEM ENHANCEMENTS

This examination of over fifty hours of end user searching of full text magazine articles reveals many system and database enhancements that would improve the process, results, and satisfaction of the users. Some of the suggested features are already available on some full text systems, but all are not available on any one system. To summarize, these suggested enhancements include:

---the system should ask users if they retrieved too many or too few and offer suggestions to modify. Better yet, for novice searchers automatic modifications based on the searcher's interaction should occur,

---a trouble-shooting help screen should always appear if zero documents are retrieved,

---automatic stemming of singulars and plurals and other common word forms is essential for novice end users. Experienced searchers should be able to turn this off,

---automatic searching of common equivalencies (such as abbreviations) is important, but it too should be able to be turned off,

---dictionaries and synonym lists should be included with full text systems. The systems could display multiple meanings as part of the search enhancement process or use linguistic parsing and word co-occurrence to infer the meaning of ambiguous search words,

---controlled vocabulary descriptors offer a good way to conduct precise cost-effective searches for entire articles. The thesaurus must be online, including all cross references and narrower terms, and broader terms,

---other value-added fields provide opportunities to modify searches to meet the individual needs of searchers,

---in a multi-type article database, categories for types, level, and target audience of articles and magazines would eliminate many false drops

---searchers can usually identify a particular article as useful or not, even if they cannot articulate why. They should be able to point to a retrieved document and tell the system to retrieve more "like that one" (or not like that one),

---frequency counts are an important indicator of relevance and output should at least be sortable by frequency or the searcher given the option of looking at the 10 (or so) most likely to be relevant,

---where in the document search words occur may predict relevance and weighting by location may be appropriate for certain types of articles (e.g., the lead paragraph of news stories, conclusions in research studies or eliminate calendars of future events in articles),
good browsing and display features make the searcher feel good about the search process, feel in control, and be more satisfied with the search results.

6.1 Need for Affective and Cognitive Support for Searchers

The searchers asked a remarkable number of questions in their first sessions, for example, one searcher asked 78 system and strategy related questions. This demonstrates a very significant demand for information about the system and search strategy continuously throughout initial search sessions. This need was partially met for these searchers by the monitors, but most end users are supported to search independently, with minimal assistance. These results suggest that the system might provide more support for novice end users. Evidence from the data suggests that searchers have a variety of needs involving affective and cognitive contact that could be met with current technology. Such new functions may be most useful to new end users and could be suppressed for experienced users, however, such changes may also lead to the development of cognitive and affective support for experienced searchers.

--give reassurance by including helpful messages to the user throughout the search, e.g., "You may enter your command now." "You typed the command incorrectly. Please backspace and enter it according to this example: ss3 and dance/de.", and respond with, "Thank you, it will work now." "Type DS when you want to see the sets you have created."

--ask helpful questions throughout the search, e.g., "Would you like to narrow or broaden the search?" "Which documents are closest to what you are searching for?" "Would you like more that are similar these?" "How many would you like?" "Would you like to see your sets?"

--allow more flexibility in display options, e.g., the KWIC function could excerpt in sentence units rather than word units, and allow KWIC to be set to 75 or 100 rather than only 30 and 50.

--appear non-threatening and 'friendly' with greetings and congratulations, and provide opportunities for feedback, e.g., "How are you (name) today?" "What would you like to search for?" "Good strategy!" "Thank you for searching in the system today." "Please type in your comments and a rating for today's session."


### TABLE 1

<table>
<thead>
<tr>
<th>REASON</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>word stems</td>
<td>fund? retrieved fundamental, fundamentalists in addition to fund, funds, and funding</td>
</tr>
<tr>
<td>words near but not related</td>
<td>&quot;The Sheraton Hotel hosted the Robotics conference&quot; when wanted use of robots in hotels</td>
</tr>
<tr>
<td>mentioned only in passing</td>
<td>&quot;The symptoms of x disease are similar to y&quot; when y was wanted</td>
</tr>
<tr>
<td>wrong database</td>
<td>articles inappropriate level</td>
</tr>
<tr>
<td>figurative speech</td>
<td>dance retrieved &quot;dance to the tune&quot;</td>
</tr>
<tr>
<td>poetic language</td>
<td>Japanese(5N)danc? retrieved &quot;leaves dancing and Japanese lanterns sway&quot;</td>
</tr>
<tr>
<td>common non-content words</td>
<td>grant retrieved Cary Grant</td>
</tr>
<tr>
<td>unsolvable multi-meanings</td>
<td>Indians (American or Eastern) more??</td>
</tr>
<tr>
<td>inappropriate document types</td>
<td>fiction when wanted research or facts</td>
</tr>
<tr>
<td>inappropriate journals</td>
<td>retrieving frivolous or suspect titles when purpose was term papers or research</td>
</tr>
<tr>
<td>punctuation</td>
<td>string of unrelated ideas separated by commas</td>
</tr>
</tbody>
</table>

"66 of them?!"

"And, Could this Roger Rosenbl..."

"(Laughing) Zet ready to give th..."

"Well, hooray, I..."

"Yeah, that's go one is perfect."

"Is that what I..."
AFFECTIVE OBJECT 1: REACTIONS TO RETRIEVALS

Context

End user wants to locate a known article. End user creates a set: au=roger, then combines it: sl and JN=time. End user wonders exceedingly how this author could have written so many articles in Time magazine.

Transcript Lines

"66 of them?!"

"And. Could that be, it has 66 entries for Roger Rosenblatt in Time Magazine?!"

End user still trying to locate the same known article, after many failed attempts uses a final strategy to combine author name with a word thought to be in the title: s sl and water. End user quits the search.

"(Laughing) Zero! Okay. Well, I'm about ready to give this up."

End user successfully combines a set with compound terms, retrieving a satisfactory number of hits (48) by typing: s alchoholics and s7. (s7=adult(w)children) The success comes immediately after a failed search on another topic.

"Well, hooray, hooray, I got something!!"

End user reviews a retrieval in a search for sentences using the word "antithesis" for an English language class. End user is encouraged by good progress.

"Yeah, that's going to be great, that one. This one is perfect."

AFFECTIVE OBJECT 2: REACTIONS TO SEARCH STRATEGY

End user types a command statement, then asks the monitor to approve it before entering the command.

"Is that what I'm supposed to be doing?"

While working out the correct Type command statement to display citations with KWIC excerpts, after entering the command, end user suddenly fears she made a keying error when it actually was correct. She is reassured by the monitor that it is correct.

"Whoops!"
AFFECTIVE OBJECT 3: REACTIONS TO THE SYSTEM

End user exclaims after many frustrating attempts to locate a known article by a known author by searching for name, magazine name, and a title word using various strategies to combine the terms, including proximity operators. End user attributes the search failure to the system itself.

"I can tell you this is never going to sell. To be that awkward to put in a title of an article, it will never sell. (Laughing.)"

PROTESTING A SYSTEM FEATURE

End user does not like to be kept waiting by the system, wants to continue searching, but is held back.

"Is there any way we can go on working while this is printing?"

COMPLAINING ABOUT A CONSTRAINT

End user discovered a satisfactory hit, but wants to get a bit more of the text in the KWIC 50 word excerpt, but refuses to wait for the full text to be displayed.

"Well, that's not worth it, it's not worth it."

COMPLAINING ABOUT A CONSTRAINT

End user needs more of the text than the KWIC 50 word excerpt allows.

"This one would be equally good if I could finish the sentence."

COMPLAINING ABOUT A CONSTRAINT

AFFECTIVE OBJECT 4: REACTIONS TO THE HUMAN MONITOR

End user failed in first search strategy. End user ignores monitor's attempt to suggest an alternative and tries own strategy.

"Just watch and see."

TAKING INITIATIVE

End user refuses to accept monitor's suggestion of an alternate form of a search term. End user quit without trying it. Failed search.

"I don't think it would be spelled with one word."

DISAGREEING

End user is flustered and unable to follow the monitor's explanation for changing the KWIC option from 30 to 50.

"I don't understand what you were..."

EXPERIENCING CONFUSION WITH INSTRUCTIONS

AFFECTIVE OBJECT 5: REACTIONS TO THE SELF

End user admonishes self to discriminate among display options.
"I really should have just gotten the citation."

End user was scanning the screen looking for the "?" prompt after displaying full text. End user *embarrasses* self and *strives* to develop effective search habits, including where to look on the screen at a given stage.

"(Laughing) It's just down in a place that I don't look. It's always on the bottom, instead I'm always looking on top."

End user *strives* to develop effective habits that are secondary to the search, and *warns* self.

"I should learn to keep track of my own notes."

Table 2 Affective Objects in the Online Environment