WHERE SHOULD THE PERSON STOP

AND THE INFORMATION SEARCH INTERFACE START?

by

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ABSTRACT

Many users of online and other automated information systems want to take advantage of the speed and power of automated retrieval, while still controlling and directing the steps of the search themselves. They do not want the system to take over and carry out the search entirely for them. Yet the objective of much of current theory and experimentation in information retrieval systems and interfaces is to design systems in which the user has either no or only reactive involvement with the search process. It is argued here that the advanced information retrieval research community is missing an opportunity to design systems that are in better harmony with the actual preferences of many users--sophisticated systems that provide an optimal combination of searcher control and system retrieval power.

The user may be provided effective means of directing the search if capabilities specific to the information retrieval process, that is, strategic behaviors normally associated with information searching, are incorporated into the interface. There are many questions concerning 1) the degree of user vs. system involvement in the search, and 2) the size, or chunking, of activities, that is, how much and what type of activity the user should be able to direct the system to do at once. These two dimensions are analyzed and a number of configurations of system capability that combine user and system control are presented and discussed. In the process, the concept of the information search stratagem is introduced, and particular attention is paid to the provision of strategic, as opposed to purely procedural capabilities for the searcher. Finally, certain of the types of user-system relationship are selected as deserving

particular attention in future information retrieval system design, and arguments are made to support the recommendations.

I. INTRODUCTION

Much of the advanced research and development of automated information retrieval systems to date has been done with the implicit or explicit goal of eventually automating every part of the process. New theoretical and technological developments have made possible impressive system designs--internal design features allowing many aspects of the search and retrieval to be handled automatically, often including modelling of the user and more or less natural language interfaces [1-10]. An unspoken assumption seems to be that if a part of the information search process is not automated, it is only because we have not yet figured out how to do so.

Some systems are designed to assist users to do their own searching [11-12], and some permit browsing [13-15], but much experimental research seems to be moving toward an ultimate ideal of the system that takes a request in natural language, goes off and searches the information store, and returns to the user the ideal best retrieved set of documents or information.

In other cases, the user is brought more into the search process, but in a reactive way. The implicit assumption in much information retrieval (IR) system design is that the system (and behind that, the system designer) knows best. The user provides information and responds when called on, but the system controls the pace and direction of the search.

Effective systems, in which everything is done for the user, will doubtless be produced, will be very useful for many searchers, and, indeed, may not be far over the horizon. But--and this is a very important qualification--not all searchers want that kind of a response from an information system. There are times for many people when they want to do their own searching, that is, to *direct* their own searching. They may still want the power and speed of an automated information retrieval system to work for them, but only in doing certain things.

There is considerable empirical research available that supports the idea that at least some people want to control their own searches or else do things that typical automated systems do not allow and, often, do not even aspire to make possible (see [16-20], also discussion and review of research in Bates [21]). Many want a sense of control over the search; they want to know what is going on during the search, and what information is being included and rejected and why.

One of the reasons that there is so much effort to design systems to do the searching for the user is that current systems are difficult to use. It is argued here that that difficulty has much to

do with the fact that current systems are often not designed around the actual behaviors that people find compatible in information searching in manual environments. The interfaces are not designed around search behaviors that promote the strategic goals of an information search, and that make using good search strategy easy and natural. Currently, the exercise of good strategy is usually achieved in spite of, or is superimposed on, information system designs.

Consequently, the goal has been formed in much IR research to have the system do the searching for us, but that is not the only alternative. It should also be possible to design search interfaces that harmonize with and make easy the prosecution of good search strategy, systems that make it easy for novices to move quickly into good searching because the system promotes it.

Elsewhere I have used the analogy of automatic shifts and automatic cameras [22]. Side by side with these highly automated forms of technology there is a parallel very strong demand for stick shift automobiles and cameras with hand settings. These latter forms may incorporate many wonderful new automated parts, which their buyers are happy to have, but certain aspects of the operation of both stick shift automobiles and manual cameras remain in the control of their users. In like manner, we may find that many users of sophisticated information systems are happy to take advantage of computer power, but insist on retaining a heavy component of user power as well.

Therefore, in this article we do not ask the more usual question, "How can we automate everything in an information retrieval system?" Rather, we ask, "Which things shall we automate and which not?"

Once such a question is raised, the matter of design quickly becomes more complicated than that question sounds. If we design an information retrieval system and interface intended to be controlled during the search process by the user, then we may want to design *whole new capabilities* that are not of relevance when the entire process is taken out of the searcher's hands. So, let us reword that last question more precisely: "What capabilities should we design for the system to do, and what capabilities should we enable the searcher to exercise?"

In recent years, there has been an explosion of writing on the design of the human-computer interface, and a number of authors have given attention to developing general models of the nature of the interface and design principles to use in creating the interface, e.g., [23-33]. It is assumed in this discussion that good general design principles of the sort suggested by the above-referenced authors will underlie any interface developed for an information retrieval (IR) system.

In addition to general design principles, however, there are design issues specific to the information search process that should be considered as well in attempting to create an optimal interface for information retrieval systems. These information-search- specific features are the

focus here. Thus, for example, suggestions to be made in this article are largely independent of one of the most common distinctions made among interface designs, namely, whether activities are carried out through use of menu, prompt, command, or direct manipulation modes. On the other hand, we will give a great deal of attention to facilitating elements of behavior that are specific to information searching.

Another commonly discussed issue regarding interfaces will be largely ignored here as well, namely, design for novices vs. advanced users. Design features to be proposed can be adapted up or down for users with greater or lesser experience; my concern at this point is the prior one of identifying the features in the first place.

Some of what will be discussed in this article involves capabilities that, to be workable, have to be incorporated in the internal design of the system, that is, into the searching and file organization, as well as into the interface. My primary interest is in what the user experiences when searching, and that, of course, entails the interface. However, that is not to imply that only interface design is involved in the suggestions to be made.

In this article, various ways of dividing up the labor of an information search between the person and the system will be considered. We will look at a number of different configurations composed of the two dimensions of degree of system involvement in the searching, and types of search activity carried out by the person or by the system. The merits of the various possibilities are considered and recommendations made for future research and development.

II. HOW CAN THE LABOR BE DIVIDED BETWEEN SYSTEM AND USER?

Levels of System Involvement

Table 1 lists five levels of system involvement (SI) in searching. By implication, the amount of the user's involvement is the complement of that of the system--that is, the more the system involvement, the less the user has to do in the actual search process.

[Table 1 here]

In Table 1, the general terms "search activity" or "action" are used to cover several types of search thinking or behavior that the user or system might engage in. Those activities will be discussed in the next section.

At Level 0 the designated search activities are human generated and executed; they are not suggested or carried out by the system. At Level 1 the system may list available or recommended search actions when asked. It may also explain how to carry out search

activities, or instruct the user in search strategies. System ability to list these activities, however, in no way necessarily entails system capability to *carry out* the activities. The latter capability may be in the hands of the searcher only, the system, or both.

At level 2 the system can actually carry out search actions on command of the searcher. It still responds passively to the searcher, however, having no capability to analyze searches or develop strategies. At Level 3, the system shows some artificial intelligence for the first time. Using more or less sophisticated techniques, the system can now monitor a search dynamically, analyze it, and recommend search activities, either when a searcher asks for help (3a), or at any time it detects problems (3b). Finally, at Level 4 the system receives the user's query and executes the entire search for the user, either informing the user of decisions made along the way (4a), or not (4b).

It should be noted that these levels are not at all necessarily descriptive of entire systems. That is, any given IR system may contain subsystems or features drawn from various of these levels.

Type of Search Activity

Our second problem is to decide how to chunk search behavior. In Table 2, four levels or types of search activities (SA) are described.

[Table 2 here]

The "move," or identifiable thought or action that is a part of information searching, is the basic unit of analysis of search behavior considered in this model, in much the same way that "field" is the basic unit of analysis in the literature of file organization. It is the smallest unit used in our discussion of searching, just as "field" is for file organization. The term may be operationalized in different ways in particular instances, depending on the needs of the moment. For example, in using "field," in catalog design, the "imprint," i.e., place of publication, publisher, and date, may be defined as a single field for some purposes, and in other cases the individual components may be considered fields.

In like manner, in observing search behavior, we may want to define "enter search formulation" as a move, or pick on some smaller actions as moves, such as "enter term A," "enter AND operator," etc. "Move," like "field," is a basic-unit, workhorse term, and is to be applied to small, discrete thoughts or actions associated with information searching.

"Move" is a neutral term, and can be applied to any sort of activity associated with searching. Moves can be a part of orderly, well-planned searches or random, formless efforts

by people who do not know what they are doing. (Compare Fidel's use of the term "moves" specific to online searching in current systems, which is "changes in query formulation, ...made to resolve three problem situations," viz., when retrieved sets are too large, too small, or off target [34, p. 61].)

"Tactic" represents the first level at which strategic considerations are primary. A tactic is a move or moves made with the purpose of improving or speeding the search in some way. A tactic is carried out either in anticipation of problems, or in response to them, even if the "problem" is simply taking longer to find something than one would like.

Table 3 includes definitions for some example tactics representing the range of categories of tactics suggested by the author to date. For example, the tactic SUPER is to move upward hierarchically to a broader term. SUPER is strategic because the searcher does it to improve the search in some way. To SUPER may increase the recall, since broader terms often describe larger sets of documents. Or, the searcher may use SUPER because she now realizes that an initial term used covered only part of the concept she wanted to express. (The reader is referred to Bates [35-36] for fuller lists of tactics. Other techniques specific to searching in operational database retrieval systems are discussed in Harter [37] and Fidel [34].)

[Table 3 here]

A "stratagem" is a complex of a number of moves and/or tactics, and generally involves both a particular identified information search domain anticipated to be productive by the searcher, and a mode of tackling the particular file organization of that domain. A stratagem is larger than a tactic because it generally involves a repetitive sequence of activities designed to exploit both a particular information domain and a mode of searching selected to be particularly effective in that domain.

A domain might be a series of volumes of a journal, a citation index, an online directory of addresses, or any of a number of other bodies of information characterized by common features and organizational structure. A shrewdly chosen line of attack on that organizational structure can lead to very effective retrieval. Choice of a stratagem and its associated information domain is often a part of designing a strategy for a search. Strategies frequently involve the search of several information domains, with different stratagems for each domain. Table 4 lists and defines some example stratagems.

For example, the "Journal Run" stratagem involves identifying a promising journal and scanning through it for articles of interest. The search domain is the run of volume years examined and the search technique is to locate the journal and scan through contents lists and

relevant articles within the issues. A searcher would ordinarily engage in this stratagem after having noticed that many articles of interest for the topic at hand are published in the journal.

Stratagems are discussed in more detail in [21], though not under that name. Research evidence is reviewed there supporting the importance of these techniques to searchers. All of the example stratagems in Table 4 are currently implementable manually, and some online. It is argued in [21] that all should be available online, and means of implementing them online are discussed.

The military sense of stratagem is a "maneuver designed to deceive or surprise an enemy" [38, p. 1273]. There is no implication of deception in the usage of the term here, however. A stratagem may, in some cases, constitute the entire search; more often, an entire search involves many moves, tactics, and stratagems.

[Table 4 here]

A "strategy" is a plan for an entire search, and may contain all of the previously mentioned types of search activity. A strategy for an entire search is difficult to state in any but the simplest searches, because most real-life searches are influenced by the information gathered along the way in the search. Searchers alter the search formulation and the next steps to be taken in light of information discovered in the search process [21]. However, here is an example search strategy for a fairly simple search:

To write a five-page report on the history of the Universal Decimal Classification scheme:

Search the online catalog by subject or title for a basic text on library classification and cataloging. Locate the text and read basic information about the history of the scheme. Note references in the text to books and articles giving more detail on the scheme. Look up call numbers of referenced books and journals in the catalog. Locate items.

If desired, this strategy could be described in even more detail by listing the individual moves needed to accomplish each step in this description. For example, each move needed to look up and locate the text in the stacks could be described.

Now that the search activity levels have been defined, more needs to be said about the relationships among these types. Search activities have been arrayed top to bottom in Table 2 from small to large amounts of activity that would commonly be associated with each. Tactics might involve one or more moves, a stratagem may include tactics and moves, and strategies may include all three.

However, it should be noted that these four types of activity are not just different sizes of the same thing. It is not the case that one can necessarily put some moves together to make a tactic, some tactics together to make a stratagem, and some stratagems together to make a strategy. Sometimes a tactic is a single move; sometimes several. A stratagem may employ tactics or not. And so on. Each of these is an "emergent" phenomenon, that is, each higher level of search activity is conceptually different, that is, has different properties, from the lower levels, as well as (usually) being more extensive in some sense, just as water is something different from and more than merely the addition together of hydrogen and oxygen.

Furthermore, no claim is made that tactics and stratagems exhaust the kinds of more global activities that a searcher would engage in beyond moves. Any particular search may include other behaviors and cognitions. Thus, a search composed entirely of tactics, or entirely of stratagems, would not be common nor would it be an objective to be desired. At this point, all other activities that searchers engage in besides tactics and stratagems, for want of a more complete model, must be described in terms of the moves of which they are composed. Currently, the description of a strategy may include various combinations of all three lower types of search activity.

System Involvement and Search Activities Combined

Now we are in a position to combine the two dimensions, levels of system involvement (SI), and types of search activities (SA), into a single table. See Table 5.

[Table 5 here]

The table creates twenty combinations (plus subcategories at levels 3 SI and 4 SI) of system involvement and search activity level. To put it differently, the categories represent twenty different ways in which the user and the system can share the activities of information searching.

From here on, the twenty possible configurations will be labelled with a two-part number: The first part represents the level of system involvement and the second part represents the level of search activity. These number combinations are all listed in Table 5; for example, "0-2" represents no system involvement associated with tactics.

Each cell of the table should be seen as representing a possible configuration of combined human-system search activity. That activity may be realized through many different possible specific designs and specific capabilities. For example, the ability of the system to carry out a

tactic at the searcher's command (cell 2-2) may be manifested through many different types of interface designs (menu, direct manipulation, etc.), and there are many different particular tactics that designers may choose to implement. So each cell represents a whole class of capabilities and designs, not just one.

On the other hand, each configuration represented in the table need not define a whole system. These combinations are ways of thinking about human-system relationships in an information retrieval system. In a system of any complexity there may be many different combinations of that relationship implemented in different parts of the system. For example, one system may have excellent methods of implementing tactics and strategies in the interface, while at the same time make no provision for stratagems. Or, a system may monitor (Level 3 SI) one function of the search interface, but have no monitoring capability regarding several other functions, and so on. A designer who chooses to use any of these configurations may combine it in countless ways in a full system design. The purpose here is to present these possible configurations.

Note that the fundamental focus in the table, as well as throughout this article, is on *human direction of activities*. Thus while every cell represents some combination of human and machine activity, that combination is assumed, wherever possible, to be directed by the searcher. So, for example, looking at Level 1 SI and scanning left to right across the table, we can say that this level is concerned with designing configurations in which the searcher can direct the system to display possible moves the searcher can carry out (cell 1-1), direct the system to display possible tactics the searcher can carry out (1-2), etc.

As we go from top to bottom in the table, the system has greater and greater power in searching; likewise, moving from left to right in the table, the system can carry out search activities that are larger and larger. In systematically examining the various combinations of system involvement and search activity, we hope to gain a fuller understanding of, and a new way of thinking about, the powers that can be put into the hands of the user of an IR system.

In the remainder of this section, each row of Table 5 is considered in turn.

Level 0 System Involvement

At the 0 SI level there is no system involvement in the designated search activity. Said activity must be carried out by people, either at the system terminal or completely manually. So, for example,with a system that permitted moves, but had no strategic capabilities (i.e., no tactics, stratagems, or strategies--a configuration common in online systems today), the searcher would have to break every strategic intent down into a series of moves that the system could understand.

To illustrate this example, the searcher may decide to use the tactic CONTRARY when searching on the term "literacy." This tactic is to search for the term logically opposite from that describing the desired information. So, where there is no system involvement at the tactics level (0-2), the searcher must think up the tactic, that is, get the idea to search for the logical opposite of "literacy," then actually think of the logical opposite, which is "illiteracy," and finally, search on the term "illiteracy." The first two moves are mental, and the last, to search on the term, "illiteracy," may involve one or several further moves on or offline, such as verifying the term in a thesaurus, then entering it as both a controlled vocabulary and free text term in an online search.

So, in this example, many moves were involved, and they made it possible to carry out a tactic in an online search, but there was no system involvement with the tactic *as a unit.* The system did not talk about CONTRARY in its interactions with the user--not as a possible search behavior (Level 1 SI), not as a command the searcher could use (Level 2 SI), not as a recommended action (Level 3 SI), and not as a unit automatically carried out (Level 4 SI).

Level 1 System Involvement

At Level 1 the searcher can ask for information about searching. Little of the information currently offered searchers online is strategic in nature; most of it is at the move level. Help screens instruct people in how to word commands and the like, but seldom offer advice on higher level search activities. When we are thinking about possible information that can be provided the user who requests it in an IR system, recommendations about search strategy, including the use of stratagems and tactics, should be included in our thinking as well, whether or not the system has the capacity to carry out these techniques itself.

Recommendations associated with Level 1 can be put in even broader terms: *Information should be provided by the system at the level of the human process engaged in, rather than just in terms of explaining the system to the user.* It is not the job of the user to conform to the system; rather it is the job of the system to help the user achieve his/her goals through the system. The user should be the reference point. Explaining the mechanics of a command is all right for the person who requests that, but information should also be available to assist the searcher in using that command as a part of the search process as understood and thought about normally by human beings. That system assistance then suggests links between the human conceptual process and system capabilities that aid the user in carrying out his/her desired activity.

This is an important point. We want to look here at various possible combinations of human and searcher effort. One way for the system to help is to provide information that

promotes the searcher's thinking process, even if actions at that level are not available directly to the searcher in that system. For example, if the searcher asks for help on tactics, the system may suggest CONTRARY, even if there is no CONTRARY command. It is still of value to the searcher to have this tactic suggested, because it might well be one that he or she would not have thought of otherwise, and the searcher can then figure out how to effectuate this particular activity using the existing system. So this particular form of system involvement, though elementary, does make a material difference, potentially, in the quality and satisfactoriness of the search.

Note that at this level the system is not monitoring the search--it is not figuring out what the searcher should be doing. Rather it is passively responding to the request of the searcher for more information. In the following, each cell in Level 1 SI is considered in succession:

1-1: This level corresponds most closely to current help screens in IR systems. The searcher uses a command such as "help" or "explain" along with a command or feature and is told how to use that capability. In most current operational systems, such as online catalogs and databank search services, e.g., DIALOG, the level of search activity available to searchers is almost all at the "move" level. This holds true whether the system operates with a menu or command approach. An example command would be "Help Subject," with the system responding with instructions such as, "To search by subject enter 'Find subj' followed by the subject you want to search." (To choose to search by subject is a strategic decision, but that decision has usually already been made by the time the searcher asks for the help. The response to the query is purely procedural, i.e., at the move level.)

1-2: In this category, in response to requests from the searcher, the system provides information on tactics the searcher can use. This is the first level at which the information is *strategic* rather than purely procedural. Here the searcher wants to know about techniques that can be used to make a better search.

In the left-hand column of Table 6, "Suggested Tactics in Response to Requests," are listed some request phrases that the searcher might enter, and in the right-hand column are listed suggested tactics. A "Help Help" command could list the possible request phrases. Only the tactics' names are listed in Table 6, but in the actual response the tactics could be defined and examples given, either automatically, or in response to a command or mouse click by the searcher.

Definitions of tactics given in Table 3 were originally developed to facilitate the searching of knowledgeable, generally professional, searchers. Choice of tactics to propose to users and wording of definitions could be simplified for casual end users.

[Table 6 here]

1-3: In like manner to level 1-2, in response to requests from the searcher, the system responds with lists and descriptions of stratagems. Each stratagem could be defined and suggestions made for when best to use each one.

1-4: Here the system would describe an entire search strategy for a user who requested it. As noted earlier, since searches often change in mid-stream, depending on what searchers have already found, this approach might be of limited value for more sophisticated searchers. However, in cases where a type of need is very common, and a certain sequence of steps can be identified as being usually useful in that case, such an approach could be of considerable value.

For example, it might be quite helpful to undergraduate students in a college or university to be able to select one of a set of common search strategies and be told how to carry it out. A partial list of strategies that could be listed in a college or university online catalog help screen appears in Figure 1:

[Figure 1 here]

When the student selects one of these strategies, the system displays a general purpose list of steps to take that are likely to be productive in the stated situation.

Level 2 System Involvement

At Level 2 the system executes search activities at the searcher's command. This level is of particular interest because it represents the possibility of designing system configurations in which the searcher enters, as a single command, instructions to do various types of search activities, many of which are themselves strategic units. In most current information retrieval systems, the user must assemble a variety of atomistic moves, in the right order, and with correct spelling and formatting of a series of commands, to produce what he or she may be thinking of as a single unit. If, for example, the searcher can input a command to carry out a particular tactic that would ordinarily involve a half dozen mental and online moves, it may be much easier and faster for that searcher to do a good search on an automated system.

In this section we consider ways in which systems might be designed to enable the searcher to enter a single command that would accomplish an entire move, tactic, stratagem, or strategy. Each cell in this row of Level 2 SI is considered in succession below:

2-1: This is the level at which most online systems work most of the time. Most of the things a user can do are at the level of moves. For the most part the search capabilities available

to the users are neutral, that is, they are not linked to strategic considerations in optimizing a search.

2-2: With search capabilities in this category the searcher can tell the system to carry out a tactic for him or her. Here, for the first time, the searcher does not have to do all the thinking and search formulating in carrying out a tactic. At this point, at last, the system itself starts to have the ability to carry out strategic activities (not just describe or instruct in them, as at Level 1 SI).

To return to an example used earlier, if the user inputs "CONTRARY literacy" the system could look in its thesaurus for the logically opposite term to "literacy," OR it in with "literacy," and search on it too. Artificial intelligence techniques are not needed-- only proper indications in the stored thesaurus.

Other term tactics would be relatively easy to program. SUPER, SUB, and RELATE could all revise search formulations automatically to include broader, narrower, or related terms listed as such in a thesaurus resident in the IR system. Implementation of such a capability might be along these lines: The searcher highlights the component in a search formulation that is to be altered, types in or hits some function key that indicates, e.g., SUB, and the thesaurus automatically substitutes an ORed set ("hedge") of narrower terms for the indicated term.

REARRANGE can be handled with a straightforward permutation algorithm, and RESPELL and RESPACE can be carried out with the help of dictionaries and algorithms that look for terms that vary by only one or two characters or spaces.

Search formulation tactics, in particular, EXHAUST, REDUCE, PARALLEL, PINPOINT, and BLOCK, could be implemented by allowing the searcher to edit search formulations on screen, similar to editing in word processing. Postings set sizes and example brief citations could be displayed after each modification to enable the searcher to assess the effectiveness of the tactic in improving the search.

These last five tactics all involve manipulating the search formulation by adding or subtracting ANDed and ORed terms. Inherent in the Boolean logic, as is well known, is the fact that each additional AND element will produce an output set that is the same size or smaller than the previous set, and each additional term ORed with a preexisting term in the search formulation will produce an output set that is the same size or larger. So dropping or adding OR and AND elements can increase or decrease output sets as desired by the searcher. Ability to implement these tactics quickly, without laborious re-entering of terms, could make fast, powerful improvement in search formulations and results possible. (See also discussion in [35, 39].)

2-3: At this level the searcher can call up stratagems from the system. Stratagems involve a search domain and a method of searching the domain. The searcher calls up the stratagem and

the system asks for any information it needs to implement it. The purpose here is to make it possible for the searcher to do quickly and easily what he or she would normally do in carrying out a stratagem manually.

The Journal Run was used earlier as an example of a stratagem. It might be implemented by allowing the searcher to input (or select through a menu) the phrase "Journal Run." The system then asks for the journal title and years to be reviewed, and whether the searcher wants to see contents lists or the full text of the journal articles first. Since people doing a Journal Run in a manual environment often browse through articles and read short sections of the article here and there, the system might also offer "snapshots," or randomly selected passages from the articles (see [21]).

Thus, in response to the request for a stratagem, the system makes available to the searcher a package of capabilities specific to that stratagem, with the interaction at the interface designed to be as well fitted as possible to the search needs associated with that particular stratagem. The specific configuration of the interface interactions and the specific combination of capabilities for the searcher will be different in the case of each stratagem. Elsewhere I have suggested key design features associated with each of six stratagems (though not under the name of "stratagem") [21].

2-4: Here the searcher can call up an entire search strategy. This might be doable in cases where the search is relatively straightforward and requires a routine series of actions. An excellent example of that is Rita Bergman's "scripts" [40] for common types of searches in the chemistry literature, such as the search for a Registry Number. After asking for the search, the user is shown a prompt screen, which asks for the relevant information needed by the system to carry out that search type.

Another variant of allowing the searcher to select whole strategies is the following: The searcher is shown a full array of strategic search devices--moves, tactics, stratagems, and strategies. He/she may then select any desired combination, rather like punching in programming on a video cassette recorder. The system then executes just what the searcher has asked for in a predetermined sequence.

Level 3 System Involvement

This is the level at which the configurations begin to show artificial intelligence, in monitoring and reacting to the search dynamically. Not surprisingly, it is more difficult, on the whole, to implement capabilities at this level than was the case with the previous levels.

Levels 3a and 3b refer, respectively, to suggesting help only when the user asks for it, or always when the system identifies a need. Since people do not always know when they need help, or when help would make a difference, a compromise might be for a message such as "Help Available" to appear in the corner of the screen when the system identifies a problem. If the user ignores it, the message goes away after a minute. Thus the user is informed but not forced to respond or deal with a screen that overrides the current search.

3-1: At this level the system monitors searcher moves and suggests improvements, either when the searcher asks, or at any time. The easiest problem to identify is incorrectly spelled or nonexistent commands. Poor choice of moves, on the other hand, is a strategic problem that is difficult to identify at the level of moves, except where a move is illegal or impossible at a certain point in a search.

In the IIDA project Charles Meadow [11] experimented with identifying some common problems at the move level and giving feedback to searchers. For example, the searcher might get a message if commands were repeated too often or if "thrashing" was observed.

3-2: At this level recommendations are made when some tactic would be beneficial or when current tactical behavior is observed to be inadequate. Tactics can be recommended when the system observes problems. Here are some examples: When a very large or very small number of postings, or no postings at all result from a search formulation, the system can suggest that the searcher use one or more tactics from a list of tactics helpful at those points (see Table 6).

The use of all very broad terms in the search formulation can lead to a message suggesting SPECIFY; a very lengthy complicated search formulation can lead to the suggestion of SELECT.

3-3: Monitoring of searches to suggest stratagems is an approach with some interesting possibilities. Most stratagems involve identifying a domain of information that potentially has a lot of information of the type desired. For example, in a manual library environment the searcher may notice that a lot of the articles of interest to him in a new area appear in one particular journal. Thus, to go to that journal and look through issue after issue for relevant articles is a good stratagem at that point in the search. Suppose the searcher does that, and notices two or three articles by the same individual that are exactly in the topic of interest. The searcher may then do an author search to find everything else the author has written on that topic. Having identified those articles by that author, our searcher now scans through the references at the end of the articles to find other articles, authors, or journals of interest. And so on.

In this example, the searcher uses three stratagems in a row, journal run, author subject search, and footnote chasing. A system that is monitoring user searches might also be able to

identify points where certain stratagems look like smart things to do. Suppose the searcher described above enters a standard Boolean search in a bibliographic database. The search formulation produces a retrieved set of 100 items. The system tallies the frequencies of journals and authors in that set. Where the number of publications in the retrieved set that appear in any one journal exceeds a certain threshold, then the journal run stratagem is suggested. In like manner, where the number of publications by any one author in the retrieved set exceeds another threshold, the author subject search is suggested.

3-4: At this level the system would be monitoring the search in order to suggest whole strategies. If the system recognized that an individual was inputting the necessary elements for a certain type of search for which a strategy was already available, e.g., a Registry number search in chemistry, it might suggest that the user call up the strategy instead.

Level 4 System Involvement

At this level the system conducts the given activity automatically for the user. At level 4a, the user is informed of what the system is doing as it goes along; at Level 4b, the user is informed only of the final result. Since no system is yet available that can read minds, useful activities at this level presuppose that the searcher has in some way communicated a need to the system. From that point, however, the system conducts its activities automatically.

Level 4a would involve describing system activities to the searcher--whatever their internal system design--in ways that are meaningful and useful to the searcher. The need for a user to know what has been done for him or her, even when the results are satisfactory, has often been ignored or underestimated by human intermediaries and IR system designers alike. People frequently need to make their own assessment of whether all likely sources of information, including search terms used, have been examined, in order to determine whether their search has been adequate or should be extended to other domains. Thus, even Level 4a gives the user some control of a type not often available in more advanced IR systems.

At level 4a SI we may imagine that the system reports back its activities as moves, or tactics, or stratagems, or strategies, or some combination thereof. That is, the various cells at level 4a represent different ways of reporting to the user what the system is doing automatically. Design configurations that might be tested would answer questions such as: Do people want to learn what the system is doing in a move-by-move way (Level 4a-1), or in higher-level strategic terms (Levels 4a-2, 4a-3, 4a-4)?

For the general user, it would seem to make a lot more sense to show searchers what is happening in strategic terms, such as "expanding the search by using broader terms," than saying merely, "replacing term A with term B." However, professional searchers may want to

see more of the search at the move level, so that they know exactly what is being altered and how.

Level 4b, where the system carries out whole searches automatically, is the level which resembles the objective being sought by much IR research today. Here the user would describe a need and the system would determine a strategy and carry it out automatically. In this case the user's involvement in directing the search is minimal.

III. RECOMMENDATIONS

Having engaged in the two-way analysis of levels of system involvement in searching by types of searching activities, we are now in a position to return to the question posed at the beginning of this article: Where should the person stop and the information search interface start? Table 7 summarizes the current implementation status of the various categories of user-system searching capabilities, as well as the recommended directions for future research.

[Table 7 here]

Operational information retrieval systems, particularly online catalogs and database search services, are currently implemented largely at the move level (1-1 and 2-1). Strategic behavior in information searching must overwhelmingly be exercised by the human searcher (0-2, 0-3, 0-4). Little or no strategic advice, let alone actual operational capability of a strategic nature, is provided by systems to the user.

The goal of many experimental information retrieval systems, on the other hand, is to leap over most of the possible mixtures of human and system involvement to a completely automatic search for the user (Level 4b SI). Exciting as these possibilities are, I believe that there are equally exciting areas of development that are being overlooked.

I recommend that more research and development attention be paid to the central area of Table 7 (1-2,1-3, 2-2, 2-3, 3-2, 3-3). It will be argued in various ways in the remainder of this section that we can expect a high payoff for the development of these capabilities. Furthermore, as these capabilities are tried out, we may learn more about how to develop the remaining categories in the table, in particular, providing assistance with strategies for whole searches (1-4, 2-4, 3-4), and improving the all-automatic searches (Level 4 SI), where so much energy is going now.

It is recommended that, for the most part, we bypass level 3-1, wherein the system monitors a search and suggests moves. Meadow's excellent study found that this combination

required sophisticated design and was difficult to do (11). Many actions at the move level do not track well with human thinking about searching. It is often hard to tell from search moves what search strategies or tactics are intended by the searcher. If we choose to invest the considerable effort that would be required to do such sophisticated monitoring, and I think it *is* desirable to be able to give users such feedback, let us first try to develop the monitoring in terms of search activities that are strategic, that is, that correspond better with human thinking about searching. It may actually prove to be easier to determine the searcher's intent, and thus provide good monitoring and advice, when the searcher's allowable actions are in strategic, rather than move-level units. Research efforts may thus pay off more if they are invested at the tactics level and above, 3-2 and 3-3, rather than at the 3-1 (move) level. Also, computer systems have improved greatly since Meadow's efforts in the mid-1970's; we might find it easier to develop search monitoring in association with IR systems that give users strategic search capabilities directly as tactic and stratagem commands rather than through the combination of many moves that are subject to many interpretations.

In addition to the above general points, I make the following arguments for the recommendation to develop the center area of Table 7 :

1) Research has demonstrated that people are familiar with, and want, capabilities at strategic levels. Strategy development and modification, particularly with subject searching, has been frequently identified as the most, or one of the most, difficult of all phases of searching [41-46].

The response of the information science research community so far has been mainly to try to eliminate the stage of strategy development altogether for users. But other research shows that at least some users take it for granted that they should control their information searching, and rarely delegate the task [16-19]. We still do not know how widespread these attitudes are, but then we have tended not to ask the question either, since so much research is geared toward producing the perfect automatic Level 4b search.

There is also evidence that many queries begin in a very unclear state [47-48]. It is just not possible to clarify the query without some interaction and experimenting. Donald Norman makes some cogent points in this regard:

> Third-person interaction [command mode] is well suited for situations in which the job is laborious or repetitive, as well as those in which you can trust the system (or other person) to do the job for you properly. Sometimes it is nice to have a chauffeur. But if the job is critical, novel, or ill-specified, or if you do not yet know exactly what is to be done, then you need direct, first-person interaction. Now direct control is essential;

an intermediary gets in the way. [49, p. 184].

It is certainly the case that many information searches are "critical, novel, or ill-specified." Thus, the possibility of designing a "stick shift" information search interface and system deserves considerably more exploration.

2) Closely related to these points about the desire and need to have control of search strategies and behaviors are issues about control generally in an automated interface. Human beings have a variety of social and emotional, as well as intellectual, needs. Things they interact with in their environment, even supposedly neutral machines, tend to get incorporated into the human social world and to play roles determined by people that may not be the ones originally intended. Designers who do not acknowledge these needs and behaviors may find their products misapplied or rejected.

Most people have a strong desire for a sense of effectiveness in and mastery of their environment, particularly with respect to things that affect them in a close and personal way. Control of tools or powerful machinery can touch deep issues of personal power and freedom. For example, in the United States, where cities are spread out over large areas, learning to drive and acquiring a driver's license is a veritable rite of passage for many American teenagers. Ability to drive marks a transition to freedom, mobility, and power over one's circumstances that provides, at one blow, many of the perquisites of adulthood. I think it is no accident, therefore, that many American citizens are resistant to the use of public transportation or car pools, even in those cases where they are convenient and cheaper than cars.

As computers are experienced more and more as commonplace personal utilities, I think we can expect to see the same urge for control over computer systems, including information retrieval systems, that we see with cars. To quote the refrain of a popular television commercial of a few years ago, "Mother, I'd rather do it myself!" Experiences with many hand-holding menu-driven systems are showing that after a modest amount of experience, users frequently want the capability of controlling the processing more directly themselves. In seeking to provide the convenience of a wholly automatic Level 4b information search to users, we in information science may unwittingly be robbing people of the power and freedom of choice that they want to keep for themselves.

3) Donald Norman makes another critical point relative to the issues discussed in this article:

> When I use a direct manipulation system--whether for text editing, drawing pictures, or creating and playing games--I do think of myself not as using a computer but as doing the particular task. The computer is, in effect, invisible. The point cannot be overstressed: make the computer system invisible.

> This principle can be applied with any form of system interaction, direct or indirect. [49, p. 185]

Information retrieval systems designed at the move level (0-1 through 4-1) are definitely not systems in which the computer is invisible. Moves allowable in many current IR systems, including some advanced experimental ones, are conceptualized in terms of the mechanics of operating the system (system focus), rather than in terms of the search steps that usually characterize human thinking about finding information (human focus). With most current systems, the searcher must translate, or break down, every desired search action into moves, largely meaningless strategically, which can then be understood by the system. Users might get the feeling that the computer system is invisible if they could carry out actions that track better with their normal thinking about searching. Systems designed with tactics and strategies available to users in various forms should be a step closer to that goal.

4) As noted earlier, the goal of much theoretical information science research has been to produce the perfect Level 4b automatic search. But most of this research is based on the idea of retrieving information from a database of document surrogates (usually bibliographic citations with or without abstracts), or occasionally full text documents. As I noted in [21], however, we are already moving into an era in which a much wider range of information sources is being put online. In using those different types of sources in manual print environments, searchers are now using a wide variety of stratagems. We may expect them to want to use the same stratagems in advanced new information retrieval systems as well. Yet neither the stratagems nor the full variety of types of databases are generally even considered for inclusion in many of the experimental IR systems now under development. Thus users may soon be demanding search capabilities and databases which are not even planned for these otherwise very sophisticated systems.

It is very difficult to design IR systems that produce good automatic searches for users, and so it has made sense that research so far has been restricted largely to one type of database at a time. However, with operational databanks already expanding beyond the type of sources available in many experimental systems, the latter, no matter how clever the system architectures that are being developed, are at risk of falling behind the practical demands of systems already in use.

5) The final argument for developing the center cells of Table 7 is that to do so may prove interesting philosophically, psychologically, and in terms of IR theory. We may learn a lot more about how people think about and carry out information searches in trying to make search capabilities available at various levels. We may also learn a lot more about what sorts of intellectual symbiosis are possible and workable between humans and computers.

If we use, rather than ignore, the special traits of humans in the design of human-computer interfaces for information systems, we may find our abilities enhanced in unpredictable and creative ways. Those of us who use word processing systems have long since noted that our writing patterns and fluency have changed considerably since we abandoned the typewriter. A really good information retrieval system that allows us to exercise strategic search choices quickly and easily may, in like manner, lead us to explore knowledge and research our information needs in far more powerful and creatively stimulating ways than we ever imagined in the days of the manual library or the simple online bibliographic database.

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LEVEL	DEFINITION
0	No system involvement. All search activities human generated and executed.
1	System lists search actions when asked. Searchers request listings but otherwise execute actions themselves.
2	System executes specific actions at human command.
3	System monitors search process and suggests search activities:
a	Only when searcher asks for suggestions
b	Always when it identifies a need.
4	System executes actions automatically and then:
a	Informs the searcher
b	Does not inform the searcher.

TABLE 1: Levels of System Involvement

LEVEL	NAME	DEFINITION
1	Move	An identifiable thought or action that is a part of information searching.
2	Tactic	One or a handful of moves made to further a search.
3	Strategem	A larger, more complex set of thoughts and/or actions than the tactic; a strategem consists of multiple tactics and/or moves, all designed to exploit a particular search domain thought to contain desired information.
4	Strategy	A plan, which may contain moves, tactics, and/or strategems, for an entire information search.

TABLE 2: Levels of Search Activities

MONITORING TACTICS:

CHECK	To review the original request and compare it to the current search topic to see that it is the same.
RECORD	To keep track of trails one has followed and of desirable trails not followed up or not completed.

FILE STRUCTURE TACTICS:

SELECT	To break complex search queries down into subproblems and work on one problem at a time.
SURVEY	To review, at each decision point of the search, the available options before selection.
CUT	When selecting among several ways to search a given query, to choose the option that cuts out, eliminates, the largest part of the search domain at once.
STRETCH	To use a source for other than its intended purposes.

SEARCH FORMULATION TACTICS:

SPECIFY	To search on terms that are as specific as the information desired.
EXHAUST	To include most or all elements of the query in the initial search formulation; to add one or more of the query elements to an already-prepared search formulation.
REDUCE	To minimize the number of elements of the query in the initial search formulation; to subtract one or more of the query elements from an already-prepared search formulation.
PARALLEL	To make the search formulation broad (or broader) by including synonyms or otherwise conceptually parallel terms.
PINPOINT	To make the search formulation precise by minimizing (or reducing) the number of parallel terms, retaining the more perfectly descriptive terms.

TERM TACTICS:

SUPER	To move upward hierarchically to a broader (superordinate) term.
SUB	To move downward hierarchically to a more specific (subordinate) term.
RELATE	To move sideways hierarchically to a coordinate term.
REARRANGE	To reverse or rearrange the words in search terms in any or all reasonable orders.
CONTRARY	To search for the term logically opposite from that describing the desired information.
RESPELL	To search under a different spelling.
RESPACE	To try spacing variants.

IDEA TACTICS:

RESCUE	To check for possibly productive paths still untried, in an otherwise unproductive approach.
BREACH	To breach the boundaries of one's region of search, to revise one's concept of the limits of the intellectual or physical territory in which one searches to respond to a query.
FOCUS	To look at the query more narrowly, in one or both of two senses: (1) to move from the whole query to a part of it or (2) to move from a broader to a narrower conceptualization of the query.

TABLE 3: Selected Example Search Tactics

(See [35,36] for other tactics.)

Journal Run of	Having identified a journal that is central to one's topic of interest, one reads or browses through issues or volumes the journal.
Citation Search citation	Using a citation index or database, one starts with a and determines what other works have cited it.
Area Scan	After locating a subject area of interest in a classification scheme, one browses materials in the same general area.
Footnote Chase	One follows up footnotes or references, thus moving backward in time to other related materials.
Index or Catalog Subject Search	One looks up subject indexing terms or free text terms in a catalog or abstracting and indexing service (online or offline) and locates all references on one's topic of interest.
Author Subject Search	Having found an author writing on a topic of interest, one looks up that author in catalogs, bibliographies, or indexes to see if he or she has written any other materials on the same subject.

TABLE 4: Example Stratagems

Search Activity Level / System Involvement Level	Moves 1	Tactics 2	Strategems 3	Strategies 4
No system involvement 0	0-1	0-2	0-3	0-4
Displays possible activities 1	1-1	1-2	1-3	1-4
Executes actions on command 2	2-1	2-2	2-3	2-4
Monitors search and recommends 3	3-1	3-2	3-3	3-4
Executes automatically 4	4-1	4-2	4-3	4-4

TABLE 5: System Involvement by Search Activity

INFORMATION SEARCH STRATEGIES

Select most appropriate strategy for your need:

1. Locating information for research term paper.
2. Locating information for book report.
3. Locating materials on professor's reading list.
4. Verify or complete a reference for a bibliography.
5. Locate section in book stacks on your topic of interest.

FIGURE 1: Help Screen Partial List of Strategies

SEARCHER COMMAND	SYSTEM RESPONSE LIST
TOO MANY HITS	SPECIFY EXHAUST PINPOINT BLOCK SUB
TOO FEW HITS	NEIGHBOR TRACE PARALLEL FIX SUPER RELATE VARY
NO HITS	RESPACE RESPELL REARRANGE CONTRARY SUPER RELATE NEIGHBOR TRACE
NEED OTHER TERMS or WRONG TERMS	NEIGHBOR TRACE SUPER SUB RELATE
REVISE TERMS	RESPACE RESPELL FIX REVERSE CONTRARY SUPER SUB RELATE
REVISE SEARCH FORMULATION	SPECIFY EXHAUST REDUCE PARALLEL PINPOINT BLOCK

TABLE 6: Tactics Suggested in Response to Searcher Requests

Definitions of most of above tactics in Table 3; others in [35].

System Involvement Level \ Search Activity Level	Moves 1	Tactics 2	Strategems 3	Strategies 4
No system involvement 0	Search activities carried out by searcher			
Displays possible activities 1	Most operational	Area of		Hold
Executes actions on command 2	IR systems now	recommended		for
Monitors search and recommends 3 a		development		later
b	Bypass			
Executes automatically 4 a		Hold for later		
b	Common current objective of IR experimental design			

TABLE 7: Implementation Status and Recommendations