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The Effect of Human Behavior on the Design of an Information Retrieval System Interface

ZHANG JIN & SARA FINE*

ABSTRACT

While current research trends concern such human *factors* as physical and intellectual compatibility with an information system, little research exists that focuses on human *behavior* in the information seeking process. The purpose of this paper is to identify some of the behavioral factors that influence the design effectiveness of an information retrieval system and to apply some principles of human behavior to the design of the user interface.

INTRODUCTION

One of the major changes taking place in a rapidly evolving technological environment is that the profile of the user is losing its sharpness and becoming more diffuse. More and more people on different socio-economic levels, with varying degrees of technological sophistication and from many different parts of the world are becoming directly involved in information retrieval. At the same time, the functions of retrieval systems are becoming more complex and the resources available within those systems are increasingly rich and varied. One of the ongoing concerns of systems designers has been to create systems with increasingly complex functions that are still user-friendly and easily accessible to users, whether those users are experienced with retrieval tools or novices seeking information as a way to enhance their own lives.

System designers have long realized that user characteristics as well as the physical and social environments in which information is sought

*Please address all correspondence to: S. Fine, School of Information Sciences, University of Pittsburgh, Pittsburgh, PA 15260, USA. E-mail: fine@lis.pitt.edu

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constitute the framework for retrieval and the context for use.[1] They have also known that the system's performance as well as the relevance and usefulness of the documents retrieved will bring about the ultimate goals of search efficiency and user satisfaction. Most systems that survive in today's marketplace reflect the interdependence of the factors that must complement each other — the human factors and the organizational context as well as design and technological factors.[2]

Within the retrieval process the user interface is the communication bridge that links the user with the information retrieval system, and the effectiveness of the interface plays a crucial role in the success of the interaction.[3] No matter how carefully the retrieval system itself has been designed to be human compatible, the key to an effective system lies in understanding how human beings behave when they are searching or browsing or learning. It is not enough to understand common user characteristics; it is also essential to understand that people bring their own behavioral characteristics, habits and patterns, cultural idiosyncracies, tendencies and inclinations, and even their human frailties to the endeavor.

The design and quality of a user interface directly influences retrieval efficiency. Based on empirical investigations into user-perceived quality of an interactive system, a well designed interface must address several standards of effectiveness: (1) suitability for the task, (2) clear self-descriptiveness, (3) controllability, (4) discriminality, (5) conformity with user expectation, (6) error tolerance and (7) suitability for individualization and learning.[4] However, even when all of these standards are suitably addressed in the design of the interface, the human factor component sometimes gets lost to other design imperatives. The problem is in where the designer concentrates attention and whether the technological system is seen as complex while the human system is viewed as simple. The

[1]Saracevic, T. (1989) Modeling and measuring user-intermediary-computer interaction in online searching: design of a study. *Managing Information and Technology, Proceedings of the 52nd Annual Meeting of the American Society for Information Science.*

[2]Hornby, P., Clegg, C.W., Robson, J.I., Maclaren, C.R.R., Richardson, S.C.S., O'Brien, P. (1992) Human and organizational issues in information systems development. *Behavior and Information Technology* **11**(3), pp. 160–174.

[3]Van Hoe, R., Poupeye, K., Vandierendonck, A., De Soete, G. (1990) Some effects of menu characteristics and user personality on performance with menu-driven interfaces. *Behavior & Information Technology* **9**(1), pp. 17–29.

[4]Dzida, W. (1995) Standards for user-interfaces. *Computer Standards & Interfaces*, **17**, pp. 88–97.

reality, of course, is that not only is the user a complex physical, psychological and social organism, but unlike technological information systems each one is unique and changeable. As system designers attempt to develop more flexible systems to correspond to the varieties of user abilities and styles, there is still an emphasis on the general characteristics of users rather than on their behavior. Yet we know that the most sophisticated and comprehensive system will fail in the marketplace if it does not reflect the way people really are, not the way we *think* they are or *wish* they were.[5]

Research and theory development on human factors is broad, rich, varied and growing. A sampling of the literature suggests that the emphasis has primarily been on the characteristics of users and the cognitive aspects of computer-human interaction.[6] For example, Ingwersen[7] examined the cognitive aspects of user-machine interaction and how a user's particular cognitive knowledge structure responds to the structures of the system. Bates[8] and Belkin *et al.*[9] developed models of browsing and searching strategies on online systems. Fidel's[10] model proposes aids in recognizing special and individual characteristics of searching behavior; Saracevic *et al.*[11] studied cognitive traits and user characteristics. There are numerous studies of the different information needs and search approaches of experienced versus novice users,[12,13] of age factors in information seeking[14] and of users with various professional

[5]Vigil, P.J. (1983) The psychology of online searching. *Journal of the American Society for Information Science* **34**(4), pp. 281–287.

[6]Hartson, H.R. & Boehm-Davis, D. (1993) User interface development processes and methodologies. *Behavior & Information Technology* **12**(2), pp. 98–114.

[7]Ingwersen, P. (1982) Search procedures in the library — analysed from the cognitive point of view. *Journal of Documentation* **38**(3), pp. 165–174.

[8]Bates, M.J. (1989) The design of browsing and berrypicking techniques for the online search interface. *Online Review* **13**(5), pp. 407–424.

[9]Belkin, N.J., Marchetti, P.G., Cool, C. (1993) BRAQUE: design of an interface to support user interface in information retrieval. *Information Processing & Management* **29**(3), pp. 237–251.

[10]Fidel, R. (1984) Online searching styles: A case-study-based model of searching behavior. *Journal of the American Society for Information Science* **35**(4), pp. 221–225.

[11]Saracevic, T., Kantor, P., Chamis, A.Y., Trivison, D. (1988) A study of information seeking and retrieving; I. Background and methodology. *Journal of the American Society for Information Science* **39**(3), pp. 161–176.

[12]Jacobson, T.L. (1991) Sense making in a database environment. *Information Processing & Management* **27**(6), pp. 647–657.

[13]Payne, S.J. (1991) Display-based action at the user interface. *International Journal of Man-Machine Studies* **35**(3), pp. 275–289.

[14]Solomon, P. (1993) Children's information retrieval behavior: A case analysis of an OPAC. *Journal of the American Society for Information Science* **44**(5), pp. 24–264.

orientations.[15,16,17,18] Other models focus on the user's cognitive psychological state in the information seeking process (Dervin, 1977, 1989; Kuhlthau, 1988; Jacobson, 1991).[12,19,20]

From this sampling of studies, it seems that current research is concentrated either on the use of established information retrieval systems with respect to human factor variables or on hypotheses about common human physical and cognitive factors as they affect the design of information systems and their interface aspects. One is hard pressed to find any research on the relationship between human behavior and the design of information retrieval system interfaces.

The purpose of this paper is to explore the impact of human *behavior* rather than human *factors* on the design of a human compatible information retrieval system interface. The user interface refers to both structure and function. The structure is the keyboard, mouse, command and menu, all of which constitute the means of communication between a user and the system. The functions are eliciting a user query and feeding back information, providing retrieval results, and any other retrieval activities between a user and an information retrieval system carried out through the interface, the technological intermediary.

In the following section some principles of human behavior are described as they may affect the design of the user interface. The principles discussed below were chosen because the authors of this paper, representing very different cultural and national orientations, agreed that these behavioral observations seem to be universal and to cut across cultural differences. Even so, international and intercultural factors are often subtle and sometimes cannot be distinguished until a user interface has been implemented and tested. Given the international scope of technological activities, any discussion of human behavior in terms of technological design must take the cultural dimension into account.

[15]Reynolds, J. (1995) A brave new world; User studies in the humanities enter the electronic age. *The Reference Librarian* **49/50**, pp. 177–196.

[16]Case, D. (1991) Conceptual organization and retrieval of text by historians: the role of memory and metaphor. *Journal of the American Society for Information Science* **42**(9), pp. 657–668.

[17]Borgman, C.L. (1989) All users of information retrieval systems are not created equal: An exploration into individual differences. *Information Processes & Management* **25**(3), pp. 237–251.

[18]Sutton, S.A. (1994) The role of attorney mental models of law in case relevance determinations: An exploratory analysis. *Journal of the American Society for Information Science* **45**(3), pp. 186–200.

[19]Dervin, B. (1977) Useful theory for librarianship: Communication not information. *Drexel Library Quarterly* **13**, pp. 16–32.

[20]Kuhlthau, C. (1988) Longitudinal case studies of the information search process of users in libraries. *Library and Information Science Research* **10**, pp. 257–304.

The Effects of Human Behavior on Interface Design

The essential function of a user interface is to facilitate information exchange between users and systems. In other words, it is a medium for communication.[21] Some of the behavioral principles of communications that operate between the human parties in an information service environment, e.g., a library, have profound implications for the technological interface between a user and a system.[22] For example, based on the assumption that user satisfaction implies not only pleasure with the search process or outcome but that the search has produced relevant, useful and useable information, a librarian responding to a reference query must go beyond the initiating "reference question" to an understanding of the problem the person is trying to solve and must offer information in a way the user can accept, understand, assimilate and use it. In an ideal technological environment the information retrieval system "understands" the problem and can respond in a way that is compatible with the unique user who is seeking information to solve a problem, make a decision or reduce anxiety.[23,24] While the technological system is unlikely to achieve this degree of sensitivity and intuitiveness, the closer it moves towards the ideal the more successfully it fulfills the purpose for which it was designed. If the interface is not designed along behaviorally compatible lines, it becomes a communication *barrier* to the process rather than a conduit for the effective transfer of information.[5]

Following are some of the other behavioral principles that apply to the design of the interface, based on the assumption that it is the link through which the user and the system communicate with each other.

The Saturation Principle

When a user is saturated with information, additional information will not help in making a decision or aid in solving a problem. The reverse is more likely to result; the user will become psychologically incapacitated until some balance has been achieved between the amount of information tendered and the person's ability to absorb it.[22]

The problem in designing an interface is that users have different abilities to adapt to a systems environment as well as different abilities and

[21]Marchionini, G. (1992) Interfaces for end-user information seeking. *Journal of the American Society for Information Science* **43**(2), pp. 156–163.

[22]Fine, S. (1995) Reference and resources: The human side. *The Journal of Academic Librarianship* **21**(1), pp. 17–20.

[23]Belkin, N.J. (1980) Anomalous states of knowledge as a basis for information retrieval. *Canadian Journal of Information Science* **5**, pp. 133–143.

[24]Dervin, B. (1989) Users as research inventions: How research categories perpetuate inequities. *Journal of Communication* **39**(3), pp. 216–232.

requirements for absorbing information. Sometimes simply dealing with the system saturates the user with information, making it that much more difficult for retrieved information to be absorbed. Designers need to be sensitive to this doubling effect and respond appropriately. Based on this principle, an information retrieval system interface should have a mechanism which elicits information about the user which would give some indication of ability to absorb information, on what level and in what doses. The user's retrieval experience then needs to be factored into an information retrieval evaluation model, allowing the system and the user to negotiate how much and in what form the information is delivered. A novice user would have a different retrieval environment from that of an experienced user. For the novice, the system would use basic retrieval commands and a set of icon-based menus which would offer basic retrieval functions. For the experienced or expert user, more and then more complex options would be available and basic directional information eliminated. The two different retrieval environments would be integrated into the same interface so that a user could easily distinguish between them and easily shift from one to the other. Depending on the information solicited and the sophistication of the user, the number of retrieved documents could be automatically controlled until the user indicated readiness to handle the next level of output.

The saturation principle is one of the more sensitive areas of compatibility between user and system because sometimes the user inadvertently demands to be saturated. The system, then, needs to hold back. If the system can determine if the results of a search will be too broad — for example, with terms such as "finance" or "politics" — there are a number of approaches that would respond to the user's query without the inevitable saturating mass of citations that would result from too broad a question. One might be the use of a ranked output, where the user is presented first with a list that the system has determined contains the *best* candidates for the query and then with subsequent lists as the user requests more. Or the system could make suggestions for query modification before responding as, for example: "The term *politics* is very general. Here are some narrower terms that might be closer to your query. Would you like to select one of these or perhaps a combination of several?" The objective in the design of the system is to respect the user's query style without inflicting the psychological punishment of overloading the human system.

Related to the saturation principle is the ability of the system to incorporate substitutions, enhancements or extrapolations. A friendly system does not tell its user that it has nothing of value in response to the query. Rather, it again emulates human thinking. When faced with a

problem to be solved and limited available information, a person will substitute one concept for a related one, draw new conclusions from old data, or extrapolate from a known theory and apply it where needed. Just as a human being will deal with a lack of information by using what *is* available to its full potential, so should the system be designed to produce new insights and creative alternatives, not only by providing other *terms* with similar or related meanings but by offering alternative *concepts or ideas*.

The Concreteness Principle

This principle tells us that across cultures, human beings understand and accept a concrete, real concept over an abstract, virtual concept. Looking at an image has a more immediate and often more powerful impact than words. In information retrieval, spatial representation of information plays an important role in the way the human mind and information interact.[25,26] The absence of spatial representation in such abstract systems as on-line retrieval may impede the transaction that occurs between humans and computers. In fact, information retrieval systems designers sometimes image complex, abstract information evaluation models and information retrieval processes in a high dimensional document space to find some hidden, indirect relationship among a query, reference points and retrieved documents. In such cases, users cannot directly observe the relationships within a high dimensional document space. Yet it is the relationship between these three elements that ultimately determines whether the documents are relevant and useful or not.

For example, it is hard for a user, especially a novice, to visualize a document space of more than three dimensions, let alone image the retrieval process. Therefore the information retrieval system should provide a tool for visualizing complex and abstract information retrieval evaluation models, revealing the potential and hidden relationships in a low dimensional display space which could facilitate information retrieval and achieve comprehensibility, consistency, discriminability, conciseness and conformity at a high level.

The Principle of Least Resistance

If faced with a choice between ease of access and usefulness of

[25]Egan, D.E. (1988) Individual differences in human-computer interaction. *In* M. Helander (Ed.) *Handbook of human-computer interaction*. Amsterdam. North-Holland. 1988.

[26]Miller, G.A. (1968) Psychology and information. *American Documentation* **4**(3), pp. 286–289.

information, users are inclined to select resources that are easily accessible over those that are most relevant to the problem at hand. If the information retrieval system is difficult to use because it has too many steps or because the commands are unclear, or because of language or cultural barriers in an international arena, users tend to avoid using the system and settle for less or less relevant or less complete information. The convenience of gaining information becomes more important than the value of the information itself. This principle is basic in human information seeking behavior and must therefore be central to the design of an interface.

For example, even experienced users must acquire the information they need to operate effectively in the system from the device's display during the interaction. They will not necessarily remember detailed instructions and will need a way to refer back to them.[13] In the design of a help file for an information retrieval system, the contents of the file that appears on the screen in different situations should coincide with the current retrieval need of the user. In current systems, help files usually contain the same help information regardless of the user's current need. This comprehensive approach to help files tends to be perpetuated on the assumption that users need to have all the possible commands in front of them whenever they ask for help. In fact, users probably stay with the functions that are the most easily maneuvered. The principle of least resistance may be operating; that is, users may simply be making the most use of easiest-to-use strategies, not the ones that are best suited to the problem at hand.

A more human compatible design would create the contents of the help file as dynamic and changeable, depending on the user's need for referring back. To counteract the human tendency to settle for what is readily accessible, the contents of the help file should be dynamically displayed and changeable. Retrieval commands could be classified into three categories according to their functions and relationships: (a) basic commonly used commands which will satisfy the casual searcher as well as the inexperienced user; (b) commands which have a close relationship with those initially displayed but are likely to be used in the next level of retrieval; and (c) a third level of remaining commands. The user is instructed in the purpose and use of the three options in the menu. In other words, help would be available as the need arises, no more and no less. The user would not be frustrated by the need to rummage through a host of help options, some of whose meanings are obscure and others that are irrelevant and so require some effort to ignore them. In addition, the user has the psychological advantage of knowing that help is available

on more than one level and that when one level has been exhausted, there is some place to turn for more.

The Familiarity Principle

People have a tendency to engage in repetitive behavior even in the face of its inappropriateness. Users tend to depend on the databases, information retrieval evaluation models and retrieval terminology with which they are familiar even if their information requirements have changed, even when the user's familiar patterns are not necessarily the most appropriate to the situation at hand. If the information retrieval system interface were designed to "understand" users' problems and their contexts, it could help them select databases, choose evaluation models and determine retrieval terms that are most compatible with the intention of the search.

The Stimulation Principle

It is human nature that people prefer material and environments that are varied and stimulating as long as there is not too much variety or too many stimuli to absorb. Assume two systems which are identical in terms of their functions, resources and conveniences. One engages the eye with color and shape while the other is stark. Users will tend to be attracted to the one that stimulates their senses and attracts their attention.

The best case in point is the use of color. A considered use of color in the interface not only stimulates users' interest but can be used to help distinguish different levels of retrieval status. For example, when the status level of a menu is increased, the brightness of color could be increased correspondingly. The same principle of stimulating interest while clarifying meaning could be applied to auditory stimuli as well. While there are many creative ways current systems employ to help the user understand features, formats and command usage, the principle of attraction and stimuli has not been fully exploited. The caution is that more is not always better and too much, too fast, or too colorful may upset the careful balance between attraction and overload, at least for some users.

The Certainty Principle

If they feel lost and uncertain, users have a strong tendency to seek balance and regain their sense of control. Uncertainty often accompanies the process of information retrieval in a computer environment. For example, a menu structure is widely applied in the interfaces of information retrieval systems. System performance is affected not only by

the way the menu is structured but by the depth of the menu system, the presence of escape facilities and the structure of the alternatives within the menu.[3] When a user activates an item in a menu, a new subwindow containing a new menu appears. As the number of menu levels increase, the possibility that the user will get lost also increases. This phenomenon occurs when a user navigates in a hypertext-based database as well. Perhaps the most frustrating moment in the use of information systems occurs when users find that they do not know where they are or how to return to the initial status. How to exit is sometimes more of a problem than how to get in and creates more confusion, uncertainty and sometimes panic. In the process of information retrieval, once a user is lost the priority becomes restoring certainty and control rather than searching for information. In fact, when the user is lost it becomes impossible to concentrate on the retrieval task.

The user's anxiety would be reduced and the ability to regain control restored if the interface included a special window containing past retrieval trace information. From this window a user could arbitrarily go back to any previous step, review previous processes, revise the search strategy or begin a new search. The design of this special window would improve the controllability of the interface and thus reduce uncertainty.

The Simplicity Principle

When people engage in the task of searching for information, their expectation is that descriptions, instructions and structures will be clear, precise and simple. Theoretically, any complex concept can be expressed in a relatively simple way. The difficulty lies in discovering such a way.

Here is an example of how this principle can be applied in designing an on-line user help file. Detailed information, lengthy descriptions and specific instructions are sometimes necessary to understand the structures, formats and functions of an information retrieval system, particularly for new users or for experienced users handling an unfamiliar system. But descriptions of how the system functions should appear in manuals or user guides rather than in online user help files. Observe that when users want to consult a help file, their main objective is to resolve a problem in searching rather than to understand the system. If descriptions and instructions are mixed together in the help file the user again must sort through irrelevant materials and may be diverted from the task at hand. Often users need to refer to the instructions again and again until they become habitual. These instructions should be as simple as possible; include examples that are representative, concise and clear; and be displayed in a way that even those with limited visual acuity can readily find the specific detail sought. Easily understood instructions belong in a

help file; descriptions do not. As the number of functions in an information retrieval system increases, designing the interface to be compatible with what the user needs at the time it is needed will enhance the user's perception that the system is a simple device, even while knowing that its complexity is simply out of sight.

The Following-Form Principle

The query is a case in point on this principle. From observations of court testimony and from experience with opinion surveys, it seems clear that the way a question is stated strongly affects the nature of the response; e.g., people reply to a question by following the form of the question as it was asked, rarely considering the motivation of the questioner or the purpose of the question. The information system user then expects that the system will follow form in responding to a query.

The problem is that we cannot assume that a user knows how to clearly express a query or even that the user has formulated the correct query. Since the dialogue between a user and a system is an important means for the system to get an accurate and pertinent information query from the user, understanding this principle is crucial for the design of the interface.[5]

There are three basic types of dialogue: (a) structured: menu dialogue, command dialogue; (b) semi-structure: direct manipulation dialogue; (c) unstructured: form filling dialogue. Different types of dialogue could be employed to elicit different types of information from users. For eliciting basic facts, structured questions are effective and efficient; for data about the user's information search, semi-structured or unstructured questions are more appropriate. There are two reasons for using semi- or unstructured questions to elicit complex and sometimes ambiguous data from the user: individual users have different purposes, sometimes for the same query, and information needs are comprehensive, multiple dimensioned, problem oriented and context based. This kind of information is impossible to generalize into a fixed format. If structured questions are asked, the user will respond in kind with single dimensioned responses which misled and restrict both the user and the system. If the system does not understand the question, it can only give an answer to a question it does understand. It will attempt to put a complex human problem into a simple subject category. The result is an underutilized system and a frustrated user.

Conclusion

Growing bodies of research on human factors and user characteristics have produced some important understandings for system designers and

allowed for physical and intellectual compatibility between human beings and information systems. But those same systems need to be designed to account for the way human beings actually behave and to be in harmony with our natural inclinations and even with our flawed reasoning. Another kind of research belongs in the repertoire of the information scientist, based on models and methods from the social and behavioral sciences and reflecting the influence of cultural and international factors in the design, acceptance and usefulness of an information system. Such research would allow the design of information retrieval system interfaces to truly be interactive communication tools, responsive to the nature of human beings and designed so that there is harmony and comfort between user and system.[27]

[27]Fine, S. (1986) Terminal paralysis or Showdown at the interface. *In* D. Shaw (Ed.) *Human aspects of library automation*. Urbana. University of Illinois. 1986.