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Abstract

The paper describes a descriptive study of the functional components of browsing, which is viewed as the strategic and adaptive technique that people use to search, scan, navigate through, skim, sample, and explore information systems. Data on browsing is collected from thirty participants -- ten each in three browsing formats: print, command-driven computer version, and hypertext window-environment version. Data collection is by means of several techniques: the collection of thinking-out-loud, task-concurrent protocols; open-question interviews during the task; observation; and video and sound recording. The aim of analysis is to describe functions of browsing such as: orientation, place-marking, transition, comparison, identification, and resolution of anomalies, and the relationships among these functions.

1. INTRODUCTION

The research described in this paper is a study of the functional components of browsing behavior. The long-term applications of this research will be to provide design specifications for interfaces that help people use their natural browsing abilities to cope with and navigate through automated information systems. As these systems are becoming more powerful and more complexly structured, and as networking and sophisticated internal search mechanisms are providing access to overwhelmingly large amounts of potential information, users of all levels of experience are faced with the increasingly frustrating burden of dealing with large undifferentiated data sets, confusingly presented displays, and poor or non-existent navigational aids. In other words, people are retrieving more than they can meaningfully use, and the systems do not offer adequate help in dealing with it. It is also true that humans are able to invoke a variety of mechanisms to deal with poorly structured and ambiguous stimuli. One of these mechanisms is the behavior known generally as "browsing."

Browsing is variously defined in the literature as searching, scanning, navigating, skimming, sampling, and exploring. People use browsing as a strategic and adaptive technique in many situations in everyday life, and increasingly, systems designers and researchers have been arguing for the incorporation of browsing as a design feature of information-provision systems [Bates, 1989; Larson, 1986; Marchionini and Shneiderman, 1988].

2. BACKGROUND

2.1. Related Research.

Browsing has received a great deal of attention recently, primarily because of its perceived importance in information retrieval systems developed for non-trained users. Various systems rely on some form of browsing as part or all of the retrieval mechanism [e.g., Croft & Thompson, 1987; Noerr & Noerr, 1985; Oddy, 1977; Oddy & Balalcrishnan, 19911. Such systems facilitate searches that can be controlled and defined by the browser along some predefined dimensions that have been isolated as potentially useful combinations of discriminators.

Other researchers investigate the use of browsable displays as a feature of the interface [e.g., Shneiderman, et al., 1986; Seabrook & Shneiderman, 19891. The use of browsing as a navigational strategy has received attention especially in hypertext systems where the user can easily get lost and disoriented [e.g., Kerr, 1990; Marchionini & Shneiderman, 1988; Nielsen, 1990].

In investigating the nature of browsing, several authors have attempted to establish typologies of browsing [e.g., Apted, 1971; Herner, 1979; Hildreth, 19821, distinguishing one kind of browsing from another by the presence or absence of a goal or purpose or the activity's "seriousness" or formality. Canter, Rivers and Storrs [1985] devised a set of indices for the physical activity of navigation through data structures. The proposed study continues in this mode, with the emphasis placed on creating a description of the functional components of browsing.

There is another aspect of browsing which is also very important, and this is the role of browsing in innovative and creative thinking. Apted [1971] characterizes browsing as "an untidy operation -- an activity which provokes new thought by exposing the user to a wide variety of stimuli." Marcia Bates speaks of an iterative and evolutionary type of activity that she characterizes as "berry picking" [1989]. In this sense, browsing emphasizes sudden insight, hitherto unrecognized relationships [Apted, 19711 and "lateral thinking" [DeBono, 19701, in which the process of navigating through information is perhaps in itself more valuable than getting an answer; where information is used for its effects rather than for its own sake (what we call heuristics); where we might seek out the irrelevant in an attempt to "shake up" the existing conceptual structures; where ambiguity is sought out rather than rejected; and where the process is generative rather than selective, that is, the process of finding information creates new patterns of knowledge [Bawden, 1986; DeBono, 1970; O'Connor, 19881.

The present work is highly indebted to these authors and seeks to extend their work. They have laid the conceptual groundwork by first of all, identifying the potential of browsing in information-system use and by helping to define the phenomenon. In this research we attempt not to replace or correct previous work, but rather to complement it by providing a description of browsing based on the function of the various behaviors that make up this activity.

2.2. Rationale.

While browsing is one of those intuitively simple behaviors that we all use, appreciate, and recognize, it is nevertheless quite difficult to define precisely enough in a way that could be incorporated into system design. The notion of browsing is mentioned explicitly in the literature, either as a feature or inherent design principle, but it is often taken as a self-evident behavior and there is no agreement on the definition of browsing, the conditions under which browsing is browsing and not something else, or on the interaction of browsing with other aspects of system use. The purpose of this study is not to clear up these ambiguities, but rather to conduct a study of browsing with the purpose of extracting some general principles that could be used as specifications for design. Put another way, the study aims to discover what it is people actually do and what they accomplish functionally when they "browse." Palay and Fox's [1981] definition of browsing as a "heuristic search in a well-connected space of records," has been adopted for this study because it emphasizes the dynamic nature of the process, the fact that the behavior is a kind of search or exploration, and that it evolves heuristically rather than analogically. Specifically, the outcome of this research will be a descriptive model of browsing that will consist of typical browsing components and the overall function these components play in a person's interaction with an information-provision system.

2.3. Preliminary work.

In a preliminary study [Kwasnik & Yoon, 1990; Kwasnik, 1990], we collected data on people engaged in browsing. Whereas most automated information-provision mechanisms require people to browse among

representations of concepts and things (usually words), we broadened the scope to a general context and collected data on people browsing among physical objects, images, numbers, as well as words. By looking at browsing in a variety of situations, we hoped to isolate and describe any general patterns across the diverse situations. In choosing situations to observe, we tentatively identified three dimensions of such situations that the literature suggested might make a difference: 1) purposive vs. non-purposive situations, 2) objects and representations of objects, and 3) structured vs. unstructured browsing environments.

Two participants were asked to browse, "with no particular purpose in mind," at a farmers' market: a large, warehouse-like structure in which farmers and other vendors can display and sell produce, baked goods, plants and so on. Two other participants were asked to browse, with the general purpose of "choosing a gift for a friend," in an un indexed but thematically arranged mail-order gift catalog consisting of photographs, text, and numbers describing a variety of household, ornamental and gadgety items. All four were asked to think out loud as they browsed. In the case of the farmers' market, a map of the market had been drawn just prior to the data collection so that the person's route could be tracked by the researcher. In the case of the catalog, the booklet itself served as its own map. These protocols were recorded by means of a lapel mike and a small, battery-operated tape-recorder, and then transcribed.

2.4. Results of preliminary work.
The following observations were the result of our preliminary attempts at identifying important components of browsing behavior:

2.4.1. Nodes and views.
In our analysis we focussed on the movement of people's attention from item to item or from representation to representation. Movement was signalled by physical movement (walking, page-turning, finger pointing, and so forth) and by verbalizations that showed evidence of a shift in focus. The definition of unit of analysis proved to be a thorny problem. If browsing is a kind of movement among a set of well-connected nodes, then what is a "node"? When a person browses in a library, for instance, we think of the individual book as a node in the browsing; if a person is browsing/scanning a menu or list on a computer screen, then each item on the list is considered a node. In the browsing environments we observed, however, it was difficult to define a node operationally. This basic difficulty suggests that a linear item-to-item description of human browsing behavior will probably be very inadequate.

We then developed the notion of a view. A view is what a person articulates as seeing at one time, that is, a span of attention. We have some good clues for operationally identifying views because the participants almost always labelled them. The notion of view also shifts the emphasis from physical movement to cognitive movement and allows us to account for changing focus even if there is no evidence of physical movement. People talk about views as if they were conceptual entities, and for this reason the view may prove to be a more workable unit of analysis.

2.4.2. Structured vs. unstructured environments.
The data, and common sense, suggest that the structure of the browsing environment will affect the way in which a person navigates the space. Structure can consist of physical arrangement, such as pages, aisles, clusters, and so on, or conceptual structures, such as thematic (rather than physical) proximity or relationships. What we did find was that the notion of an unstructured environment is probably not a useful one since people make efforts to discover structures even in the most chaotic or seemingly random environments. Choosing environments a priori as structured or unstructured is probably not as important as observing what structures are perceived and how they affect the behavior.

2.43. Purposeful vs. non purposeful browsing.
We found a similar phenomenon with regard to distinguishing browsing as purposeful and non-purposeful. While it may be true that behavior may be different if people really know what they are searching for or if they are "just noodling around," there does not seem to be any browsing that is truly non-purposeful. Even if it starts out that way, people quickly brings purpose to it by relating the activity to their lives.

2.4.4. Functions of browsing behaviors. We defined browsing as movement in a connected space. In order to achieve this movement, people undertake certain actions: they shift their gaze, they alter their position, they skip over things, they glance at things briefly, from afar, or close up, they back up, they pause or stop, and they respond to interesting phenomena. Groups of these activities can be thought of as browsing functions. Functions are the roles a set of behaviors plays in the overall process of browsing. We have tentatively identified a number of such functions that seem to recur with some regularity in all the cases we studied. These are:

- **2.4.4.1. Orientation.** Learning the structure and content of the browsing environment. It does not happen once and for all at the outset, but develops and is modified as the activity progresses.
- **2.4.4.2. Place marking.** Marking a view for a potential second consideration. The physical (e.g., putting finger in between pages) or mental (e.g., memorizing a landmark) place markers are tentative and liable to change as new experiences restructure purposes and interests.
- **2.4.4.3. Identification.** The process of browsing relies on the identification or recognition of potentially interesting or definitely not interesting items. The decision to proceed further or stop depends on the person's ability to summarize the probable content of a view. This is accomplished by identifying the view based on some readily discernible and salient characteristics.
- **2.4.4.4. Resolution of anomalies.** Anomalies, that is, something that is puzzling, not clear, or doesn't seem to fit, occur both in the structure and content of the browsing environment. Consistent with the notion that browsers create structure and orient themselves as they go along is their pronounced effort to resolve anomalies, even, it seems, when the item being "resolved" does not seem to be of great interest otherwise.
- **2.4.4.5. Comparison.** Browsers make comparisons at all levels: they compare one item to another, the environment as a whole to other environments, and various aspects of the structure of the browsing environment. These comparisons serve to orient, identify, and solidify purposes and aims
- **2.4.4.6. Transitions.** The movement from one view to another is a transition. We have identified two kinds of transitions: 1) a movement towards something, that is a movement in anticipation of a goal, and 2) a movement away from something, as when a view has been identified and rejected, or when the browser has sufficient information or has exhausted existing information.

3. THE PRESENT RESEARCH

The research outlined in this paper is presently underway. It seeks to expand the study previously described and to answer some of the questions that emerged from that investigation. The overall aim remains the same: to describe browsing behavior functionally and precisely enough so that those functions can be incorporated into information system design. The rationale is that people seem to bring formidable browsing skills to bear in coping with information, and it would be useful to incorporate knowledge of these skills into helping resolve some of the difficult human-computer interaction dilemmas. In order to do this, we need a description of browsing that can be translated into system functionality.

3.1. Research Questions.
The following research questions guide the study:

3.1.1. Are the browsing functions summarized in the previous section sufficient to describe the browsing process, or are there other functions? For example, in the preliminary study, we did not have an opportunity to observe the function of choosing a starting or ending point. These were defined by the researcher.

3.1.2. How does the structure of a browsing environment (i.e., the physical and conceptual arrangement of the entities in the environment) affect browsing? Specifically, how does the structure affect movement? How does it help bracket views? How does the structure help or hinder orientation? How does it help or hinder the making of identifications and comparisons?

3.1.3. Assuming that people either start browsing with a specific purpose in mind, or quickly develop such a purpose, how are purposes brought to bear on the browsing process and browsing strategies?

Specifically, as purposes strengthen or get discarded, what changes are observable in the browsing process?

3.1.4. What role do place-markers play in structuring browsing behavior? How many place markers seem viable at one time? What happens to them as things change?

3.1.5. What techniques do people use to orient themselves at the outset, as they go along, and when they are "lost"?

3.1.6. What is the nature of transitions in browsing? Do movements away from something require different navigational aids than do movements towards something

3.2. Method and Procedures.

Thirty participants, faculty, staff, and students recruited from the University, are asked to browse through a catalog of records of several hundred sound recordings. The purpose of the browsing is to choose a recording for themselves. As a form of repayment for their time and effort, this recording is actually ordered for them and they will receive it in a few weeks after their participation in the research. Thus the task is a real task and not a canned one.

3.2.1. The Browsing Environment in Three Formats. Participants are asked to browse through a catalog of information about sound recordings which we have produced for the purposes of this study. Each participant is asked to browse in a catalog presented in one of three formats, described below. The database of information about the recordings was created using Personal Librarian, a software package designed for building information storage and retrieval systems. Data for this database came from information from one issue of the mail-order brochure produced by Columbia House Record Club, which this company sends to its members each month. Each record in the database, describing one sound recording, consists of fields containing the title, artist(s), songs, recording studio, cassette or disc formats available, general category (e.g., Hard Rock, Jazz, etc.), and summaries (when provided) of each recording. The formats which we can then generate from the database are as follows:

Format 1. This format is a printed book catalog very much like the one sent out by Columbia House but minus the exact layout, photographs, and prices. The entries are arranged as they are in the real catalog: loosely organized by type of music with the occasional featured item set off in a box. Within the types of music, items are arranged more or less alphabetically by recording artist. Sometimes, a few entries are grouped together out of alphabetical order for some special promotional reason and we follow this arrangement as closely as possible. The format seems to be specifically designed by Columbia House to require browsing rather than a direct search. There is no index.

Format 2. This format is an online version in which browsers can access the same information as in Format 1 by using search commands for any of the fields mentioned above. The display of retrieved items is similar to the one in the book format, that is, a record consisting of all the information available about the sound recording. The overall design resembles the online catalog most members of the university community use in the library. Boolean searching is possible and is the default if search terms are combined.

Format 3. In this format, the same information as in Formats 1 and 2 is organized into a hypertext format that runs in a window environment. In addition, we have added some links not available in the other formats. For example, browsers are offered the option of accessing all recordings with the term "greatest hits" in the title or notes fields.

These three formats offer the same information in a variety of browsing environments. Each has its own special advantages in terms of browsing. For example, in the book catalog, the browser has a sense of the whole --a sense of the size of the collection. In the hypertext version, the browser has some advantages in terms of navigational ease (mouse and clicking) and possibly the advantage of the pre-determined links,

but he or she may easily get lost. In Format 2, the browser can design a powerful search by coordinating search fields and by iteration, but may get very large retrieval sets.

3.2.2. Data Collection. Each of thirty participants is assigned to one of the three formats by drawing lots, for a total of ten in each condition. If they are assigned to a computer version, they are given brief instructions on the mechanics of using the system, and a summary card. The researcher is present for the search. Participants are asked to browse through the catalog in order to choose a recording for themselves. In return, they must verbalize their thinking as they search, scan, navigate, and orient themselves to the system. At points where transitions are made (a pause or a movement) the researcher prompts the participant with questions in order to stimulate further verbalizations. These questions are of the "neutral questioning" variety, which attempt to encourage the participant to reveal the processes by which he or she is making sense of the situation, but which are not overly directive. Such questions are not planned in advance as in a questionnaire, but are invoked in response to specific activities. Typical neutral questions are:

> Why have you stopped?
> What would you like to know/understand at this point?
> [in response to an explanation of a move] How will that help you?
> What will you do next? Why?

The verbal, thinking-out-loud protocols are tape-recorded and transcribed. The browsing behavior itself is recorded in one of two ways for later playback. In the case of Format 1 (book catalog), the browsing is videotaped by means of a small camcorder mounted on a tripod. In the case of the online formats, the browsing sessions are captured directly from the computer to a videotape.

In summary, data on browsing is collected from thirty participants -- ten in each condition. Data collection is by means of several techniques: the collection of thinking-out-loud, task-concurrent protocols; open-question interviews during the task; observation; and video and sound recording. In this way we hope to minimize the drawbacks of using any one method alone. In previous work done by the researcher, these techniques have proven to be productive and viable [Kwasnik, 1989]. Several steps have been taken to ensure that the description of browsing that results from this study is a fair reflection of browsing behavior: efforts are made to study the behavior while maintaining as natural a setting as possible in that the task is a "real" task, the process is studied as a whole rather than by artificially dissecting it into parts, and, the duration is kept as normal as possible, given that the participant is verbalizing what are usually silent thoughts and also answering questions.

3.3. Data Analysis.
Analysis of the audio- and videotaped protocols proceeds generally as follows:

3.3.1. The immediate goal of analysis is to identify the role or function that various behaviors play in the process of browsing. The aim is to describe the data in terms general enough to cover more than one instance, but specific enough to be useful in later articulating system specifications. The first step is to identify those places in the protocols in which the participant has offered information that will help describe browsing. Our previous work suggests that transitions, movements (such as shift of focus) and pauses are such instances because they mark spots where people have used strategies or made choices.

3.3.2. Having identified these places, the researcher then aims to interpret the transitions, movements and pauses, using the explanations of the participant as a guide. The questions driving the analysis are: "What is the person accomplishing by doing this? Why is he/she doing this now? What role (function) does this behavior play in the overall activity? For example, if a person says, "I'll just give it a quick once over to get a feel for the place," we can interpret that to mean they are trying to get oriented, that they are invoking a strategy, and so on.

3.3.3. Next, the researcher describes these activities by summarizing them into descriptive phrases or labels. The functions of orientation, place-marking, and so on, as described in the preliminary study,

are used as a starting point. Each protocol is studied to see if the functions identified in the preliminary study occur in this study as well. Any additional functions are identified and described. A codebook is built up containing definitions of the functions and illustrative instances for each component are provided from the data.

3.3.4. Each protocol is then coded to mark all the instances of these functions. The data can then be described in terms of the functions. Recurring patterns and strategies are noted.

3.3.5. Next, descriptive comparisons are made among the participants, the formats, the various stages of browsing, and along any other dimension that is revealed by the data.

3.3.6. Finally, a summary model of browsing is created in as much detail as possible. This model consists of a typology of browsing functions and the components of these functions, typical or recurring relationships among the functions, and observations on the effects of structure and purpose on the browsing process.

3.4. Testing.

In qualitative, descriptive research such as this, the output of analysis is valuable if it can be used to describe new but similar phenomena. That is, the interpretations of the researcher in terms of identifying functions of browsing and the relationships among them can be tested by applying them to new instances of browsing behavior and seeing if they describe the new data adequately and completely. An adequate description is one that seems to fit the new data smoothly and coherently. A complete description is one that accounts for all the new instances without having too much left over.

Towards this end, we will conclude the study by choosing six additional participants, two for each format condition. They will be asked to follow the same procedures as the original thirty. This new set of data will be interpreted and coded by a person other than the researcher or her assistant. The extent to which this can be done using the model and categories developed previously, will be a test of the utility and value of the analysis.

In the future, the best test for the findings of this study will be the ability to translate the description of browsing into design specifications and to implement them in an information-provision system

4. DISCUSSION

4.1. Significance of the Research.

Designing systems that allow people to browse is not just a question of introducing a single, special feature of an interface called a "browsing capability." Browsing is a whole approach to dealing with information rather than a single strategy. For a system to be truly amenable to browsing, it must be structured in such a way that allows the iteration, exploration, and evolutionary development that characterizes browsing. If we were to understand browsing better, however, and if we could translate this knowledge into design specifications, the provision of browsing capabilities in information systems would be advantageous for a number of reasons:

- Browsing is not a passive activity. The browser makes use of his or her own formidable strategies and is in charge of the direction, pace, and depth of the search. This sort t. f sharing of the process between the system and the user is seen as advantageous because it allows for more flexible and dynamic searches [see e.g., Bates, 1990; Oddy, 1977].

- The decisions and strategies a person makes during browsing can be incorporated as useful feedback for systems featuring intelligent interfaces.

- Browsing relieves the browser of having to formulate a precise search strategy by taking advantage of the principle that it is easier to recognize what is interesting or useful than it is to specify it in advance.

- If a system provides a well-connected space and navigational aids, it is possible, by browsing, to explore the information in a system without prior knowledge of the content. In this way, browsable systems can be invaluable to users in crossing over into new and unfamiliar domains.

- Browsers have the opportunity to generate fresh viewpoints by new and unsuspected juxtapositions of information.

- A browsable environment takes advantage of the fact that information is presented in context. The context can help reduce ambiguity and in itself provides information to the user that then need not be explicitly provided by the system designer in some other form.

In summary then, knowing more about browsing and incorporating this knowledge into system design will be beneficial by reducing the cognitive load on users, producing more flexible systems, allowing creative and evolutionary search strategies, and enabling people to use natural capabilities in navigating and coping with complex information systems.

4.2. Future Research.

This study is a preliminary and exploratory investigation of browsing. It will raise many new questions for further research. The model of browsing will have to be further refined and specified. Browsing will have to be studied in a variety of applications. Studies will have to be conducted to investigate specific aspects of browsing and their effects on the overall behavior. Finally, the results of the research will have to be translated into system design. The long-term plan would be to design a system which utilizes the knowledge gained from this work.

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