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Interactivity and Control: The Case of Dynamic Maps for Navigation in Hypertext

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ABSTRACT

Rich information environments such as online tutorials and web-books pose considerable difficulties for users, of which the most notable is being 'lost in hypertext'. If these environments are to become commonplace, they must be designed to relieve users of these difficulties. In this paper we study the effects of dynamic navigational maps on orientation and search performance. We designed a conceptual map that tracks the user's position vis-à-vis the content of the web-book and the history of the user's visits. We show how these maps improve search performance significantly in terms of efficiency (number of clicks) but only weakly in terms of time or accuracy. We call for more research on how to enhance user control in complex information environments.

Keywords

Web-book, e-book, orientation, disorientation, navigation, dynamic maps, feedback, search efficiency.

INTRODUCTION

Finding information on the Web and within a specific website is today a common, yet increasingly difficult, activity. In particular, the task of interacting with a specific website is becoming difficult because of the growing size and complexity of websites and their diversity in terms of types of content and structure. The most frequently reported difficulty is 'getting lost' in hypertext, making it urgent and important to seek effective navigational aids to facilitate better orientation when traveling the website. Indeed, the phenomenon of "Lost in hypertext", i.e., losing your sense of location and direction (Conklin, 1987) seems to be spreading as the population of users grows. Furthermore, the aggregate cost of lost productivity is enormous due to the vast number of users now encountering disorientation problems.

Our research aims at a better understanding of the role navigational aids can play in facilitating more efficient interaction. More specifically, we look at common navigation devices, i.e., navigational maps, and use their interactive features to provide the user with dynamic feedback on the user's progression within the site. In effect, the feedback provided by these interactive maps enhances the user's sense of control (reduces the disorientation). The underlying theory is therefore one of interactivity and control, and the use of navigational maps is seen to be a special case of the broader call for enhanced control in the face of complex interactions users face nowadays. Thus, websites create new navigational problems of getting lost in hypertext, on the one hand, but offer new opportunities for overcoming these problems with dynamic feedback, on the other hand. This research concentrates on the impact of dynamic maps on the user's behavior and sense of orientation in websites that function as professional books e.g., online manuals, learning materials and professional papers. We refer to such websites as web-books.

Static and dynamic diagrams in web-books

Printed professional books such as learning materials and reference manuals frequently use diagrams to explain concepts and structures, e.g., a class diagram of an information system. Diagrams are also used to help provide the 'overall picture' of the book, i.e., help organize the materials. In this latter sense, diagrams functions like maps, helping the reader navigate in the conceptual world of the book by providing the reader with a stable context for understanding the more detailed arguments made throughout the book. Thus, we regard these diagrams as conceptual maps that provide the reader with context information.

Such diagrams, when they include concepts and relationships among concepts, are often referred to as cognitive maps. Furthermore, the overall map is often exploded (zoomed in) to produce more detailed maps of more limited scope. The more detailed maps are used to provide a narrower context for the more detailed materials thus creating a hierarchy of diagrams. For example, you may expect a very general diagram outlining the entire structure of the book in the introductory chapter and more detailed diagrams in the subsequent chapters. All in all, diagrams are useful devices for depicting the structure of the book as it relates to the content and thus helping the reader to navigate the book.

Clearly, diagrams can also be used in web-books and other online documents in the same fashion. Furthermore, in online documents they can serve as sensitive maps that incorporate links to specific locations in the text, turning

the map into an effective navigational device by enabling direct access to the target location. Indeed, several researchers have proposed cognitive maps as navigational aids to hypertext (Dillon et al., 1993; Nielsen, 2000; Germonprez and Zigurs, 2003).

The discussion so far has been about static maps. Below, after we develop the notion of orientation, we return to the design of dynamic maps, which we claim are more effective in enhancing orientation and search performance.

Maps are useful for both target-led searches and browsing. Although we emphasize search performance in the experiment described below, we also look at the effect of maps on browsing. Several distinct research streams suggest that finding information involves a duality of interaction modes: searching (or querying) that is focused on an explicit search target and browsing that gathers information whilst scanning with only a rough idea, if at all, of a target (Byrne et al., 1999; Choo et al., 2000). Moreover, both modes require control over the interaction process, although the consequences of poor control, such as low precision or discomfort, may differ from one mode to another (Te'eni and Feldman, 2001).

Dynamic maps combine the powerful spatial features of static navigational maps discussed above with the ability to provide timely context information (Zizi and Beaudouin-Lafon, 1995). For instance, site maps that register the paths taken and provide them in an auxiliary window seem to be useful in helping plan your next move (Zaphiris, Shneiderman and Norman 1999). We believe the same idea holds true for conceptual maps (e.g., cognitive maps) that are supplemented with context information dynamically, which according to the findings noted above should promote orientation. Moreover, the placement of the context information (feedback) on the navigational map is an advantage in comparison to presenting the paths on auxiliary windows because it requires less cognitive effort, as in the principle of direct manipulation.

We summarize this discussion on the impact of dynamic maps in the following hypotheses 1& 2.

Hypothesis 1. Searching with dynamic navigational maps, compared with static maps, will lead to higher orientation.

Overall, we expect improved orientation to lead to better search performance. Improved orientation, by definition, should reduce errors in navigation, should therefore also result in fewer unnecessary steps (clicks) and, correspondingly, a shorter search time. Indeed, Nielsen (2002) studied Site Map usability, and found that on average, users visited 0.3 erroneous destinations for each task that asked them to go to a page linked directly from the site map. (Erroneous clicks increased to 1.1 per task when we asked users to perform tasks that required going to pages that were two clicks from the site map, rather than directly linked).

Hypothesis 2. Higher orientation will lead to improved search performance

2.1 Higher orientation will lead to higher search accuracy.

2.2 Higher orientation will lead to faster searches.

2.3 Higher orientation will lead to shorter searches.

EXPERIMENT

This section describes the web-book and its two versions (static and dynamic) on which the experiment was conducted, the experimental procedure, the pilot study and the measurements.

The web-book is a professionally edited article about organizational communication that also appears in print (see details in Te'eni, 2001). The 100-page article was reorganized in a hierarchical-networked structure.

As can be seen in Figure 1, the interface is divided into 3 main frames: in the left column is the TOC, in the upper right area is the navigation diagram, and in the lower right area is the text display along with the forward / backward arrows. Each level in the TOC can be expanded or contracted. Selecting an item through any of the three navigation aids updates both the text area and the current pointer in the TOC. The reader can travel to the topics noted on the navigation diagram and zoom in and out of more detailed diagrams.

The difference between the static and dynamic maps is that the latter includes the current location in a red wire-frame box (WFB) and the previous locations visited painted in gray. For the purpose of this publication and in order to depict these additional features in black and white print, we annotated the gray areas in the online system with diagonal lines and the redrew the WFB with thicker lines.

Procedure

Fifty students in an Information Studies program participated in the experiment, and were randomly distributed to one of the two experimental groups: one group received the static navigational map and the other received the dynamic navigational map.

Tasks

Each subject was asked to perform 8 search tasks. The first two were taken as exercises (this is in addition to the short tutorial they received). The last two were rendered unfit for analysis because of the low proportion of people finishing the tasks successfully. Our analysis concentrated on the four middle tasks, which are detailed in Table 1. Each task required the subject to read the question and find the answer in the text.

What is the name of communication goal #3?
Read about communication impacts and name the person who developed the theory of communicative action!
With reference to Proposition 2B: a) what is the name of the proposition? b) on the impact of which strategy does it hypothesize?
What type of communication complexity affects the strategy of affectivity?

Table 1. The four search tasks in the experiment.

Dependent variables

1. Reaction time – the amount of time a user took to perform each task. It is calculated by measuring the time taken to get from the current page to the target page. The measurement was calculated according to the log file mechanism.
2. Efficiency – a count of the clicks a user made to reach the target page minus the optimal number of clicks for that task. The measurement was based on the log file mechanism.
3. Accuracy - the percent of correct answers to the search tasks.
4. Accurate representation of the web-book – the percent of correct answers to question about the representations of the Web-book's structure as modeled by the user.
5. Orientation - the aggregation of four Likert type questions about the user's sense of orientation (see below).
6. Diagram interface usage – the number of tasks in which the user clicked the diagram links. This variable was used as a manipulation check. It was based on the log file mechanism.
7. Total navigational aids usage – total number of clicks on diagram, TOC menu and navigation arrows. The measurement was based on the log file mechanism.

RESULTS

Descriptive statistics

The average experiment time was 1033 seconds (17 minutes and 13 seconds). The shortest time was 617 seconds, and the longest 1600 seconds. The static-map group averaged 1065.6 seconds (std 256.05) and the dynamic-map group averaged 999.48 seconds (std 193.83). Table 2 summarizes the data for each group (manipulation) for the dependent variables, averaged over the four tasks.

Manipulation	Reaction Time	Efficiency	Accuracy
Average – Static map	132.24 (122.78 std)	2.11 (1.40 std)	0.66 (0.48 std)
Average– Dynamic map	118.17 (89.04 std)	1.54 (1.42 std)	0.63 (0.49 std)
P-Value	0.3546	0.0049	0.6595

Table 2: Data for the aggregated four tasks

Results on Hypotheses

1. *Searching with dynamic navigational maps will lead to higher orientation than static navigational maps.*
2. *Higher orientation will lead to improved search performance*

These two hypotheses were examined in a path analysis, described below. The only path that was found to be statistically significant was the search efficiency. However, there were no corresponding paths for reaction time and accuracy.

Using linear regression we tested the mediator effect of orientation and concluded that static-dynamic maps affect performance through orientation.

In addition we also examined the subjects' perception of the structure of the Web-book, i.e., their mental model of the book (see dependent variable #4). We found that using an interface with a dynamic diagram, improves the accuracy of mental model representation of knowledge architecture within users. See Table 3.

Manipulation	Correct answers to questions checking the representations of the Web-book structure
Average – Static Diagram	0.40 (0.27 std)
Average– Dynamic Diagram	0.60 (0.25 std)
P Value	0.005

Table 3: Accuracy of web-book structure.

DISCUSSIONS

We looked at web-books – a growing information environment that has been shown to have challenged our cognitive capabilities leaving many of us 'lost in hypertext'. For this environment we sought effective navigational designs to help overcome these disorientation problems. The most important result found in this research is the impact of dynamic maps, in

comparison to static maps, on the user's orientation and on search efficiency. The impacts of dynamics maps on search time and on accuracy, although in the expected direction, were not statistically significant. The lack of correspondence between the efficiency (the number of steps taken) and the reaction time deserves our attention. The exact trace of the steps taken provided a clear comparison between the actual path and the optimal path. Clearly, the users working with a dynamic map were able to come closer to the optimal path. One possible explanation for this was the need to consider the information and use it to plan ahead. This takes time, which may however decrease with experience. In any event, the impact on efficiency is an important result. Our aim in this paper was to demonstrate how navigational aids can be designed to enhance control (orientation) and boost search performance in information environments that have become extremely popular. We claim however that there is an important more general message here – the need to actively seek better control for the user.

Generalization

We began this research with a claim that dynamic maps and navigation in web-books is a special case of interactivity and control. We showed how dynamic maps provide context information (feedback) that enhance orientation and, thereby, search efficiency. Orientation represents control and the lack of it (disorientation) is the loss of control. Dynamic maps are one form of feedback but we can think of other forms that may boost our control over the human-computer interaction. Unlike printed books or non-interactive systems, online hypertext documents are designed to support instant interaction with users and should do so by providing dynamic feedback as in the dynamic maps. Online hypertext may be designed, however, to provide other forms of feedback to enhance user control. For example, a better understanding of the hypertext (the mental model) will likely enhance control. Other forms of dynamic feedback provided in audio or visual cues, could inform the user about her or his surroundings in the hypertext (who are my current neighbors). Again, such information is known to be important to people for their interactions by reducing uncertainties – why not provide it to enhance user's control?

Our aim in this paper was to demonstrate how navigational aids can be designed to enhance control (orientation) and boost search performance in information environments that have become extremely popular. We claim however that there is an important more general message here – the need to actively seek better control for the user.

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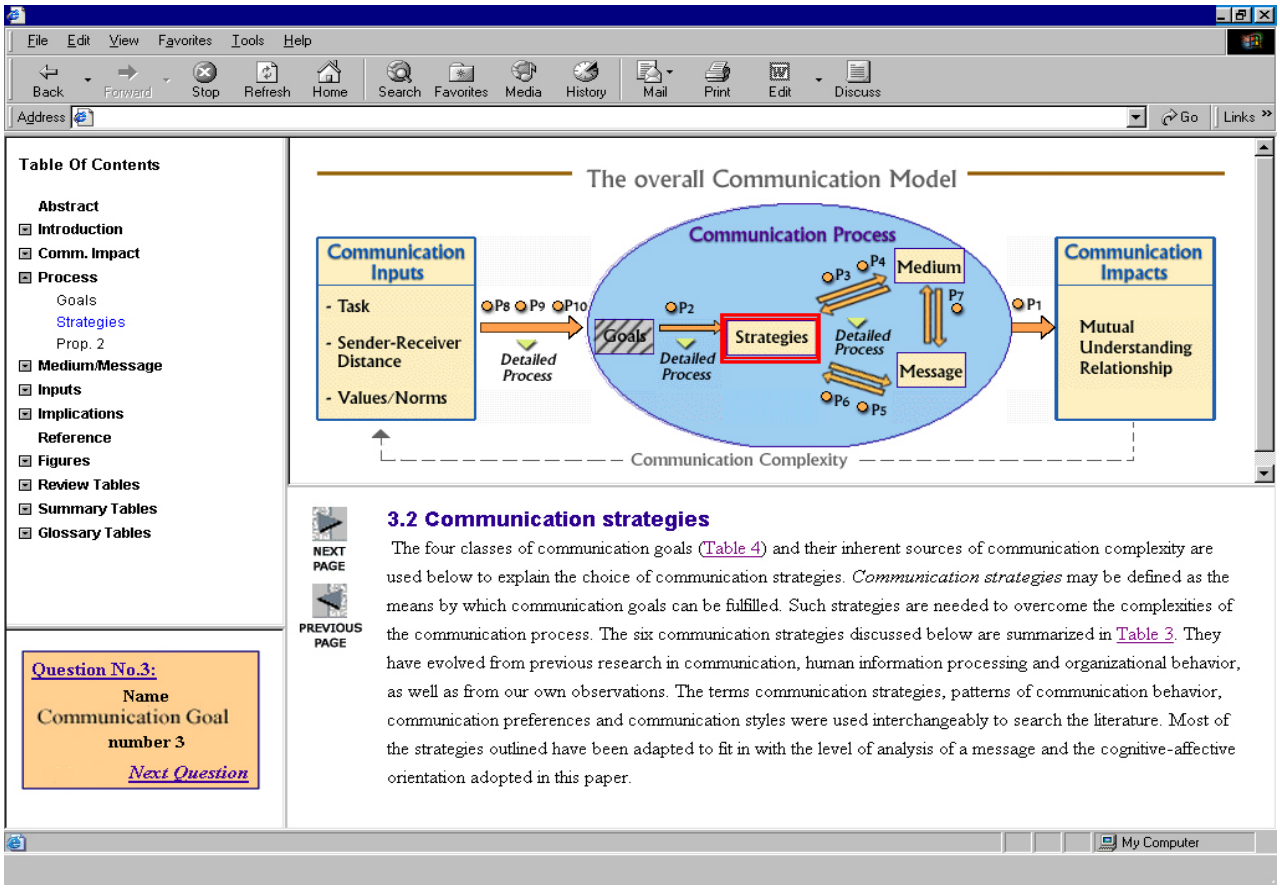

Figure 1. User Interface of the dynamic map with the WFB and history in gray – (Gray areas are shaded with diagonals here, for lack of color-print version)