

The Effect of Structural Cues on User Comprehension, Navigational Behavior, and Perceptions

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Abstract

Web authors need writing strategies based on empirical studies of real Web users, strategies that will produce comprehensible Web documents that facilitate readers on the Web. The study reported here investigated the effect of structural cues (text previews and navigational tab menus) on user comprehension, navigational behavior, and perceptions. We found that text previews with embedded links to related pages (children nodes) enhance comprehension and discourage site exploration. We also found that lists of links (in lieu of previews) encourage site exploration and are well liked. And, we found that navigational tab menus encourage site exploration and enhance user perceptions. Our findings underscore that good Web design must be context specific—structural cues that promote understanding are not necessarily those that promote exploration or enjoyment. Keywords: hypertext comprehension, navigation, perceptions of use, remote user testing, signaling, structural cues.

Introduction

The World Wide Web delivers vast quantities of information to us daily. To process this information, we must construct mental representations of online text structures from information displays that vary from Web site to Web site. We are finding, as Web readers, that the skills gained from centuries of reading print documents no longer sustain us.

As the Web replaces more familiar avenues of information access, the need for empirically-based guidelines for Web authoring becomes more urgent. And because the linearity of Web-based documents varies widely, these guidelines must reflect an understanding of

hypertext structures and the Web spaces in which they reside.

Structural cues—or signals—announce or emphasize content or reveal content relationships. These cues help readers build mental representations of text and thereby improve comprehension. Signals in print include headings, previews, overviews, tables of contents, and logical connectives such as "as noted before" or "consequently." Readers of hypertext on the Web also need structural cues in order to facilitate comprehension. Many print-based signals, however, are not suitable for Web-based documents because Web authors often cannot predict the path that Web readers will choose through the hypertext space. Further, hypertext spaces often lack the structural cues afforded by physical print materials—cues that reveal the extent of the space and the user's position within that structure.

The goal of this study was to examine the effect of two types of structural cues—textual previews and navigational tab menus—on comprehension, navigational behavior, and perceptions. After a review of the literature and a discussion of our hypotheses and methodology, we present the results and discuss their implications.

Related Literature

The following briefly reviews some of the related research that motivated and informed this study.

Structural cues

Decades of empirical research on reading comprehension and related fields have informed guidelines for authors of print materials [1], [2], [3], [4], [5], [6], [7], [8]. Guidelines for authors of Web-based materials, on the other hand, often lack this empirical basis; they frequently rely on expert opinion, common practice,

small-scale laboratory studies, and research from print documents. Thus, design decisions based on these guidelines may not produce useful and comprehensible Web sites [9], [10], [11].

Empirical studies have shown that signals in print documents can enhance reading performance by helping readers develop mental representations of text; they help readers encode text, which leads to better retention and retrieval [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23]. Previews that announce upcoming topics lead to faster reading times, even if the order mentioned in the preview does not match the order of the topics presented in the text [24].

Navigational structures and hypertext features can serve as cues to the structure of the hypertext space, yet empirical studies of these cues have produced a variety of results. Text previews improve knowledge acquisition and search [25]. Overviews and organizers facilitate comprehension [26], [27], enhance user perceptions and increase time spent with the text [28], decrease perceptions of disorientation [29], and focus browsing [27].

Authors of hypertext documents may also provide other types of navigational aids such as embedded hyperlinks, indexes, and local navigational links [30], [31]. The hypertext system or Web browser interface itself may provide other navigational aids (e.g., search functions and back and forward buttons) [32]. Placement of hyperlinks within the text provides context for those links, while placement of hyperlinks in lists outside of the text may enhance search efficiency, particularly if the information associated with the hyperlinks is already known [33]. While these aids can assist readers in moving through the hypertext space, they may or may not function effectively as cues to aid comprehension.

Context and user characteristics

Our study was also informed by research that examined the interaction of user performance with context (e.g., task, setting) and reader characteristics (e.g., prior knowledge, interest, ability). This research emphasizes that design guidelines should vary with the setting and the reader [34], [35], [36], [37], [38], [39].

Empirical studies have shown that readers receive more benefit from signals with specific versus nonspecific tasks [40], [41] and that subjects with specific versus nonspecific tasks have lower comprehension scores [42] and display more constrained navigation [43], [42].

Studies have shown that readers benefit less from signals if a topic is familiar, easy, enjoyable, or interesting [44], [45], [46], [38], [23], [17], [47], [48], [49]. However, readers may indeed benefit from signals and the coherence they provide if they lack prior domain

knowledge or find a text difficult to comprehend [29], [26], [50], [23].

The study

The studies described previously indicate that user performance is enhanced by the presence of structural cues. The study presented here seeks to further the body of research regarding the effect of structural cues on user performance and provide an empirical foundation for Web design guidelines.

Specifically, our study assessed two types of structural cues: text previews and navigational tab menus.

We constructed three levels of text previews:

1. A top-level page with a paragraph that previewed the content at the next level down in the site hierarchy and had embedded links to children nodes (“previews/embedded links”).
2. A top-level page with a preview paragraph, identical to that in condition 1, with no embedded links yet a list of links to children nodes sitting beneath the paragraph (“previews/link list”).
3. No textual preview and only a list of links to child nodes (“link list only”).

We created two levels of navigational tab menus:

1. Presence of navigational tab menus.
2. Absence of navigational tab menus.

The navigational menus, when present, were “tab menus” that displayed tabs for all four content areas plus links to the articles in the current content area. The six resulting conditions are shown in Figures 1 and 2.

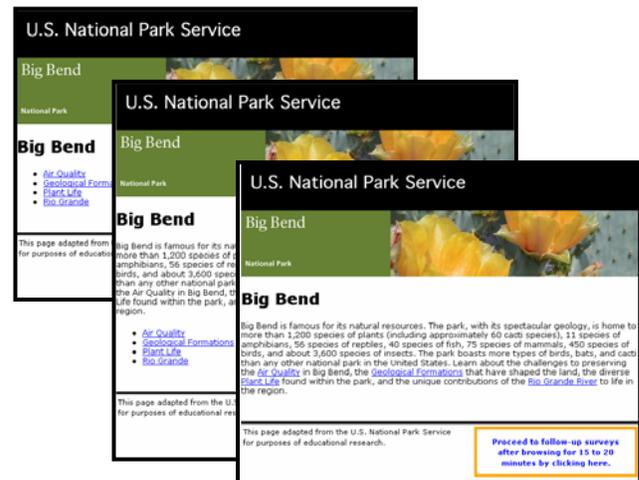


Figure 1. The top-level Web page from three versions of the experimental Web site (the three levels of previews with no navigational tab menus).



Figure 2. A top-level Web page from three versions of the experimental Web site (the three levels of previews with navigational tab menus).

Existing literature led us to expect that: (1) previews would facilitate comprehension, increase engagement with the site, and enhance user perceptions; (2) navigational tab menus would facilitate comprehension (especially factual), increase site exploration, and enhance user perceptions; and (3) previews would interact with navigational tab menus.

Methods

Participants

Our study included 282 undergraduate students from engineering courses at the University of Washington (UW): 76 percent were male, and 90 percent were between the ages of 18 and 25 years. Incentives included course participation points and an opportunity to enter a drawing for an Amazon.com gift certificate.

Materials

Experimental Web site. The experimental Web site was adapted from the U.S. National Park Service Web site for Big Bend National Park in Texas. The natural science content from this Web site was chosen for general interest and likelihood of unfamiliarity. We selected 21 pages that were arranged in a three-level hierarchy to use for the experimental Web site. The previews and navigational tab menus described previously were implemented on the top-level page and on the four second-level pages. Additionally, we standardized the number of embedded links and removed links that led outside the experimental Web site.

Introductory and instructional materials. The Welcome page contained general information about the

goals and logistics of the experiment and provided for informed consent. The Instruction page asked participants to spend 15 to 20 minutes browsing the Web site, and provided a scenario that asked participants to learn as much as they could from the experimental Web pages in preparation for an upcoming summer job as a tour guide at Big Bend National Park.

Surveys. The Pre-Survey gathered information on computer experience and demographics. The Post-Survey addressed (1) perceptual information through questions from the Systematic Usability Scale (SUS) (Brooke 1996) and questions about site organization and navigation; (2) comprehension of the content of the experimental Web pages (16 factual and 16 inferential questions); (3) text judgments (ratings of familiarity with, interest in, and difficulty of the experimental Web page content); and (4) perceptions of knowledge gained, extent of site seen, and general reactions to the site's content and structure.

Procedure

Participants logged on to the study site anonymously, read the Welcome page and proceeded to the Pre-Survey. After completing this survey, they proceeded to the Instructional page, where they clicked a button that said "Continue to study pages."

Participants were then randomly assigned to one of six versions of the experimental Web site to browse the Web pages. After browsing, participants took the Post-Surveys and then exited or entered the drawing for a gift certificate.

WebLab UX administered all instruments, constructed the Web site versions, distributed participants to one version, captured survey results, tracked navigational behavior, and recorded all data. Data were analyzed in SPSS Version 14.0 for Windows. Significance was determined by an alpha level of .05.

Results and Discussion

On average, subjects spent 13.3 minutes within the experimental Web pages with no significant difference in time across the six conditions.

Computer/Web experience. Our participants were computer savvy. They reported being generally comfortable with computers (67% stated that they were somewhat comfortable or very comfortable) and generally comfortable with the Web (69% stated that they were somewhat comfortable or very comfortable). Over 99% had used the Web for three or more years.

Comprehension. Previews affected comprehension, but menus did not. Inferential comprehension was

significantly higher for previews/embedded links than for previews/link list, indicating that the previews with embedded links helped participants build a situation model, which facilitated inferential comprehension. There were no significant differences between the other conditions for inferential comprehension. Factual comprehension was not influenced by the type of preview. And, finally, neither inferential or factual comprehension was affected by the presence or absence of navigational menus.

Navigational behavior. Link lists and navigational tab menus increased site exploration. Site exploration, as measured by the percent of the total Web pages visited, was significantly higher for link list only than for previews/link list. There were no significant differences between the other conditions. Site exploration was also significantly greater for navigational menus present than for navigational menus absent.

Perceptions. Previews and menus were perceived differently. Participants' SUS ratings of the Web site were significantly higher for previews/link list and for list of link list only, than for previews/embedded links. Thus, although previews with embedded links enhanced comprehension, they led to lower SUS ratings. SUS ratings were significantly higher with navigational menus present than with navigational menus absent. In addition, there was a significant interaction between previews and navigational menus with respect to SUS ratings, demonstrating that participants did not like previews with embedded links, especially when they had no menus to rely on for navigation. The results for participants' perceptions of use ratings echoed the SUS results just described.

Text judgments. Ratings of text familiarity, difficulty, and interest suggest that our participants would benefit from signals. Participants reported the content of the experimental Web site to be rather unfamiliar (72% rated the content unfamiliar or very unfamiliar); slightly easy (43% rated the content easy or very easy); not very enjoyable (only 17% rated the content enjoyable or very enjoyable); and not very interesting (only 25% rated the content interesting).

Additional results are still being analyzed and will be reported at a later date.

Conclusions and Recommendations

Some of our hypotheses were supported and some were not. Yet overall our results do lead to solid conclusions and recommendations for Web designers.

Previews

Our hypothesis that previews would facilitate comprehension was partially supported. Previews with embedded links to subordinate material enhanced inferential comprehension, indicating the development of stronger situation models. Previews with list of links to subordinate material listed below the preview, however, did not enhance inferential comprehension. We suggest that participants likely clicked on the list of links for access to subordinate information without reading the preview text that intended to reveal the structure of the hypertext space and the relationship between the pages. Previews with embedded links also did not enhance factual comprehension. We believe that the time constraints of study participation may have prevented us from adequately assessing factual comprehension.

Our hypothesis that previews would increase engagement with the site was not supported. We found no significant differences in total time spent in the experimental Web site between any of the preview or navigational menu conditions. We still need to analyze time spent on individual pages, which may yield more detailed results..

Our hypothesis that previews would enhance user perceptions was only partially supported. Previews with links to subordinate material listed below the preview were well liked. However, previews with embedded links to subordinate material—the same previews that facilitated inferential comprehension—were disliked by participants, as they were unfamiliar and unexpected.

It follows from these conclusions that Web designers can facilitate comprehension of Web page content by creating text previews on upper-level pages that overview the structure of the hypertext space, reveal the relationships between the content in the lower-level pages, and contain embedded links to those pages.

Navigational tab menus

Our hypothesis that navigational tab menus would facilitate comprehension (especially factual) was not supported—both factual and inferential comprehension were unaffected by the presence or absence of navigational menus.

However, our hypothesis that navigational tab menus would increase site exploration was supported. Menus are a standard in Web design—users are comfortable with them. Participants with navigational menus explored more of the experimental Web site than those without menus.

Finally, our hypothesis that navigational tab menus would enhance user perceptions was supported. Navigational menus are expected and well liked—and without them users are forced to rely on browser navigation.

It follows from these conclusions that Web designers can encourage wide site exploration and enhance user perceptions by including navigational menus in their Web pages.

Interaction of previews and navigational tab menus

Our hypothesis that the effect of previews would be influenced by the presence or absence of navigational tab menus was partially supported. While we did not see an interaction of the variables on comprehension or navigational behavior, we did see one for user perceptions. Participants do not like previews with embedded links, and they like them even less if they have no navigational menus to rely on.

General conclusions

This study underscores the importance of considering context when designing for the Web—designs that effectively facilitate comprehension are not necessarily the same designs that promote positive user perceptions. Rather than being forced to address one set of needs over another, Web designers are encouraged to incorporate redundancy that would allow for meeting different needs with the same design.

Designers should consider the goal of the Web site. For an e-commerce site, one might like to have users browse broadly, covering as many of the available Web pages as possible; for an e-health site, one might prefer to have users narrow in on a few specific pages and read the content in depth for understanding.

This study also supports the conduct of remote user testing—assessing real users of Web sites, interacting from a location and at a time of their choice. The ability to test for comprehension, survey perceptions, and track navigational behavior provides a wonderful opportunity to triangulate data sources and to gain a very informative picture of user interaction with a Web site. In addition, remote user testing provides an affordable way to acquire this information from a very large number of users.

Future Directions

This study produced a wealth of user data, and we have more to analyze and report.

We will continue investigating the effect of design variables on user performance in order to gain insight into authoring strategies for facilitating comprehension and goal-appropriate navigational strategies.

We will also continue to refine our experimental approach. We plan to investigate different recruitment and incentive strategies, and to manipulate the difficulty and length of the experimental browsing materials. In addition, we would like to improve the survey

instruments in order to target factual and inferential comprehension more precisely. We will, also continue to refine WebLab UX to be compatible with a wider range of platforms, applications, and research questions.

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