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Using structural cues to guide readers on the internet

This paper reviews three studies that examined the effect of (1) explicitness of local navigational links, (2) intriguing and informative phrasing of hyperlinks, and (3) text previews and navigational menus on user performance. The results reveal that sites with highly explicit navigational links increase site exploration as well as site perceptions; a mismatch between navigation and embedded link labels increases comprehension and site exploration; and previews with embedded links increase inferential comprehension, though they are disliked. We suggest a combined approach to structural cueing and emphasize that good design is context specific – designs that support comprehension do not necessarily receive high marks for usability.

Introduction

The internet has radically altered the way we access and read information. As we increasingly read information online, we must construct mental representations of text structures from presentation formats that vary noticeably from website to website. We are finding that the skills and experiences we have acquired from centuries of reading print documents must be adapted to a new environment.

Hypertext readers often experience cognitive overload as they struggle to divide their attention between comprehending text and making navigational decisions, and they frequently become disoriented (Conklin, 1987; Thuring et al., 1995). Following embedded links in hypertext can interrupt the narrative flow of text, forcing readers to provide context and make inferences about information relationships, further consuming cognitive resources (Thuring et al., 1995; Burbules, 1998; Dalal et al., 2000). Hypertext research has emphasized that the problems of cognitive overload and disorientation must be mitigated for readers to fully benefit from the advantages that hypertext offers. One way to mitigate these problems is through the incorporation of structural cues.

Many web designers fail to provide adequate cues about information structure when they migrate print materials to the web. Designers often conflate the structural cues that readers of print text have learned to rely on as they attempt to emulate traditional print-based structural cues (e.g., headings, previews, tables of contents) with web design features. Linear documents that would have appeared on separate print pages become long scrolling webpages. Global menus on home pages often disappear as readers follow links and fall into a chasm of separate linear articles. Many of these quick
design decisions result in navigational nightmares for readers who have little understanding of the webspaces they are navigating. And when readers lack structural understanding of an information space, their comprehension and their desire to pursue the website suffers.

The work reported here sought to develop a theoretical understanding of how structural cues can best signal relationships in online informational spaces and how these cues affect readers’ mental representations of text. This work also sought to improve the methods for studying user interactions with websites remotely, including the development of a software tool called WebLab UX that automates the process of constructing and delivering different website versions, and collecting data for analysis. (See http://depts.washington.edu/intres/ for further information.)

With these goals in mind, the studies presented here examined the effect of (1) explicitness of local navigational links, (2) intriguing and informative phrasing of hyperlinks, and (3) text previews and navigational menus on comprehension, perceptions, and navigational behavior.

**Relevant literature**

The three research studies reported here lean on literature about the use of structural cues, and the interaction of such cues with user characteristics and tasks. Structural cues, or signals, help readers develop schemata or mental representations of text, identify relationships in text, and can ultimately improve comprehension. Such cues create expectations for readers that enable them to incorporate new information into existing information in a way that is more readily understood and remembered (Kintsch, 1998).

Signals traditionally found in print include such features as headings, previews, overviews, tables of contents, and logical connectives. In print, signals help readers encode text, which facilitates retention and retrieval of information (Bartlett, 1932; Brooks & Dansereau, 1983; Hartley et al., 1980; Hyona & Lorch, 2004; Lorch & Lorch, 1996a; Lorch & Lorch, 1996b; Lorch et al., 2001; Sanchez et al., 2001; Spyridakis, 1989a; Spyridakis, 1989b; Spyridakis, 1991; Sanders & Noordman, 2000). Signals in print also provide cues about information importance, which affects recall (Eysenck & Keanne, 1990; Hartley, 1987; Waller, 1982). When these signals are distinguished into those about content importance and those about relationships, it is possible to discern more positive comprehension effects for importance signals and better processing speed for relational signals (Degand and Sanders, 2002; see also Sanders & Noordman, 2000). Previews that announce upcoming topics lead to faster reading times, even when the topic order in the preview and the subsequent text do not match (Murray & McGlone, 1997).

Studies of signaling in online environments have revealed many effects. Textual previews improve knowledge acquisition and searching (Cress & Knabel, 2003). Overviews in a left-hand column serve as “advance organizers” and encourage positive perceptions (Brinkerhoff et al., 2001). Structured versus unstructured overviews, and graphical versus text overviews, facilitate comprehension (Potelle & Rouet, 2003; Puntambekar et al., 2003; Muller-Kalthoff & Moller, 2003), enhance user perceptions, increase time spent engaging with the text (Brinkerhoff et al., 2001), decrease perceptions of disorientation (Muller-Kalthoff & Moller, 2003), and focus browsing (Puntambekar et al., 2003).

Studies of hyperlink wording find benefits for both content and structural cueing. Link labels that reveal content of the target node promote focused reading, while unlabeled links promote exploration (Welsh et al, 1993). Further, link labels that reveal the semantic relationship between source and target nodes boost comprehension and enhance perceptions (Zhao et al., 1994). Local navigational links (i.e., “next” and “previous”)
conflict with the browser’s navigational aids, “forward” and “back,” and confuse users (Bachiochi et al., 1997).

Design guidelines commonly recommend phrasing hyperlinks in enough detail to inform users of where links lead (e.g., Spool et al., 1997; Spyridakis, 2000). Clear and unambiguous hyperlink wording aids information retrieval (Lee et al., Whalen et al., 1984; Dumais, & Landauer, 1983). Informative and explicit hyperlinks improve search accuracy (Spool et al., 1997; Lee et al., 1984; Snowberry et al., 1985; Dumais & Landauer, 1983) yet highly detailed, verbose link annotations do not (Fraser & Locatis, 2001). “Eye-catching” information engages readers and encourages exploration, but may cause misinterpretation of the intended message, and seductive details may distract from main points in either print (Harp & Mayer, 1998; Schraw, 1998) or on the web (Baylor, 2001).

Research has yielded mixed effects for embedded hyperlinks. Hyperlinks embedded in narrative text may distract from searching tasks (Spool et al., 1997) or may make searching fast and effective (Koved & Shneiderman, 1986; Vora et al., 1994). Embedded hyperlinks provide context for links while hyperlinks in lists outside a text enhance search speed and perceptions of search efficiency, particularly if the information associated with the hyperlinks is already known (Bernard et al., 2005).

The effectiveness of structural cues is known to interact with text and reader characteristics. When texts are familiar, easy, or enjoyable, readers are less likely to benefit from signals (Lorch & Lorch, 1996a; McDaniel et al., 1988; Huhmann et al., 2002; Mullen & Koester, 1975; Blasko & Connine, 1993; Conway & Dewhurst, 1995; Niederhauser et al., 2000; Spyridakis, 1989a, Spyridakis, 1989b; Spyridakis, 1991). Readers without a personal interest in the content of a website comprehend significantly more with medium- versus high-frequency headings but readers with a personal interest in the information have significantly higher perceptions of new knowledge gained with medium- versus high-frequency headings (Schultz and Spyridakis 2004). If readers have considerable domain knowledge, they may benefit from less coherent texts on some comprehension measures (McNamara et al., 1996). High knowledge readers also perform equally well when coherence is explicitly versus implicitly marked (Kamalski et al., in press). In contrast, when readers find text unfamiliar or difficult, signals that provide text coherence may lead to better understanding (Salmeron et al., 2005; Spyridakis, 1991; Kamalski et al., in press).

### Summary of the literature and overview of the three studies

We noted some major gaps in the research about structural cues in online environments. A majority of research on this topic stems from print-based studies. Many of the web-based studies focus on searching tasks, not browsing tasks and comprehension measures. Further, few studies assess users in their own environments, and even fewer triangulate data about comprehension, perceptions, and behavior.

The work reported here attempts to close these gaps. All three studies assessed comprehension, perceptions, and navigational behavior, but they investigated different independent measures: the explicitness of local navigational links, the intriguing and informative phrasing of hyperlinks, and text previews and navigational menus.

It will prove helpful to begin with an overview of the methods shared by the three studies. The studies were conducted remotely through the internet from participants’ own computers, at locations and times of their own choice. All studies used naturally occurring websites from which we extracted segments of the site for experimentation purposes. We chose webpages that would not be too familiar, interesting, or easy; would be explorable in 15-20 minutes; would contain expository content with general appeal (or specific appeal if called for by the study); and would lend themselves to the assessment of
different versions of structural cues. All three study sites were originally created from linear documents placed online without much ado. The native webpages tended to exceed one screen (i.e., users needed to scroll). For samples of the study sites, see http://depts.washington.edu/intres/paststudies.shtml.

Participants were recruited through links on content-based websites (e.g., e-health websites), email lists, or flyers. All studies began with online introductory pages that provided human subject consent information and asked participants to spend about 15-20 minutes browsing the study website. All website pages contained a Proceed to Survey link, and all studies contained multiple surveys. Introductory information told participants not to return to the study websites after they had entered the post-browsing surveys and offered incentives such as course credit or gift certificate drawings. The alpha level for all studies was .05.

**Study 1: Explicitness of local navigational links**

Many informational websites contain linear articles that provide forward and backward navigation with local navigational links labeled “next” and “previous.” These articles often contain embedded hyperlinks that enable users to jump to new locations within the same webpage, across webpages within the same article, or across articles within the website. When following embedded links and moving between articles, users encounter a new series of “next” and “previous” local navigational links yet they may not realize that they have just moved from one linear article to the another because the link labels remain the same and are so nonspecific. This study sought to determine whether these links confuse users and make it difficult to construct mental models of the hypertext space and whether providing more explicit semantic or structural link labels would alleviate this confusion and thus reduce cognitive overload and disorientation. To this end, Study 1 examined the effect of the explicitness of wording of local navigational links on users’ comprehension, perceptions of use, and navigational behavior (see Mobrand & Spyridakis, 2007). We anticipated that replacing the generic link labels of “next” and “previous” with more explicit labels would lead to higher comprehension, more positive perceptions of use, and greater site exploration.

**Methods**

The study comprised 84 subjects from the general adult population: 70 percent were female and 93 percent were native English speakers. The average age was 48.5 (SD = 14.2).

The experimental website contained 28 webpages excerpted and adapted from four linear articles about arthritis located on the University of Washington Orthopedic website. Study participants were asked to browse the study website for at least 15 minutes, with a scenario in mind that they had a friend or relative with arthritis and they would like to find out about helpful foods, medications, and coping strategies.

To investigate the effect of navigational link wording, we created four experimental conditions, as shown in Table 1.

The top portion of a webpage from each of these four conditions is shown in Figure 1. The centered text and horizontal arrows identify the conditions, but did not appear on the experimental pages.

To create the experimental browsing pages, we standardized the number of embedded links, preserved all content verbatim, removed links that led outside the four articles, and removed the navigation column so users would have to rely on the local navigational, embedded, home, and survey links. We then replaced the generic local navigational link labels (“previous” and “next”) with the link labels created for each condition. (See Figure 2 for a screen shot from the study site.)
The study employed multiple surveys. A pre-browsing survey assessed participants’ connection to arthritis and use of medical websites, and ended with an 18-item multiple-choice pre-test on arthritis. The pre-test augmented the browsing scenario, gave a second measure of prior knowledge, and served as a covariate in the post-comprehension analysis. The post-browsing survey assessed demographics and included the same 18-item multiple-choice test on arthritis, a survey on perceptions of use, and an open-ended comment section.

To enter the study, participants logged into a web server at the University of Washington, read instruction pages, and took the pre-browsing survey. They read the browsing scenario and were randomly assigned to one of four experimental websites. After browsing, participants took the post-browsing survey and had an opportunity to enter an Amazon.com drawing. Navigational behavior was captured with standard web server logs (e.g., page requests, referring pages, time of request).

Results and discussion
This section discusses participants’ relationship to study materials, comprehension, perceptions of use, and navigational behavior. Participants were very connected to
arthritis: 71 percent reported having arthritis or having a relative or close friend with arthritis. Participants were moderately familiar with the content of the experimental webpages (M = 2.89, SD = 1.05; 1 = very unfamiliar, 5 = very familiar), were quite interested (M = 3.8, SD = 1.03; 1 = very uninterested, 5 = very interested), and found the text relatively easy (M = 3.87, SD = 0.85; 1 = very difficult, 5 = very easy). In summary, participants in this study were very unchallenged readers with a strong connection to the page content.

An Analysis of Covariance (ANCOVA) revealed a significant main effect for explicitness of link wording on comprehension (F(3, 81) = 3.305, p = 0.024), as shown in Figure 3. Post hoc tests revealed that participants in the organizational condition had significantly lower comprehension than participants in the semantic/organizational condition and the semantic condition; there was a trend towards significance (p = .061) for the scores in the organizational condition being lower than those in the generic “next” and “previous” condition.

The low comprehension in the organizational condition was likely due to the ambiguity of the label itself (e.g., “Section 3 of 5”). Because these labels resembled page numbers, participants may have been confused about whether the labels referred to the location of the current node or the target node, making these labels poor structural cues. The lack of differences between other conditions suggests that any assistance provided by explicit cueing may have been offset by the fact that the new wording was less familiar than the traditional “next” and “previous” labels: users often do better with convention, even if that convention is not the most effective (e.g., Nielsen 1998; Spyridakis, Wei et al., 2005). In addition, participants had high prior knowledge and interest and, thus, would be expected to benefit less from signals (or navigational aids).

ANOVAs were run to evaluate the effect of link explicitness on the perceptions of use variables. There was a trend toward significance (p = .068) on one perception measure: participants in the semantic/organizational condition reported following more embedded links than participants in other conditions. This trend could reflect increased confidence to move between articles when participants have explicit information about site structure and their place within that structure. The lack of significant differences among conditions on the other perceptual variables could be a reflection of high prior knowledge and interest compensating for deficiencies in site design, meaning that structural cues may have provided little advantage.

A Chi-square analysis was run to assess positive versus negative open-ended comments by condition; it revealed a significant difference (χ² (df 3) = 142.16, p = .000). A larger proportion of positive comments were made by participants in the organizational and semantic/organization conditions than by those in the generic and semantic conditions (see Figure 4). The fact that participants in the semantic/organizational condition...
made the most positive comments and reported the highest frequency of following embedded links supports the idea that positive perceptions reflect comfort with the site and, hence, willingness to explore between articles, which required the use of embedded links.

A Chi-square analysis of the log file data revealed significant differences in the percent of the site visited by condition ($\chi^2$ (df 3) = 135.69, $p = .000$). Participants who had the most explicit cues (semantic/organizational condition) saw the largest proportion of the site and those in the organizational condition saw the smallest (see Figure 5). Further, weak and ambiguous cues (the organizational condition) discouraged navigation and exploration, which helps explain why participants with weak cues had low comprehension scores. With test questions drawn from pages across the experimental website, participants who saw the fewest pages would encounter less of the content from which the questions were drawn and, thus, likely answer fewer questions correctly.

**Study 1 conclusions**

Although our original hypotheses were not supported, the wording of local navigational links clearly affects user experience, a result that has practical implications for web authors. Web authors should choose link wording carefully, as ambiguous or confusing labels can degrade comprehension, reduce user's ratings of the site, and constrain navigation. Web authors also should consider using cues that provide more than one type of signal to readers: wording that effectively reveals the site content, structure, and the user's place within that structure can enhance comprehension and user perceptions, and can encourage site exploration. And, finally, web authors should be very cautious when modifying traditional, accepted link label wording (i.e., “previous” and “next”), replacing it only with well thought out link wording that cues readers effectively.
Study 2: Informative and intriguing hyperlink phrasing

Given Study 1’s investigation into link explicitness, Study 2 followed on to investigate other aspects of link labels, specifically assessing the effect of informative and intriguing hyperlink wording in a site-wide navigation menu and embedded within body text on users’ comprehension, perceptions, and browsing behavior with an informational website (see Wei, et al., 2005). We expected that informatively worded links would improve comprehension whereas intriguing links would encourage users to explore more of the site.

Methods

The study comprised 475 engineering students from the University of Washington: 78 percent were male and 82 percent were native English speakers. Their average age was 21 (SD = 2.87).

The experimental website contained 19 informational webpages excerpted and adapted from a U.S. National Park Service website about the American Samoa national park. Study participants were asked to browse the study website for about 15 minutes, with the scenario in mind that they were a new ranger learning about the park.

To investigate the effect of link wording, we created five versions of the website (see Table 2) by varying hyperlink wording in the site-wide navigation menu and embedded links within the body text. Given the constraints in the number of conditions we could test, of the five conditions we did assess, three had a match between the wording of the navigation menu and embedded links in the text (see Conditions 1, 4, and 5), and two did not (see Conditions 2 and 3). (See Figure 6 for a screenshot from the study site.)

The link wording was operationalized as follows:

- Generic links were simple, short, descriptive wordings, often the native links found on the actual site (e.g., “Local Culture”)
- Informative links were explicit, descriptive wordings (e.g., “Traditional Samoan Culture”)
- Intriguing links were cleverly worded to pique interest (e.g., “The Samoan Way”)

Table 2. Link wording in experimental conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Navigation menu links</th>
<th>Embedded links</th>
<th>Match between navigation menu links and embedded links</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Generic</td>
<td>Generic</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Generic</td>
<td>Intriguing</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Generic</td>
<td>Informative</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Intriguing</td>
<td>Intriguing</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Informative</td>
<td>Informative</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Figure 6. Web page from the generic navigation menu and intriguing embedded link condition
The study employed multiple post browsing surveys that assessed participants’ web experiences and their relationship to the study website, perceptions of the site, and comprehension with a 38 multiple-choice item test. Half of the comprehension questions assessed factual information from the webpages and half required participants to draw inferences between stated facts or between fact and common knowledge. The factual questions sought to test participants’ knowledge at the level of the text base and the inferential questions sought to test participants’ situation models (McNamara et al., 1996). (See http://depts.washington.edu/intres/paststudies.shtml for a live version of this study).

The complexity of the study – requiring random assignment of participants to conditions, automatic generation of five conditions, random ordering within the navigation menu, administration of surveys, and recording of user browsing behavior and link clicking – prompted the in-house development of the WebLab UX toolkit to manage all technical aspects of the experiment. The toolkit automated the development of the experimental pages with PHP scripts, and captured all study data including survey answers, pages visited, and links clicked. The toolkit supported analysis of individual user behavior as well as in the aggregate.

Results and discussion

This section discusses participant demographics and their relationship to study materials, comprehension, perceptions of use, and navigational behavior. Participants were experienced web users with an average of 7.47 years using the web (SD = 2.11). Participants found the information in the study website to be somewhat unfamiliar (M = 1.99, SD = 0.881; 1 = very unfamiliar, 5 = very familiar), somewhat interesting (M = 3.27, SD = 0.922; 1 = very uninteresting, 5 = very interesting), and somewhat easy (M = 3.52, SD = 0.826; 1 = very difficult, 5 = very easy). Participants were experienced web users, and although they stood to benefit from informative links given their lack of familiarity with the text; their interest and views of text ease could counter that situation.

ANOVA was used to assess the effect of the link wording on inferential, factual, and total comprehension. There was a significant effect on inferential comprehension (F(4, 470) = 2.54, p = 0.040). A post-hoc test revealed that participants in the Generic–Informative condition answered significantly more inferential questions correctly than participants in the Intriguing–Intriguing condition (see Figure 7). There was also a significant difference in total comprehension (F(4, 470) = 2.86, p = 0.023) with participants in the Generic–Informative condition answering significantly more questions correctly than participants in the Informative–Informative condition (see Figure 8). Although there were no significant differences in factual comprehension across conditions, factual comprehension appears to have influenced total comprehension, which may explain why participants in the Intriguing–Intriguing condition had the lowest inferential comprehension scores while participants in the Informative–Informative condition had the lowest total comprehension scores.

![Figure 7. Effect of link wording on inferential comprehension](image-url)
The comprehension results revealed that unmatched conditions (i.e., different wording in the navigation menu versus embedded link wording) facilitated comprehension. This pattern held with regard to site exploration as revealed through analysis of log data. ANOVAs, with post hoc tests, revealed that participants in the Generic–Informative condition clicked significantly more links overall \((F(4, 470) = 4.87, p = 0.001)\) than participants in Intriguing–Intriguing or Generic–Generic conditions. Also, participants in the Generic–Intriguing condition clicked significantly more embedded links \((F(4, 470) = 5.27, p = 0.000)\) than participants in Intriguing–Intriguing, Generic–Generic, and Informative–Informative conditions. The two conditions with unmatched wording between links in the navigation menu and embedded in text encouraged significantly more link clicking than two of the three matched conditions. Interestingly, only one perceptual question about the site produced significant differences across conditions: participants in the Generic–Generic condition rated the importance of the navigation menu links more highly \((F(4, 464) = 2.618, p = 0.013)\) than participants in the Generic–Informative condition. Apparently when the navigation menu was rather uninformative and matched its embedded links, participants viewed the menu as being important, even though this result did not match up with comprehension or browsing behavior.

**Study 2 conclusions**

We had predicted that informative links would improve comprehension and intriguing links would increase site exploration – the results were not that simple. The mismatch in link wording between navigation menu and embedded links in the generic-intriguing and generic-informative conditions appears to have driven the differences in the results, affecting comprehension and browsing. Significantly higher inferential comprehension scores for participants in the unmatched conditions suggest that participants successfully built a situation model. Participants with a generic-informative or generic-intriguing condition had an additional source of information about target content or extra encouragement to click links. If the navigation menu did not motivate clicking, embedded links with a different style of wording may have provided the additional information or intrigue to compel clicking and site exploration. Matched conditions, e.g., informative-informative, did not provide this kind of supplemental navigation information.

In sum, this study suggests that web designers, who may find it unfeasible to manipulate the wording of navigation menus, might want to explore using more informative or intriguingly worded embedded links so as to encourage browsing and learning. If the navigation menu links remain generically worded, then users in effect would have two completely different modes of access into a website, increasing the likelihood that they would find an avenue into the online material that best suits them.
Study 3: Text previews and navigational menus

Our two studies of hyperlink wording led us to investigate other types of cues to site structure. Informational websites containing hypertext documents typically feature hierarchical organization with higher-level parent pages introducing lower level pages. When parent pages fail to provide textual previews of their subordinate pages, users must rely solely on the navigational menu structure to determine how the pages of text relate. This becomes increasingly difficult if the navigational menu also disappears as users move into the subordinate pages, as is the case in many informational websites. Study 3 investigated the effect of textual previews and navigational menus on comprehension, perceptions of use, and navigational behavior. We expected that previews would result in higher comprehension (especially inferential), greater site exploration, and more positive user perceptions; and navigational menus would result in higher comprehension (especially factual), greater site exploration, and more positive user perceptions.

Methods

The study comprised 282 undergraduate students from engineering courses at the University of Washington: 76 percent were male and 90 percent were between the ages of 18 and 25 years. Nonnative English speakers were excluded from all analyses in this study because they significantly differed from native English speakers on many dependent measures.

The experimental website consisted of 21 informational webpages excerpted and adapted from a U.S. National Park Service website about Big Bend National Park in Texas. Participants were asked to browse the experimental site to learn as much as possible about the park in preparation for a summer job as a tour guide. To investigate text previews and navigational menus, we created six experimental conditions from two independent variables: text previews and navigational menus (see Table 3).

To construct the experimental study site, we chose a section of the Big Bend website that was organized in a three-level hierarchy. Level 1 consisted of a single homepage that contained links to the four level 2 sub-areas. Level 2 consisted of top pages that contained links to the four level 3 sub-areas, for a total of 16 content pages at level 3. We wrote texts previews for level 1 and 2 pages, standardized the number of embedded links within the text on the 16 content pages, and removed links that led outside the experimental webpages. The level 1 page from each of the six experimental conditions is shown in Figure 9. (See http://depts.washington.edu/intres/demo/bb/ for a live version of this study).

The study employed a pre-browsing survey that assessed demographics and participants’ web experience and a post-browsing survey that assessed participants’

Table 3. Experimental conditions from text previews and navigational menus

<table>
<thead>
<tr>
<th>Condition</th>
<th>Text Previews</th>
<th>Navigational Menus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Text previews with embedded hyperlinks to subordinate pages.</td>
<td>Absent</td>
</tr>
<tr>
<td>2</td>
<td>Text previews accompanied by a list of links to subordinate pages.</td>
<td>Absent</td>
</tr>
<tr>
<td>3</td>
<td>No text preview; only a list of links to subordinate pages.</td>
<td>Absent</td>
</tr>
<tr>
<td>4</td>
<td>Text previews with embedded hyperlinks to subordinate pages.</td>
<td>Present</td>
</tr>
<tr>
<td>5</td>
<td>Text previews accompanied by a list of links to subordinate pages.</td>
<td>Present</td>
</tr>
<tr>
<td>6</td>
<td>No text preview; only a list of links to subordinate pages.</td>
<td>Present</td>
</tr>
</tbody>
</table>
Figure 9. Screenshots of the six conditions with previews and menus varied.
site perceptions and comprehension. The 32-item multiple choice comprehension test contained 16 questions that assessed factual information from the webpages and 16 that required participants to draw inferences. The factual questions sought to test the participants’ knowledge at the level of the text base and the inferential questions sought to test the participants’ situation models (McNamara et al., 1996).

Results and discussion
This section discusses participant demographics and their relationship to study materials, comprehension, perceptions of use, and navigational behavior. Participants were experienced web users with 65 percent reporting that they had used the web for 6-10 years and 27 percent reporting more than 10 years. Participants were relatively unfamiliar with the text on the experimental webpages (M = 2.09, SD = .90; 1 = very unfamiliar, 5 = very familiar), were somewhat interested (M = 2.64, SD = 1.07; 1 = very uninterested, 5 = very interested), and found the text relatively easy (M = 3.30, SD = 0.888; 1 = very difficult, 5 = very easy). Participants in this study were at a midline for being challenged readers in need of strong structural cueing in that they lacked familiarity but found the text somewhat interesting and relatively easy.

An ANOVA revealed a significant effect for previews on inferential comprehension ($F(2, 281) = 3.128, p = 0.045$) (see Figure 10). A post hoc test showed that previews with embedded links led to significantly higher inferential comprehension than previews with a list of links below them: previews with embedded links contributed to the participants’ building of a situation model. No significant differences were found on factual or total comprehension. Additionally, no effects were found for navigational menus on the comprehension measures.

An ANOVA for the effect of previews and menus on participants’ ratings of the website on the System Usability Scale (SUS) (Brooke, 1996) revealed a significant effect for previews ($F(2, 281) = 8.828, p = 0.000$). Post hoc tests revealed that previews with a list of links below and only a link list were rated significantly higher than previews with embedded links. As expected, the experimental conditions with navigational menus present received significantly higher SUS ratings than sites without the navigational menu ($F(1, 281) = 34.397, p = 0.000$). A significant interaction also occurred ($F(3, 281) = 7.629, p = 0.000$), showing that SUS ratings were most negative for previews with embedded links in the absence of menus.

An ANOVA for the effect of previews and menus on percent of pages visited at least once revealed a significant effect for previews ($F(2, 281) = 3.216, p = 0.042$) with a post hoc test showing that the link list only condition led to greater exploration than previews followed by a list (see Figure 11). No effect was found for navigational menus.
Study 3 conclusions

Our hypothesis that text previews would improve knowledge acquisition was supported in that previews with embedded links to subordinate materials improved participants’ ability to make inferences about the material they had read – a result that suggests these participants developed a strong situation model. Text previews without embedded hyperlinks did not equally support inferential comprehension. Because the text previews without embedded links had the list of subordinate links below them instead of embedded in them, it is possible that this condition discouraged thorough reading of the preview and instead allowed participants to skim and use only the list of hyperlinks. Web designers should consider constructing previews with embedded links on top level pages so as to improve readers’ comprehension of their sites – if comprehension is their goal.

Our hypothesis that previews would lead to greater site exploration was not supported in that the link list only condition led to greater exploration than the previews followed by the link list. Web designers should consider using lists of links if site exploration alone is their goal.

Our hypotheses with regard to the presence of navigational menus were partially supported. Navigational menus did not result in higher comprehension or site exploration but they did lead to higher perceptual ratings.

As we have found in our other studies, Web designs that support comprehension do not necessarily receive higher usability perception scores. As was shown here, website designers may need to choose between a site design that their users claim to like versus a design that enhances comprehension. Alternatively, designers should consider redundancy in their design to support both facets of user performance. And, merely collecting website users’ perceptions about a site may not predict actual performance as was shown in differences between comprehension and browsing performance.

Overall conclusions

Designers of online information should understand the need for structural cues in online spaces. Study 1 found that users are comfortable, perform well, and explore more of a website with clear, explicit local navigational links (i.e., semantic/organizational cues) as well as with conventionally worded local navigational links. Further, ambiguous wording for local navigational links degrades comprehension, perceptions, and site exploration. Study 2 found that maintaining simple link labels in navigation were well liked. However, previews with embedded links to subordinate material – the same previews that facilitated inferential comprehension – were disliked, as they were unfamiliar and unexpected.

Our hypothesis that previews would lead to greater site exploration was not supported in that the link list only condition led to greater exploration than the previews followed by the link list. Web designers should consider using lists of links if site exploration alone is their goal.

Our hypotheses with regard to the presence of navigational menus were partially supported. Navigational menus did not result in higher comprehension or site exploration but they did lead to higher perceptual ratings.

As we have found in our other studies, Web designs that support comprehension do not necessarily receive higher usability perception scores. As was shown here, website designers may need to choose between a site design that their users claim to like versus a design that enhances comprehension. Alternatively, designers should consider redundancy in their design to support both facets of user performance. And, merely collecting website users’ perceptions about a site may not predict actual performance as was shown in differences between comprehension and browsing performance.
menus is possible, but user comprehension and site exploration improves if links embedded in text have more informative or intriguing labels than the generic navigation menu labels. Study 3 found that previews with embedded links to subordinate pages help readers comprehend more although readers may not like them, particularly in the absence of navigational menus. In sum, the three studies show the benefit of combined approaches to structural cueing.

The studies also show that readers may perform differently than they perceive, and they may not like what is good for them. Ultimately design decisions must be made in context. The designers of an ecommerce site may want structural cueing that encourages site exploration and positive perceptions. In contrast, the designers of an ehealth site may see comprehension as the gold standard for user performance.

The research reported here just touches the surface of some design issues regarding structural cueing. Our work supports the assessment of real users browsing websites in their own environments and responding to comprehension surveys, scaled surveys of their perceptions, and open-ended questions, while structured weblog files gather useful data about navigational behavior. The triangulation of these methods provides a rich picture of a user's experience with a website. This picture can contribute significantly to an empirically-based set of web authoring guidelines for effectively disseminating information on the web.

Clearly, conducting remote studies of users in their own environment has its challenges. Some researchers may doubt the feasibility of remote studies because they fear a loss of experimental control. One must decide whether uncontrolled environmental factors threaten a study's internal validity or contribute to its external validity. We maintain that involvement of the uncontrolled natural world with all its complexities is a boon to internet-based web design research and helps give such studies far greater external and ecological validity than studies conducted within the confines of a laboratory.

References


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