The Importance of Graphics: Implications for Educational Hypertext Material

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Abstract: This paper reports a series of experiments providing empirical evidence that conventional webpage graphics facilitate learners' successful navigation to find information in complex informational websites and hypertext instructional materials. During visual search of a webpage, graphics strongly influenced learners' success/error rate locating common interactive Web objects, e.g., search engine or navigation bar menu link. In the capstone experiment, 58 undergraduate participants had to locate the webpage widget (4 graphic and 4 text widgets) to accomplish a specific task. Tasks were performed in 4 different types of webpages (2 location conditions x 2 graphics conditions). One set of webpages used conventional graphics and locations, the second used conventional graphics but violated location expectations, a third used conventional locations but lacked conventional graphics, and the final set lacked both conventional graphics and object locations. Graphics accounted for 40% of the treatment effect compared to 15% accounted for by location expectations.

Introduction

Imagine a young mother, call her Jane, who goes to the Internet to look for information about head injuries. Just before bedtime her preschool son fell down the deck stairs and hit his head on the concrete landing at the bottom of the stairs. Jane needs to know whether she needs to take her son to the emergency room, call her doctor, or just let her son sleep through the night. How can we predict whether Jane will be successful in finding the information she needs?

Jane comes to each webpage with her learning goal and a set of expectations about different types of webpages and about various webpage widgets typically found on webpages. For example, if Jane has an ingrained propensity to use site search engines, she may search for the site search engine as soon as the webpage loads. If Jane expects the content area of the webpage to have the information she needs, she will search for the content area of the webpage and scan it to assess whether it is relevant to her current learning goal about head injuries. If Jane wants to be sure that site is accredited before she searches it for medical information, then she may search first for the accreditation logos. If she began by entering a search query on Google or Altavista, and clicking on one of the results delivered by the search engine has delivered her to some webpage deep in a medical/health website, Jane may search for the site logo or a text or button link to the home page, so she can restart her search at the home page of the website.

To assess the probability that Jane will quickly and accurately find the webpage widget that she wants, we need to examine two types of visuospatial information. First, we need to assess whether each of the webpage widgets is in the place where Jane expects it to be in the webpage. Second, we need to assess if the graphic design facilitates rapid and accurate visual search for the widget independent of its location within the webpage layout.

CoLiDeS

One cognitive model that can help us understand how likely it is that Jane will find the information she needs in an efficient manner is the **Co**mprehension-based **Li**nked model of **De**liberate **S**earch, or CoLiDeS. CoLiDeS was developed to help understand cognitive processes involved in Website navigation and comprehension, and provides an excellent predictive model of semantic influences of the text on a Webpage. The theory maintains that successful navigation and comprehension hinge on successful reading comprehension and attention management. The CoLiDeS model sees the learner's schema for a webpage as an important factor in the search process. A schema represents a conceptual picture of the typical webpage – what objects will likely be on the page, where the objects are typically located, and what actions, if any, are associated with each particular object. There is ample research elsewhere that schemas are used to guide a person's actions and facilitate their understanding of natural scenes (Henderson & Hollingworth, 1999).

According to CoLiDeS, a search task involves four cognitive processes (Kitajima, Blackmon, & Polson, 2000, 2005):

1. parsing the webpage into subregions,
2. focusing on a subregion,
3. comprehension of screen objects in the attended subregion, and
4. selection of an available action among the objects in the attended subregion.

Much research as been done on steps 3 and 4 of the model, however little has been done in relation to steps 1 and 2 of the process. The research described in this paper takes a first look at these first two steps, with the expectation that the conventional Webpage graphics help individuals, such as Jane, parse the page into subregions and that location expectations then help in the process of focusing on a subregion.

The Importance of Layout Location

Many design experts stress the importance of maintaining a consistent layout design for webpages. Krug (2000) insists that, "Conventions are your friends" (p. 34). Conventions can be thought of as commonalities of appearance and function that occur within and across websites. Krug goes on to say that, "Well-applied conventions make it easier for users to go from site to site without expending a lot of effort figuring out how things work" (p. 35). There is a substantial body of research showing that the advice of expert designers is on target: People quickly learn and make use of location consistencies when performing a visual search (Biederman, Mezzanotte, & Rabinowitz, 1982, and Quinlan, 2003). Research also leads us to expect Jane to have developed a sense of where to find common widgets on the webpages as she searches for information on head injuries (Bernard, 2001; Oulasvirta, Karkkainen, & Laarni, 2004). There is also evidence that violating location expectations will make it harder for Jane to find the widget (Pearson & van Schaik, 2003).

Where would Jane expect to find common widgets? A survey by Hinesley (2005) revealed a wide range of agreement of where common webpage widgets are likely to be located (see Table 1 below). What was most interesting about these results was the general trend that frequently used widgets, such as the search engine, were usually expected to be located at the top of the page, whereas, more people expected the widgets seldom used to be at the bottom of the webpage than any other location. There was one notable exception, however: More people expected to find advertisements at the top of the page than any other location.

Whereas some interest shown in the effects of location of navigation menus, or bars, these studies tend to confound location with conventional graphics (Oulasvirta, Karkkainen, & Laarni, 2004; Pearson & van Schaik, 2003; van Schaik & Ling, 2001): the navigation bar usually consists of a color panel, referred to as "Yellow Fever" by Nielsen (Pearson & van Schaik, 2003). This means that any effects of location expectations were confounded with the effects of graphics, and as you will read below, graphics have been found to have an impact on visual search.

Widget	Frequency of Use	Location Expectation
Search Engine	4.39	Top (73.1%)
Drop Menu	3.34	Top (48.7%)
Home	3.24	Top (56.1%)
Different Topic	2.78	Top (39.0%)
Accreditation	2.04	Bottom (56.1%)
Advertisement	1.85	Top (41.4%)
Contact	1.83	Bottom (82.9%)
Newsletter	1.76	Bottom (39.0%)

Table 1: Frequency of Use and Location Expectations for Common Webpage Widgets.

The Importance of Graphics

Expert designers emphasize the importance of graphics in directing the attention of webpage users. One of the foremost considerations of many designers is *perceptual organization*. For example, Mullet (1995) contends that "Spatial organization is a central aspect of communication-oriented visual design" (p. 15). This aspect of design draws heavily on Gestalt psychology. Gestalt psychology maintains that when we look at a collection of discrete objects, or parts, we will often see it organized into subsets or groupings. Palmer (1992) has proposed that common region, or enclosure, be added to the principles of organization (similarity, proximity, continuity, and closure). According to the law, elements that are located within the same perceived region tend to be grouped perceptually. Could it be that conventional graphics help with the parsing of the webpage?

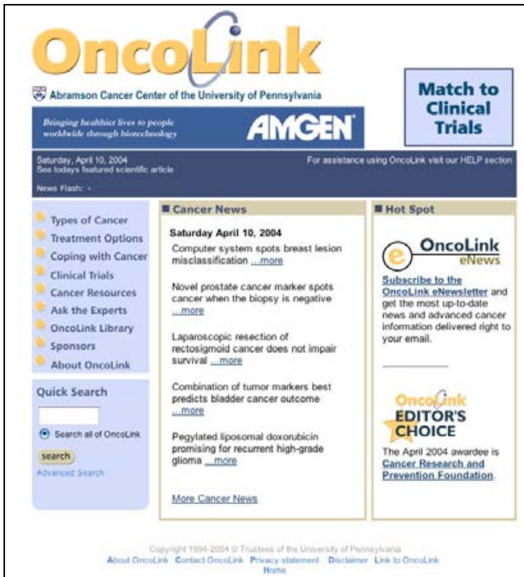

Figure 1: Original Webpage

Figure 2: Webpage with text changed to *x*'s.

Preliminary Studies of the Influence of Graphics

Because of the pioneering nature of the work, we wished to conduct some pilot work to provide some evidence that individuals can use cues from graphic conventions to help them find task related widgets. In our initial pilot study, we used real websites gathered from the return of a Google search for medical related conditions (sexually transmitted diseases, migraine headaches, and skin cancer). All text was carefully replaced with *x*'s to remove all semantic influence while maintaining the graphics, and every effort was made to maintain the font style, size, and color (see Figure 1 above). Results provided clear evidence that learners can successfully find both text widgets (such as the links to the privacy statement and contact information) and graphic widgets (such as the site logo and the search engine) in the absence of any semantic cues. Of particular interest, however, was our finding that the graphic widgets were found in fewer clicks than text widgets (1.47 and 2.43 clicks, respectively).

In a larger follow-up study, we compared the normal, unaltered website pages used in the first pilot study, with the *x'*ed out versions. Results again provided clear evidence that learners did not need the text to find a widget, and that graphic widgets were easier to find than text widgets. It comes as no surprise that text widgets took fewer clicks to find on the normal pages than the pages with the textual cues removed (1.62 and 3.09, respectively). However, this was not necessarily the case for graphic widgets. Advertisements, drop menus and the print icon all followed the same pattern as the text widgets: participants found them in fewer clicks on normal as opposed to the altered webpages. The website logos (1.33 clicks) and search engines (1.16 clicks), however, showed near perfect performance on both types of pages; while finding the accreditation link was difficult (2.75 clicks) for both the normal and altered webpages (Hinesley, 2005).

Whereas using real webpages gave our initial studies some external validity, it did not afford us much control. The experiment discussed in this paper sought to give us control over such factors as page complexity and object location.

Exploring Factors Affecting Graphic Widget Usability

Because graphic widgets are a common part of any webpage design, it important to understand how the use of graphic widgets impacts website usability. The experiment was designed to examine whether graphic widgets are affected by the same factors that affect text widgets. In the following experiment, we remove semantic, graphic, and location cues while controlling for familiarity and location expectations. Removal of semantic, graphic, and location cues can be viewed as similar to the violation of "good practices" used in the study of reading comprehension (Kintsch, Mandel, & Kozminsky, 1977) and illustrated instructions for copier machines (Rodriguez, 1986).

Removal of semantic influences through the use of Greeked text is a common practice for graphic design, and was adopted for research purposes by Tullis (1998). Greeking is accomplished by replacing all text with gibberish or a random collection of words written in a language other than the predominant language, such as the use of Greek in the United States. This technique forces the learner to search the webpage using visuospatial cues. Preliminary studies have shown learners can successfully complete all search tasks under Greeked conditions, albeit with an increase in the number of attempts in some cases (Hinesley, 2005).

Removal of location cues is typically accomplished by moving functional units, such as the navigation bar, from a conventional location (e.g., the left side) to an unusual location (e.g., the right side) on the page (van Schaik & Ling, 2001). To the degree that graphic widgets are salient and unique, they should "pop out" from the webpage (Treisman & Gelade, 1980), making them easier to locate than text widgets despite the unusual location.

Lastly, the removal of all cues (semantic, graphic, and location), was expected to present the most difficult of all conditions for both types of widgets.

Methods

Participants

Fifty-eight undergraduates (24 females and 34 males) participated in the experiment. All students were enrolled in an introductory psychology course at the University of Colorado and received course credit for participating.

Design

We used a Graphics (present v. absent) x Location (conventional v. unconventional) x Widget Type (text v. graphic) repeated measures design (see Table 2 below for the classification of widgets). The dependent variables were the Time to First Click, Total Task Time, and Total Number of Clicks – that is, the number of times a participant clicked on various webpage widgets until they successfully completed the task. During analysis, scores were collapsed across the twelve different mock webpages for each condition.

Graphic Widgets	**Text Widgets**
Accreditation	Contact
Advertisement	Newsletter
Search Engine	Home
Drop Menu	Different Topic

Table 2: Task Widgets

Materials and Apparatus

Mock webpages were constructed using popular design software. Each mock webpage was carefully constructed to contain a similar number of functional elements. All mock pages had a content area, navigation bar, top menu, bottom menu, logo, search engine, drop-down menu, advertisement, accreditation web objects. All but two of the mock webpages contained an email and a printer icon as well. All text on all webpages was Greeked.

For the No Location condition, we took each Normal webpage and moved each of the functional units to an unexpected location (see Figure 4 below). Unexpected locations were based on the least often location picked by participants as the first place they would look according to the user survey (Hinesley, 2005). For the No Graphics condition webpages, we took the same webpages used in the Normal Condition and removed all graphics (see Figure 5 below). This left all Greeked text in the exact position found in the Normal webpages. We then changed all text to the same font, type style, color (black), and size (where feasible). For the No No condition, we took each No Location webpage and removed the graphics and altered the fonts in the same manner described above for the No Graphics Condition webpages (see Figure 6 below).

Figure 3: Example of Normal Webpage.

Figure 4: Example of NoLocation Webpage.

Figure 5: Example of NoGraphic Webpage.

Figure 6: Example of NoNo Webpage.

A functional unit was any set of web objects typically grouped together by web designers because they served similar functions. For example, the navigation bar located on the left side of most normal web pages would be considered a functional unit, as would the content area, the website logo, the top menu, the bottom menu, the accreditation widget, the search engine (complete with text box, "Go" button and any other related text), the drop-down menu, the advertisement, and the print and email icons.

All webpages were given "hot spots" to make the pages interactive. A hot spot is a clickable field on a webpage. Participants could see the hot spots when the mouse pointer changed to a hand as it moved over the clickable area. Hot spots were based on functional units. For example, the entire left navigation bar was considered a functional unit, and therefore had one hot spot for the entire unit.

Participants were tested using G4 iMacs with 17" flat-panel displays running the latest version of OS X. The computers were connected to a dedicated Apache server through a high-speed, local-area network. Microsoft Internet Explorer 5.2 for Mac was preset with the browser window sized to fit the entire screen, and only the button bar enabled (that is, the status, address, or explorer bars were not accessible).

Stimulus sets consisted of two pages representing each condition. Participants were only exposed to a particular page in one form. For example, if webpage 12 was used in the Normal condition, it could not be used for the No Location condition for that particular participant.

Procedure

Six different order permutations were used to counter-balance for practice and order effects across participants. Each participant was randomly assigned to one of the six presentation orders of the a stimulus set. Participants were shown a screen with the task instructions and asked to click on a link below the instructions when they were ready to proceed to the test item. Participants were told to select the area of the webpage where they expected to find the test item by clicking on it using the mouse.

Participants saw an “Oops!” page and asked to click a link back to the test page if they selected the incorrect hot spot for any given task. Participants received a “Correct!” page and a link to move to the next item if they made a correct selection. There was no time limit set for completion of the tasks.

Participants had to find each of the eight widgets (see Table 2, above), for each of the eight pages in their stimulus set. For our analyses we used the within-participant margin means for each task collapsed across the two pages used in each condition (Normal, No Location, No Graphic, No No). This served to eliminate the twelve different webpage designs used in the four conditions as a factor.

Results and Discussion

The results provide strong evidence that Text and Graphic Widgets respond differently when semantic, location, and graphic cues are manipulated. Text and Graphic Widgets responded differently to the various Page Conditions (Normal, No Location, No Graphics, and No No). There were highly significant main effects for Graphics, Location, (see Figure 7 below) and Widget Type. Graphics also seem to play a facilitating role for the widget itself: It is significantly ($F_{3, 171} = 3.19$, p = .025) easier to find Graphic Widgets (2.5 clicks) than Text Widgets (3.06 clicks).

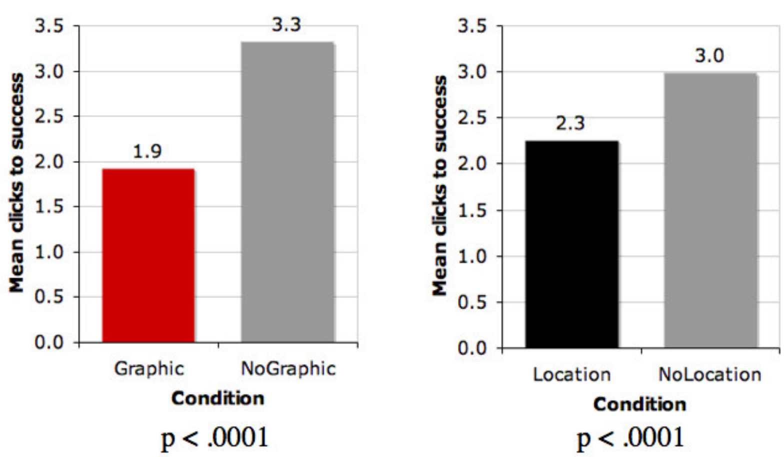

Figure 7: Main Effects

Impact of Graphics

With one exception (the Drop Menu), removal of graphic cues results in poorer search performance for Graphic Widgets. For example, the Search Engine is one of the most frequently used Graphic Widgets. In conditions in which the graphics were present (Normal and No-Location Page Conditions), the Search Engine was located in just 1.4 clicks–near perfect performance despite the lack of textual, and location cues. However, without graphics, the Search Engine task goes from one of the best performances of all tasks tested to the absolute worst–from 1.4 to

5.2 clicks (p < .0001). An examination of Figure 8 (see below) clearly shows that the loss of graphic cues has a larger impact on search performance than the loss of location cues (p < .0001).

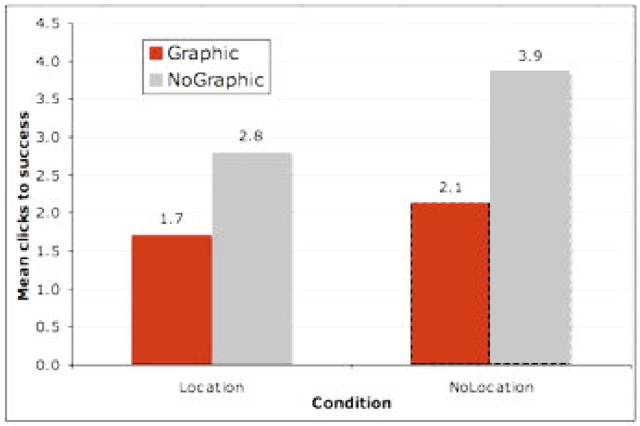

Figure 8: Interaction of Graphic and Location.

The evidence suggests that graphics play a role in the search for Text Widgets too. With the exception of the Different Topic task, all Text Widgets showed the same step-like pattern of response differences due to Page Condition: performance declined as one went from Normal, to No-Location, to No-Graphics, to No-No Page Conditions. The Home (*p* < .001), Contact (*p* < .001), and Newsletter (*p* < .0001) tasks all showed a significant decline in performance when comparing the Normal and the No-Graphics Page Conditions.

While graphics maybe an integral part of Graphic Widgets, the same is not the case for Text Widgets. Why is it then that the removal of webpage graphics interferes with search performance? The cognitive model underlying CWW, the Comprehension-based Linked model of Deliberate Search (CoLiDeS) provides us with a plausible answer: graphics may make the parsing of the page easier and thus facilitate search. According to CoLiDeS, the search and selection process consists of an *attention phase* and an *action selection phase.* During the attention phase, the user breaks, or *parses*, the webpage into regions. Using his or her general knowledge of webpage layout conventions, the user generates a brief description of each region and uses this description to select a particular region for more detailed processing.

We suspect that the graphics facilitate in the parsing process, using the colored tabs and bars to break the webpage into meaningful units. Research by Gestalt psychologists provides evidence that individuals use color and form to automatically group objects on displays. It may be that similar processes are at play in this experiment. Further research is needed to decide the issue however.

Impact of Location

As with graphics, search of the two widget types are affected differently by Location Expectations. The Graphic Widgets with Low Location Expectations (Drop Menu and Ad) were found in significantly ($F_{1, 57} = 56.08$, $p < .0001$) fewer clicks than Graphic Widgets with High Location Expectations (Search Engine and Accreditation). In contrast, there was no significant difference found among the Text Widgets based on Location Expectations. Again we have evidence that Graphic and Text Widgets must both be addressed by usability assessment methods.

What makes the Different Topic task stand out from the other Text Widgets (and Graphic Widgets, for that matter) is the total absence of any Page Condition Effect. The flat response pattern over the various page conditions (2.65 clicks) more than likely reflects a conflict in location expectations between the participants. The survey used to classify the widgets found 39% of the people surveyed would expect the widget leading them to a different topic to be located at the top of the webpage, and this is where it was placed for all the Normal and No Graphics webpages in this study. However, a similar number of people surveyed (32%) expected to find the widget on the left, where the side navigation bar normally is located.

When looking at the web object the learner made their first click on, we found that 38% of the participants selected the side navigation bar as their first choice, while 37% selected the "correct" top navigation menu for the Normal Page Condition. However in the No-Graphics Page Condition, in which the lure of the side navigation bar may have been somewhat diminished, 37% of the participants selected the side navigation bar and 42% selected the top navigation menu as their first choice. These results suggest that location expectations may in fact play some role in determining an individual's search response–at least, in terms of their initial web object selection. More research is needed to clarify this issue, however.

Effect Size

As can be seen in Figure 9 below, the removal of conventional graphics had a much bigger impact on search performance than placing widgets in unusual locations. Effect size was computed using Bakeman's (2005) recommended computation of generalized eta squared for repeated measures designs.

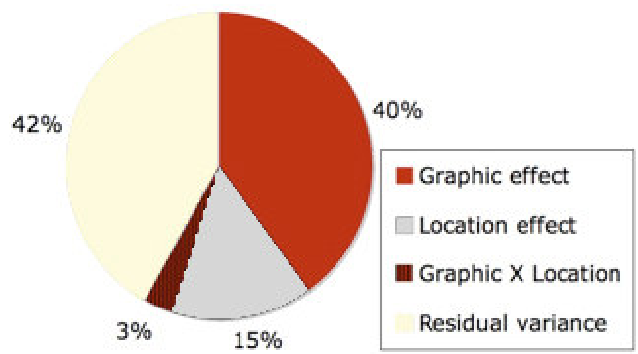

Figure 9: Effect Sizes

Conclusions

It seems clear that the visual search for graphic widgets is driven by different factors and/or strategies than those used in the search for text widgets. Further research needs to be done to examine in detail what these differences are so that our usability assessment methods can be expanded to address the influence of non-textual elements on learner interface issues. Graphics–not semantics–seems to be the key to how learners find and recognize popular, conventional graphic widgets such as the search engine. The graphic layout of the webpage–such as the use of color bars and tabs–also has a significant influence on the search for text widgets as well. It is essential that we begin the process of understanding when and how the graphics component of the learner's interface influences people's ability to find information in hypertext material. We believe that CoLiDeS provides us with the best theoretical model for understanding the graphic influence.

The research discussed here would suggest that the designers of educational hypertext would be wise to make use of conventional graphics to ensure people like Jane find the widgets they need to facilitate his or her search for information in a hypertext environment. Graphics may facilitate search by helping the individual to parse the webpage into subregions before proceeding with a more deliberate, linear search (Kitajima *et al*., 2000, 2005). Other advice that may be gleaned from this research would be to place frequently used widgets at the top of the page, because this is were people are likely to look first. Finally, critical tasks can be greatly facilitated through the use of graphical widgets. That is, uniquely designed widgets, such as the search engine and drop down menu, seem to "pop out", making their location faster and almost error-free.

We suspect, however, that factors that affect graphic widgets are even more complex than mere semantics. One cannot help but suspect that the physical characteristics of a graphic widget (such as the color and shape of a shopping basket) are more influential than the physical characteristics of a text widget (such as the font and style of the home hyperlink). Therefore, research is needed to establish the defining features of common graphic widgets.

In conclusion, graphical elements of both webpage design and common graphic widgets play an important role in webpage search. It is time that research resources be applied to gaining a strong understanding of the critical factors and cognitive processes involved.

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