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A STUDY ON THE ROLE OF NON-HYPERLINK TEXT ON WEB NAVIGATION

Abstract

Cognitive models of web navigation have been used for evaluating websites and predicting user navigation behavior. Currently they predict the correct hyperlink by using information from the hyperlink text alone and ignore all other textual information on a webpage. The validity of this assumption is examined by investigating the role of non-hyperlink text on user navigation behavior. In the first experiment, we created two versions of a website by removing the non-hyperlink text from it. We found that there was no significant effect of non-hyperlink text on the user navigation behavior. Participants were equally accurate, selected the same set of pages to visit and spent the same amount of time on that common set with or without non-hyperlink text. This result validates the assumptions of those models of user-navigation behavior that consider information from the hyperlink text only. However, in a follow-up experiment, we included high-relevance and low-relevance pictures on the website, and repeated the experiment with and without non-hyperlink text. We found that participants were more accurate in the presence of non-hyperlink text than without it. This result suggests that the presence of pictures might prime the users to pay attention to non-hyperlink text, which increases the task accuracy.

Keywords web-navigation, main-content, text, semantics

1. Introduction

The last decade has seen an explosive growth in all aspects of the World Wide Web: from the amount of multimedia content that is available; to the development of technologies like Web 2.0 that allow a user to actively interact with the content as well as with other users; and to the vast number of users, ranging from novice to experts, who regularly access this content using the newest technologies. All these factors pose a daunting challenge to a website designer, who has to organize and present the information in such a way that novice and expert users alike can find what they are looking for efficiently. To help the designer in this task, a number of empirical studies have been done of the user behavior while navigating a webpage, models have been proposed that predict the user behavior based on these studies, and tools have been developed based on these models to optimize the design for a given class of users.

For example, users are known to employ strategies to optimize their efforts in finding the content they are looking for. They, intuitively and subconsciously perhaps, estimate the cost and value associated with taking a particular action [5] and, according to the information foraging theory [13], tend to follow paths that give the highest *information scent*, which is defined as the [intuitively] perceived estimation of the cost or value associated with taking a particular action such as clicking on a hyperlink. Several computational models that simulate and predict user-navigation behavior like CoLiDeS, CoLiDeS+, SNIF-ACT and CoLiDeS + Pic have been based on this concept of information scent. These models are useful not only to provide support to the users facing difficulty in navigation (ScentTrails [12], IONS-VIP [7]) but also for designers in evaluating their website navigation architecture. (See, for example, Cognitive Walkthrough for the Web [4, 2, 3] and Bloodhound [6]). We briefly describe here a few such models.

1.1. Related work: Models of user-navigation behavior

CoLiDeS (Comprehension-based Linked Model of Deliberate Search) developed by [10] posits four different stages to model the web-navigation behavior of a user. *1) Parsing*: The user first divides a webpage into high-level schematic regions based on both bottom-up perceptual features and top-down influences like knowledge of layout conventions, frequency of use etc. *2) Focusing*: The user picks one of these regions depending on the degree of relevance to his or her goal. *3) Comprehension and Elaboration*: Parts of the focused region are then comprehended in more detail and elaborated based on user's goals and past experiences. *4) Selection*: Within that focused region, the user compares links with respect to their relevancy to the goal and, finally, the link with the highest 'information scent' [13] (the highest semantic similarity between the link and the user' goal) is selected. For assessing semantic similarity, Latent Semantic Analysis (LSA) technique is used [11]. (It is possible that the parsed top-level schematic regions can be further decomposed into sub-regions. In such a scenario, the CoLiDeS model can be applied recursively to each of the top-level regions, which are parsed again into their constituent sub-regions.) This process is then repeated for every page visited by the user until he/she reaches the target page. Figure 1 shows a schematic representation of the processes underlying CoLiDeS.

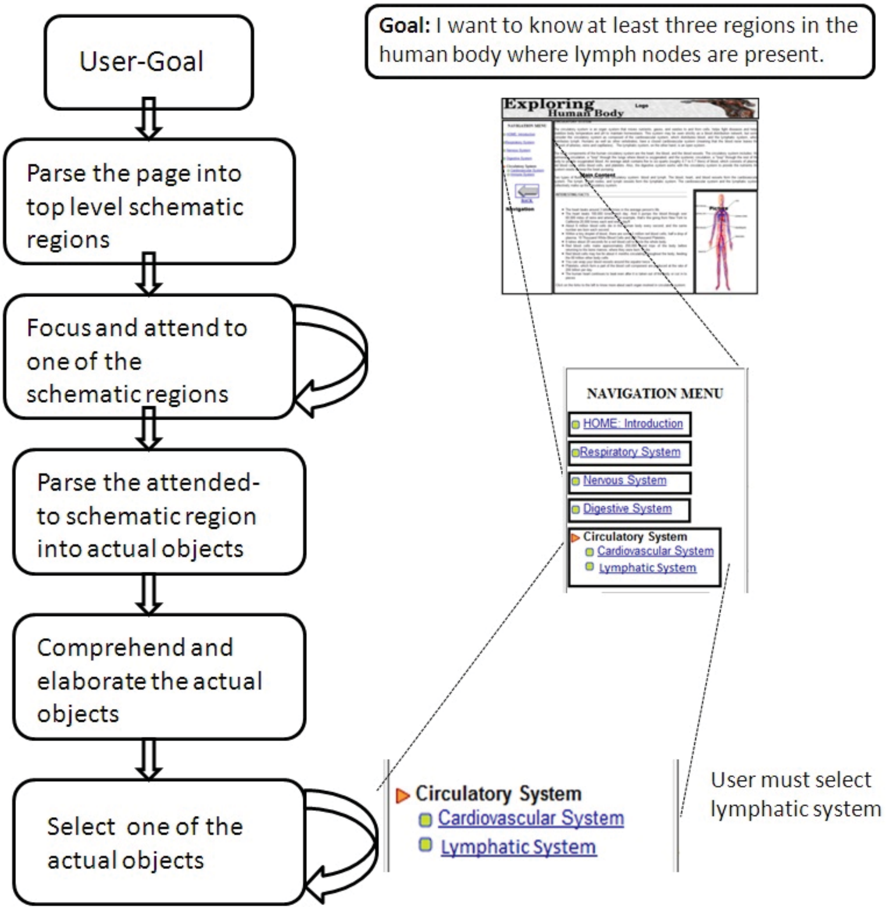

Figure 1. CoLiDeS.

For example, if the user goal is "*Name at least three regions in the human body where lymph nodes are present*" and he/she is presented with a website on the human body, the page is first parsed into different top-level regions like logo, navigation menu, picture and main content and then the user focuses on the navigation menu. The navigation menu itself consists of four hyperlinks. The user considers each of these hyperlinks, and comprehends and elaborates them based on his/her background knowledge, determining their degree of relevance to the goal. The user then selects the most relevant hyperlink, i.e., the link with the highest information scent. The similarity measures between the goal and each of the hyperlinks obtained from LSA are as follows: respiratory system (0.23), nervous system (0.11), digestive system (0.16) and circulatory system (0.48). Therefore the most relevant hyperlink is circulatory system and the user selects it. Similar processes are repeated on the subsequent page that is displayed for circulatory system. The similarity measures for the hyperlinks in the new page are cardiovascular system (0.02) and lymphatic system (0.39). The user now selects lymphatic system, which is the target page.

Two major extensions of CoLiDes have been attempted. CoLiDeS+ [8] incorporates the concept of path adequacy to the concept of information scent. CoLiDeS + Pic [9] is the same as CoLiDeS with the exception that semantic information from pictures is incorporated into the computation of information scent, in addition to the semantic information from hyperlink text. It has been found that CoLiDeS + Pic with high-relevance pictures added to the context of the webpage predicts the correct hyperlink more frequently and more accurately than CoLiDeS.

Another computational cognitive model, *Scent-based Navigation and Information Foraging in the ACT Architecture* (SNIF-ACT) [14] predicts navigational choices and simulates user behavior as they perform information retrieval tasks on the World Wide Web. Actions such as which link to click, where to go next, when to leave the website are decided based on the measure of information scent, which is computed by a spreading activation mechanism. Activation spreads from the main user-goal through memory associations to the text and images seen on the webpage. The strength of association among words is determined by the word occurrences and word co-occurrences on the World Wide Web. Mutual relevance between the user-goal and the link texts is computed. SNIF-ACT predicts that users choose links that have high information scent, and they leave the website if the information scent falls below a threshold value. SNIF-ACT is based on ACT-R architecture [1] and incorporates both declarative and procedural knowledge. Declarative knowledge is manifested in functionalities of different buttons, content of hyperlinks etc. Procedural knowledge is represented as production rules in memory. Similar to CoLiDeS, SNIF-ACT 1.0 serially evaluates all hyperlinks present on a webpage before selecting one for action.

1.2. Research question

All these cognitive models of web-navigation compute information scent from the hyperlink text alone and ignore the influence of non-hyperlink text, that is, the text in the main content area. Our goal in this research is to empirically investigate the influence of non-hyperlink text on user navigation behavior. If the assumption of the above mentioned models is correct that web users ignore the non-hyperlink text, there should not be a difference in navigation behavior between a condition with text and a condition without text in the main content area. We report here the results of two preliminary studies that explore this issue. In the first study, we used two versions of a mock-up website – with non-hyperlink text and without non-hyperlink text – to get data on user navigation behavior. In the follow-up experiment, we introduced high-relevance and low-relevance pictures on the website to investigate if the picture information influences the role of non-hyperlink text in user navigation behavior.

2. Experiment 1: Role of non-hyperlink text

2.1. Method

2.1.1. Participants

Eighteen participants (five female and thirteen male, mean age: 23), all undergraduate students of computer science, participated in this study. All participants were volunteers and were given a complimentary gift voucher for their participation.

2.1.2. Design

A between-subjects design was used in our experiment: one condition in which non-hyperlink text (text in the main content area) was presented (*with-text* condition) and the other condition in which non-hyperlink text was removed (*without-text* condition). Nine participants participated in each condition; they were randomly assigned to conditions. There was no significant ($p > .05$) difference between conditions on the prior knowledge test.

2.1.3. Material

We did not want the prior knowledge of our participants to influence their navigation behavior. Since all our participants were students of computer science, we choose the topic: "Human Body". A mock-up website on the human body with a hierarchical structure was designed, consisting of 34 pages and four levels of depth. Eight user-goals (or tasks) were designed, two for each level, which required the users to navigate, search and find the answer (see Table 1). Figure 2 shows the website architecture and Figure 3 shows the snapshot of a webpage in the two conditions. For all the pages in the without-text condition, the text was removed keeping the same layout and index of the links as in the with-text condition. The participants could still click on the hyperlinks and navigate through the website in the without-text condition. A questionnaire with 6 multiple-choice questions on human body, the topic of our mock-up pages, was presented to the participants. Correct answers were scored as 1 and wrong answer as 0. For each participant, total score was calculated by taking the sum of individual scores of each question. All our participants scored low on this test ($M = 1.3$, $SD = 0.5$). We therefore assume that our participants had low prior domain knowledge.

2.1.4. Measures

Our dependent variables were task accuracy, task-completion time and number of clicks to finish a task. Task-completion time was measured by considering the time from which a participant was presented the home page until the time he/she clicked the target page. This ensured that the difference due to typing the actual answer in the with-text condition is removed. Task accuracy was computed in both conditions as follows: for each goal, a correct target page identified by the user was scored 1 and a wrong target page was scored 0. We also measured the proportions of common page-views and the proportion of time spent on common pages, which is explained below in Section 2.2.

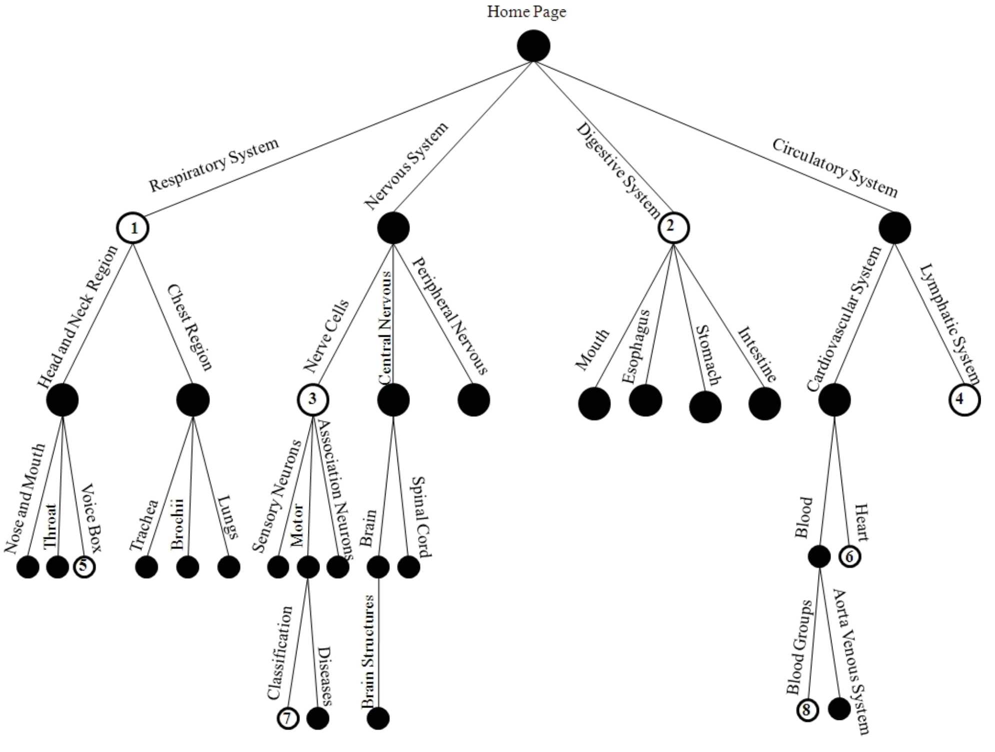

Figure 2. Human Body website architecture.

Figure 3. Snapshots of the mock-up website for with-text and without-text conditions.

Table 1
Information Retrieval Tasks.

Human Body Website	
Level	**Task Description**
1	The muscles of the oesophagus contract in waves to move the food down into the stomach. What name is given to these contractions?
1	Which centre in the brain controls the automatic process of breathing?
2	Name at least three chemicals that aid in transmission of information from one neuron to the other in our nervous system.
2	Lymphatic System contains immune cells called lymphocytes, which protect our body from antigens. They are produced by lymph nodes. Name at least three locations in the body where lymph nodes are present.
3	In the respiratory system, what name is given to the valve that drops down when we swallow in order to protect our lungs and trachea?
3	Name the three layers of tissue that form the heart wall.
4	If a blood sample contains A-antigens and anti-B antibodies, what name is given to this according to ABO system?
4	What specific name is given to those motor neurons that act on the muscles of the face and the neck?

2.1.5. Procedure

Participants were seated in a quiet laboratory with no disturbances. They were then given eight information retrieval tasks in random order as shown in Table 1. Participants were first presented with the task description on the screen and then the website was presented in a browser. The task description was always present in the top-left corner, in case the participant wished to read it again. In the with-text condition, participants had to navigate through the website, find the correct target page, find the answer in that target page and type it. For example, for the goal: "*In the respiratory system, what name is given to the valve that drops down when we swallow in order to protect our lungs and trachea?*" the correct navigation path is: Home: Introduction > Respiratory System > Head and Neck region > Voice box. The participants would have to reach the "Voice box" page, search for the answer in this page ('Epiglottis' for this example), type it in the space provided and click OK.

In the without-text condition, participants had to navigate through the website and find the correct target page where they thought the answer to the goal would be and click OK. Participants had to choose and click on only the hyperlinks on the path leading to the target page. Thus, participants had to only identify the correct path to the target page in the without-text condition. For the same example goal as above, participants would have to correctly navigate to the target page "Voice box" by clicking on the links "Respiratory System", "Head and Neck region" and "Voice box" and then click OK. They need not type the answer 'Epiglottis': there is no content so they cannot do it.

Thus, in an ideal scenario, assuming no deviation from the optimal path, the navigation behavior should be the same in both with-text and without-text conditions, until the target page is reached in the last step. In other words, if the assumption made by cognitive models of web-navigation about the non-hyperlink text (text in the main-content area) is correct, we should not see any difference in the difficulty in finding the correct target page in both conditions.

2.2. Results

For our analysis, we computed standard error by dividing the standard deviation of the scores in a group by square root of the number of participants in that group.

2.2.1. Task accuracy

An independent samples t-test between the mean task accuracies in both conditions was performed. It was found that though task accuracies were less in the without-text condition, the difference was not significant ($p > .05$). Figure 4 shows the (mean) task accuracies in both conditions.

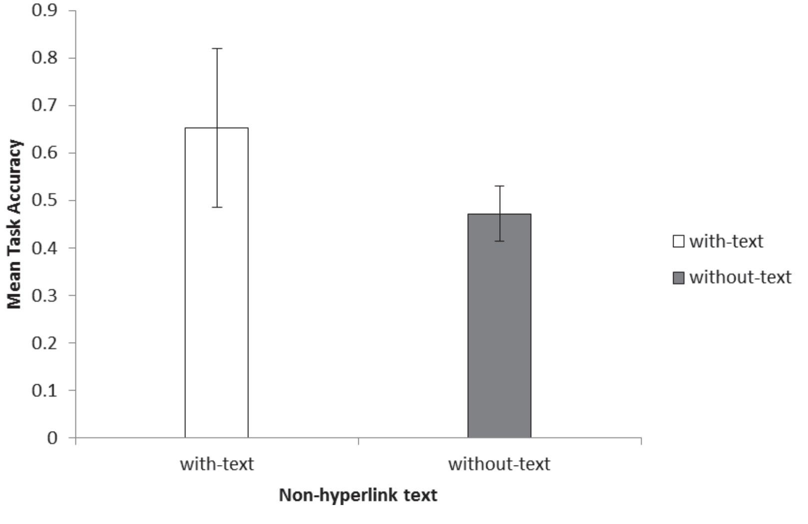

Figure 4. Mean task accuracy for with-text and without-text conditions.

This implies that with or without the non-hyperlink text, users were reaching their target page or link with equal probability. In other words, the non-hyperlink text was not influencing the user decisions in selecting the correct hyperlinks to reach their target page differently than the links alone.

2.2.2. Number of clicks

An independent samples t-test between the two conditions with mean number of clicks as dependent variable was performed. The number of clicks in the without-text condition was found to be less than the number of clicks in the with-text condition. But the difference, again, was not significant ($p > .05$). Figure 5 shows the mean number of clicks in both conditions. This implies that irrespective of the presence or absence of the text around the hyperlinks, users were making approximately the same number of clicks in reaching their target page.

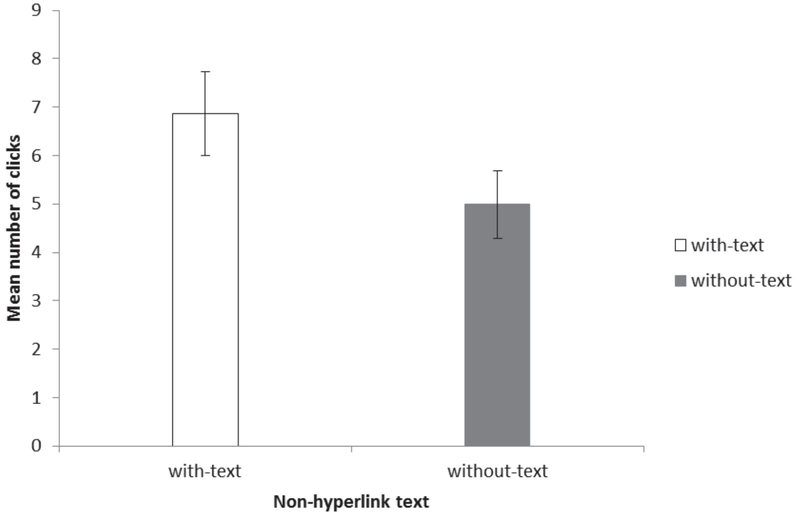

Figure 5. Mean number of clicks for with-text and without-text conditions.

2.2.3. Task-completion time

An independent samples t-test between the mean task-completion time for with-text and without-text conditions was performed. The difference in times was found to be significant. ($(t(16)) = 2.85p < .05$). Participants took significantly less time when non-hyperlink text was not presented. Figure 6 shows the results.

Though we tried to equalize the time measurement in both conditions by considering only the time until the target page is clicked, we conjecture that the different nature of the tasks in the two conditions also has some influence on the task-completion time. In the presence of non-hyperlink text, participants had to find the correct answer and type it whereas in the absence of non-hyperlink text, it was sufficient for the participants to locate the page or link where they expected the answer to be found. Therefore, in the with-text condition, the participants had to be reading the non-hyperlink text to look for the answer. A better indicator of user behavior would be to analyze the navigation patterns in both conditions based on the proportion of page views and the proportion of time spent on common and different pages.

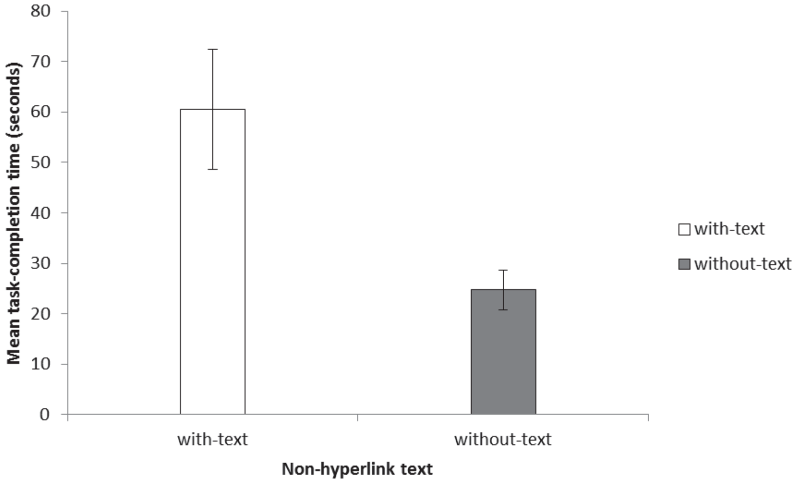

Figure 6. Mean task-completion times for with-text and without-text conditions.

2.2.4. Analysis of visited pages

For each task, the pages visited by all participants in the with-text condition were identified. Similarly, the pages visited by all participants in the without-text condition were also identified. From this we extracted pages that are common in both conditions (common pages), and pages that were visited in one condition but not the other (different pages).

(a) Percentage of common-page views. Each time a page was viewed by a participant, it was counted as one page-view for that page. For each task, we first identified the common and different pages as defined above. We then computed the number of page-views by all participants for both kinds of pages. Figure 7 shows the percentage of page-views for common pages in both conditions. It can be observed that close to 93% of page-views in the without-text condition were for the common pages. Similarly, 85% of page-views in the with-text condition were for the common pages. A t-test between the scores of the two conditions showed no significant difference ($p > .05$). This implies that non-hyperlink text had no influence on user clicks: a major percentage of user-clicks were for pages that were visited commonly in both conditions.

(b) Percentage of time spent on common pages. Next, the percentage of time spent on common and different pages in both conditions was analyzed. Again we found no significant difference ($p > .05$) between the proportions of time spent on the common pages for with-text (57.3%) or without-text (67.5%) conditions. In other words, the participants spent approximately equal amount of time on similar web pages in both conditions, as shown in Figure 7.

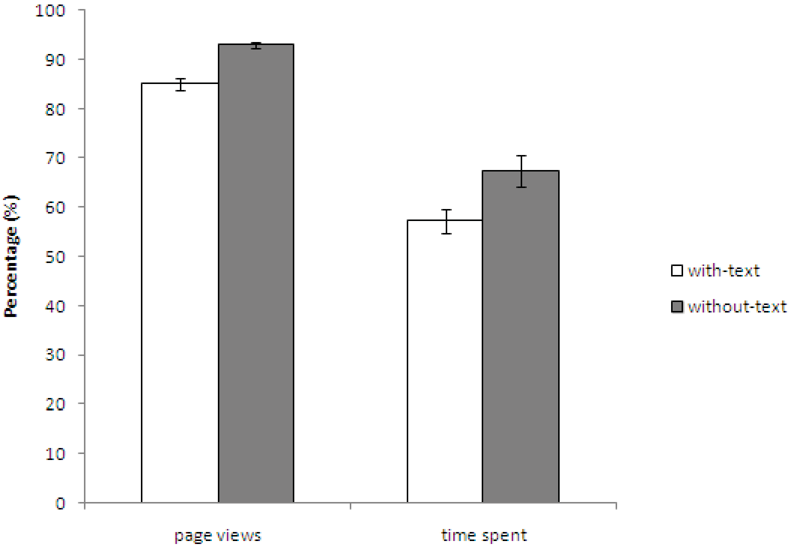

Figure 7. Percentage of page-views and time spent on common pages for with-text and without-text conditions.

All these results demonstrate that non-hyperlink text does not influence the user in deciding which hyperlink to click on, or how much time to spend on a page.

3. Experiment 2: Effect of picture information

3.1. Introduction

The results of Experiment 1 indicate that the non-hyperlink text has no impact on the user navigation behavior in terms of number of clicks and task accuracy. Also, users in both with-text and without-text conditions seem to select the same pages and spend about the same amount of time on these common pages. To explore this issue further, we considered more realistic websites that include pictures along with the text. Following our previous research [9], where we had studied the effect of high-relevance and low-relevance pictures on web navigation behavior, we designed a second experiment using the same paradigm to see if the presence of pictures makes the non-hyperlink text more relevant.

Our hypothesis is that in the presence of low-relevance pictures, the users would be more confused and therefore would need additional contextual information to choose the appropriate link. Therefore, the non-hyperlink text should exert some influence in the presence of low-relevance pictures. But when high-relevance pictures are present, we expect that the results will be similar to Experiment 1 in that there will be no significant impact of non-hyperlink text on the user navigation behavior.

3.2. Method

3.2.1. Participants

Thirty-six participants (twelve female and twenty-four male, mean age: 22.5), all undergraduate students of computer science participated in this study. All participants were volunteers and were given a complimentary gift voucher for their participation.

3.2.2. Design and Materials

We systematically combined the with-text and without-text conditions with the low-relevance pictures and high-relevance pictures conditions in a 2×2 design. Thus, we had four versions of the same mock-up website in this experiment: 1) With-text and with high-relevance pictures; 2) without-text and with high-relevance pictures; 3) with-text and with low-relevance pictures; and 4) without-text and with low-relevance pictures. We had nine participants randomly assigned for each condition. Figure 8 shows snapshots of the four versions of our stimulus pages.

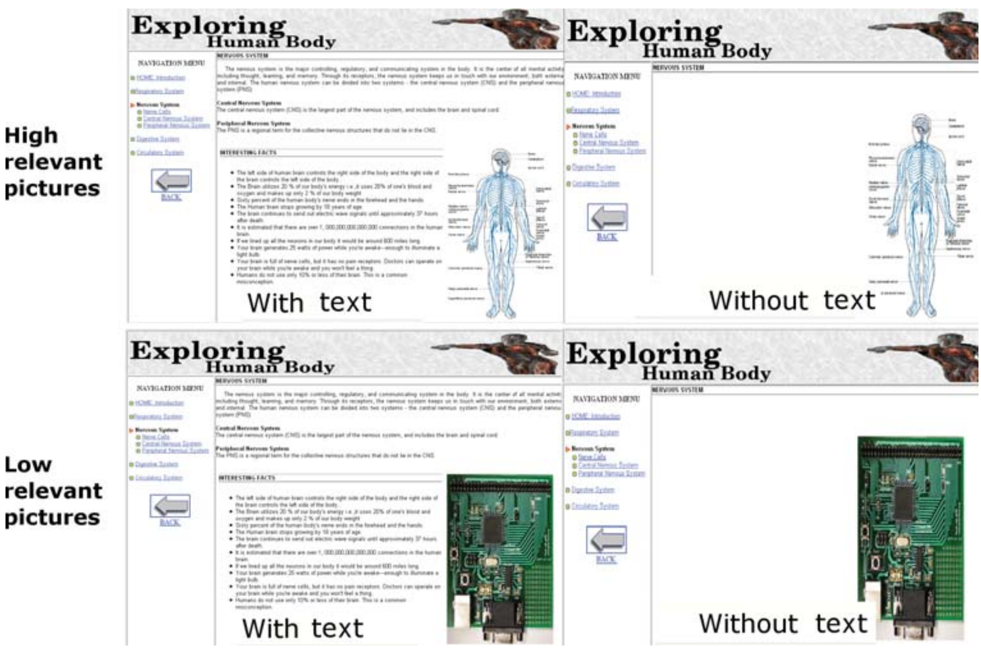

Figure 8. Snapshots of mock-up websites as a function of non-hyperlink text (with-text vs. without-text) and picture relevance (high vs. low).

3.2.3. Procedure for deciding high-relevance and low-relevance pictures

We followed the same method as described in our earlier research [9]. For each webpage, we first collected a set of ten pictures. A group of three judges selected five of them with a varying degree of relevance (on an intuitive basis) with respect to the contents of the webpage. Next, in the feature-generation task, we asked 50 participants to generate semantic features describing the pictures in the context (goal and links). Then we arranged the features in the order of how often they were generated, and the top five most frequently generated features were selected to represent each picture. The semantic similarities between the user-goal and the selected features for each picture were computed using Latent Semantic Analysis [11] and, based on this, we chose the most similar picture as the high-relevance one and the least similar picture as the low-relevance one for each page.

3.2.4. Measures

The same pre-test as in Experiment 1 was administered here as well, and only those participants that scored low on the pre-test were selected to participate in the experiment. There were no significant differences ($p > .05$) in the pre-test scores of the participants assigned to four experimental conditions.

Our dependent variables were again task accuracy and mean number of clicks to finish the task. We used the same methods to compute the task accuracy as in Experiment 1 for with-text and without-text conditions. Here we did not measure the task-completion time because, as mentioned in Experiment 1, in the with-text condition, the participants had to be reading the non-hyperlink text to look for the answer, which leads to a confounding effect. But we measured the proportion of pages that were visited in all four conditions and the amount of time spent on these pages.

3.2.5. Procedure

We followed the same tasks and the same steps as in Experiment 1.

3.3. Results

3.3.1. Task accuracy

A 2×2 between-subjects ANOVA was performed with non-hyperlink text (with-text and without-text) and picture (high-relevance and low-relevance) as independent variables and mean task accuracy as the dependent variable. There was a significant main effect of non-hyperlink text: participants were significantly more accurate in the with-text condition than in the without-text condition ($F(1, 32) = 24.335$, $p < .001$). The main effect of high-relevance picture was significant as well: participants were significantly more accurate in high-relevance picture condition than in the low-relevance picture condition ($F(1, 32) = 18.793$, $p < .001$). The interaction of non-hyperlink text and picture was not significant ($p > .05$). Figure 9 shows the mean task accuracies as a function of the presence or absence of non-hyperlink text and picture relevance.

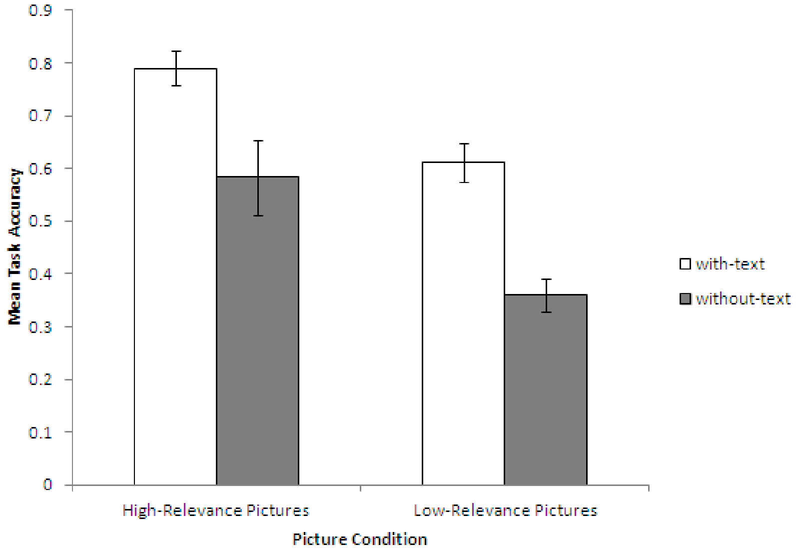

Figure 9. Mean task accuracy as a function of non-hyperlink text (with-text vs. without-text) and picture relevance (high vs. low).

3.3.2. Mean number of clicks

A 2×2 between-subjects ANOVA with non-hyperlink text (with-text and without-text) and picture (high-relevance and low-relevance) as independent variables and the mean number of clicks as a dependent variable was performed. There was no significant main effect of either non-hyperlink text or picture relevance ($p > .05$). The interaction of picture relevance and non-hyperlink text was also not significant. Figure 10 shows the means plot.

There was no (significant) impact of the presence or absence of non-hyperlink text in both the high-relevance and low-relevance picture conditions on the number of clicks a user took to finish his/her tasks.

3.3.3. Analysis of visited pages

As in Experiment 1, we further investigated the navigation behavior by identifying, for each task, pages that were visited by the participants in both with-text and without-text conditions (common pages) and pages that were visited in one condition only and not in the other (different pages). We did this analysis separately for both low-relevance and high-relevance picture conditions, and for each class of pages, percentage of page views and percentage of time spent were computed for with-text and without-text conditions.

(a) Proportion of common-page views. The results of this analysis are shown in Figure 11. We did not find any significant difference in the number of page views for commonly visited pages either in high-relevance picture condition (90.7% with-text

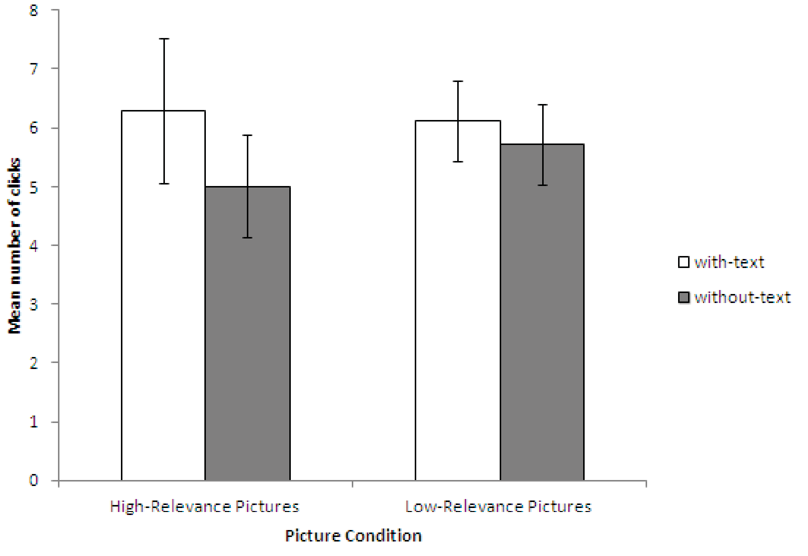

Figure 10. Mean number of clicks as a function of non-hyperlink text (with-text vs. without-text) and picture relevance (high vs. low).

92.8% without-text) or in low-relevance picture condition (88.75% with-text, 93.17% without-text).

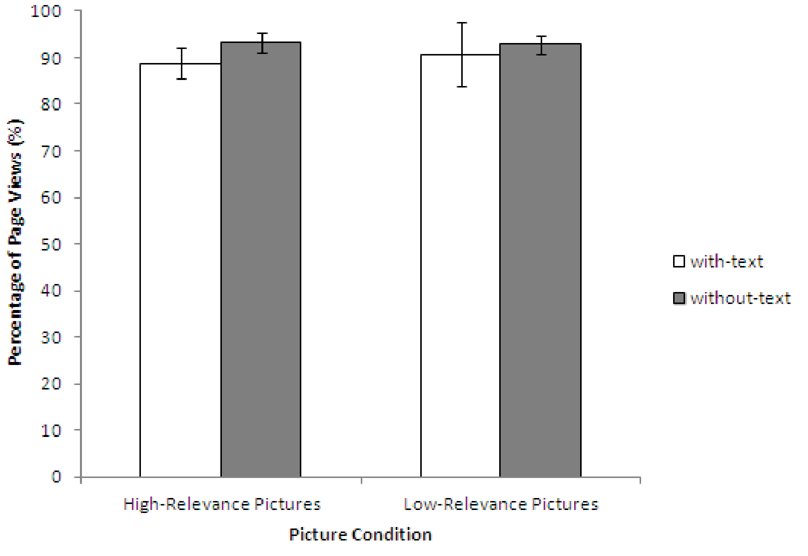

Figure 11. Percentage of page views as a function of non-hyperlink text (with-text vs. without-text) and picture relevance (high vs. low).

(b) Percentage of time spent on common pages. This result is shown in Figure 12. We did not find any significant difference in the percentage of time spent for commonly visited pages both under high-relevance picture condition (53.7% for with-text condition and 71.5% for without-text condition) and low-relevance picture condition (57.13% for with-text condition and 58.75% for without-text condition).

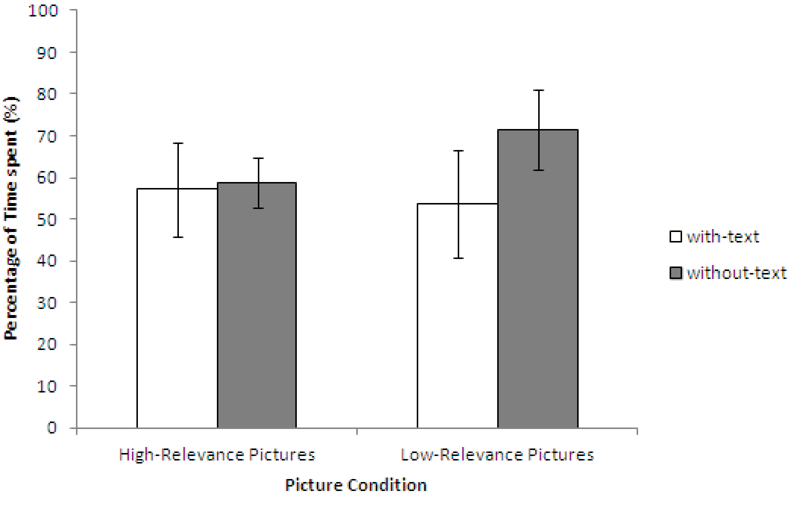

Figure 12. Percentage of time spent as a function of non-hyperlink text (with-text vs. without-text) and picture relevance (high vs. low).

4. Conclusions and discussion

To summarize, the results of our first experiment showed that the presence of non-hyperlink text does not have any significant effect on the user behavior, However, the second experiment shows that when pictures are included in a website, non-hyperlink text helps the user with respect to the task accuracy of search, though on the other measures such as number of clicks, and visits and time spent on common pages no differences between conditions were found. These results, however, should be taken as suggestive only, for there are a number of other factors that still need to be studied. For example, unlike real web pages, our experimental stimuli did not include any hyperlinks other than those in the navigation column. The user has to read part of the non-hyperlink text to understand whether it is the correct page and navigate further if found otherwise. In a more realistic situation, it may not be obvious whether the target information is available on the current page, which would require scanning the non-hyperlink text, or one needs to click on another hyperlink. In such situations, non-hyperlink text can be expected to play a more central role.

But as far as the models of user-navigation behavior that we discussed in the introduction are concerned, they largely focus on the 'navigation' part only, and in that respect, the results of our Experiment 1 seem to validate their assumptions. The results of the second experiment, however, point out that when picture information is present, it somehow draws the user's attention towards the non-hyperlink text, and they start to have an effect on the 'navigation' part as well, at least when we take task accuracy into account. Therefore, it may well be useful to consider navigation support systems that incorporate semantic information from the non-hyperlink text [12, 7].

Moreover, recent findings show that coherence, interest and link position as three main criteria that determine which links are chosen [15]. We therefore need to undertake a deeper investigation on the role of relevance of words used for the hyperlinks for navigation. When the words are confusing or unfamiliar, non-hyperlink text may help the user in understanding what the hyperlinks mean. Another factor influencing the user-navigation behavior is the motivation: users with high learning goals are found to choose more optimal links than the user with low learning goals [16]. A careful study of all these factors is left for future research.

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