A Comparison of Eye Movements When Searching Web Pages between Americans and Koreans

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Abstract. The purpose of this research was to identify the differences and similarities in eye movements between American and Korean participants when searching Web pages of different levels of complexity. Several eye-movement metrics were employed using eye-tracking systems. The results revealed that there was no significant difference between Americans and Koreans in terms of attention to visual elements and areas of the Web pages.

Keywords: cultural differences, eye movement, Web design.

1 Introduction

Due to the large portion of international users of in the Internet, the fields of Web design and development have addressed the cultural issues in Web design. Many previous design guidelines and much of the empirical research addressed various cultural aspects in Web design by comparing users' preferences and behaviors.

However, little research on the cultural differences in users' preferences regarding Web-site design and performance has been conducted from the point of view of cognitive differences. For an insightful understanding of the cultural aspects of interface design, the cognitive aspects of human-computer interaction should be studied along with user behavioral characteristics. Therefore, it is important for a user-interface designer to understand and consider whether each culture has its own cognitive style when it comes to viewing Web pages.

In this study, eye-tracking methodology was used to examine patterns of eye movement when searching information on Web pages among members of two different cultures, Americans and Koreans. The research question for this study is to identify what, when, and where people pay attention to on a Web page and what visual elements attract a visitor's attention.

2 Research Background

2.1 Cognition and Culture

The cultural differences in cognition between Easterners (especially, East Asian) and Westerners have been shown in many experiments, specifically those conducted by

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Nisbett et al.[1] Nisbett and Masuda [2] argued that "East Asians and Westerners perceive the world and think about it in very different ways" (p. 11163). This difference extends to attention and perception. According to Nisbett et al. [1], Westerners, in particular North Americans, attend more to focal objects, whereas East Asians attend more to contextual information. Chua, Boland, and Nisbett [3] tried to understand these differences in cognitive processing by examining users from members of different cultures (American and Chinese), recording patterns when they viewed naturalistic scene photographs that have a focal object on a complex background. The results showed that "Americans fixed more on focal objects than did the Chinese, and Americans tend to move their attention to the focal object quickly. In addition, the Chinese made more saccades to the background than did Americans" (p. 12629).

3 Methodology

In this study, the usability method was adopted only to collect eye movement data during the procedure of the usability test. The Web pages used for this study were not evaluated by the usability test.

3.1 Apparatus and Stimuli

Apparatus. The Tobii 1750 eye-tracking system was used. All of the hardware for the eye tracker were integrated into a slim metal casing of a 17" thin-film transistor (TFT) display at a resolution of 1024 x 768 and 32-bit color quality so that no camera or other hardware were visible to the user. This system was set up to sample the user's eye position every 20msec with an accuracy of 0.5-degree gaze estimation.

Stimuli. To select Web pages that had different levels of Web complexity, a two-step procedure was used. In the first step, 89 undergraduate or graduate students looked at 30 Web pages selected from global websites that had multiple language versions one by one on a projection screen for 10 seconds. After they looked at each Web page, they were asked about the complexity of the Web pages and their familiarity and experience with the Web pages. Web-page complexity was evaluated on a 10-point scale (1: least complex, 10: most complex). Once the data were collected, they were statistically analyzed, and twenty Web pages used in the first step were categorized into three categories: simple, moderately complex, and complex. If there were more than two Web pages in a category, the Web pages were compared based on the metrics and researcher's intuition for Web-page complexity. Then finally one Web page for each level of complexity was selected. Selected Web pages (see Table 1.) for both countries have almost identical Web-page layout and content. Each pair was modified to have the identical layout and content.

Table 1. Screenshots of Web Pages and Complexity

Com-plexity	Simple	Moderate	Complex
Screen Shots			

3.2 Measurement of Eye Movement

The following six eye movements and one performance variable were measured: (1) fixation count on each area of interest (AOI)—number of fixations on each AOI; (2) total gaze time in each AOI—total fixation duration in each AOI, (3) time to first fixation and first fixation area, (4) fixation order (order in which each AOI was fixed), (5) fixation transition (transition of fixations going from each AOI to all other AOIs), and (6) task completion time.

In this study, a fixation is defined as a series of samples within a 30-pixel radius for at least 100 msec.

3.3 Participants

Nineteen American graduate and undergraduate students (13 males, 6 females) and 19 international Korean graduate students (11 males, 8 females) participated. All participants had earned their high school diplomas in their native countries. The American participants primarily came from the field of information technology or information studies, while the Korean participants came from various fields of study such as social science, math, psychology, law, and information studies. About 78 percent of the American participants and 68 percent of the Korean participant regularly used the Internet more than two hours a day to access a Web page. There was no compensation given for participation.

3.4 Procedure

In this experiment, the participants were asked to find a link based on the instructions. The instructions were shown on the computer monitor in English or Korean in PDF format. Some key words for the searching tasks were written in Korean for the Korean participants. Once the participants said they were ready, the Web page for the task was loaded. And participants were then asked to look at it approximately two seconds and close the browser if they thought they had found the correct link, because

there were no clickable links on the pages. To avoid order effects, the order of task presentation and level of Web-page complexity were counterbalanced across participants.

4 Data Collection and Analysis

4.1 Data Collection

In this study, the Tobii 1750 eye tracker collected the sample of the user's eye positions every 20msec. ClearView 2.7.1. software, provided with the eye tracker, was used to analyze the data. To obtain accurate data, validity code and eye filters were used. When reviewing the validity code, if a participant had many bad and missing sequences of gaze coordinates, the data from the participant were excluded. Data obtained from the participants whose searching time was more than two standard deviations above the mean for individual participants were also excluded.

4.2 Data Analysis

Descriptive and statistical analyses were conducted by using SPSS (Version 13). The gaze and fixation data were also visualized using gaze plots and hotspots to provide an overview of the eye movements of individuals, multiple participants, or groups. A tool called Hotspot visualizes gaze positions from multiple participants and creates hotspot maps based on various statistical eye-movement data such as gaze time and fixation count on the Web page. In addition, patterns in eye-movement sequences from one AOI to another were analyzed by the fixation transition metrics (probability of fixation transition). In this study, the discussion analysis tool (DAT) developed by Jeong [4] was used to compute transitional probabilities of fixation transition among AOIs. A z-score of +– 1.28 at .10 alpha level was used to identify whether transitional probabilities were significantly higher or lower than were expected probabilities.

5 Results

5.1 Searching Task on the Simple Web Page

For the searching task on the simple Web page, the Dell home page was used. The simple Web page was divided into 10 different AOIs (see Fig. 1).

In this task, participants were asked to assume that they had ordered a laptop from the Web site and wanted to know the order status. Then, the participant was asked the find the link for checking the order status. The answer for the question was located on the top right corner (topmenu). About half of the participants in both groups finished their searching task in seven seconds.

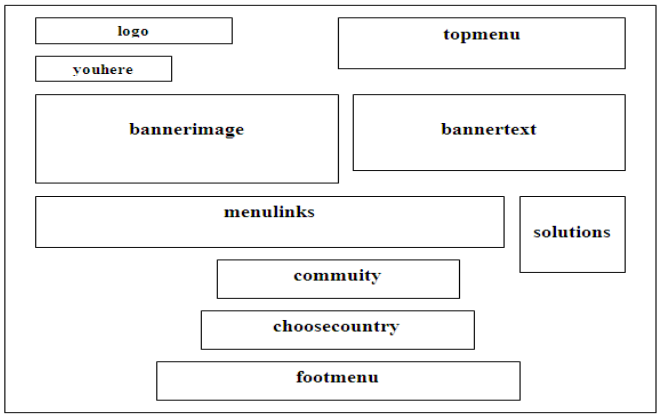

Fig. 1. AOIs of the Dell homepage

Fixation and Gaze on the AOIs. The average fixation count on each of the AOIs for both groups was very similar. As a percentage of subjects viewing AOIs, the Korean participants fixated a little more all over the AOIs on the Web page than did the American participants. Specifically, the Korean participants fixated about two times longer on the menulinks area than did the American participants. Both groups of participants fixated longer on the banner text area than on the banner image area, although the big banner image occupied almost one-sixth of the screen. It is interesting to note that the participants fixated more often on text content than on images. It seemed that the Korean participants spent more time on the menulink than the American participants. However, no significant differences were found between the two groups in the aggregate gaze time and the mean gaze time on each of the AOIs.

Fixation Transition and Gaze Plots. About 72 percent of the American participants reached the top menu area (target area) within 1000 msec, and about 80 percent of the Korean participants looked at the top menu area within 1000 msec. The majority of the American participants reached the top menu area within 20 fixations, while the Korean participants needed more fixations to reach the topmenu area. Participants who completed the task quickly fixated on a couple of AOIs and reached the top menu area, while participants who took a longer time for task completion visited more AOIs. The target AOI (top menu) received the most frequent transition from the banner text between the two groups. The Korean participants seemed to have more diverse fixation transitions among the AOIs than did the American participants. However, there were no significant differences in overall fixation transitions among the AOIs ($c2$ (6, N = 130) =3.80, $p > 0.05$).

5.2 Searching Task on the Moderately Complex Web Page

The Bayer homepage (see Table 1) was used for the searching task on the moderately complex Web page. The Web page was divided into 12 AOIs in terms of location and content of the Web page (see Fig. 2).

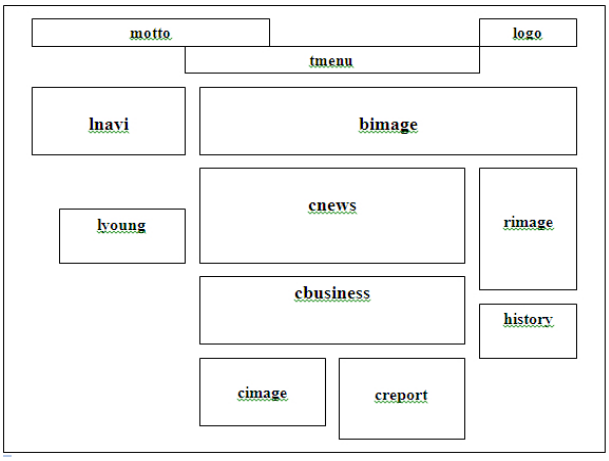

Fig. 2. AOIs of the Bayer homepage

Participants were asked to find the link for Bayer's history. The correct link was located in the history AOI. The longest searching time of the American participants and the Korean participants was 45.82 seconds and 37.76 seconds, respectively. The average searching time of American and Korean participants was 17.7 seconds (SD = 7.37) and 14.7 seconds (SD = 6.26), respectively. However, there were no significant differences in the searching time between the American and Korean participants ($U = 113$, $p > 0.05$).

Fixation and Gaze on the AOIs. The left navigation area (lnavi) had the most fixation counts followed by the history area. Both groups fixated more on the text area than on the salient areas with images. That is, participants in both groups selectively looked at the text links and headings of the short passages rather than on the images because the participants anticipated the correct link in the navigation areas or texts areas that had links. Both groups spent the most time on the left navigation area (AME: 19 percent, KORE: 24 percent) followed by the top menu (tmenu) or the right images area (rimages) except on the history area, in which the correct link was located. During the debriefing phase, several participants mentioned they thought the correct answer for the task was in the company link on the top menu. Overall, there seemed no big differences in terms of the fixation counts in each of the AOIs.

Fixation Transition and Gaze Plots. About 70 percent of the American participants started their search on the banner image. They then moved to the top areas of the Web page such as the logo, the motto, or the top menu area. About half of the Korean participants initially looked at the banner image; they moved to the top area of the Web page as well. Both groups of participants then moved to the left navigation area followed by the center news area (cnews) and images in the right column (rimages). In general, participants who found the correct followed an S shape of the gaze plot starting in the banner image (bimage) or top menu (tmenu). However, there were no

significant differences between the two groups in fixation transitions among the AOIs ($c2$ (10, N = 383) = 14.42, $p > .05$).

5.3 Searching Task on the Complex Web Page

For the searching task on the complex web page, the Oracle homepage (see Table 1) was used. The homepage was divided into 12 AOIs (see Fig. 3).

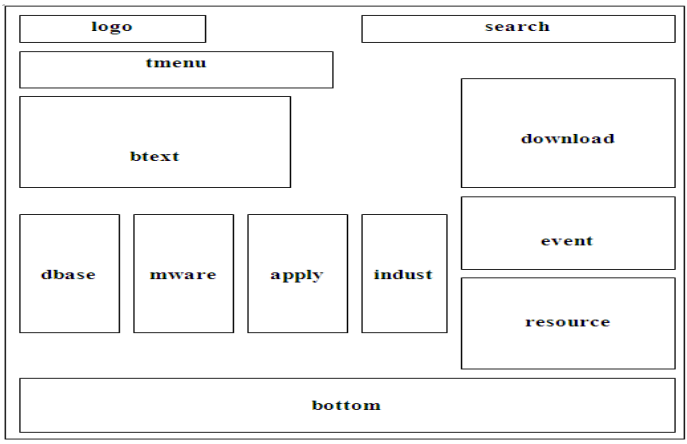

Fig. 3. AOIs of the Oracle homepage

In this task, participants were asked to find the link for information about what and why Oracle products are used in the health care industry. The correct link was located in the indust AOI. One outlier in data collected from the Korean participants was excluded.

Fixation and Gaze on the AOIs. The top menu area (tmenu) received the second highest number of fixations for both groups. The Korean participants looked at the right navigation area (download, event, and resource) about twice as much as American participants did. Other than that, participants for both groups paid similar attention to the other AOIs. Both groups spent more time in the AOIs (dbase, mware, apply, and indust) composed of high-dense English text. In particular, the Korean participants' average fixation duration on those AOIs was higher than that of the American participants.

Fixation Transition and Gaze Plots. Participants for both groups fixated first on the upper areas of the Web page such as the banner, search, logo, or download areas. Sixty-six percent of the American participants and 77 percent of the Korean participants fixated first on the banner area (btext) and then quickly moved to the top menu area (tmenu).

It is interesting that the first fixation time to the AOI, where the correct link was located, for the Korean participants (M = 6.6sec) was faster than it was for American participants (M = 9.3 sec). However, the Koreans' task completion time was slower than that of the American participants. Reviewing the gaze plot and transition matrix revealed that although many Korean participants glanced through the industries area earlier than did the American participants, the Koreans missed the correct link and moved to the other AOIs.

Two common viewing patterns were determined for the participants who found the correct link in the average time by analyzing individual gaze plots and transitional probability matrices: (1) the participants for both groups fixated first on the banner text followed by the top menu and then moved vertically onto the database link area (dbase). Then the participants scanned horizontally until they reached the industry links area (C shape), or (2) the participants first gazed at the banner text followed by the top menu and followed in a clockwise direction (converse C shape). No significant difference was found between the groups in terms of fixation transitions ($c2$ (9, N = 342) = 8.86, $p > 0.05$).

6 Discussion

6.1 Attention

The level of Web page complexity in searching task did not much affect the allocation of attention for either group. The participants of both groups tended to allocate a large amount of their fixation and gaze time in the navigation area and scan through the navigation area regardless of the level of Web-page complexity. In regard to clusters of fixations, the levels of complexity of Web pages did not seem to have much influence on the density of fixation clusters. It is interesting that icons and images, which are regarded as salient elements in Web-page design, did not receive fixations first when they were displayed alongside text descriptions. By analyzing hotspots more closely, both groups of participants tended to give more attention to text information than to images.

Familiarity with the Web page, or previous Web searching experience might influence searching time and viewing patterns on the Web page. The participants might guess the location of the link on the Web page from their previous Web searching activities as they read the instructions. This suggests that in the searching tasks, participants might expect the target link in text format rather than in image format. Therefore, users intentionally tended to try to find the target link in the text format link on the navigation area, menu area, or content area first.

Overall, there were no significant differences between the two groups regarding visual attention and the eye-movement patterns in all different levels of Web-page complexity.

6.2 Cross-Cultural Web Design Practice

American participants tended to give more attention and spend more time on the banner image than did the Korean participants. Korean participants tended to allocate

their attention and spend more time on viewing navigation areas; Korean participants might want to know the whole structure of a Web site to which the Web page belongs. Nevertheless, given that no significant findings were observed, it may be too strong to state that Korean participants had a more holistic viewpoint when they looked at a Web page. However, it is worth considering that a navigation area needs to represent the whole structure or context of a Web site in greater detail when designing a Web page for Korean users.

In general, participants for both groups reached about five AOIs (banner image, banner text, logo, top menu, and right top area) in three seconds in searching tasks regardless of the level of complexity. With respect to fixation transitions, the participants for both groups tended to make direct transitions to the menu or navigation areas. In addition, Korean participants seemed to require more cognitive effort when they viewed the dense text areas such as navigation areas or main contents areas than did the American participants. Specifically, Korean participants' mean fixation durations were longer when they read English than the American participants were. Therefore, these differences in eye movements when viewing a Web page between two groups should be taken into consideration depending on the purpose of a Web page and the visual complexity of a Web page.

6.3 Limitation of the Study

Although eye-movement data obtained from the experiment were reliable, the findings of this study cannot be generalized because of the limitations of the methodology. First, the Web pages used in this study were not actual Web pages. They looked like active Web pages, but, in fact, they were image files (jpg). Nothing was activated on the Web page. Moving graphics such as flash banner images or active icons could be an important factor that could influence eye movement. Second, participants for both groups were not a perfect match. All the American participants were majoring in information science or information technology, while only about half of the Korean participants were majoring in information science. All the Web pages used in this study except one Web page were information- or computer systems-related Web pages. Familiarity with the Web pages used in this study and the participants' majors might have affected their eye movement behavior.

Overall, eye movement characteristics revealed in this study may not generally apply to all types of Web pages. The pattern of eye movements can vary depending on other factors such as the domain of the Web page, task difficulty, individual experience, familiarity with a Web page, or the visual elements of a Web page.

7 Conclusion

The research examines whether differences in eye movement exist between groups from two cultures (United States and Korea) when viewing a Web page, and if so, whether their eye movements are affected by the types of activities and the levels of Web-page complexity. Although this study showed similarities and differences in eye

movement behaviors when searching information on a Web page, this study did not show significant differences between American participants and Korean participants in terms of initial attention to visual elements and areas on the Web pages. With respect to viewing patters, similar patterns were found between the groups. The findings and observations obtained in this exploratory eye-movement experiment could suggest guidelines for Web page design from the cognitive viewpoint for different cultures and provide a methodological example for future cross-cultural usability tests.

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