Exploring Cultural Variation in Eye Movements on a Web Page between Americans and Koreans

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Abstract. This study explored differences in eye movement on a Web page between members of two different cultures to provide insight and guidelines for implementation of global Web site development. More specifically, the research examines whether differences of eye movement exist between the two cultures (American vs. Korean) when viewing a Web page, and if so, whether their eye movements are affected according to the level of Web page complexity. This study employed eye tracking methods and several eye movement metrics were measured.

Keywords: eye movement, cultural differences, human-computer interaction, web design cultural cognition.

1 Introduction

Web sites are developed in many different cultures (countries) all over the world and are open to not only domestic users but also a wide range of international users. These users react to Web sites in a different ways while navigating Web sites. Some users may suddenly feel uncomfortable and overwhelmed so they leave immediately, or give more attention to a certain design element at first glance.

Much previous research argues that Web site design and interface elements appear to be influenced to some degree by the culture in which Web sites originate [1,2,3,4,5] and there is some evidence that users performed better in a Web site culturally orientated for them [6]. Nisbett et al. [7] also argue that Westerners, in particular North Americans, attend more to focal objects, whereas East Asians attend more to contextual information.

Although not every user has the same perception and interpretation of the information contained in Web sites, different cultural groups may have different cognitive styles related to visual and multimedia factors. These differences may affect how users respond to and use online material. People from different cultures may have different levels of attention to the various visual elements or areas of a Web page. Therefore, one of the greatest challenges for Web developers is developing cross-cultural Web sites concerned with not only language, but with the cognitive aspects inherent in cultural diversity [6].

One method for exploring visual and cognitive perception is the use of eye-tracking technology. Although all cognitive differences between cultures cannot be

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explained by examining eye movement, there is some possibility of explaining underlying mechanisms in cognitive processing by examining patterns of eye movement between two different cultures [8]. This study explores whether there are cultural variations in eye movements on Web pages between members of two different cultures, American and Korean, in order to suggest a cognitive basis for cross-cultural Web design.

2 Methodology

2.1 Measurement of Eye Movement

The following six eye movement measures and one performance variable were measured: (1)Total fixation time, (2) total gaze time in each AOI, (3) fixation count on each area of AOI, (4) time to first fixation and first fixation area, (5) Fixation order, and (6) fixation transition.

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

2.2 Apparatus and Stimuli

The Tobii 1750 eye tracking system was used. This system tracked both eyes simultaneously, and sampled the user's eye position every 20msec. Accuracy of gaze estimation was 0.5 degree.

In this study, home pages or internal Web pages activated from global Web sites that have multiple language versions for each country were used as stimuli. Three Web pages in different levels of complexity for each country were modified based on existing global Web sites. Each pair of Web pages was modified to have the same layout and content with different languages (English and Korean). Although a Web page may be modified, it cannot be exactly identical due to the characteristics of language that create differences in white space, length of a sentence, or length of a paragraph. The Web pages looks like live Web pages. However, the Web pages consisted of only image files, and there are no clickable links on the pages in order to prevent from unnecessary clicks during the tasks.

This study is not to examine how specific variables affect patterns of eye movement, but rather to study how users actually see Web pages that consist of various Web design elements. Therefore, using current real Web pages is more appropriate for the purpose of this study.

2.3 Participants

Nineteen American graduate and undergraduate students (13 males, 6 females) and 19 international Korean graduate students (11 males, 8 females) at Florida State University were participated. The average age of the Korean participants was 33 with a range from 26 to 38. The average age of the American participants was 28 with a range from 20 to 43. All The Americans except one participant who moved to the US at age 2 and the Korean participants were born in their native country and were raised there at least until they earned their high school diploma.

2.4 Procedure

Three phases of tasks were performed: Phase One was learning phase: Phase Two was eye movement experiments; Debriefing sessions were conducted in Phase Three.

In Phase Two, participants were asked to perform browsing on each Web page in their native language version. For the browsing task subjects were asked to look through the Web page for thirty seconds, and asked the following questions to motivate their browsing before the subject see the Web page: "You are going to browse a Web page about 30 seconds. After you brow a Web page, you will be asked about the Web page's visual presentation (good and bad). How do you like the Web page in terms of visual presentation?"

The subjects were given about 30 seconds for browsing the Web page and eye tracking systems recorded eye movement data until the Web browser was closed by the experiment administrator.

3 Data Analysis and Results

Although the subjects were given about 30 seconds for browsing tasks, only first 15 seconds of eye movement data were analyzed. ClearView 2.7.1. Software provided with the eye tracker helps to handle the volume of data and analyze the data. To have accurate data, a validity and eye filter were used. By reviewing the validity code[1], only one American participant should be excluded from the entire data. The data from this participant had many missing sequences of gaze coordinate.

3.1 Browsing Task on the Simple Web Page

For the browsing task on a simple Web page, the LexisNexis global Web page was used. As shown in Fig. 1, the Web page was divided by eye the tracking software into seven AOIs, which are invisible to the participants. The Korean Web page for this task also had the same number, almost identical in size and location of the AOIs.

American participants fixated and allocated their fixation on the banner image (*faces*) and banner text area (*btext*) more often than Korean participants: American participants allocated their fixations about 31% on the banner image (*faces*) and the banner text area (*btext*), while Korean participants gave about 25% of their fixations on those areas. Korean participants gave more attention to the right top area (*righttop*) and learn about area than American participants. It is interesting that although the banner text is expected to be viewed by all participants about 26 % of Korean participants (5 participants out of 19 participants) did not fixate at all on the banner text in the 15 second frame. More than half of the participants in each group did not fixate on the bottom area of the Web page. Although there are three images (logo, map, and banner image) on the Lexis-Nexis Web page, participants tended to fixate

[1] The validity code is a measure of the system's certainty that it has recorded the correct data ranging from 0 to 4, and is used for data filtering. The manual recommends removing all data points with a code of 2 or higher: 2) recorded one eye, and has no way of determining if this is the left or the right eye, 3) the actual gaze is incorrect or corrupted, and 4) the actual gaze data is missing or definitely incorrect (Clearveiew 2.7.1 user manual, p. 17).

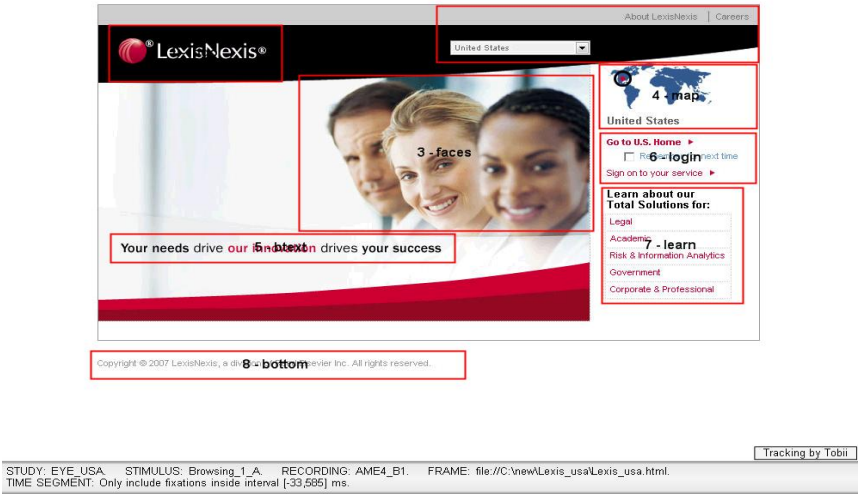

Fig. 1. LexisNexi Web page for American

less on the images the except banner image than text areas such as login and learn areas on the left column.

The Korean participants spent about 49 percent of their total gaze time on three AOIS: *learn* (21%); *empty space* (14.7%); and the *faces* AOI (13.1%). American participants also allocated about 47 % of their gaze time on the same AOI and empty spaces as Korean participants did. The average gaze time on the banner image (bimage) and the banner text (btext) for American participants is higher than that of Korean participants. However, an average gaze time on learn about area (learn) for Korean participants is higher than that of American participants. Corresponding to the fixation count and average gaze time, Korean participants gave less attention to the banner image (faces) and the banner text (btext) than American participants, but allocated more fixation count and gaze time in viewing the learn about area (learn), which is written in English, than American participants.

Both groups of participants fixated first on the *faces* (average time to first fixation for face :AME 530msec and KOR: 1136 msec), followed by *logo* (average time to first fixation for logo:AME: 2351 msec, KOR:1655msec). Almost 80 % of the Korean subjects and 75 % of American subjects fixated first on the banner face image, and then about 80 % of them fixated on the logo area. Interestingly, Korean participants reached the banner text area relatively late.

The Korean participants fixated on the right column area of the Web page such as map, login, and learn AOI faster than the American subjects did, while the American participants gave more attention and spent more time on the banner image (*faces*) and the banner text area (*btext*) than the Korean participants. However, there was no difference in the fixation transition among the AOIs.

3.2 Browsing Task on the Medium Complex Web Page

For the browsing task on a medium complex Web page, the Cisco Web page was used. As shown in Fig 2, the Web page was divided into 11 AOIs.

The right navigation area (*rnavi*) that has 12 links received the most fixations with an average of about eight fixations and about nine fixations from the American participants and the Korean participants, respectively. Both groups of participants allocated about 30% of their fixations on the banner image area (*bimage*) and the banner text area (*btext*) in the center of the Web page, and about 36 % on the login area (*topr*) in the upper right of the page. However, latest news area (*news*) and featured product area (product) received an average of 3-4 fixations from the subjects for both groups. American subjects fixated more on banner image than banner text, while Korean subjects gave more attention to the banner text area (*btext*) than the banner image area (*bimage*). Interestingly, two small images (*twoim*), which were located right below the banner image, did not receive any fixations from the American participants at all, and received only one fixation from a Korean participant. Apparently, the log area (*logo*) in the upper left corner is the area that received the least fixations on average along with the bottom area (*bottom*).

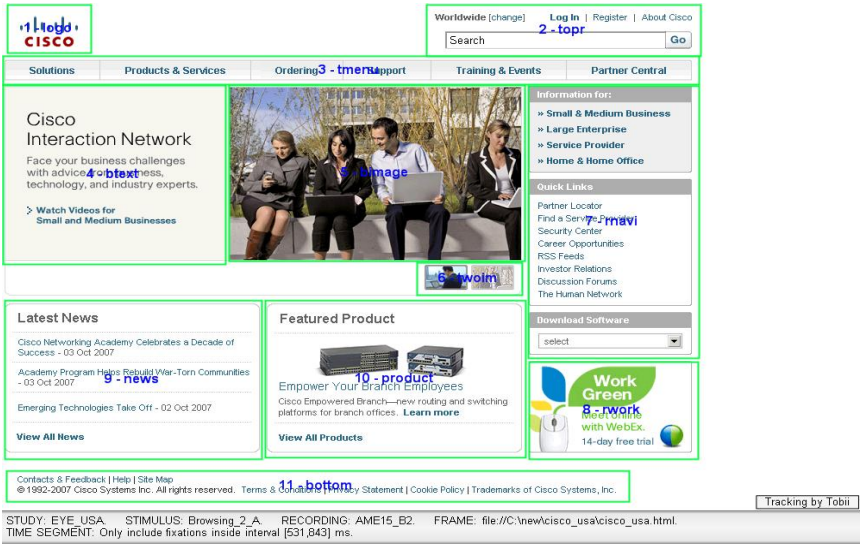

Fig. 2. Cisco Web page for American

The American participants and the Korean participants spent almost the same percentage of gaze time (AME: 49.1%, KOR: 49%) on the upper area of the home page such as, the logo area (*logo*), the top right area (*topR*), the top menu (*tmenu*), the banner text area (*btext*), and the banner image area (*bimage*). The Korean participants spent more time on the banner text area (*btext*) and the right navigation area (*rnavi*) than the American participants, while the American participants spent more on the top right area (*topr*), and banner image area than the Korean participants. The Korean

participants allocate their gaze more on the banner text area (18.4%) than banner image area (9.5%), while the American participants spent slightly more on the banner image area (14.3%) than the banner text area (12.4%). Other areas of the Web page such as logo, two small images under the banner images, news and product areas received similar gaze time and allocation of gaze time between two groups.

Sixteen participants for both groups, about 88% of American and 84% of Korean participants, fixated first on the banner image. About 45% of American participants moved to the banner text area as a second target area followed by the top menu, whereas the Korean participants' second target was the top menu, logo, or banner text area with about 31% each.

Overall, the AOIs receiving the earliest fixation from the participants for both groups were center and top left areas such as, banner image area (*bimage*) and banner text area (*btext*), logo area (*logo*), and top menu area (*tmenu*). Areas under the banner image received their first fixation relatively later than upper parts of the Web page.

American subjects fixated more on banner image than banner text, while Korean subjects gave more attention to the banner text area (*btext*) than the banner image area (*bimage*). The Korean participants spent more time on the banner text area (*btext*) and the right navigation area (*rnavi*) than the American participants, while the American participants spent more on the top right area (*topr*), and banner image area than the Korean participants. Common gaze sequences for both groups followed clockwise or counter clockwise directions.

3.3 Browsing Task on the Complex Web Page

For the browsing task on a complex Web page, the Seagate Web page was used. As shown in Fig 3, the Web page was divided into 14 AOIs.

The left navigation area (*lnavi*) received the most attention for both groups of participants (AME: 189, KOR: 184) with an average of about 11 fixations, followed by the banner text (*btext*) for American participants and the top customer story (*cstory1*) for Korean participants. The American participants gave more attention to the banner image (*bimage*) and the banner text (*btext*) areas than the Korean participants, while the Korean participants allocated their attention more on the upper customer story area (*cstory1*) and right story area (*rstory*). However, both groups did not read the whole story, while some participants seemed to read the whole story. The rest of the AOIs did not receive a significant number of fixations. The left navigation area (*lnavi*), the right story area (*rstory*), and the upper customer story area (*cstory1*) received good attention from both groups of participants.

The Korean participants spent slightly more time on the content areas such as the right story area (rstory) and the first customer story (cstory1) than the American participants. The American participants allocated their gaze time more on the banner image and the banner text area than the Korean subjects. Participants for both groups spent about 65% of their gaze time in viewing the banner image and the banner text, the left navigation area, and the right column. Participants allocated less than 20% of their gaze time for viewing the content displayed in the center column. They spent only 12% of their gaze time in viewing administrative content such as the logo, the account, the country selection, and the foot menu.

The American participants made the most frequent transitions from the other AOIs to the banner image, while the Korean participants made the most frequent transition from the AOIs to the text contents area.

Overall, participants for both groups seem to have similar patterns of eye movement in the browsing tasks. Participants for both groups tend to see upper section of the Web pages more often and relatively long. The level of Web complexity does not seem to affect participants' initial attention. Korean participants tend to spend more time on navigation area than American participants, while American participants spent more in viewing banner images than Korean participants. With respect to scanpath in browsing tasks, common scanpath were not found. However, more various scanpaths were found in the complex Web page.

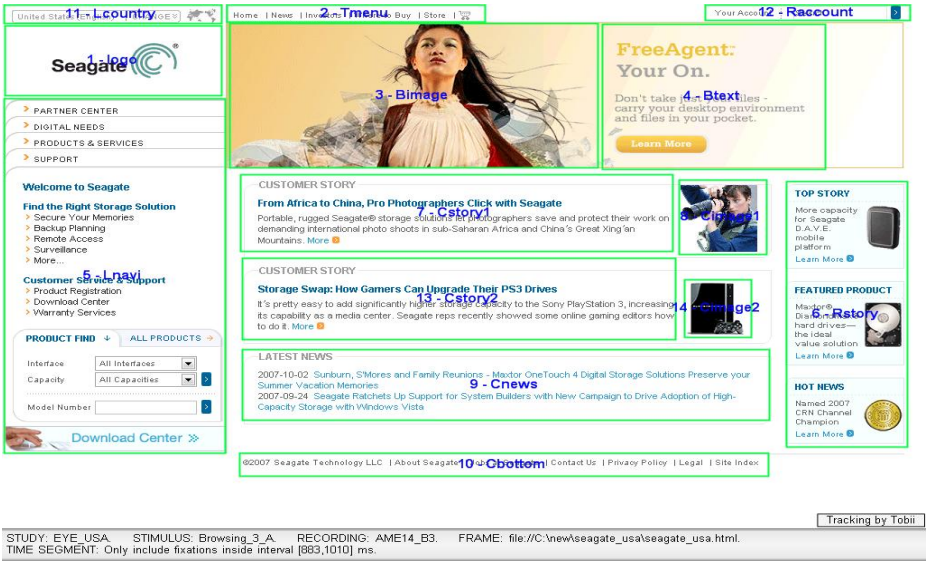

Fig. 3. Seagate Web page for Americans

3.4 Cultural Differences in Attention and Viewing Pattern

The differences in terms of allocation of viewing time between American participants and the Korean participants were not found except that American participants spent more time in viewing banner images than Korean participants, while Korean participants spent more time in viewing navigation or menu areas. In the current study there is no significant difference between American participants and Korean participants in terms of initial attention to visual elements and areas on the Web pages.

However, there are differences in the allocation of fixation and gaze time on the AOIs, especially on the banner images and navigation areas, in browsing tasks. American participants tended to give more attention to the banner images than Korean participants in browsing tasks on all levels of complexity of Web page. Korean participants tended to allocate their fixations and spend more time in viewing

navigation areas. This finding somewhat supports Nisbett et al.'s [7] holistic versus analytic cognition and partially supports Chua et al.'s [8] study.

Although this study was investigating similarities and differences in viewing patterns between both groups, it is difficult to show the differences and similarities with statistical evidence due to the lack of tested methodologies that compare scanpaths between groups. According to Chua et al.'s findings, the Korean participants who have a holistic view point would be assumed to reach the AOIs sooner than the American participants. However, there is no significant difference between the two groups. In browsing tasks on the medium complex and complex Web pages, the numbers of AOIs visited over a 21 second period is similar.

4 Future Research and Conclusion

Due to the small sample size differences between groups might not be observed in this study. For future research, it is necessary to examine ocular behavior when viewing a Web page with a large sample size to provide statistical evidence in various types of Web pages with many different tasks. It will also be very interesting to see how increasing cognitive loads affects ocular behavior in different cultures when users search, or view, a Web page. Since many Web pages include multimedia elements such as video or audio, it is also necessary to examine how ocular behavior is affected when users interact with a multimedia Web page. The data obtained from this study reveal there are similarities existing in terms of attention and viewing patterns among individual participants. This also proposes future research questions. It is necessary to examine whether correlations exist between individual differences and eye movement characteristics. In addition, it should be explored which individual factors affect more on eye movement than cultural factors.

The fundamental research questions for this study are to understand whether there are cultural differences in ocular behavior when viewing a Web page in order to provide practical insight and guidelines for designing Web pages for a particular cultural group. Although this study could not provide strong evidence that there are cultural differences in eye movement behavior when viewing a Web page, this study shows many cultural variations in eye movement when viewing a Web page with different tasks and raises methodological issues in eye movement research for cultural studies in the files of information science.

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