The Effects of Culture on Users' Perception of a Webpage: A Comparative Study of the Cognitive Styles of Chinese, Koreans, and Americans

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Abstract This study aims to reveal the relationship between cognitive style and Webpage perception. In particular, Webpage perceptions of people with different cognitive styles are compared. Based on Nisbett's cognitive model on holistic and analytic thought, this study hypothesizes that differences between holistic thought and analytic thought can be reflected in Webpage perception. An experiment was then carried out involving American, Chinese, and Korean participants. The users' eye movements, which can provide specific information about their cognitive processes, were recorded while browsing different language versions of Webpage prototypes. In the end, the hypotheses of this study were supported. Findings from the analysis suggested that the Chinese, Koreans, and American participants employed different viewing patterns on the Webpage, revealing a positive relationship with Nisbett's cognitive theory. Given that cognitive differences exist among holistically minded people and analytically minded people, it is suggested that Webpage design should be carried out according to the target audiences' specific cognitive style to enhance the perception and usage of the Webpage.

Keywords Cross-cultural study • Cognitive style • Webpage perception • Eye tracking

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1 Introduction

Since its creation, the World Wide Web (WWW) has become the most popular medium of communication around the world. At present, Web sites can potentially be visited by people around the world, and people from different cultures may employ different usage strategies on a Web site. An effective Web site requires consideration of these factors and should be designed to accommodate the needs of people with diverse cultural backgrounds [1]. Many studies have been carried out to shed light on the effects of cultural differences on Web usability. The term "Culturability," emphasizes the importance of the relationship between culture and usability in WWW design. A user interface should be designed to accommodate cultural preferences and bias to increase its usability [2]. The Webpage acts as an interface, allowing people to interact with the Internet. Good interface designs can enhance the user's capacity to process the information on the Webpage. Additionally, a number of cross-cultural Web design studies, which were grounded in Hall [3, 4] and Hofstede's [5, 6] cultural theories were carried out. These studies compared Web sites from different countries by taking cultural dimensions as criteria and derived characteristics of Webpage design in different cultural contexts [7, 8, 9].

Research on cultural differences from various perspectives such as linguistic studies, cultural patterns, cultural models, and cognitive style has contributed to cross-cultural Web design. Cognitive style plays an important role in the design of Web content because a Web design should ultimately accommodate an individual's typical mode of perception, thinking, remembering, and problem solving to promote usability. Differences in cognitive style are magnified when East Asians and Westerners are compared. Nisbett's recent research [10] on cultural cognition provides a theoretical framework for cross-cultural study. Through observations of how people from diverse cultures view images, he defined holistic and analytic cognitive styles. Nisbett combined cultural and cognitive perspectives that enrich the aspects of cultural influence in Web usability research, thus creating a new approach in this field. Research in the field of online communication has focused on the consistency of the cognitive style of people within the same cultural context, such as the influence of cultural context on the cognitive style of Web site designers and users [1, 11]. This research conducted a new approach for connecting cognitive style with the Webpage usability.

2 Cultural Cognitive Style

Cognitive style, as defined by Riding and Rayner [12], is "an individual's preferred and habitual approach to organizing and representing information," or as Ford et al. [13] stated, "A tendency for an individual consistently to adopt a particular type of strategy is known as a cognitive style." Anthropological and psychological studies of general cognitive processes suggest that cognitive styles are connected to culture [12, 14–16].

Nisbett and Masuda [17] revealed the perceptual differences of East Asians and Westerners through an experiment in which underwater scenes were shown to Japanese and American participants. The participants were asked to recall what they had seen. Japanese and Americans made equal numbers of statements about the focal fish which is larger than others, but Japanese made about 70 % more statements about the field and twice the amount on the relationships between the fish and the background than Americans did. This study revealed differences between East Asians and Westerners. That is, East Asians are more focused on the field and relations, while Westerners are more focused on objects and detach objects from the field. These different styles of thoughts were summarized as holistic versus analytic thought.

Nisbett and Norenzayan, in their paper, "Culture and Cognition" [15], proposed that cognitive processes differ according to holistic and analytic perspectives. They stated that cultural differences in cognitive: processes are tied to cultural differences in basic assumptions about the nature of the world (i.e., holistic vs. analytic). Scholars in a number of disciplines maintained that East Asians and Westerners differ greatly in their methods of reasoning. Holistic and analytic reasoning was summarized as follows:

Holistic thought involves:

(1) Orientation to the context or field as a whole, including attention to the relationships between a focal object and the field; (2) a preference for explaining/predicting events on the basis of such relationships; (3) An approach that relies on an experience-based knowledge rather than abstract logic and the dialectical; (4) an emphasis on change, recognition of contradiction, and the need for multiple perspectives.

Analytic thought includes as follows:

(1) A detachment of the object from its context; (2) a tendency to focus on the attributes of the object in order to assign it to categories; (3) a preference for using rules about the categories to explain and predict the object's behavior; (4) inferences that rest in part on the decontextualization of structure from content, use of formal logic, and avoidance of contradiction [15].

3 Eye Tracking in Usability Testing

The process of visual perception is an essential part of a user's interaction with an interface. Modern eye tracking equipment now makes it possible to track and analyze this process. Research in eye movement flourished with major advances in both eye tracking technology and the psychological theory to link eye tracking data and cognitive processes. Eye tracking provides insight into the user's cognitive strategies and allows us to identify patterns that even the users do not consciously see. Cowen et al. [18] claimed that eye movement data can augment data obtained through user testing by providing more specific information about the user's cognitive processes. Most of the work in this area is focused on research in psychology

and physiology and explores how the human eye operates and what this can reveal about perceptual and cognitive processes. Salvucci [19] stated that eye movements provide a rich and informative window into a person's thoughts and intentions. Through eye movement, users' behavior in using an interface can be examined.

4 Hypotheses

Cultural differences between East Asian and Western thought, communication, and interaction serve as an increasing influence in the use of Web. Westerners have an analytic cognitive style, which tends to detach the object from its field and focus on categories. East Asians have a holistic cognitive style, which tends to see the field as whole and focus on the relations. In the operation, viewing a Webpage is similar to viewing an image. East Asians and Westerners may show different viewing patterns and perceptions while browsing Webpages. Thus, this research proposes a new approach to enhance the usability of Webpage design by applying the culturally different cognitive styles of East Asians and Westerners.

The main hypothesis is as follows:

H0: Holistically minded people and analytically minded people show different viewing patterns on the Webpage.

This hypothesis can be examined through several sub-hypotheses:

H1: Holistically minded people show spread fixations over the page, while analytically minded people show concentrated fixations over the page.

H2: Holistically minded people show a nonlinear reading pattern, while analytically minded people show a linear reading pattern.

5 Experiment

5.1 Participants

This research attempts to gain an in-depth understanding of how people's cognitive style influences their behavior when browsing a Webpage. In terms of qualitative research, one study indicates that testing four or five participants will expose the vast majority of usability problems [20]. Rubin [21] claimed that most of the usability problems may be exposed with four participants, but there is still a good chance to overlook a problem that could have severe ramifications. He proposed testing at least eight participants if at all possible.

In this experiment, American, Chinese, and Korean participants were recruited. A total of 41 people were invited to take part in the experiment, including 14 Westerners, 15 Chinese, and 12 Koreans. Due to problems with the device and participants, only nine eye movement data from nine subjects per each group qualified for analysis. (Due to technical problems related to the device, the camera

Fig. 1 Chinese version of the prototype

could not track the participants' eye movement normally if they wore thick glasses or did not open their eyes wide enough or blinked too often.) All participants were between the ages of 24 and 35, with 6 males and 3 females from each culture, and all of them had experience on browsing Webpages.

5.2 Webpage Prototype

The prototype used in this experiment was designed by imitating a popular Web site, Yahoo! The Webpage prototype was designed with the most basic Webpage elements and page layout. The clearly and neatly divided areas were designed to easily allocate eye movements data. Stylization of the design was restrained so as to limit distraction to the participants (see Figs. 1, 2, 3). Prototypes with identical contents and layout, as well as identical page elements, were designed.

Three different language versions of the prototype were provided in English, Chinese, and Korean. It is well known that English text flow is left-to-right. Even though in ancient China and Korea, the text was written starting mostly at the top right corner of the page and proceeding downward to the bottom, nowadays the Chinese and Korean text flow are the same as in English. The prototype was originally created in English. It was then duplicated, and the English text was removed and replaced by Chinese and Korean text. Before the main experiment, the Chinese

Fig. 2 English version of the prototype

Fig. 3 Korean version of the prototype

prototype was tested with Chinese volunteers in order to check for confusing words and content. Based on the volunteers' comments, those prototypes were finalized.

Those prototypes are bitmap images and are designed to fit in one screen. They are not clickable and cannot be scrolled down. In order to imitate the real Web environment, a browser-like interface, including a toolbar and a status line, was added to the final prototype. According to the resolution of the monitor (a part of the Eye Tracking device), all prototypes were set to a resolution of 1,024 × 768 in order to be displayed without interpolation, thereby providing the clearest possible image during the experiment.

5.3 Apparatus

The hardware component, the Eyegaze Development System, used in this experiment was developed by LC Technologies, Inc. The software EMT tracker was used to record users' eye movement data.

Eye tracking metrics are used to measure eye tracking data. The selection of eye tracking metrics varies according to different eye movement studies. The main measurements used in eye tracking research are "fixation" and "saccades."

Fixation: The focusing of the eye on an object is termed fixation. A fixation defined by the eye position stabilizes within some threshold of dispersion (typically ~2°) [22] over a duration lasting from 66 to 416 ms (218 ms on average).

Saccade: A rapid eye movement from one location to another is termed a saccade. It is the movement occurring between fixations, typically lasting for 20–35 ms [23]. During a saccade, no information is obtained.

More eye tracking metrics are also commonly used:

Scan path: A spatial arrangement of a sequence of fixations. It usually consists of a sequence of fixations and interconnecting saccades.

Area of Interest (AOI): Area of a display or visual environment that is of interest to the researcher or design team and is thus designed by them (not by the participant).

Gaze duration: Cumulative duration and average spatial location of a series of consecutive fixations within an area of interest. Gaze duration typically includes several fixations and may include a relatively small amount of time for the short saccades between these fixations.

In addition, software named EyeGo was developed and used to review and analyze the recorded eye tracking data.

5.4 Procedure

Participants were given brief instructions after they arrived to the experiment room. They were told that the purpose of the test was to compare how people from different countries would view a Webpage. They were informed that an eye tracking device would be used in the test and that it would not directly come into contact with them. In the experiment, their eye movement would be recorded, and the

recorded result would be only used for the research and not for evaluating users. They were encouraged to relax during the test.

After being seated in front of monitor and eye tracking device, participants were informed of the details of the experiment including how the eye tracking device would work and what they would be asked to do in the experiment. They were also asked to keep their head motionless during the experiment for better eye tracking. The experiment began with device calibration, which calibrates the participants' eye to the screen of the monitor on which the prototype is to be presented. Once calibrated, participants were asked again to avoid moving their head since the experimental session on data recording was to be followed immediately. The participants were asked to use their left hand to support their head so that their head would remain steady during the test. Participants were exposed to the prototype version in their native language, and they were asked to freely look at the Webpage without clicking on anything since the task was trying to let people show how they actually view a Webpage without a specific searching item so that their natural viewing pattern could be revealed. As soon as the prototype was shown on the display, the eye tracking device was triggered by the experimenter to record the eye movements, and the recording was stopped after 30 s.

6 Analysis Results

6.1 Prototype Webpage Area of Interest (AOI) Division

The prototype page was divided into several AOIs, which are used for allocating eye tracking data and analyzing those data (see Fig. 4).

6.2 Analysis According to Eye Tracking Metrics

6.2.1 Accumulated Number of Areas of Interest (AOIs) the User Visited in the First 25 s

From pilot test, people showed different viewing patterns within 30 s. In this experiment, all participants have qualified eye tracking data within the first 25 s. Thus, 25 s were set as time range for analysis. Original collected data includes the following.

(1) Time: eye movement was recorded from 0 to 25 s; (2) Moves: refer to the number of AOIs the participant visited each second; (3) Areas: indicate which area the participant visited in each second; and (4) Accumulated number of AOIs the user visited: refers to the total number of AOIs the participant visited previously during each second.

Comparison of accumulated area moves in the first several seconds can reveal how often participants moved their eye among the content areas.

Figure 5 shows the results of the accumulated number of AOIs that a participant visited in the first 25 s. The mean of each group of participants' movements among AOIs in each second were used to make the diagram. The blue line with rhombus

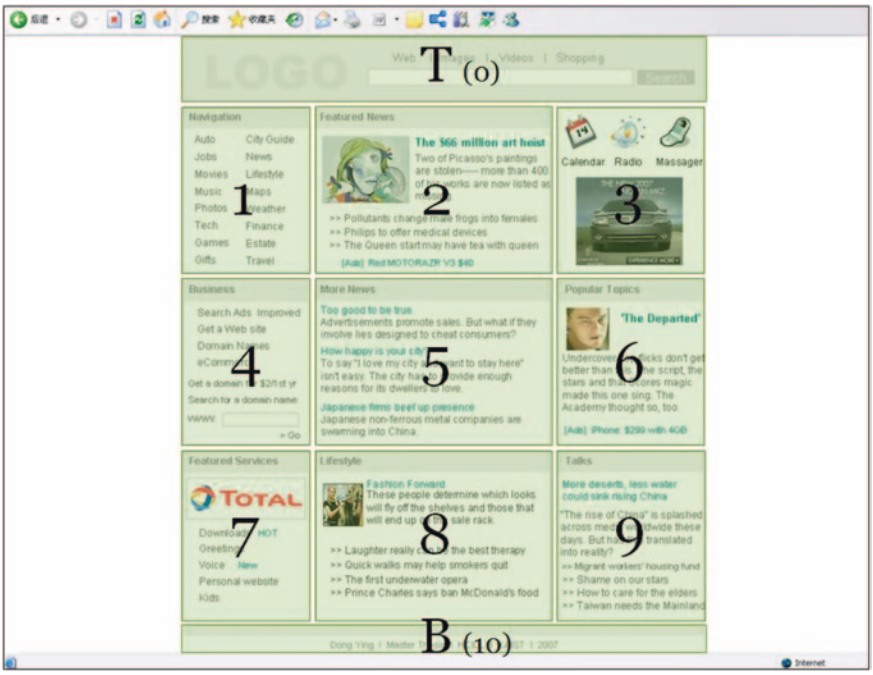

Fig. 4 Prototype Webpage with defined areas of interest

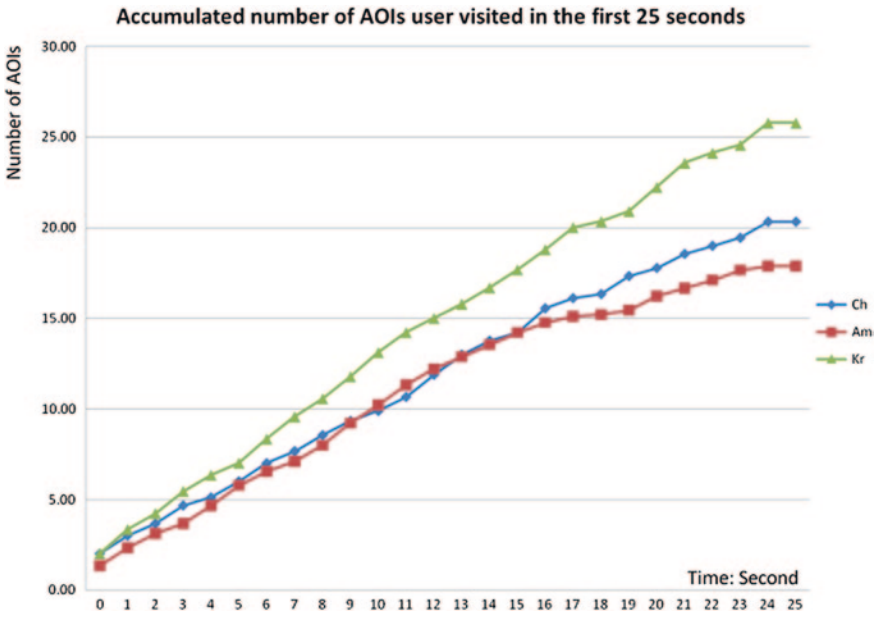

Fig. 5 Accumulated number of AOIs the user visited in the first 25 s

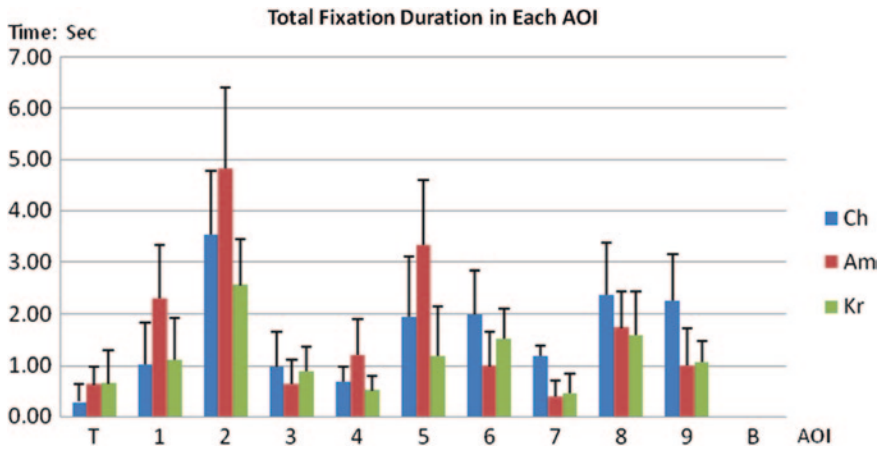

Fig. 6 Total fixation duration in each AOI

dots denotes Chinese participants, the red line with square dots denotes Americans, and the green line with triangle dots denotes Koreans. Figure 5 shows that the green line is always above the other two lines, which indicates that the Korean users moved a great deal on the page starting from the beginning of the session. They moved across more areas in each second than the other two groups. Chinese and Americans showed similar movements before the 15 s, while Chinese AOI movements were slightly more frequent than the Americans' within the first 10 s and exceeded those of the Americans shortly after. After the 15 s, the rate of increase of AOI movements of the American participants was lower than that of the Chinese participants, which reflected that the Americans began to stabilize their eye and focus on something on the page.

6.2.2 Fixation(s) Duration in Each Area of Interest (AOI)

This metric measures how long participants remained in each AOI. The duration of fixations in an area reflects the relative importance of the area to the participant. Area 2, which is located at the top middle area, is especially important. It attracted substantial attention from all three of the groups. Overall, the Americans had longer fixation duration in areas 1, 2, and 5 than the other two groups. The Chinese had longer fixation duration in Areas 6, 7, 8, and 9 than the other two groups (Fig. 6).

A mixed between-within subjects analysis of variance was conducted to explore the impact of nationality and AOIs on the total fixation duration. There was a significant main effect for AOIs (area) [$F(10, 15) = 62.93$, $p = 0$] within the three groups, and the effect size was large (partial $\eta^2 = 0.98$). There was also a significant main effect for nationality [$F(2, 24) = 5.56$, $p = 0.010$] between the groups, and the effect size was also large (partial $\eta^2 = 0.32$).

6.3 Analysis from an Eye Tracking Map

6.3.1 Eye Tracking Data Visualization

Each individual's eye tracking data was visualized for the subject's own language version of the prototype Webpage. Examples are provided in Figs. 7, 8, and 9. The viewing sequence on the prototype is displayed by different colors: green denotes the start of the eye movement and red the end (in a black and white print out, green is printed as a lighter color, while red is darker; thus the lighter color denotes the start, and the darker color represents the end).

6.3.2 Viewing Pattern Defined

The analysis procedure from the eye tracking map is as follows (Fig. 10): by reviewing each individual's eye tracking map, a few keywords of viewing pattern were defined based on each eye tracking map. After reviewing all eye tracking maps from the three groups and defining viewing patterns on each map, all defined viewing patterns were gathered and synthesized into several viewing pattern categories. These viewing pattern categories were used as the analysis criteria for mapping three groups into a chart so that the similarities and differences can be revealed among these three groups.

By reviewing and synthesizing all eye tracking maps, six viewing patterns were defined. They are as follows:

- *Sequential Reading*: The eye moves sequentially from one area to the neighbor area and continuously reads contents within one area.
- *Circular Scan*: The scan path is similar to a circle being drawn on a page.
- *Scan Back and Forth*: The eye moves back and forth among the contents; the participant visits one area repeatedly within a short time.
- *Only Scan*: Participants only scan the page without reading in detail. It shows rapid eye movements on the eye tracking maps.
- *Focus on Title*: Participants pay a comparatively high amount of attention to the title.
- *Read Navigation*: Participants pay attention to the navigation bar and spend some time reading navigation items.

The viewing patterns defined above were classified as "Analysis Criteria 1," which shows whether participants read or scan the page and the way of reading and scanning the page. Also, another analysis method, "Analysis Criteria 2" was defined in order to show how participants would proceed in viewing the page. It shows a visualized image of the viewing pattern. The "Analysis criteria 2" includes the following:

- "0" *Shape*: Eye movement is similar to drawing a "0" on the page
- "5" *Shape*: Eye movement is similar to drawing a "5" on the page. (Typically, the eyes visit areas in the following sequence: area 2, 5, 6, 9, 8, 7.)

Fig. 7 Chinese eye tracking map

- "N" *Shape*: Eyes move down in one column and then move over to another column.
- "Z" *Shape*: Eyes pass over columns first and then move down the page.
- "X" *Shape*: Eyes move diagonally across the page and scan the page with random jumps.

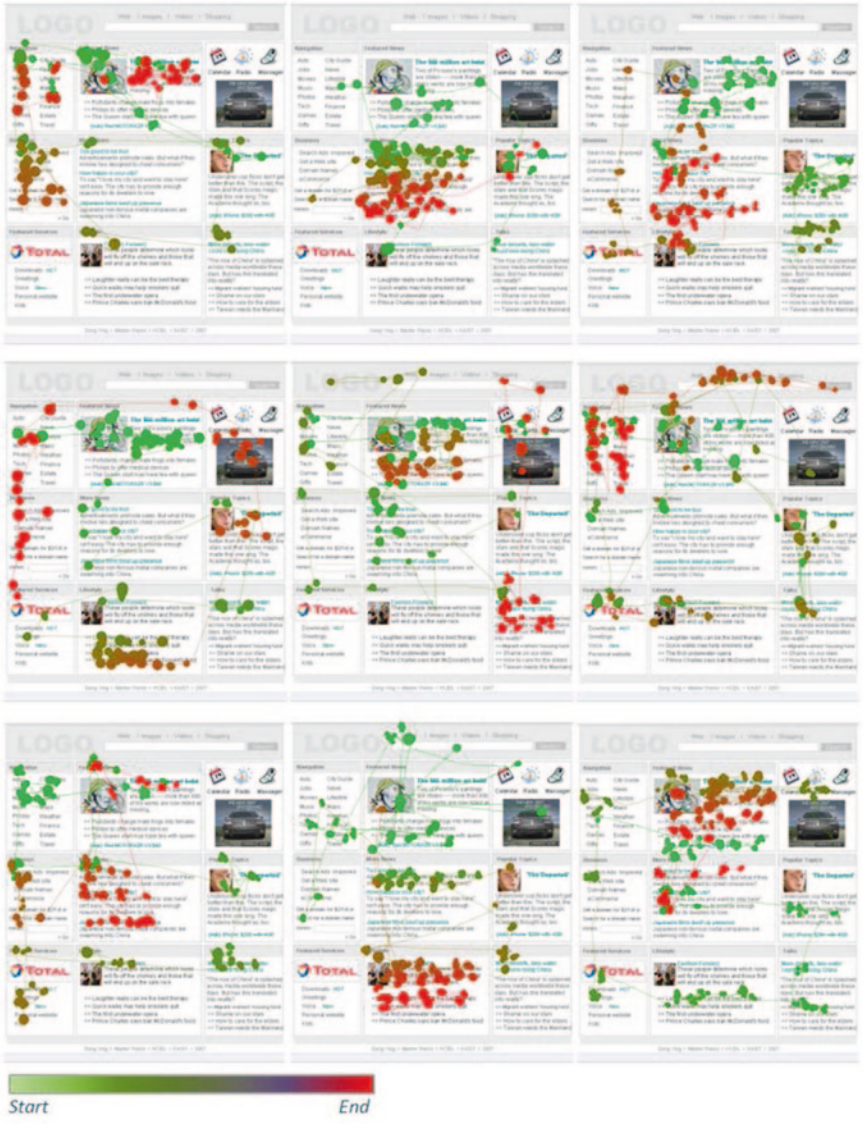

Fig. 8 American eye tracking map

6.4 Analysis Results

With the viewing patterns defined as given above, each eye tracking map from the three different national groups can be marked in a chart according to each analysis criterion. Two radar charts were made according to Analysis Criteria 1 and 2, respectively. For each analysis criterion, the viewing patterns were set as

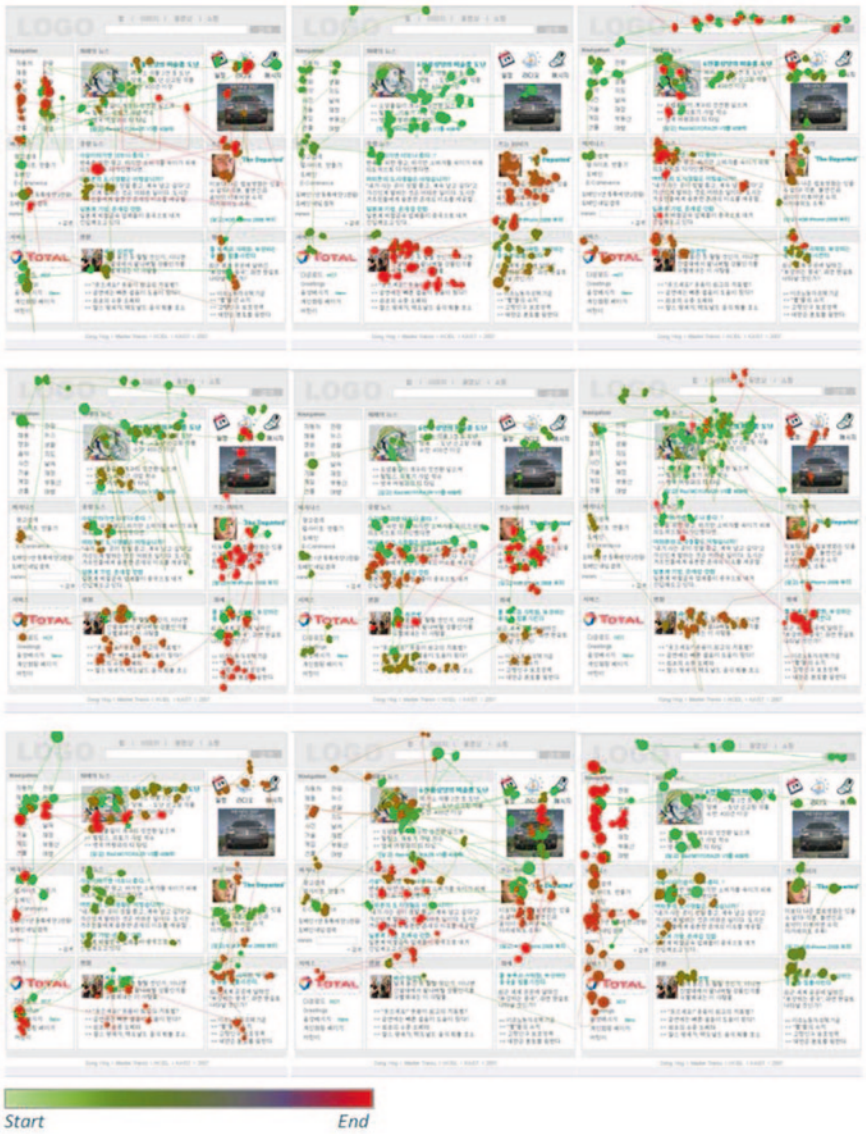

Fig. 9 Korean eye tracking map

an axis, and the axis was divided into several sections according to the number of people. In one national group, the people who showed the same viewing pattern are accumulated and marked in the relevant viewing pattern axis. In this way, the total number of a certain viewing pattern among the three groups can be compared.

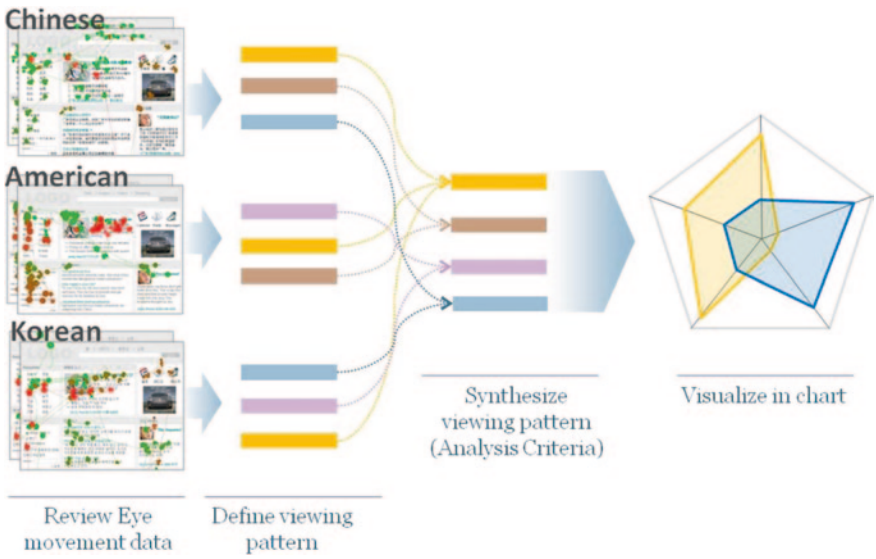

Fig. 10 Eye tracking map analysis procedure

Figure 11 shows viewing patterns mapped in a chart according to Analysis Criteria 1. Each group's results are marked on the viewing pattern axis. The results displayed in Fig. 11 indicate that each group has a moderately different viewing pattern that partially overlaps the others. For example, 7 out of 9 American participants tend to read the prototype page in sequential order, while few Chinese and Korean participants show sequential reading patterns. On the contrary, the Chinese and Korean participants are more likely to scan back and forth between page contents, and they are more likely to scan the page in a circular pattern. When we suppose that a Webpage is perceived as an image, we can imagine that the image is filled up with informative objects such as information items and/or information boxes, and the whole page can be perceived as a field. Holistically minded people have tendency to see the field as a whole, so they employ a strategy to perceive the Webpage by scanning across each information box. Scanning back and forth implies that Chinese and Koreans are not really reading carefully, but just randomly scanning the page. Since analytically minded people tend to detach objects from their background field, those people tend to focus on each piece of information one by one, and this behavior leads to a sequential reading pattern. Americans seldom scan without examining the details and rarely scan back and forth between contents. Americans are likely to focus on the page title and also likely to read the navigation, while few Chinese and Koreans do so. Analytically minded people are inclined to think in categories, so knowing what kind of categories the Web site has would help them to perceive the Web site. The graph below clearly illustrates similarities and differences in the viewing patterns among these three groups.

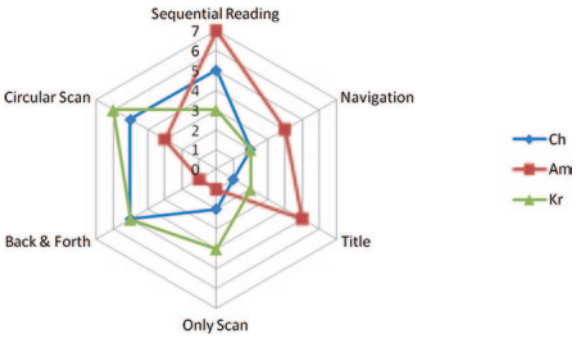

Fig. 11 Mapping viewing patterns according to Analysis Criteria 1

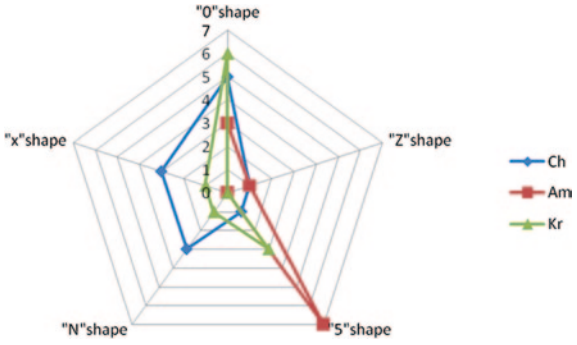

Fig. 12 Mapping viewing patterns according to Analysis Criteria 2

Figure 12 shows viewing patterns mapped in the chart according to Analysis Criteria 2. The chart illustrates that most Chinese and Korean showed a "0" shaped viewing pattern, while Americans showed a more "5" shaped eye movement on the page. "0" shape implies that Chinese and Koreans tend to scan the whole page which is similar to the circular scan above. Most Americans show a tendency to read from the center to the periphery of the page. Other viewing patterns in Analysis Criteria 2 do not seem to be significantly employed by a certain group.

7 Conclusions

Nisbett proposed that the thought patterns of East Asians and Westerners differ greatly and classified these differences as holistic and analytic. Holistically minded people have a tendency to perceive a scene globally; in other words, to perceive the context and field as a whole. They also tend to focus on the relationships between objects and the field, which means that they are more field-dependent. Analytically minded people have a tendency to perceive the object separately from the scene and tend to assign objects into categories. Analytically minded people are more field-independent.

In this study, Chinese, Koreans (holistic thought), and Americans (analytic thought) were recruited for the experiment. Findings from the analysis suggest that the Chinese, Koreans, and Americans employed different viewing patterns on the Webpage. The Chinese and Korean subjects showed more similarities to holistic thought, while Americans showed more similarities to analytic thought.

The present findings indicate that holistically minded people and analytically minded people have unique ways of perceiving the Webpage. The characteristics of perception reflect some aspects of Nisbett's proposition about cognition. It is suggested that the Webpage designer should be aware of the cognitive differences existing among holistically minded people and analytically minded people; accordingly, Webpage design must be carried out according to the target audiences' specific cognitive style to enhance the perception and usage of the Webpage.

7.1 Recommended Design Guidelines from the Study

This study primarily focused on revealing the relationship between Nisbett's cognition theory and Webpage perception. The different viewing patterns of these three groups of people indicate the potential influence on their Webpage usage, thus requiring that the Webpage should be designed to match the users' cognitive style to enhance the Webpage usability. By understanding Nisbett's theory and collecting and synthesizing of all the findings, this study thus proposes several recommendations for Webpage design.

For holistically minded people:

- To cater to a holistically minded approach to browse Webpages, which involves obtaining an overall big picture of the Webpage by scanning the entire page, content design should show the entire context of the Web site.
- Because holistically minded people tend to scan the entire page and show nonlinear scan patterns, the contents can be placed more freely on the page compared to when it is designed for analytically minded people.
- When designing a Webpage for holistically minded people, the harmony between the foreground and background as well as the relationship among all content areas should be taken into account. This guideline is derived directly from Nisbett's theory, although this study does not prove this.

For analytically minded people:

- The Webpage design should be as clear and simple as possible. Major categories and highlighted contents on the Webpage may cater to analytically minded people's usage. The Webpage layout should be clear enough to be read by users who focus on each information group.
- Because analytically minded people tend to employ sequential reading among areas and read from the center to the periphery of the page, the arrangement of all contents areas must be carefully considered.

- Category title and navigation items should be named as clearly as possible because analytically minded people tend to pay more attention to these items and gain an overall picture of the Web site from them.
- When designing Webpages for analytically minded people, efforts must be directed toward designing each content area. Independent content areas should be emphasized. This idea is taken directly from Nisbett's theory, although this study does not prove this.

7.2 Future Work

This study is only an initial step toward defining the relationship between cognitive style and Webpage perception. Most of the effort here was allocated to the eye viewing pattern itself. Consideration of other variables on the Webpage was comparatively weak. For example, different Webpage lengths could result in different viewing patterns. However, this study explored a complete analysis process which can be used or referenced in future studies.

In addition, to make this study more practical, the recommendations proposed herein must be examined. For further study, more specific Webpage design issues should be addressed, such as defining the relationship between cognitive style and Webpage layout design.

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