A Cross-Cultural Comparative Study of Users' Perceptions of a Webpage: *With a Focus on the Cognitive Styles of Chinese, Koreans and Americans*

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This study aims to reveal the relationship between cognitive style and webpage perception. In particular, webpage perception of people with different cognitive styles is compared. Based on Nisbett's cognitive model of holistic and analytic thought, this study hypothesizes that differences between holistic thought and analytic thought can be reflected in webpage perception. Working with this hypothesis, an experiment was carried out involving Chinese, Korean, and American participants. The users' eye movements, which can provide specific information about their cognitive processes, were recorded while browsing different language versions of a webpage prototype. In the end, the hypothesis of this study was supported. Findings from the analysis suggest that the Chinese, Korean, and American participants employed different viewing patterns when viewing 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 audience's specific cognitive style in order to enhance perception and usage of a webpage.

Keywords **–** Cross-Cultural Study, Cognitive Style, Webpage Perception, Eye Tracking.

Relevance to Design Practice **–** This study uncovers differences in webpage viewing patterns by Chinese, Koreans, and Americans, and proposes design guidelines that take these differences into account. The results of the study can help designers to understand user behavior by taking into consideration cognitive differences and to design cross-cultural interfaces with enhanced usability.

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Introduction

Since its creation, the World Wide Web (WWW) has become the most popular medium of communication around the world. At present, websites can potentially be visited by people from many different countries. Considering that people from different cultures may employ different usage strategies on a website, an effective site requires consideration of these differences and should be designed to accommodate the needs of people with diverse cultural backgrounds (Faiola, 2005). 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. That is, a user interface should be designed to accommodate cultural preferences and bias so as to increase its usability (Barber & Badre, 1998). 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, grounded in Hall (1959, 1976) and Hofstede's (1980, 1991) cultural theories, have been carried out. These studies compared websites from different countries by using cultural dimensions as criteria and derived characteristics of webpage design for different cultural contexts (Marcus, 2000; Yuan, Liu, Xu, & Wang, 2005; Singh, 2005).

Research on cultural differences from various perspectives, including linguistics, cultural patterns, models of cultures, 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 in order to promote usability. Differences in cognitive style are magnified when East Asians and Westerners are compared. Nisbett's (2001) recent research on cultural cognition provides a theoretical framework for cross-cultural study. Through observation of how people from diverse cultures view images, he has defined two different cognitive styles: holistic and analytic. Nisbett (2001, 2002, 2003) combines cultural and cognitive perspectives that enrich the understanding of cultural influence in web usability research, thus creating a new approach in this field.

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Research in the field of online communication has previously focused on the consistency of the cognitive styles of people within the same cultural context (Kim & Allen, 2002; Faiola, 2005). This research offers a new approach to connecting cognitive style and webpage usability.

Cultural Cognitive Style

Cognitive style, as defined by Riding and Rayner (1998), is "an individual's preferred and habitual approach to organizing and representing information," or as Ford, Wood, and Walsh (1994) state, "A tendency for an individual consistently to adopt a particular type of strategy is known as a cognitive style" (pp. 79-86). Anthropological and psychological studies of general cognitive processes suggest that cognitive styles are connected to culture (Chen & Ford, 1998; Nisbett & Norenzayan, 2002; Nisbett, Peng, Choi, & Norenzayan, 2001; Riding & Rayner, 1998).

Masuda and Nisbett (2001) revealed perceptual differences between 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. The Japanese and Americans provided equal numbers of statements about which of the fish were larger than others, but the Japanese participants made about 70 percent more statements about the general environment, or field, surrounding the fish and twice as many statements describing relationships between the fish and the background than the Americans did. This study thus revealed differences between East Asians and Westerners--that is, East Asians are more focused on the field and on relationships, whereas Westerners are more focused on objects and tend to detach objects from the field. These different styles of thoughts were categorized as holistic vs. analytic thought.

Nisbett and Norenzayan (2002), in their paper "Culture and Cognition," 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 have maintained that East Asians and Westerners differ greatly in their methods of reasoning. Holistic and analytic reasoning can be 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 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:

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 categories to explain and predict an object's behavior.
4. Inferences that rest in part on the decontextualization of structure from content, use of formal logic, and avoidance of contradiction (Nisbett & Norenzayan, 2002).

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 has flourished with major advances in both eye-tracking technology and the psychological theories that link eye-tracking data and cognitive processes. Eye tracking provides insight into a user's cognitive strategies and allows us to identify patterns that even the users do not consciously see. Cowen, Ball, and Delin (2002) claimed that eye movement data can augment data obtained through user testing by providing more specific information about a 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 (1999) has stated that eye movements provide a rich and informative window into a person's thoughts and intentions. Through eye movement, users' behavior when using an interface can be examined.

Hypotheses

Cultural differences between East Asian and Western thought, communication, and interaction serve as an increasing influence in the use of the Web. Westerners use an analytic cognitive style, which involves a tendency to detach an object from its field and to focus on categories. East Asians use a holistic cognitive style, which involves a tendency to see the field as a whole and to focus on the relationships of objects to the field. If we consider that viewing a webpage is similar to viewing an image, then East Asians and Westerners may show different viewing patterns and perceptions while browsing webpages. Thus, this research proposes a new

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approach to enhancing the usability of webpage design by taking into consideration the culturally different cognitive styles of East Asians and Westerners.

The main hypothesis is:

- H0: Holistically-minded people and analytically-minded people show different viewing patterns when viewing a webpage.

This hypothesis can be examined through several sub-hypotheses:

- H1: Holistically-minded people show a tendency to spread their fixations over the page, whereas analytically-minded people tend to concentrate their fixations while viewing the page.
- H2: Holistically-minded people follow a non-linear reading pattern, whereas analytically-minded people follow a linear reading pattern.

Experiment

Participants

This research attempts to gain an in-depth understanding of how people's cognitive styles influence their behavior when browsing a webpage. In terms of qualitative research, one study indicates that testing a webpage on four or five participants will expose the vast majority of usability problems (Virzi, 1990). Jeffrey Rubin (1994) claimed that most usability problems can be exposed using four participants, but that there is still a good chance of overlooking a problem that could have severe ramifications. He proposed testing that involves at least eight participants if at all possible.

For this experiment, American, Chinese, and Korean participants were recruited. A total of 41 people were invited to take part, including 14 Westerners, 15 Chinese, and 12 Koreans. Due to problems with the device and the participants, eye-movement data from only nine subjects of each group qualified for analysis. (Due to technical problems related to the device, the camera could not track a participant's eye movement normally if the person was wearing thick glasses or did not open his or her eyes wide enough or blinked too often.) The participants were between the ages of 24 and 35, with 6 males and 3 females from each culture. All of the participants had experience browsing webpages.

Webpage Prototype

The prototype used in this experiment was designed by imitating a popular website, Yahoo!. The webpage prototype was designed with the most basic webpage elements and page layout. Clearly and neatly divided areas were designed in order to facilitate the collection of eye-movement data. Stylization of the design was restrained so as to limit distractions for the participants (see Figures 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 traditional Chinese and Korean text is written starting at the top right corner of the page and proceeding downward to the bottom, nowadays it is generally written with the same text flow as used for English.

Figure 1. Chinese version of the prototype.

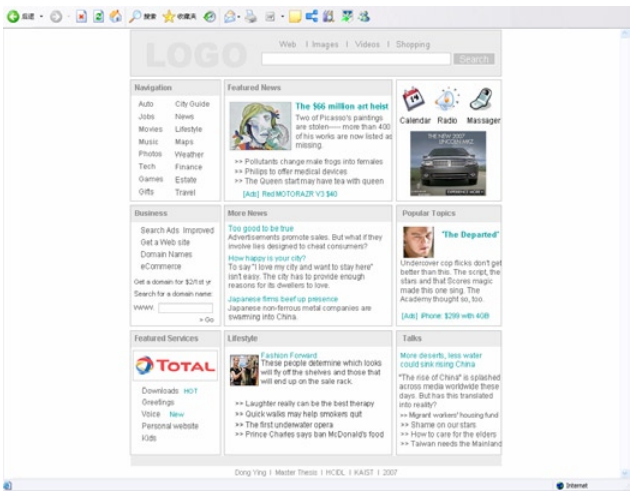

Figure 2. English version of the prototype.

Figure 3. Korean version of the prototype.

The prototype was originally created in English. It was then duplicated, and the English text was removed and replaced with Chinese and Korean text. Before the main experiment, the Chinese prototype was tested with Chinese volunteers in order to check for confusing words and content. Based on the volunteers' comments, the prototypes were finalized.

The prototypes were bitmap images and were designed to fit on one screen. They were not clickable and could not accommodate a scrolling function. 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. Based on the resolution of the monitor (a part of the eye-tracking device), all of the prototypes were set to a resolution of 1024 x 768 so that they could be displayed without interpolation, thereby providing the clearest possible image during the experiment.

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 movement was measured based on eye-tracking metrics. 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." These are defined as follows:

- ***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°) over a duration lasting from 66 to 416 milliseconds (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 to 35 milliseconds (Poole & Ball, 2005). During a saccade, no information is obtained.

Several other 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, a software named EyeGo was developed and used to review and analyze the recorded eye-tracking data.

Procedure

Participants were given brief instructions after they arrived in the experiment room. They were told that the purpose of the test was to compare how people from different countries might 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 movements would be recorded, and the recorded results would be used only for the research and not for evaluating users. They were encouraged to relax during the test.

After being seated in front of the 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 during the experiment. They were also asked to keep their head motionless during the experiment for better eye tracking. The experiment began with device calibration, during which the participants' eyes were calibrated in relation to the screen of the monitor on which the prototype was to be presented. Once calibrated, participants were asked again to avoid moving their head since the data recording was to follow 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 as the task was to determine how people actually view a webpage when not specifically searching for an item and thus to reveal their natural viewing pattern. As soon as the prototype was shown on the display, the eye-tracking device was triggered by the experimenter to record the participants' eye movements. The recording was stopped after 30 seconds.

Analysis Results

Prototype Webpage Area of Interest (AOI) Division

The prototype page was divided into several areas of interest (AOIs), which were used for allocating eye-tracking data and analyzing those data (see Figure 4).

Figure 4. Prototype webpage with defined areas of interest.

Analysis According to Eye Tracking Metrics

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

From pilot tests done in other experiments, people have revealed different viewing patterns within 30 seconds. In this experiment, qualified eye-tracking data were available for all participants

within the first 25 seconds. Thus, 25 seconds was set as the time range for analysis. The original collected data included the following.

1. ***Time***: eye movements were recorded from 0 to 25 seconds.
2. ***Moves***: refers to the number of AOIs the participant visited each second.
3. ***Areas***: indicates which area the participant visited in each second.
4. ***Accumulated number of AOIs the user visited***: refers to the total number of AOIs the participant has visited so far, up to any particular point during the experiment.

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

Figure 5 shows the results of the accumulated number of AOIs that a participant visited in the first 25 seconds. The mean of each group of participants' movements among AOIs in each second were used to make the diagram. The blue line with rhombus-shaped dots denotes the Chinese participants, the red line with square dots denotes the Americans, and the green line with triangular dots denotes the Koreans. Figure 5 shows that the green line is always above the other two lines, indicating that the Korean users moved their eyes a great deal around the page, starting from the beginning of the session. They moved across more areas in each second than the other two groups. The Chinese and American participants showed similar eye movements before the 15th second, while the Chinese AOI movements were slightly more frequent than those for the Americans within the first 10 seconds and exceeded those of the Americans shortly after. After the 15th second, the rate of increase of AOI movements of the American participants was lower than that of the Chinese participants, indicating that the Americans began to stabilize their eye movements and to focus on something on the page.

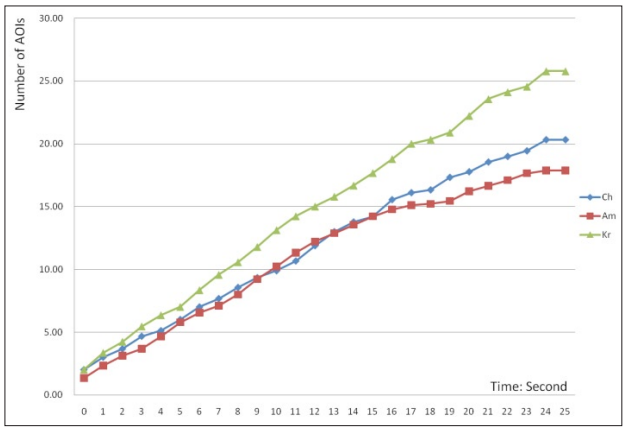

Figure 5. Accumulated number of AOIs the user visited in the first 25 seconds.

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 American participants had longer fixation duration in areas 1, 2, and 5 than the other two groups. The Chinese participants had longer fixation duration in Areas 6, 7, 8, and 9 than the other two groups (Figure 6).

A mixed between-within subject 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 η2= .98). There was also a significant main effect for nationality [F (2, 24) =5.56, p=.010] between the groups, and the effect size was also large (partial η2=.32).

Analysis using an Eye Tracking Map

Eye Tracking Data Visualization

Each individual's eye-tracking data were visualized for the subject's own language version of the prototype webpage. Examples are provided in Figures 7, 8, and 9. The viewing sequence on the prototype is displayed by different colors: green denotes the start of eye movements and red the end (in a black and white printout, the green will be printed as a lighter color, and red as darker; thus the lighter color denotes the start, and the darker color represents the end, of eye movements).

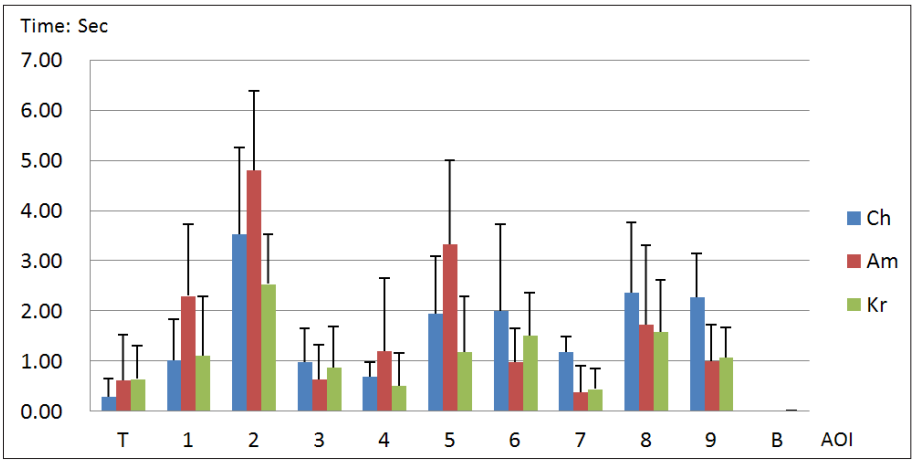

Figure 6. Total fixation duration in each AOI.

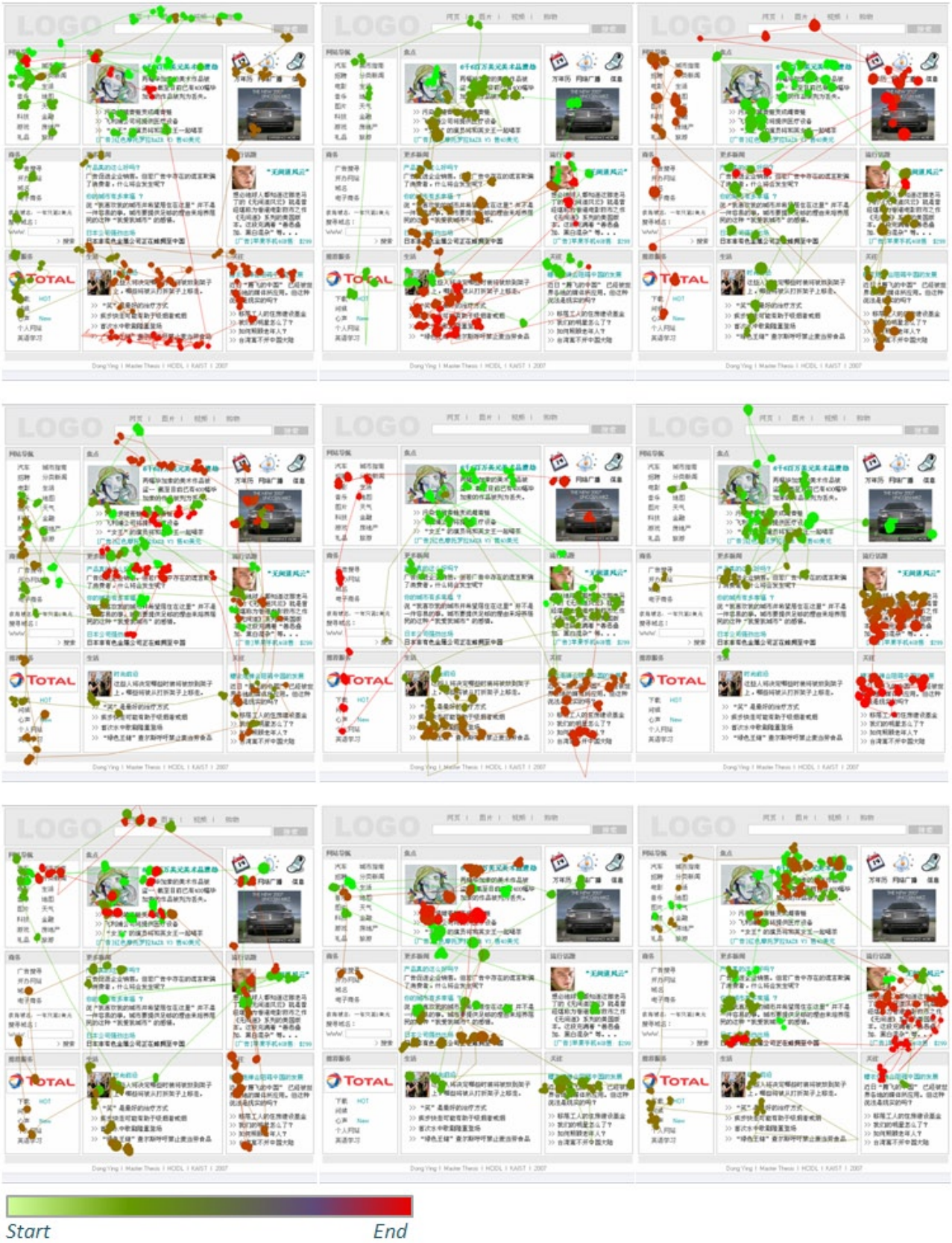

Figure 7. Chinese eye-tracking map.

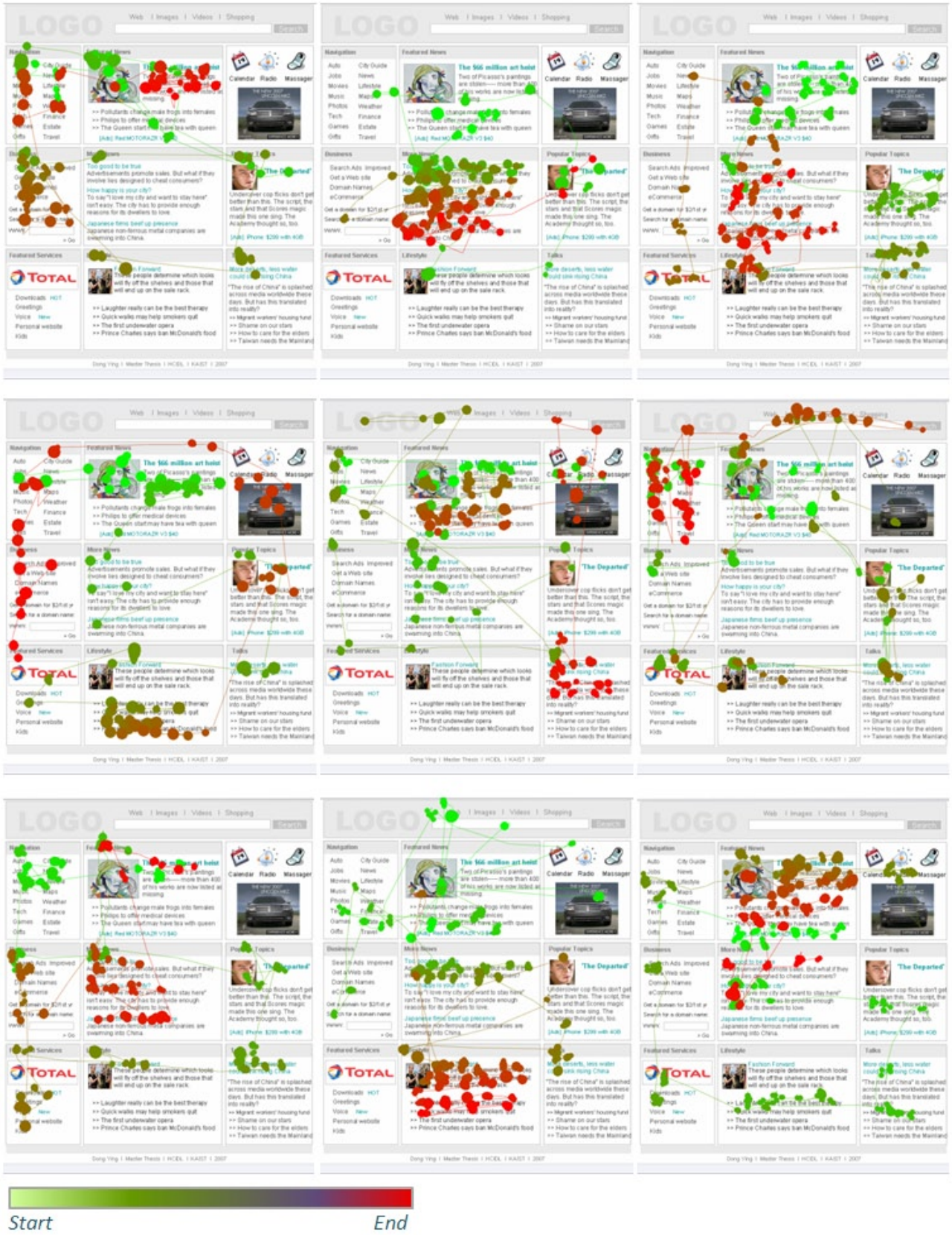

Figure 8. American eye-tracking map.

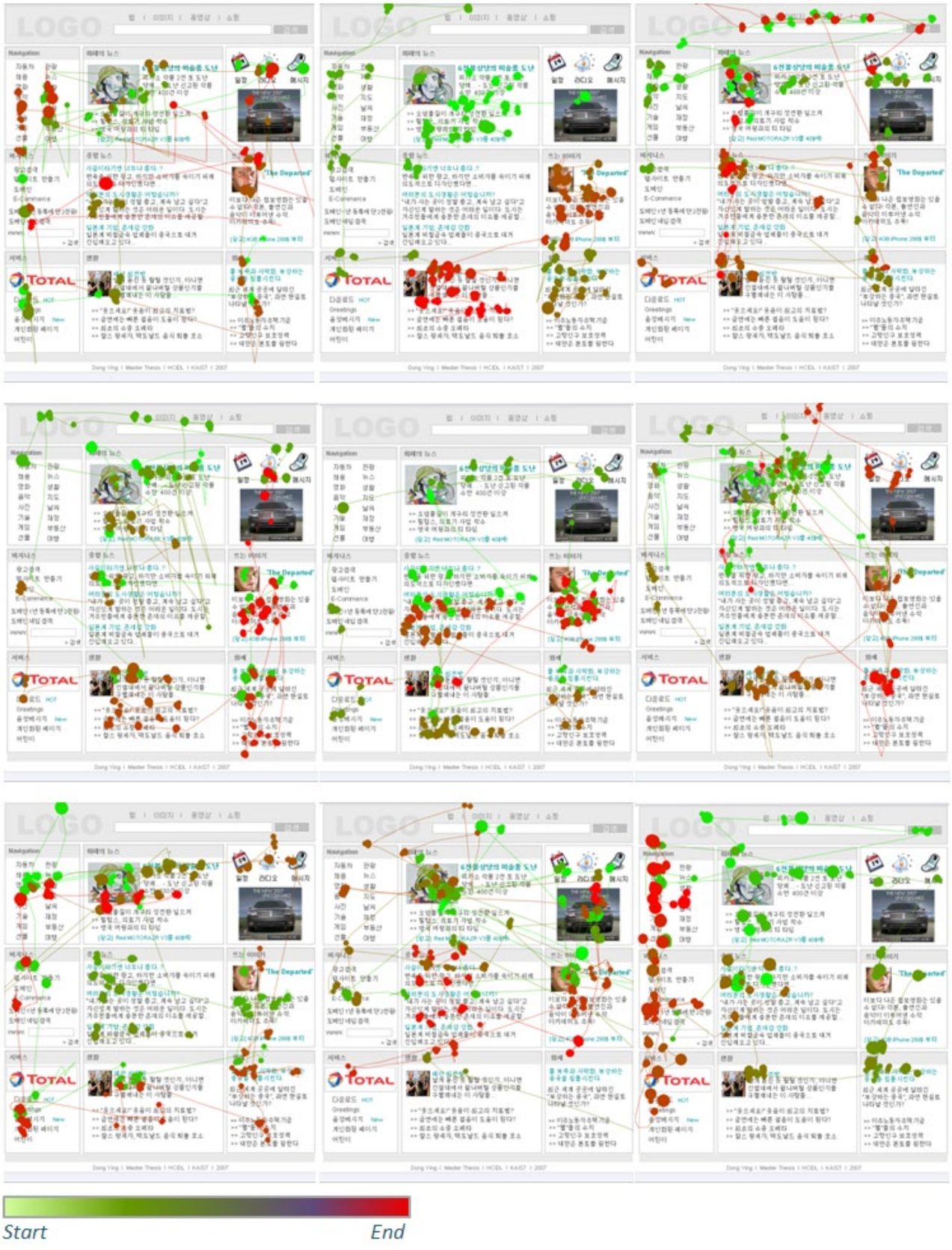

Figure 9. Korean eye-tracking map.

Viewing Pattern Defined

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

By reviewing and synthesizing all eye-tracking maps, six viewing patterns were defined:

- ***Sequential Reading:*** The eye moves sequentially from one area to the neighboring area and continuously reads contents within one area.
- ***Circular Scan:*** The scan path is similar to a circle being drawn on a page.
- ***Back and Forth Scan*** The eye moves back and forth among the contents; the participant visits one area repeatedly within a short time.
- ***Scan Only:*** The participant only scans the page, without reading it in detail. This pattern is shown by rapid eye movements on the eye-tracking maps.
- ***Focus on Title:*** The participant pays a comparatively high amount of attention to the title.
- ***Navigation Reading:*** The participants pays more attention to the navigation bar and spends some time reading the navigation items.

The viewing patterns defined above were classified as "Analysis Criteria 1," and were used to determine whether participants read or scanned the page and the way that they read or scanned the page. In addition, another analysis method, "Analysis Criteria 2," was defined in order to show how participants proceeded in viewing the page. This shows a visualized image of the viewing pattern. The "Analysis criteria 2" includes:

- ***"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: 2, 5, 6, 9, 8, 7).
- ***"N" Shape:*** Eyes move down 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.

Analysis Results

With the viewing patterns defined as given above, each eye-tracking map from the three different nationality groups could be marked on 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 an axis, and the axis was divided into several sections according to the number of participants. In one nationality group, the participants 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.

Figure 11 shows viewing patterns mapped in a chart according to Analysis Criteria 1. Each group's results are marked

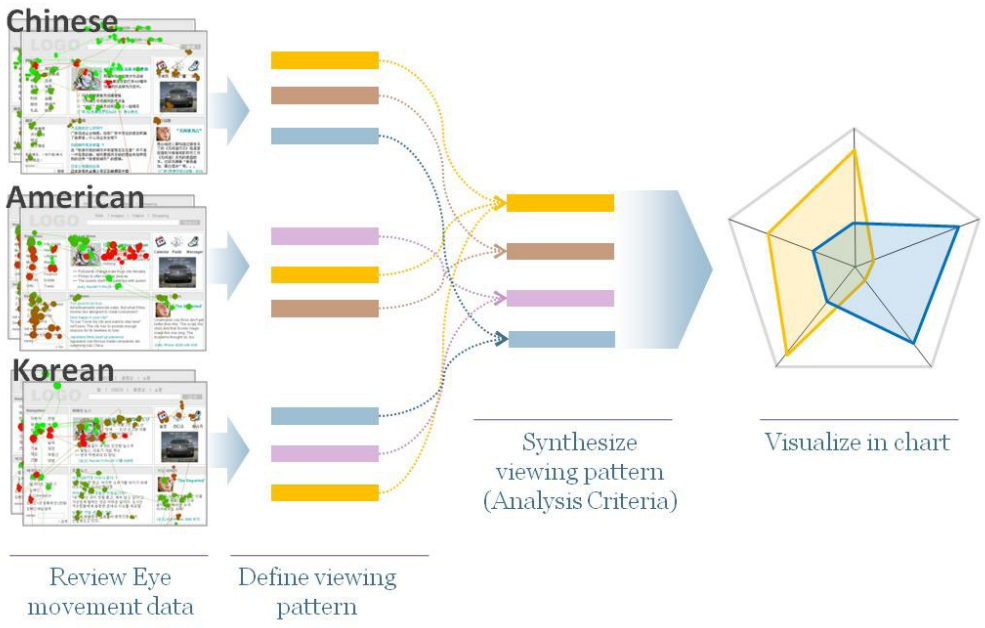

Figure 10. Eye tracking map analysis procedure.

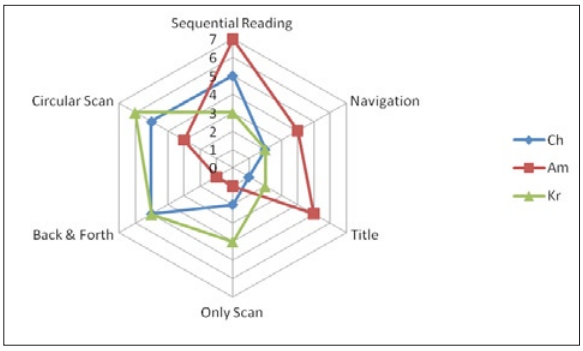

Figure 11. Mapping viewing patterns according to Analysis Criteria 1.

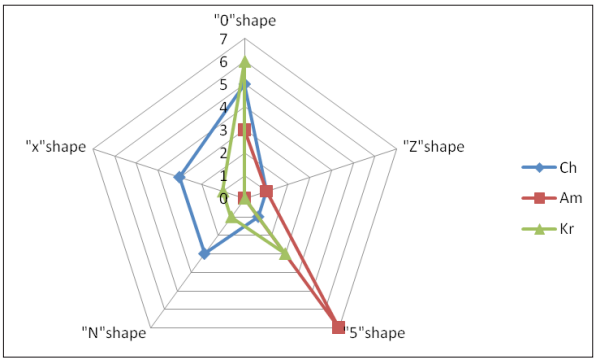

Figure 12. Mapping viewing patterns according to Analysis Criteria 2.

on the viewing pattern axis. The results displayed in Figure 11 indicate that each group had a moderately different viewing pattern that partially overlapped the others. For example, 7 out of 9 of the American participants tended to read the prototype page in sequential order, while few of the Chinese and Korean participants showed any sequential reading patterns. On the contrary, the Chinese and Korean participants were more likely to scan back and forth among the page contents, and they were 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 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 a tendency to see such a field as a whole, so we would expect them to employ a strategy in which they perceive the webpage by scanning across each information box. Scanning back and forth implies that the Chinese and Korean participants were not really reading carefully, but just randomly scanning the page. Since analytically-minded people tend to detach objects from their background field, these people tend to focus on each piece of information one by one, a behavior that leads to a sequential reading pattern. The American participants seldom scanned the page without examining the details and rarely scanned back and forth among the contents. The American participants were also likely to focus on the page title and also likely to read the navigation bar, while few of the Chinese or Korean participants did so. Analytically-minded people are inclined to think in categories, so knowing what kinds of categories a website has would help them to perceive that website efficiently. The graph below illustrates similarities and differences in the viewing patterns among the three groups.

Figure 12 shows viewing patterns mapped on the chart according to Analysis Criteria 2. The chart illustrates that most of the Chinese and Korean participants followed a "0" shaped viewing pattern, while the American participants followed more of a "5" shaped eye movement pattern across the page. The "0" shape implies that the Chinese and Korean participants tended to scan the whole page, a pattern that is similar to the circular scan above. Most of the American participants showed a tendency to read from the center to the periphery of the page. Other viewing patterns for Analysis Criteria 2 did not seem to be significantly employed by any certain group.

Conclusion

Nisbett (2001, 2002, 2003) 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 the field as a whole. They also tend to focus on the relationships between objects and the field, meaning that they are more field-dependent. On the other hand, analytically-minded people have a tendency to perceive an object separately from the scene and tend to assign objects into categories. Analytically-minded people are more field-independent.

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

The present findings indicate that holistically-minded people and analytically-minded people have unique ways of perceiving a webpage. These characteristics of perception reflect some aspects of Nisbett's (2001, 2002, 2003) proposition about cognition. It is suggested that webpage designers should be aware of the cognitive differences existing among holistically-minded people and analytically-minded people, and that webpage design should be carried out according to the target audience's specific cognitive style in order to enhance perception and usage of the webpage.

Recommended Design Guidelines from the Study

This study mainly focused on revealing the relationship between Nisbett's (2001, 2002, 2003) cognition theory and webpage perception. The different viewing patterns of the three groups of people indicate the potential influence on their webpage usage, thus suggesting that a webpage should be designed to match the users' cognitive style in order to enhance usability. Based on Nisbett's theory and on the collection and synthesis of all the findings, this study thus proposes several recommendations for webpage design.

For Holistically-minded People:

In order to cater to holistically-minded people's way of browsing a webpage, which involves obtaining an overall big picture by scanning the entire page, content design should show the whole context of the website.

Since holistically-minded people tend to scan the whole page and show non-linear scanning patterns, the contents could 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 of the content areas should be taken into account. This guideline is derived directly from Nisbett's theory, while it has not been proved by this study.

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 usage by analytically-minded people. The webpage layout should be clear enough to be read by users who focus on each information group.

Since analytically-minded people tend to employ a sequential reading pattern among areas and to read from the center to the periphery of the page, the arrangement of all content areas must be considered carefully.

Category title and navigation items should be named as clearly as possible since analytically-minded people tend to pay more attention to these items and to gain an overall picture of the website 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 is directly from Nisbett's theory, while it has not been proved by this study.

Future Work

This study is only an initial step towards 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 that can be used or referenced in future studies.

In addition, in order 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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