University of Alberta

Why Culture Influences Eye Movements? Understanding Cultural Effect on Visual Attention by Comparing Passive and Active Observation

by

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Abstract

Previous works suggest that North Americans perceive visual information more analytically while East Asians perceive visual information more holistically. However, salient objects are also known to naturally attract human attention. Current studies examined to what extent culture influences visual attention. Study 1 demonstrated that highly salient objects attract passive viewers' attention similarly across North American and East Asian cultures. In study 2, however, we revealed that such strong tendency for humans can be influenced by culture when people actively engaged in the observation. When participants were asked to report their observation, Canadian participants predominantly reported information regarding focal objects whereas Japanese participants also reported much information regarding contextual features. Consistently, culturally divergent patterns of eye movements were observed. The current study thus indicates that the active involvement in observation is especially important to understand the influence of culture on visual attention.

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In our daily life, we are surrounded by a vast amount of visual information. Whether you are browsing websites or driving on a highway, it is extremely inefficient, if not impossible, to pay attention to all of the elements in the scene. Selective attention is thus necessary to efficiently process visual information. Features that change over space and in time are visually more salient and therefore, they capture human attention (Vig, Dorr, & Barth, 2009) often involuntarily (Jonides & Yantis, 1988). Recent studies in cultural psychology, however, examined eye movements during static scene perception among individuals from North American and East Asian cultures, and indicated that the patterns of attention allocation were different depending on their cultural experiences (Chua, Boland, & Nisbett, 2005; Goh, Tan, & Park, 2009). In the present research, we examined to what extent culture would influence visual attention.

Evidence in Cultural Influence on Perception

Considerable research has been devoted to the notion that people with different cultural experiences perceive the visual world differently. Current knowledge on cultural influence on perception is largely based on the Analytic and Holistic Cognitive Theory developed by Nisbett and his colleagues (Nisbett, Peng, Choi, & Norenzayan, 2001). Due to history of socialization based on the Greek model, which focused on the autonomy and independence, individuals from North American cultures often adapt analytic cognitive styles. Focuses of analytic cognitive styles are on categorization of objects based on formal logics and rules; thus, entities are often perceived as independent of the context. In contrast, Chinese socialization has influenced Eastern philosophical and religious beliefs such as Buddhism, Taoism, and Confucianism, with a focus on collective agency and a sense of reciprocal social obligation. Such a world view in

Eastern cultures encourage holistic cognitive styles, which are characterized as orienting towards the field as a whole, and involving a great attention to the relationship between the main entities and the field. As a consequence, their perceptional process tends to be context dependent (for review, see Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005).

A large body of research provides systematic differences in perceptual processes between North American and East Asian societies. Studies using change blindness paradigm (Masuda & Nisbett, 2006; Miyamoto, Nisbett, & Masuda, 2006) showed that when American and Japanese participants were asked to compare two pictures with subtle differences in focal objects and in background objects, American participants detected differences in the focal objects more than differences in the background objects. In contrast, Japanese participants detected differences in the background objects more than those of focal objects. Kitayama and his colleagues (Kitayama, Duffy, Kawamura, & Larsen, 2005) also examined cultural difference in context sensitivity using a framed-line test (FLT). Using an experimental task with minimized social nature, researchers found that Japanese participants performed better at tasks requires incorporating contextual information than Americans, while American participants performed better at tasks requires focusing on the central object and ignoring contextual information than Japanese.

According to Chua et al. (2005), cultural difference in perception is a result of the cultural difference in visual attention at the encoding stage. Researchers asked participants to judge how much they liked each image that was consisting of a single foreground on a realistic complex background. The findings indicated that the patterns of eye movements between American and Chinese participants were significantly different

during static scene perception. Specifically, American participants allocated longer viewing time on the focal object in relation to the background compared to Chinese participants. In addition, Chinese participants made a higher number of fixations on the background area than did American participants. Although these findings demonstrated cultural variations in patterns of attention allocation with static pictures, what about stimuli that elicit involuntary attention?

Selective Attention

Salient visual cues such as color and motion contrasts are known to capture human visual attention. Among different types of visual cues, abrupt motion against a static background is especially effective to attract our attention (Jonides & Yantis, 1988; Schreij, Owens, & Theeuwes, 2008; Schreij, Theeuwes, & Owens, 2010). The eye tracking method has been used to study the mechanism of visual cognition and the operation of selective attention (van Gompel, Rischer, Murray, & Hill, 2007), and evidence with computational models indicate that the effect of visual saliency often predict eye-movements during scene perception of static (e.g., Peters, Iyer, Itti, & Koch, 2005) and dynamic scenes (e.g., Carmi & Itti, 2006).

Although it is widely accepted that visually salient objects capture involuntary attention, researchers also acknowledge that salient objects do not capture attention *always* (Koshino, Warner, & Juloa, 1992; Theeuwes, 1995; Yantis & Jonides, 1990). When researchers asked participants to engage in a visual search task with images included objects that made abrupt movements, most participants attended to the salient objects. In another visual search task with the same visual stimuli that included salient objects, however, participants were able to ignore the area where salient objects made

abrupt movements when they were instructed to attend to the other areas in advance. These findings indicate that the previous knowledge can interact with the influence of stimulus saliency in controlling attention.

Other studies indicate that task goals play a significant role in controlling eye movements when meaningful scenes are observed (Henderson, Williams, Castelhano, & Falk, 2003). According to this view, eye movements are controlled by the semantic interpretation of the scene; thus, the meaning each individual gives to the image may affect the pattern of eye-movements (Hayhoe & Ballard, 2005; Henderson & Hollingworth, 1999, 2003). The present research thus proposes that cultural differences in visual attention would be seen among North Americans and East Asians when the task involves constructing their own meanings from the images.

Speaking for Sharing

Speaking about one's interpretation of the image requires constructing some meanings (Vygotsky, 1978/1930). Brunner (1990) claims that it is necessary to construct meanings that can be shared with other members of one's culture. The evidence from a study conducted by Masuda and Nisbett (2001) supports this notion, and demonstrated that cultural experiences influenced in how people described underwater images they observed. After observing short underwater animations including large fish in the foreground and other objects such as aquatic plants and rocks in the background, American participants typically started describing the animations from the characteristic and the movement of the main objects such as the large fish. On the other hand, Japanese participants often started describing the animations from the background information such as the color of water. Overall, Japanese participants reported information related to

background contexts 60 percent more than did Americans. Although these findings demonstrated cultural variation in how individuals describe their observation, it is still unknown if cultural experiences would influence in how they allocate their attention during observation.

In the present research, we argue that the previous knowledge based on cultural experiences interact with stimulus saliency in controlling one's visual attention. This argument is consistent with previous empirical findings in culture and visual attention (Chua et al., 2005; Goh et al, 2009). We add to this work by considering the effect of speaking one's observation as a key factor for culture to interact with visual saliency during dynamic image observation. In reporting their observation, it was expected that participants would infer meanings based on their existing knowledge based on their cultural experiences. Due to analytic cognitive processes dominant in North American cultures, we expected that European-Canadian participants would predominantly focus on reporting focal fish objects. In contrast, we expected that Japanese participants, who were more likely to engage in a holistic cognitive process, would report both focal and background information. Such culturally divergent cognitive styles were also expected with patterns of eye movements. Thus, we first expected that visually salient objects would capture attention similarly across cultures when participants observe images without any obvious reasons to interpret their observations. Even with the same stimuli include highly salient objects, however, it was anticipated that cultural experiences would influence patterns of attention allocation when task involved speaking of one's observation.

Cultural Effect on Visual Cognition with Multicultural Individuals

Despite a recent attention to the effect of culture on visual cognition, the evidence of such effect on individuals with multicultural experiences is limited. Although there is some evidence suggesting that multicultural experiences facilitate creativity (Leung, Maddux, Galinsky, & Chiu, 2008; Maddux, Adam, & Galinsky, 2010) and cognitive complexity (Benet-Martinez, Lee, & Leu, 2006; Hong, Morris, Chiu, & Benet-Martinez, 2000; Tadmor, Tetlock, & Peng, 2009), only a small number of studies examined the effect of culture on visual cognition with multicultural individuals. Using Framed-Line Test, Kitayama et al. (2005) found that the perceptual styles of international students in the U.S. and in Japan were similar to those of their host cultures. Miyamoto and her colleague also found that American participants performed the change blindness task in a similar manner as Japanese participants when they were primed with pictures of Japanese scenes (Miyamoto et al., 2006). Although these findings suggest the influence of the environment affordance on visual cognition, it is still unknown how culture influences the perception of individuals who have experienced multicultural environments from birth.

Although an addition of individuals with multicultural experiences in research design would introduce theoretical and methodological complexity (Benet-Martinez, Leu, Lee, & Morris, 2002), it is a necessary path to take for cultural psychologists in order to further increase our understanding of cultural effect on cognition. Because the research on the influence of multicultural experiences on visual cognition is still generally in an early stage, the current studies aimed to answer an exploratory question: would cognitive processes of multicultural individuals be really influenced by all cultures they have

experienced? Although there are a number of different groups of multicultural individuals especially in Canada, such as sojourns, refugees, and immigrants, in the present research we focused our discussion on the second generation immigrants for the following two reasons. First, we expected the number of years spent in different cultures would influence the cognitive processes, yet it would be extremely difficult to control this variable with sojourns and refugees. In addition, the effect of multicultural experiences on scene perception has only been studied with international students (Kitayama et al., 2005; Miyamoto, Yoshikawa, & Kitayama, 2010). Thus, in the present research, we sought to examine the influence of culture on visual attention with second generation immigrants of Asian descent in Canada. In the present research, the second generation immigrants were defined as those individuals who were born in Canada to the parents who were born outside of Canada and immigrated in their adulthood.

Hypotheses

The current research proposes that speaking of one's observation is the key to understand the effect of culture on visual attention. When people passively observe scenes, their attention would be naturally drawn to the visually salient objects similarly across cultures. Therefore, it was first hypothesized that the effect of culture would be minimal when participants passively view images that included highly salient objects. Such a strong tendency for humans, however, was expected to be influenced by culture when people actively engage in observation. Particularly, when viewers attempt to verbalize their observation, they were expected to attend to the information that is culturally more meaningful regardless of visual saliency. Our second hypothesis thus states that culture would modulate how people describe their observation, and also the

patterns of eye movements when viewers actively engage in observation by verbally describing their observation.

Overview of the Present Research

To examine previously mentioned hypotheses, we utilized an eye tracking approach to study the influence of culture on visual attention among European-Canadian, Asian-Canadian, and Japanese participants. In Study 1, we first examined whether salient objects would attract visual attention in a similar manner across individuals from both North American and East Asian cultures. To test this hypothesis, we measured participants' eye movements while they passively and privately observed images. In Study 2, we examined the second hypothesis that culture would influence visual attention when viewers were actively involved in scene observation. While participants in Study 2 observed the same visual stimuli used in Study 1, they were also asked to verbally report their observation. In reporting their observation, it was expected that participants would specially attend to the information that is more meaningful based on their cultural knowledge. In Study 2, it was thus predicted that culture would influence the content of the verbal report and the patterns of eye movements, which were expected to be correlated with each other.

Study 1

The goal of Study 1 was to demonstrate that individuals from North American and East Asian cultures would attend to the image similarly when the stimuli included highly salient objects. To test this hypothesis, we employed animations of fish stimuli developed by Masuda and Nisbett (2001). We made some modification to change the location of the fish and also to increase the visual saliency based on the colors and the

movements of the focal fish. In study 1, all participants simply observed animations without any obvious reasons to interpret the content.

Method

Participants

Three groups of participants took part in the study. The European-Canadian participants were 20 undergraduate students (11 females and 9 males) at the University of Alberta and self-identified as European-Canadians, with a mean age of 20.15 years, rating from 17 to 35. The second generation Asian-Canadian participants were 16 undergraduate students (9 females and 7 males) from the University of Alberta, with a mean age of 18.56 years, ranging from 17 to 21. These students spoke both English and their heritage language fluently, and they were born in Canada to parents who immigrated to Canada from one of the following countries: Mainland China, Hong King, Japan, Korea, and Taiwan. The Japanese participants were 19 undergraduate students (12 females and 7 males) from the Kobe University who self-identified as Japanese citizens, with a mean age of 19.00 years, ranging from 18 to 20. All participants from the University of Alberta were instructed in English and they received partial credits towards their introductory to psychology courses. All participants from the Kobe University received instructions in Japanese and they were given monetary compensation (500 yen which is approximately equivalent to U.S. $5) in return for their participation.

Materials

For our visual stimuli, we adopted animated underwater vignettes developed by Masuda and Nisbett (2001). These animations were modified to increase the visual saliency of the focal objects for the purpose of present research which examined

culturally similar patterns of visual attention during passive observation. Using Adobe Flash, the movements and the colors of focal objects were changed to be more active and intense. An example image is presented in Figure 1. We prepared two practice and eight experimental trials of underwater scenes, and each of the eight experimental trials lasted for 25-27 seconds in length. Each animation included different types of swimming fish as focal objects, other small but active objects such as background fish and small sea animals, and background objects such as seashells and water vegetations. In addition, all scenes were taken place in different types of water with various colors such as green colored lake and blue colored deep sea. After modification to the location of objects, four experimental trials included the focal fish on the top part of the screen and the background objects on the bottom part of the screen. Another set of four experimental trials included the focal fish on the bottom part of the screen and the background objects on the top part of the screen.

Apparatus

Bilateral eye movements of each participant were recorded via a Tobii 1750 eye tracker with Tobii Studio™ software (Tobii Technology, Stockholm, Sweden) in the laboratories in Canada and in Japan. The animated vignettes were displayed at a resolution of 1024 × 768 pixels on a 17 inch (43 cm) monitor. The fixation filter was set with the fixation radius of 20 pixels and the minimum length of fixations of 40 ms. Gazes lasted less than 40 ms within 20 × 20 pixels were considered as saccades and discarded from the data analysis. A chin and forehead rest placed 15 inch (38.1cm) away from the monitor was used to standardize the viewing distance and minimize head movement.

Procedure

Upon arriving at the laboratory, participants were told that the main purpose of the study was to examine eye movements while rating various pictures appeared on the screen. After signing an informed consent, participants were instructed to seat and place their chin on the chin-rest. Participants first engaged in the standard 5-pointed calibration task provided by Tobii Studio. The experimenter then asked participants to engage in an advanced calibration with more complex scenes of underwater world to calibrate the eye-tracking device to each participant's natural eye movements. While participants were instructed to watch 10 animated underwater vignettes as they would naturally do, we recorded their eye movements. After two practice movies, eight experiment movies were presented in a random order. After viewing videos, an experimenter told participants the actual purpose of the study was concerned recording natural eye movements.

Results

Two areas of interests (AOI) were defined for the focal fish area and the background area (Figure 2). In all vignettes, small active objects were placed in the middle part of the screen to divide the image into the top and the bottom parts. Four of the vignettes included the focal fish swimming in the top part and the background information in the bottom part of the image, and the location of the focal fish and the background information was reversed for the other four vignettes. For the analysis, we merged the results of the eight experimental trials. Because measurements of the number and the duration of gaze fixations would allow us to examine how participants attend to the moving images, the number and the total duration of gaze fixations on focal fish and background areas were analyzed.

Preliminary Analysis

There were no main effects or interaction effects regarding gender; thus, gender was collapsed for subsequent analyses. The number and the total duration of fixations were analyzed using two-way repeated-measures analysis of variance (ANOVA) with culture (European-Canadian, Asian-Canadian, and Japanese) as between subject variable and area (focal objects area and background objects area) as within subject variables.

Total Duration of Fixations

First, there was a significant main effect of area, $F(1, 52) = 445.782$, $p < .001$, $\eta^2 = .896$, illustrating that participants in all three cultural groups spent longer time observing the focal object area than the background area (Figure 3). Neither a main effect of culture, $F(2, 52) = 1.20$, *ns*, nor an interaction between culture and area, $F(2, 52) = 1.11$, *ns*, were found.

Number of Fixations

Again, there was a significant main effect of area, $F(1, 52) = 228.42$, $p < .001$, $\eta^2 = .815$, illustrating that participants in all three cultural groups made a larger number of fixations on the focal object area comparing to the background area (Figure 4). Unexpectedly, there was a main effect of culture, $F(1, 52) = 3.257$, $p < .05$, $\eta^2 = .11$, indicating that the Asian-Canadian participants made a significantly smaller number of gaze fixations than European-Canadians in total, $t(52) = 3.16$, $p < .01$. However, there was no interaction between culture and area, $F(2, 52) = 1.67$, *ns*, indicating that all participants in the three cultural groups allocated their attention similarly, by predominantly attending to the focal fish area.

Discussion

Supporting our first hypothesis, the results of Study 1 indicated that visually salient objects captured attention similarly across cultures when observers passively viewed images. Participants in all groups made longer and higher number of fixations to the area where the focal fish were making salient movements compared to the background area where the most objects were static. These findings confirmed our assumption that when people passively observe images without considering any meanings associated with the images, their attention is naturally drawn to visually salient objects. Such tendency was common for individuals in both North American and East Asian cultures. Although the results of Study 1 supported our first hypothesis, and revealed minimal cultural effect on visual attention when viewers passively observed non-meaningful images, it is still unclear in what situation culture would influence visual attention. Study 2 was conducted to examine our assumption that speaking of one's observation would play an important role in understanding the effect of culture on visual attention.

Study 2

Study 2 was designed to examine the effect of culture on visual attention during active observation of moving images. In study 2, participants were presented with the same videos used in Study 1, but this time they were asked to verbally report their observation to the experimenter. It is important to note that participants were not restricted to attend to one object or the other, but rather, they were able to freely choose the type of information that was worth reporting. In reporting their observation, participants were expected to infer meanings based on their cultural knowledge. Thus,

due to analytic cognitive processes dominant in North American cultures, we expected that European-Canadian participants would predominantly focus on reporting focal fish objects. In contrast, Japanese participants, who were more likely to engage in a holistic cognitive process, were expected to report both focal and background information. Furthermore, we anticipated that culture would modulate the patterns of attention allocation while participants actively engaged in observation. In particular, patterns of eye movements were expected to be consistent with verbal reports such that European-Canadians would largely focus on the focal fish area and Japanese would be more balanced in their allocation of attention to the focal fish and the background areas even when the focal fish made salient movements. Hence, the content of verbal reports and the patterns of eye movements were expected to correlate with each other. Finally, it was expected that Asian-Canadians' patterns of eye movements would demonstrate the influence of both East Asian and North American cultural experiences.

Method

Participants

Three groups of participants took part in the study. The European-Canadian participants were 18 undergraduate students (10 females and 8 males) at the University of Alberta and self-identified themselves as European-Canadians, with a mean age of 18.61 years, rating from 18 to 21. The second generation Asian-Canadian participants were 22 undergraduate students (16 females and 6 males) from the University of Alberta, with a mean age of 18.43 years, ranging from 17 to 20. These students spoke both English and their heritage language fluently, and they were born in Canada to parents who immigrated to Canada from one of the following countries: Mainland China, Hong King, Japan,

Korea, and Taiwan. The Japanese participants were 26 undergraduate students (18 females and 8 males) from the Kobe University who self-identified as Japanese citizens, with a mean age of 18.88 years, ranging from 18 to 21. All participants from the University of Alberta were instructed in English and they received partial credits towards their introductory to psychology courses. All participants from the Kobe University received instructions in Japanese and they were given monetary compensation (1,000 yen which is approximately equivalent to U.S. $10) in return for their participation.

Materials

The general experimental setting followed Experiment 1 closely with the exception of changes to instructions. In addition, we included Relational, Individual, and Collective self-aspects (RIC) scale (Kashima & Hardie, 2000), to measure three aspects of the self. An important advantage of the three-part model, rather than the traditional two-part model of self, is that the three-part model of self conceptually differentiates *relational* and *collective* self-aspects, and such a model is highly recommended to distinguish cultural variations in the concept of self (for review, see Brewer & Chen, 2007). Although some past studies have demonstrated the relationship between the concept of self and neural activities (Goto, Ando, Huang, Yee, & Lewis, 2009; Hadden, Ketey, Aron, Markus, & Gabrieli, 2002), no previous research examined the relationship between self-construal and patterns of eye movements. The current research therefore attempted to investigate the relationship between patterns of eye movements and the concept of self. The RIC scale consisted of ten sentences regarding various issues of world view each followed by three options to complete the sentence (Appendix). Each of the three options reflected relational, individual, and collective self-aspects and

participants rated how much they agree with each of the three options (1 = does not describe me, not true of me; 7 = describe me, very true of me).

Procedure

After completed the standard 5-point calibration task, participants observed animated underwater vignettes and their eye movements were recorded. At the end of each animation, participants were instructed to verbally report their observation using one minute. Their reports were videotaped and transcribed for the analysis of verbal reports. Consistent with Study 1, participants engaged in two practices followed by eight experimental trials that were presented in a random order. Participants then completed the RIC scale.

Data Coding

Verbal reports were transcribed and divided into small segments for coding. Following the coding rule developed by Masuda and Nisbett (2001), each segment was coded into one of the following categories: (a) focal fish, (b) background fish, (c) active livings, (d) inert livings, (e) plants, (f) bubbles, (g) rocks and floor of scene, (h) water body, and (i) the environment. These segments were further coded according to one of the following subcategories: (a) number of the object, (b) attribution of the object, (c) emotion of the object, (d) behaviour of the object, (e) location of the object, (f) relation to active objects, (g) relation to inert objects, (h) time, and (i) the target of the relationship. Main categories are defined in Figure 5, and subcategories are defined in Figure 6. We counted the number of times each segment was used in participants' reports in the eight experimental trials, and the redundant information was eliminated. For analysis, we grouped the main- and sub- categories into the following four major aspects of the video:

Focal fish, Active objects (the combination of background fish and active livings), Inert objects (the combination of inert livings and plants) and the Background (the combination of bubbles, rocks and the floor of the scene, water body, and the environment).

Results

Verbal Report

As summarized in Table 1, we conducted one-way ANOVA on the proportion of reports regarding the following four aspects of the video: focal fish, active objects, inert objects, and background. The analysis yield significant main effects of culture on focal fish, $F(2, 62) = 12.61$, $p < .001$, $\eta^2 = .29$, active objects, $F(2, 62) = 7.82$, $p < .001$, $\eta^2 = .20$, inert objects, $F(2, 62) = 4.03$, $p < .05$, $\eta^2 = .12$, and background, $F(2, 62) = 4.39$, $p < .05$, $\eta^2 = .12$.

Planned comparisons revealed that European-Canadian participants reported characteristics of focal fish and active objects significantly more than did Japanese participants, $t(63) = 6.56$, $p < .001$ and $t(63) = 3.36$, $p < .001$, focal fish and active objects, respectively. In contrast, Japanese participants reported characteristics of inert objects, $t(63) = 3.96$, $p < .001$, and background, $t(63) = 4.94$, $p < .001$, significantly more than did European-Canadians. In addition, Japanese participants described the relationship towards inert objects significantly more than did European-Canadian participants, $t(63) = 6.47$, $p < .001$, but there was no cultural difference on the reports regarding the relationship towards active objects (Table 2).

The recalls made by Asian-Canadian participants generally fell in the middle between those of European-Canadians and Japanese, and the tendency was similar to that

of European-Canadians. The proportion of focal fish reported by Asian-Canadians were significantly higher than that of Japanese, $t(63) = 7.75$, $p < .001$ and it was not different from that of European-Canadians. Similarly, Asian-Canadians' proportion of reports regarding background was significantly smaller than that of Japanese, $t(63) = 11.66$, $p < .001$, and it was not different from that of European-Canadians. However, Asian-Canadians reported about inert objects significantly more than European-Canadian participants did, $t(63) = 4.38$, $p < .001$, and this proportion was not significantly different from that of Japanese. Finally, the proportion of active objects reported by Asian-Canadians was significantly higher than that of European-Canadians, $t(63) = 2.51$, $p < .05$, and that of Japanese, $t(63) = 5.88$, $p < .001$. Asian-Canadians also reported about the relationships toward inert objects significantly more than did European-Canadians, $t(63) = 2.97$, $p < .005$ and it was not different from that of Japanese participants.

These findings supported our second hypothesis that Japanese participants placed more importance in communicating about the information regarding both focal objects and the background objects and relationship among them. On the other hand, European-Canadian participants placed more importance in communicating about the information regarding detailed features and movements of the focal objects and relationship among the focal objects.

Eye Movements

The same AOI mask used in Study 1 was applied to divide focal objects and background areas. We analyzed the average number of fixations and the average total duration of fixations during movie viewing of eight experimental trials. There were no main effects or interaction effects regarding gender and thus, subsequent analyses

focused on the predicted cultural effects collapsed across gender. In the same procedure as in Study 1, we conducted a 3 (Culture: European-Canadian vs. Asian-Canadian vs. Japanese) × 2 (Area: focal objects area vs. background area) mixed model ANOVA with Area as a within-subjects variable.

Total Duration of Fixations

First, there was a main effect of Area, $F(1, 62) = 504.21$, $p < .001$, $\eta^2 = .89$, indicating that both European-Canadian and Japanese participants in general spent longer time watching where the focal objects made salient movements. There was also a main effect of culture, $F(2, 62) = 7.99$, $p < .001$, $\eta^2 = .205$. Importantly, the previous effects were qualified by a significant interaction of culture × Area, $F(3, 81) = 5.13$, $p < .01$, $\eta^2 = .142$. As summarized in Figure 7, European-Canadian participants ($M = 15.21$sec.) viewed the focal fish area longer than did Japanese participants ($M = 13.28$sec.), $t(62) = 4.48$, $p < .001$. On the contrary, compared to European-Canadian participants ($M = 4.05$sec.), Japanese participants ($M = 5.33$sec.) spent longer time watching the background area, $t(62) = 2.97$, $p < .001$. Asian-Canadian participants' results of the total duration fell in the middle between those of European-Canadians and Japanese. Planned comparisons indicated that Asian-Canadians' total duration of fixations on the focal fish area ($M = 15.29$sec.) was similar to that of European-Canadians, and was significantly different from that of Japanese, $t(62) = 3.54$, $p < .001$. Conversely, Asian-Canadian's total duration of fixations on the background area ($M = 5.02$sec.) was similar to that of Japanese, and was significantly different from that of European-Canadians, $t(62) = 2.26$, $p < .05$.

Number of Fixations

Again, the main effect of Area was significant, $F(1, 62) = 415.48$, $p < .001$, $\eta^2 = .87$, indicating that all participants exhibited greater interest in the area where the focal fish were moving. Also, the main effect of culture was significant, $F(2, 62) = 8.55$, $p < .001$, $\eta^2 = .216$, which is qualified by a significant culture × Area interaction, $F(2, 62) = 6.33$, $p < .005$, $\eta^2 = .169$ (Figure 8). This is because European-Canadian participants ($M = 66.16$) made significantly higher number of fixations on focal fish area than did Japanese participants ($M = 50.76$), $t(62) = 8.34$, $p < .001$, yet the cultural difference was not significant on the background area, $t(62) < 1$, *ns*. The number of fixations made by Asian-Canadians on the focal fish area ($M = 57.3$) fell in the middle between those of European-Canadians' and Japanese, and was significantly different from both of European-Canadians, $t(62) = 4.80$, $p < .001$, and Japanese, $t(62) = 3.54$, $p < .001$.

Relationship between Verbal Reports and Eye Movements

Correlation analyses were conducted between verbal reports and eye movements. Because reports of background and reports of inert objects both concerned features of the background area used in the analysis of eye movements, a new variable, reports of general background, was created by combining the proportion of reports of background and inert objects. The results indicated that the greater the proportion of the focal fish reports, the higher number of fixations ($r = 0.32$, $p < .01$) and the longer fixations duration ($r = 0.43$, $p < .001$) on the focal fish area. Also, we found that the greater the proportion of general back reports, the higher number of fixations ($r = 0.25$, $p < .05$) and the longer fixations duration ($r=0.34$, $p<.005$) on the background area. Thus, these

findings supported our hypothesis that the content of verbal reports correlated with the patterns of eye movements.

Self-Aspects Scale

We aimed to control for the response bias in the results of the RIC scale by transferring the row scores to standardized scores. Within-subject standardization was performed by subtracting each individual's average across all variables from the row scores (Fischer, 2004). On the relational-self aspect, Asian-Canadians scored lower than both European-Canadians, $t(62) = 4.90$, $p < .001$ and Japanese, $t(62) = 3.55$, $p < .001$, and there was no significant difference between European-Canadians' and Japanese scores, $t(62) = 1.35$, *ns.* On individual self aspect, European-Canadians scored higher than both Asian-Canadians, $t(62) = 3.07$, $p < .005$ and Japanese, $t(62) = 4.50$, $p < .001$, and there was no difference between scores of Asian-Canadian and Japanese participants, $t(62) = 1.44$, *ns.* Finally, on the collective self aspect, Asian-Canadians scored higher than both European-Canadians and Japanese, $t(62) = 8.57$, $p < .001$ and $t(62) = 2.41$, $p < .05$, respectively. Japanese participants also scored higher than European-Canadian participants on the collective self scale, $t(62) = 6.15$, $p < .001$.

There was a significant positive correlation between the collectivism self score and the total duration on the background area, ($r = 0.26$, $p < .001$), and also a significant negative correlation between collectivism self score and the number of fixations on fish area ($r = -0.32$, $p < .001$). There was no other meaningful correlation between the results of RIC scale and the patterns of eye movements.

Discussion

The results of Study 2 supported our key hypothesis that culture would influence visual attention during active observation of animations even when animations included highly salient objects. When participants were asked to report their observation, European-Canadian participants reported more information regarding focal fish objects compared to Japanese, while Japanese participants reported more about contextual information than did European-Canadians. These findings supported our assumption that North Americans tend to be oriented in the analytic cognitive style while East Asians are more likely to be oriented in the holistic cognitive style. Furthermore, the findings of Study 2 revealed that the patterns of eye movements were also influenced by culture when participants actively involved in the observation by verbally reporting what they saw in the animations. Specifically, European-Canadian participants allocated more attention to the focal fish area than did Japanese, while Japanese participants allocated more attention to the background area than did European-Canadian participants. These patterns of eye movements were positively correlated with their verbal reports, suggesting that consideration of culturally informative information guided cultural differences in patterns of attention allocation regardless of visual saliency in the scene.

General discussion

To what extent culture influences eye movements? The findings of Study 1 confirmed that salient objects naturally attract visual attention during passive observation similarly across North American and East Asian cultures. However, the current research also demonstrated that such a robust tendency can be culturally divergent when viewers actively engage in the observation. When participants were asked to report their

observation in Study 2, European-Canadian participants predominantly reported features of focal objects, while Japanese participants made fewer statements about focal fish but more about contextual information compared to European-Canadians. Such cultural difference in the verbal report was consistent with previous findings indicating North Americans' tendency to engage in an analytic cognitive style, and East Asians' tendency to engage in a holistic cognitive style (Masuda & Nisbett, 2001; Nisbett et al, 2001). Furthermore, when participants were asked to report their observation, the patterns of eye movements were also influenced by culture. European-Canadian participants allocated more attention to the focal fish areal than did Japanese, whereas Japanese participants attended to the background area more than did European-Canadians. Finally, the patterns of eye movements of Asian-Canadians fell in the middle of those of European-Canadians and Japanese, indicating that Asian-Canadians were influenced by both North American and East Asian cultures. Thus, when images include highly salient objects, cultural effect became pronounced when participants actively engage in observation by speaking about their observation.

The current findings may help to understand some mixed results in cultural influence on visual attention. Despite findings of Chua et al. (2005) that indicate cultural differences in eye movements during scene perception, Rayner and his colleagues maintain that cultural variation in visual attention is minimal especially when stimuli contained several objects of interest (Rayner, Li, Williams, Cave, & Well, 2007). The current studies demonstrated that the same visual stimuli can be seen similarly and differently across cultures depending on the task goal. Particularly, speaking of one's observation was especially important for culture to influence visual attention.

These results have important implications for research on culture and visual cognition. First contribution of the present research was that it provided evidence in culturally unique development of joint attention. According to Tomasello (1999), joint attention is one of the most important culturally learned cognitive competencies that distinguish humans from other non-human primates. If joint attention can only be acquired through cultural learning, it is assumed that the different types of joint attention are fostered across cultures. Using an eye-tracking method, the present research indicated that patterns of attention allocation were different across cultures only when participants reported their observation to an experimenter. When participants reported their observation, it can be considered that participants were engaging in the joint attention because they were directing experimenter's attention to their own by verbally describing what they saw. Moreover, the content of the report was corresponded with each participant's culturally dominant worldview, suggesting that participants attempted to construct meanings in a form that can be easily shared with members of their culture (Bruner, 1990). In such condition, culturally divergent patterns of visual attention were observed. On the other hand, when participants passively and privately viewed images, the pattern of visual attention was similar across cultures. Therefore, the present studies supported Tomasello (1999) and further provided empirical evidence for culturally learned joint attention, by showing different patterns of visual attention during verbal reports across cultures.

Second, this work provided evidence that different levels of involvement in the task influenced the effect of culture on visual cognition. After Masuda and Nisbett (2001), a large number of studies reported cultural difference on visual cognition. Most

research concerned cultural variation in psychological processes thus far used tasks that required participants to actively engage in, such as FLT (Kitayama et al., 2005) and change blindness task (Masuda & Nisbett, 2006; Miyamoto et al., 2006). In such paradigms, it is difficult to differentiate the effect of active involvement in the task from an automatic reaction to the stimuli. By employing an eye tracking method, the current research was able to manipulate the level of involvement in the task. The findings of the current research suggested that the active involvement was the key for participants to demonstrate culturally specific patterns of eye movements. Reporting one's observation to others can be considered as a preparation for communication. Considering the fact that culture only exists within a shared environment with multiple people, it is likely that the need of communication fosters culturally divergent behavior. Although participants were only communicating with an unknown experimenter, it is assumed that the cultural effect would be even larger if the importance of communication was made more obviously.

The results of Study 1 may appear to be inconsistent with the previous research. A recent study conducted by Goh et al. (2009) was the only other study examined cultural variation in eye movements during passive observation. In Goh et al.'s study, researchers presented a series of pictures with a combination of a single focal object and the background image to American and Chinese Singaporean participants. A series of pictures were presented in a way that the focal object and/or the background changed over the time, and the participants were asked to view these pictures and focus on the fixation signs that appeared in-between stimuli. They found that the number of gaze fixations on objects by American participants was more affected by changes in objects relative to that of Chinese Singaporean participants. Unlike their study, we did not find

cultural difference in patterns of eye movements in Study 1 when participants passively viewed the video. However, it is assumed that the difference between these two studies is largely due to the difference in visual stimuli. It is apparent that the animation stimuli used in the current studies were designed to include highly salient objects with movements, while visual saliency in Goh's stimuli may not have been strong enough to capture attention in a universal manner. Nevertheless, Goh et al. (2009) also found that both American and Chinese Singaporean participants were more sensitive to object changes than to the background changes, which suggest that visually salient objects that change in location, shape, or color, attract passive viewers' attention similarly across North American and East Asian cultures.

Limitations and Future Directions

One limitation of the present research is that it was not able to detect a causal relationship between one's selection of culturally informative information decided during observation and the patterns of eye movements. The results of Study 2 found a systematic cultural difference in the content of verbal report. Furthermore, we demonstrated that the content of verbal report was correlated with the patterns of eye movements. It is thus possible, though only a speculation, that individuals from different cultures decide what was important to report based on their cultural knowledge during their observation, which in turn directed the patterns of eye movements. Future research needs to further examine the mechanism of cultural effect on visual attention and the possibility of such mediation effect on culture and visual attention.

Future lines of research should also investigate the effect of culture on visual cognition with individuals of multicultural backgrounds. The present research showed

that Asian-Canadians' patterns of eye movements and verbal reports fell in the middle between those of European-Canadians and Japanese, indicating that their visual cognition was influenced by both North American and East Asian cultures. Importantly, these participants were born in Canada yet received heritage cultural influence from their family members. Although some studies in cultural psychology have examined the effect of culture on visual cognition with international students (Kitayama et al., 2005; Miyamoto et al., 2010), no studies thus far has examined such cultural effect with immigrants. Future studies should investigate the mechanism of cultural influence on visual cognition with multicultural individuals.

Another limitation of the present studies is the lack of correlation between the results of eye movements and self-aspects data. Although there was some correlation between the collective self-aspect and eye movements, there was no other meaningful relationship between independent and relational self-construal and the patterns of eye movements. While no existing literature examined the relationship between self-construal and the patterns of eye movements, other studies found some relationship between self-construal and neural activities (Goto et al., 2009; Hadden et al., 2002) using other scales such as Triandis' (Triandis, Bontempo, Villareal, Asai, & Lucca, 1988) and Singelis' (1994). Though it is possible that the choice of the scale may have contributed to the lack of the significant relationship between self-construal and eye movements, future research should investigate how self-construal may relate to the patterns of eye movements in scene perception.

Finally, it was rather unexpected to find the main effect of culture on the number of fixations, indicating that European-Canadian participants in general made a higher

number of gaze fixations than Asian-Canadian and Japanese participants. Although our analysis is limited to approximately defined AOIs with the entire half of the screen as the focal fish area, it is possible that European-Canadian participants followed movements of the fish closely, which may have lead them to make a large number of fixations. Conversely, Japanese and Asian-Canadians may have gathered enough information from a smaller number of fixations. Recently, Boduroglu, Shah, and Nisbett (2009) investigated the visual search strategies used by East Asian and American participants and found that Americans tend to primary focus on the small central area whereas East Asians' attention tended to cover a broader region. Therefore, it is possible that gaze fixations made by East Asian participants in the present research covered a larger area of attention than those made by European-Canadian participants. It is important for the future study to examine the possibility of cultural effect on the optimal attention window.

Conclusion

In summary, the current studies examined the magnitude of cultural effect on visual attention during dynamic animated images. People across North American and East Asian cultures similarly attended to the objects that are making salient movements during passive observation. Such an effect of stimulus saliency on visual attention can be interacted by culture, however, when viewers actively engage in the act of observation by generating verbal reports. As a French anatomist Du Laurens (1956), once referred *eyes as windows of the mind* (van Gompel et al., 2007), an examination of eye movements provides some clarifications in understanding culturally divergent cognitive tendencies.

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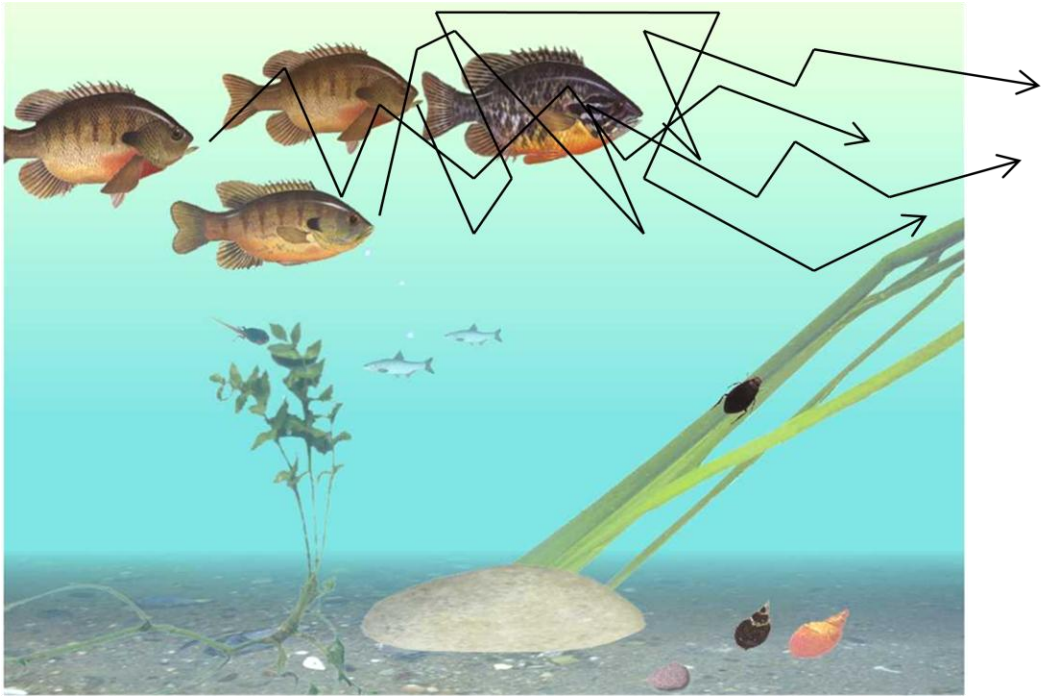

Figure 1. An example of animate vignettes used in Study 1 and 2. Arrows indicate the movements of focal fish.

Figure 2. Definition of areas of interests. Four vignettes included focal fish located in the top and background objects in the bottom such as the example. In other four vignettes, a reversed AOI mask was used to define focal fish and background areas.

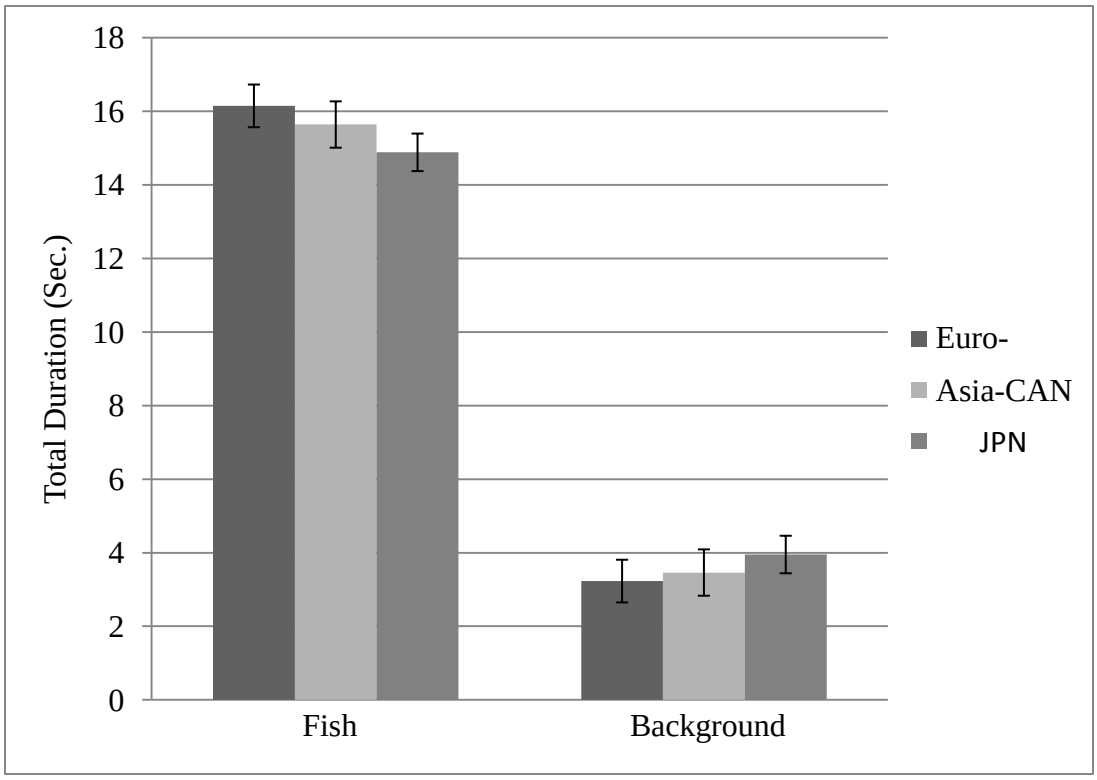

Figure 3. Mean total duration of fixations (± 1.96 SE) to focal fish and background areas across cultures (Study 1).

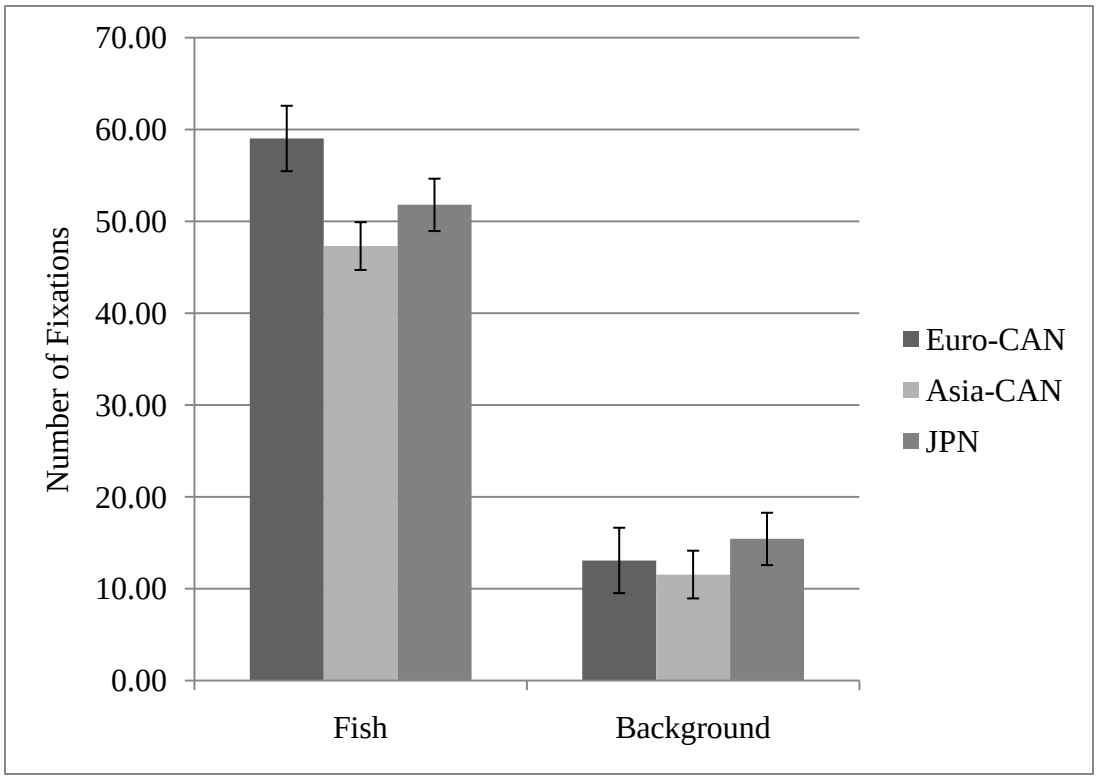

Figure 4. Mean number of fixations (± 1.96 SE) to focal fish and background areas (Study 1).

Category	Definition	Picture
Focal Fish	Large fish in different shapes and colors with salient movement e.g., bluegill	
Background Fish	Small fish in unclear shapes and colors moving slowly in the background e.g., muted carp	
Active Livings	Small animals in different colors with salient movement e.g., tadpole, turtle, frog	
Inert Livings	Background figures with little or no movement e.g., shell, mollusc	
Plants	Water vegetation in the background e.g., water grass, lotus	
Bubbles	Bubbles moving vertically, horizontally, or diagonally	
Rocks and Floor of scene	Rocks and other materials in the background	
Water Body	Background colors, current, flow	
Environment	Other background information	

Figure 5. Definition of main categories for coding verbal report.

Category		Defection
Number		Reference to the number of objects
	e.g.,	Two (fish), Five (fish)
Attribution		Reference to the color, pattern, shape, or any other physical attributions
	e.g.,	Big, small, orange, green, striped, round, spiky
Emotion		Reference to feelings or nonphysical states of the object
	e.g.,	Scary, anxious, comfortable
Behavior		Reference to movements of the object
	e.g.,	Swimming, moving, fast
Location		Reference to the location of the object
	e.g.,	At the bottom/top, on the right/left, in the foreground/background
Relation to active objects		Reference to a relationship with active objects
	e.g.,	Above (fish), near (the frog), towards (small fish)
Relation to inert objects		Reference to a relationship with inert objects
	e.g.,	On (the seaweed), under (the rock), around (the plant)
Time		Reference to time
	e.g.,	At the beginning, towards the end, for a long time
Target of the relationship		Reference to the target object of a relationship
	e.g.,	Fish, turtle, plants

Figure 6. Definition of subcategories for coding verbal report.

Table 1.

The proportion of reports for four aspects of underwater animations

Aspects	*F (p-value)*	European-Canadian *M (SD)*	Asian-Canadian *M (SD)*	Japanese *M (SD)*
Focal fish	12.61 ($p < .001$)	0.479 (.072)	0.498 (.077)	0.374 (.098)
Active objects	7.82 ($p < .001$)	0.198 (.063)	0.229 (.052)	0.164 (.053)
Inert objects	4.03 ($p < .05$)	0.108 (.037)	0.154 (.065)	0.146 (.054)
Background	4.39 ($p < .05$)	0.068 (.038)	0.08 (.051)	0.118 (.073)
n	65	18	22	26

Table 2.

The proportion of reports regarding relationships to inert and active objects

Relationship to	*F (p-value)*	European-Canadian *M (SD)*	Asian-Canadian *M (SD)*	Japanese *M (SD)*
inert objects	6.90 ($p<.01$)	0.017 (.008)	0.024(.014)	0.031 (.013)
active objects	$F<1$, *ns*	0.026 (.017)	0.026 (.195)	0.03 (.016)
N	65	18	22	26

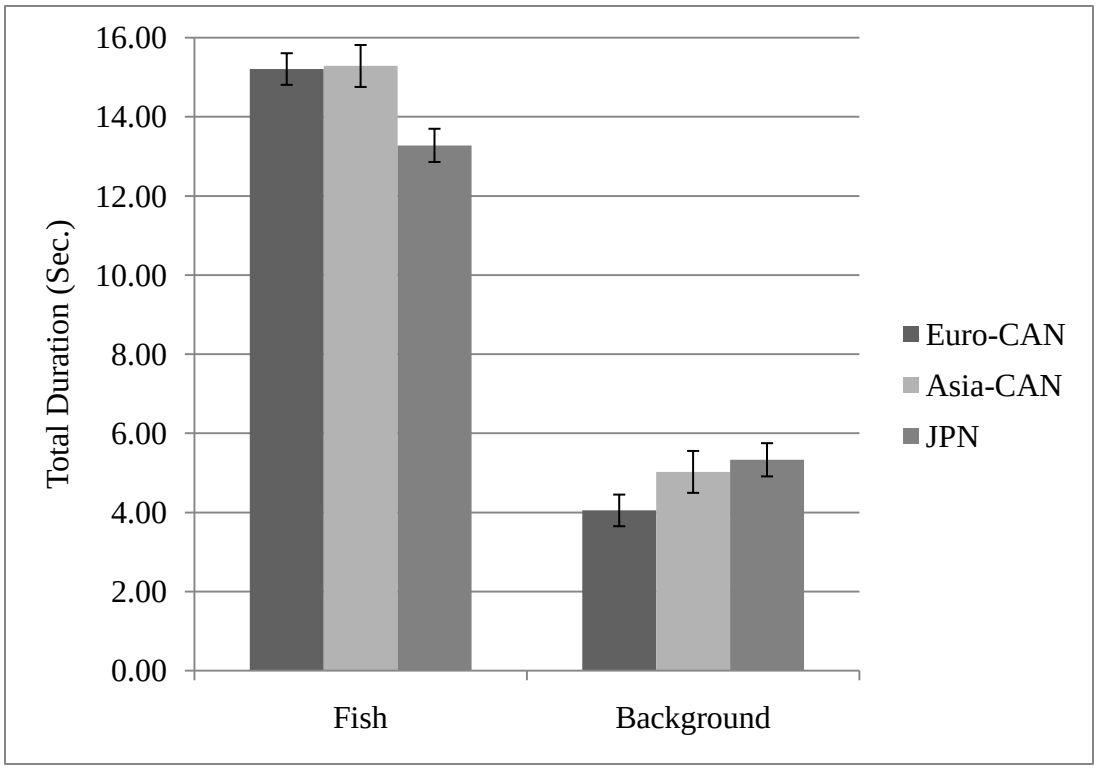

Figure 7. Mean total duration (±1.96 SE) of fixations to focal fish and background areas across cultures (Study 2).

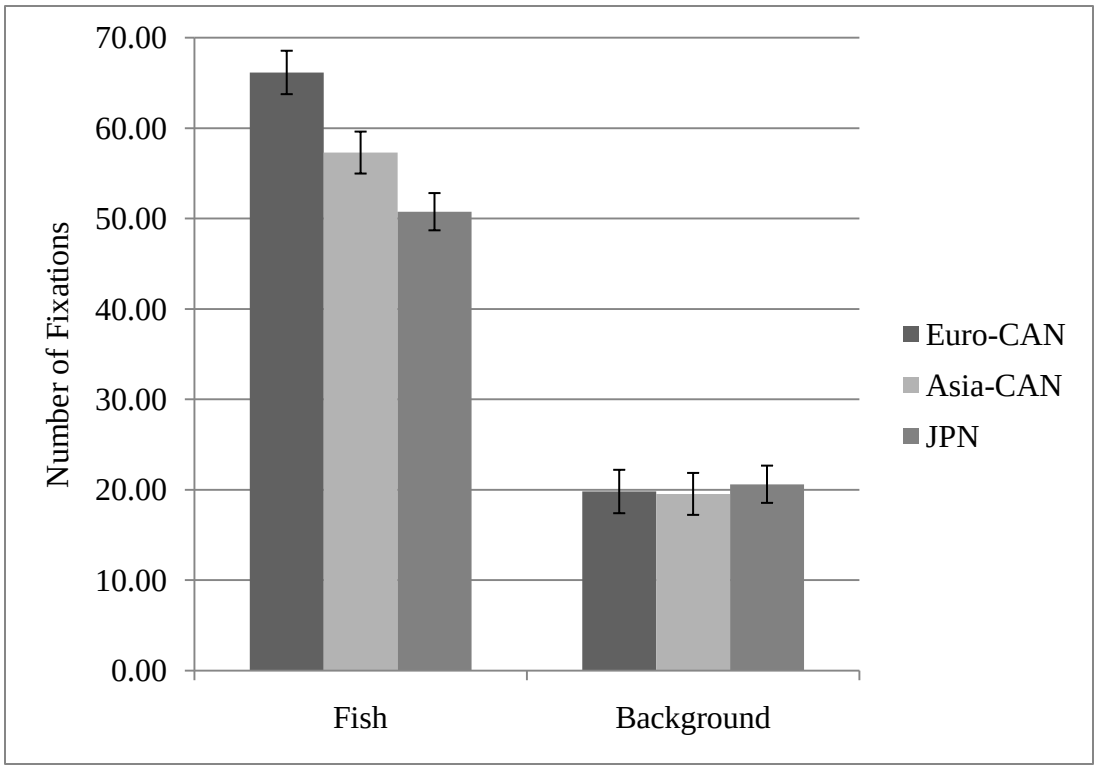

Figure 8. Mean number of fixations (±1.96 SE) to focal fish and background areas (Study 2).

Appendix. Relational, Individual, and Collective Self-Aspects Scale

Please circle the statement that describes you the most closely for each question.

I think it is most important in life to
- Have personal integrity/be true to myself.
- Have good personal relationships with people who are important to me.
- Work for causes to improve the well-being of my group.

I would teach my children
- To be caring to their friends and attentive to their needs.
- To know themselves and develop their own potential as unique individual.
- To be loyal to the group to which they belong.

I regard myself as
- A good partner and friend.
- A good member of my group.
- Someone with his or her own will, individual.

I think honor can be attained by
- Being true to myself.
- Being true to my group such as my extended family, work group, religious and social groups.
- Being true to people with whom I have personal relationships.

I would regard someone as a good employee for a company if
- He or she gets on well and works cooperatively with other colleagues.
- He or she works for the development of the organization or the work group.
- He or she takes personal responsibility for the task assigned.

The most satisfying activity for me is
- Doing something for my group (e.g., my school, church, club, neighborhood, and community.)
- Doing something for myself.
- Doing something for someone who is important to me.

When faced with an important personal decision to make,
- I talk to my family and relatives.
- I talk with my partner or best friend.
- I ask myself what I really want to do most.

I would feel proud if
- I was [raised in the newspaper for what I have done.
- My close friend was praised in the newspaper for what he or she has done.
- A group to which I belong was praised in the newspaper for what they have done.

When I attend a musical concert

- I feel enjoyment if my company (partner, friend, guest) also enjoy it.
- I feel that enjoying music is a very personal experience.
- I feel good to be part of the group.
-

I am most concerned about

- My relationship with myself.
- My relationship with my group.
- My relationship with a specific person.