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EAST-WEST CULTURAL DIFFERENCES IN VISUAL ATTENTION TASKS: IDENTIFYING MULTIPLE MECHANISMS AND DEVELOPING A PREDICTIVE MODEL

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EAST-WEST CULTURAL DIFFERENCES IN VISUAL ATTENTION TASKS:
IDENTIFYING MULTIPLE MECHANISMS AND
DEVELOPING A PREDICTIVE MODEL

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Abstract

Past research has identified East-West differences in visual attention associated with holistic versus analytic perception and reasoning strategies (Nisbett et al., 2001; Boduroglu et al., 2009). These cross-cultural differences might stem from several different mechanisms, which may include: interference suppression, response inhibition, attention to detail vs. object configuration, stimulus centrality vs. eccentricity, number of visual distractors (e.g., display set size or clutter), and others.

Although research has shown East-West differences, the results sometimes appear inconsistent with each other, or they lack clear predictions from underlying theories. For example, evidence of a preference for cluttered displays (Wang et al., 2012), evidence for being vulnerable to peripheral distractors (Masuda et al., 2008a), as well as evidence for greater sensitivity to distraction by global information (McKone et al., 2010) are all taken as evidence for the same cultural difference, even if they may be inconsistent with one another (i.e., Easterners prefer displays that are likely to lead to more distraction).

This dissertation is comprised of three related efforts: (1) two empirical research studies using multiple visual attentional tasks intended to identify East-West cultural differences in visual attention, (2) identification of the five cultural mechanisms, which are derived from previous cross-cultural studies on general philosophy, visual attention, and bilingualism, aimed at constructing a basis for hypotheses testing, and (3) a computational predictive modeling effort attempting to produce best classification and derive minimal predictors using machine learning schema, along with cross-validating empirical task results.

Results reveal inconsistent support for many possible explanations of East-West differences (including bilingual effects, general attentional differences, visual centrality vs. eccentricity) with one explanation finding support in several tasks (detail vs. object configuration). This conclusion is most strongly supported by a global-local interference task (Navon, 1977; McKone et al., 2010) in both experiments conducted, indicating that Easterners were better able to ignore the object information and attend to the contextual detail than Westerners. This conclusion was also supported by results from the dot flicker task and the predictive model. The overall findings suggest that, instead of focusing on high-level descriptive accounts of cultural difference, future research should attempt to investigate how specific attention mechanisms and strategies may differ across cultures.

Chapter 1: Introduction

1.1 Introduction

Past research has identified East-West differences in visual attention associated with a high level philosophical perspective: holistic versus analytic style. For example, research reveals that Easterners are more context-oriented focusing on contextual detail and relationships in perception of surroundings and conversely, Westerners are more object-oriented, focusing on salient, unique objects (Masuda & Nisbett, 2006; McKone et al., 2010). Additionally, Easterners pay more attention to group-related information and contextual detail in relation to target objects, while Westerners center their focus on salient objects, self-relevant, and category-related data (Masuda & Nisbett, 2001; Boduroglu, Shah, & Nisbett, 2009; Freeth, Sheppard, Ramachandran, & Miline, 2013). Easterners allocate attention more broadly than Westerners and can handle more complex visual information but have difficulty ignoring interference from contextual information even when asked to ignore it (Choi et al, 1999; Boduroglu et al., 2009; Wang, et al., 2012). Therefore, Easterners may tend to look into detailed, local information, while Westerners may focus on big, salient, global objects when performing a Navon-like global-local task. When asked to explain event causation, Easterners reference larger amounts of information with only marginal importance, but Westerners refer to smaller amounts of information (Choi et al., 2003).

These mentioned studies generally reaffirmed that Easterners tend to have a holistic viewpoint paying attention to relationship and detail, while Westerners possess an analytic cognition paying attention to salient elements and categorical data (Nisbett et al., 2001).

Little research has consistently tested human visual attention across a wide range of psychological, empirical tasks and typically researchers cherry-pick one or two tasks to examine the cultural difference and publish it. To overcome this problem I have created nine validated visual attention tasks in Experiment 1 and re-examined the tasks with significant cultural differences in Experiment 2 as a means of better understanding which cultural mechanisms account for differences between Easterners and Westerners.

1.2 Background of the Problem

Although research has shown East-West differences, the results sometimes appear inconsistent with each other, or they lack clear predictions from underlying theories. For example, evidence for a preference for cluttered displays (Wang et al., 2012), as well as evidence for greater sensitivity to distraction by global information (McKone et al., 2010) are both taken as evidence for the same cultural difference, even if they may be inconsistent with one another (i.e., Easterners prefer displays that are likely to lead to more distraction). Furthermore, a file-drawer problem might occur, which refers to the practice of researchers choosing to not publish papers that do not have statistically significant results or causal relationship. Thus, the general need for this study is to address the inconsistency of exploring limited tasks and narrowed underlying mechanisms as seen in past literature.

1.3 Purpose of the Study

The present study implemented two experiments: Experiment 1 employed nine visual attention tasks and Experiment 2 retested the tasks which showed statistically significant difference between cultures, as a means to obtain results with consistency and validity. This study uses Psychology Experiment Building Language (PEBL: Mueller, 2014) to implement tasks and performs quantitative data analysis and modeling using R programming language. Through this test-retest process across experiments, one goal is to identify culture-free tasks which do not show differences in statistical sensitivity tests. A second goal is to develop a predictive model, based on participants' response patterns, to predict human performance and to identify cultural groups.

1.4 Significance of the Study

The findings of this study will be beneficial for mutual understanding between Easterners and Westerners in the area of human visual attentional differences. This is especially valuable in this modern age with the rapid advancement in transportation and technology, which further enhance globalization and cultural interaction. For industry, the evidence of fundamental attentional differences between Easterners and Westerners can be applicable in the design of radar screens, video games, websites, user interfaces, and advertisement campaigns. For researchers, the study will help unveil the cultural mechanisms which explain the cross-cultural differences in human attention.

1.5 Primary Research Questions

If there are cultural differences, what might they stem from? They might come from general attentional differences, general philosophical differences, and bilingualism. These are theoretical frameworks used to develop the hypotheses to test which cultural mechanisms are responsible for cultural differences. Thus, the research questions in this study are to determine (1) which potential mechanisms are responsible for these differences; and (2) whether differences are shown consistently across tasks.

1.6 Theoretical Framework

Cross-cultural differences might stem from several different mechanisms, which may include: interference suppression, response inhibition, attention to detail vs. object configuration, stimulus centrality vs. eccentricity, number of visual distractors, and others.

These five mechanisms are the basis of the theoretical framework used to construct hypotheses testing in this study. Hypotheses 1 and 2 are driven by research on bilingualism that suggests that bilingual people are better at interference suppression and response inhibition as well as some cognitive functions, compared to monolingual people (Bialystok, Craik, & Luk, 2008; Bialystok, 2010; Esposito, et al., 2013). Hypotheses 3-5 examine general explanations of attentional differences which may account for observed East-West differences.

1.7 Hypotheses

Cultural differences could arise from a number of sources. Each potential source below is framed as a hypothesis that will be examined in greater detail within the dissertation:

- Hypothesis 1 (H1): Interference Suppression - Easterners are better at suppressing irrelevant interferences compared to Westerners.
- Hypothesis 2 (H2): Response Inhibition - Easterners are better at inhibiting

their natural, habitual responses and focusing on the responses required, compared to Westerners.

- Hypothesis 3 (H3): Detail vs. Object configuration - Easterners are better at detail configuration while Westerners are better at big, salient object configuration.
- Hypothesis 4 (H4): Centrality vs. Eccentricity - Easterners distribute attention more eccentrically with broader useful field of view, while Westerners distribute attention more narrowly, focusing on fixation location.
- Hypothesis 5 (H5): Number of Distractors - Compared to Easterners, Westerners can do a better job in dealing with a great amount of distractors.

1.8 Research Design

Experiment 1 recruited two groups to represent Easterners (66 Taiwanese college students recruited from multiple sites in Taiwan) and Westerners (38 Americans students recruited from MTU). Experiment 2 was expanded to include three groups, including 55 Americans, 40 Indians, and 41 Chinese from the same site at MTU. A Mandarin translation of the tasks and instructions was provided to participants in Taiwan.

The study uses a within-subjects design, with all participants competing the same set of tasks in the same task sequence. Experiments 1 and 2 took about 45 minutes and 60 minutes to complete, respectively.

Tasks were conducted on computers with color monitors. Participants' demographic data and response patterns, (i.e., response times [RTs] and accuracy), were collected through PEBL.

There were nine tasks in Experiment 1, including:

Global-local task: This task measured global versus local attention. It involved the identification of either smaller, detailed letters or a larger object configuration composed of smaller letters. It is popularly used to examine the existence of cross-cultural difference on global (object) versus local (detail) attention (McKone et al, 2010).

Visual search task: This task requires subjects to search for a target letter among other distractor letters. It is used to test subjects' ability to search for both popout (feature) and non-popout (conjunction) targets within displays of various set sizes (Treisman & Gelade, 1980; Wolfe, 1994).

Color-Stroop task: The Stroop task was first developed by Stroop (1935) to investigate attention and interference in terms of the "color-word interference effect" or the Stroop effect (Stroop 1935; Alansari & Baroun, 2004). This task can be used to measure subjects' abilities to suppress interference and inhibit natural responses in the incongruent condition.

Victoria Stroop task: This is one brief version of the Stroop test, which measured controlled visual information processing and the ability to override automatic processing (Stroop, 1935; Spreen & Strauss, 1998). This test requires subjects to perform color-naming. For example, naming the color of dots, neutral words, and naming the colors of color names which are printed in contrasting color inks. This can be used to test the relationship of color interference and cognitive slowing while gradually increasing the task difficulty (Troyer et al., 2006).

Number-Stroop task: Number-Stroop is another type of the Stroop tasks, created by Hernandez and her colleagues (Hernandez et al., 2010). In this task, participants are required to respond to the number of digits, which are presented using characters or numbers, such as “333“, “33” or “GGG,” to represent a congruent condition, incongruent condition, or neutral condition, respectively. This task is commonly used in examining the Stroop effect and Stroop interference in bilingual studies.

Simon interference task: This test was developed by Simon (1969) to investigate the Stimulus-Response compatibility effect that RT is shorter when the stimulus location is closer to the targeted response key. The stimulus might appear in different locations with different sizes and subjects have to decide whether its color is blue or red by responding with the right or left shift key. The task provides a measure of the stimulus-response compatibility effect with the manipulation of size and location (Yamaguchi & Proctor, 2012).

Eriksen flanker task: This test was created by Eriksen and Schultz (1979) to examine the impact of distractor interference during the visual search process. Subjects responded to the central arrow in a row of five horizontal, equal sized arrows. The four flankers are either pointing to the same or opposite direction as the central, targeted arrow (Stins et al., 2007). This task provides RT and accuracy measures of participants’ ability to inhibit responses to the flankers, at the same time focusing on the responses required.

Bivalent shape task: This test is a non-verbal, Stroop-like, simple test developed by Esposito, Baker-Ward, and Mueller (2013). It asks participants to ignore the color of the stimulus, but at the same time choose the response that is the same shape as the stimulus. It was used to measure bilingual children's ability to suppress irrelevant information in terms of interference suppression (Mueller & Esposito, 2014).

Dot flicker Task: This task was an implementation of flicker paradigm from Rensink, O'Regan and Clark's (1997 & 2000) change detection task. This PEBL task requires subjects to detect the changes in conditions of a scene, including changes in color, size, and location among 50 scattered background dots. This can be used to measure subjects' focused attention to search for a detailed change and their ability to detect changes in different display set sizes. The **Image flicker Task** was added to Experiment 2, using the same flicker paradigm, but with more natural, realistic images instead of artificial dot stimuli.

In conclusion, the first chapter provides an overview of the present study, including introduction, background, objectives, significance, primary research questions, and theoretical framework, hypotheses, and research designs of the study. A detailed discussion of previous research findings is provided in Chapter 2. Chapter 3 discusses the development of the five hypotheses, including interference suppression (H1), response inhibition (H2), detail vs. object configuration (H3), centrality vs. eccentricity (H4), and number of distractors (H5). Chapters 4 and 5 consist of the methodology, results, analysis, and future directions of Experiments 1 and 2. The development of a predictive model using machine learning techniques is included at the end of Chapter 5. Chapter 6 provides an overall discussion of the experimental results and the comparison with the modeling and the previous studies, as well as the conclusion and practical implication.

Chapter 2: Literature Review

This chapter contains a review of previous literature on cultural differences between Easterners and Westerners from several perspectives, including general cultural philosophy, such as cultural orientation (individualism vs. collectivism), mentality (analytic vs. holistic), view of self, emotions, orientation of self, and tracing of memory, as well as cultural differences in visual attentional study and bilingualism. I will first review general cultural differences between Easterners and Westerners, and then move on to empirical differences in human attention, such as cultural products, aesthetic viewpoints, and visual information processing. Finally cross-cultural study of bilingualism will also be provided in this chapter.

2.1 Differences in General Cultural Manner or Philosophy

Cultural differences between Easterners and Westerners are often spoken about by people in a general cultural manner or philosophy. People might be aware of the cross-cultural differences by referring to Western culture as individualistic (i.e., focusing on independence and self-achievement resulting in competition at the expense of the group goal-achievement) and Eastern culture as collectivist (i.e., emphasizing on interdependence and family or group goals above individual goals; Triandis, 1993; Skillman, 2000; Desai, 2007; Imada, 2012). However, there are some other perspectives which help categorize Eastern and Western cultural differences, for example holistic versus analytic, conformity versus uniqueness, interdependent versus independent social orientation, calm versus excitement response, and third-person versus first-person memory trace. These categorizes major effects based on cultural preference and they are supported by empirical data from studies based on participants' response patterns (e.g., test scores, RTs, and accuracy).

Western culture is seen as more analytic than holistic, which means that Westerners focus on and prefer to analyze salient, unique objects/elements (object-oriented) and categorical data, which can be traced back to the ancient Greek culture. (Triandis, 1989; Markus & Kitayama, 1991; Nisbett et al., 2001; Nisbett & Miyamoto, 2005; Varnum et al., 2010; Masuda et al., 2012; Choi et al., 2003). Western culture can trace back to traditional Greek philosophy which views things existing independently and focuses on analysis an object's characteristics.

Conversely, Eastern cultures originated from Buddhism, Taoism, and Confucianism which view things through their holistic nature, which means that they pay attention to contextual detail (detail-oriented) and group relationships in order to understand the whole picture. A good example of Easterners emphasizing a holistic view is the "Yin-Yang" symbol, which stands for balance and harmony by integrating the opposite and complementary forces, such as sun and moon, light and dark, male and female, which is used as healthy guideline for traditional Chinese medicine (Porkert, 1974; Chen, 2001). This symbol implies Easterners' holistic viewpoint, which emphasizes the importance of the process of paying attention to contextual detail and relationships in order to understand the whole picture and see it as a whole.

An empirical example is the fish recall task conducted by Masuda and Nisbett (2001), which investigated the above mentioned view that Westerners' attention is more analytical whereas Easterners' attention tends to be more holistic. Participants were asked to recall the fish seen in the previous round, which were situated in either the original background setting or in the novel background setting. The results show that American students could recall and recognize significantly more fish than Japanese students did when they have seen them in both no background and novel background tanks. Japanese students could recognize more fish in the original background tank than American students. This supports the conclusion that Americans possess more analytic perception than Easterners.

2.2 Differences in Social Orientation

In terms of social orientation, Western culture emphasizes on autonomy, independence, and uniqueness while Eastern culture focuses on group relationship, harmony, and conformity (Triandis 1989; Varnum et al., 2010). Therefore, social orientation among Easterners seems more interdependent and other people's comments, like criticisms or compliments, influence their interpretation of themselves (Markus & Kitayama, 1991). In a cross-cultural study between Americans and Koreans, Kim and Markus (1999) reported that magazine advertisements in Korea appeal to customers by emphasizing conformity; however, in America, people are more likely to emphasize objects and uniqueness.

A cross-cultural study (Ahmed, 1996) revealed cultural difference between Westerners (Americans) and Easterners (Indians), in direct expressions (e.g., individualistic visual postures, comparative tactics, and sexual portraits of women) and indirect expressions (e.g., collectivistic visual postures, and stereotypical portraits of women) of advertising contents. The author of the study suggested that cultural differences should be emphasized when making multinational advertising and promotional campaigns. People are exposed to a great number of advertisements every day, and this is why advertising is well accepted and regarded as a type of cultural practice and emphasis even in different countries (Gregory & Munch, 1997; Caillat & Mueller, 1996; Bakir, 2012; Han & Shavitt, 1994). The above discussion highlights the importance of understanding cultural attention differences and the impacts on our daily lives.

2.3 Differences in preference of emotional state and memory trace

Understanding peoples' cultural perspectives can be beneficial for applications in user interface design, marketing strategy, and consumer preference. Regarding preference on emotional states, Westerners prefer excitement emotions while Easterners would like to have calmer responses. Izard (1971) reported that Americans had higher preference on enjoyment-joy than people in English, German, French, Greek, Swedish, and Japanese. Tsai, Knutson, and Fung (2006) elicited subjects' preference and indicated that storybooks in America showed greater arousing activities, stronger exciting expressions, and bigger smiles than storybooks in Taiwan. Americans prefer to experience more enthusiasm, less guilt, as well as more pride than Chinese and Taiwanese (Sommers, 1984; Eid & Diener, 2001).

In regards to memory trace, Westerners tend to memorize personal experience from the first-person viewpoint, while Easterners prefer to recall their own experience using the third-person standpoint (Cohen and Gunz (2002). In their study, Canadian students and Asian students recalled ten different instances, such as an embarrassing memory or talking with friends. The results showed that Asian students regarded themselves as observers while retrieving their own events (third-person perspective), but Canadian students would recall their memory from their own viewpoints (first-person perspective).

2.4 Differences in Aesthetic Preference

Some studies explored cultural products and aesthetic preference and found that there are observable, habitual, cultural differences which are aligned with Western and Eastern traditions (Kim & Markus, 1999; Imada, & Yussen, 2012; Markus et al., 2006; Tsai et al., 2006). Masuda, Gonzalez, Kwan, and Nisbett (2008b) conducted three studies to investigate cultural variations in photography and art. The first study used archival data of Western and Eastern paintings from multiple representative museums, including the Metropolitan Museum, the Tokyo National Museum, the National Museum of Seoul, Korea, as well as the National Palace Museum of Taipei, Taiwan. The study included paintings of landscapes, portraits, and people in a scene.

They found that traditionally Easterner art has context-inclusive styles, while traditional Western art contains object-focused styles. These aesthetic characteristics are followed by contemporary art in each culture. Eastern paintings drew horizon lines in a higher place than Western paintings, implying that Easterners prefer to utilize more space in paintings than Westerners, and the models' sizes were smaller in Eastern paintings than Western paintings. In the second study, the authors examined the drawing of landscape pictures and the photographing of portraits between Americans and East Asian international students from Taiwan, Korea, Japan, and China. They found that East Asian international students drew landscapes with more expanded horizons and additional objects, compared to their American counterparts. The authors further explored aesthetic preferences between Americans and Japanese while taking portrait photographs. The results indicate that Easterners prefer to take pictures with wider background contexts, whereas Americans favor seeing bigger faces in the pictures. From these cultural values and aesthetic preferences of advertising and photo taking, it reveals that Easterners prefer to pay attention to busier contextual information while Westerners prefer to focus on the targeted, salient objects with less background interference. This is aligned with the theme of this present research that cultural differences tie to human's preference to focus on or suppress information.

2.5 Differences in Visual Attention: Contextual Interference

Easterners are more susceptible to contextual interference than Westerners (Masuda & Nisbett, 2006; McKone et al., 2010; Freeth et al., 2013). In a facial emotion judgment study, Ito, Masuda, and Li (2013) measured whether subjects would be influenced by other irrelevant faces on the screen, while judging the intensity of the emotion of the targeted faces. The results show that contextual information, happy or sad faces, would influence Easterners' (Japanese students) assessment of the intensity of target emotions, but not influence Westerners' (Canadian students) judgment. Similar results (Masuda, Wang, Ishii, & Ito, 2012) were obtained using subjects' eye-movement patterns to measure the emotional context effect among multiple racial groups.

Supporting evidence from the patterns of eye-movement conducted by Masuda et al. (2008a) shows that Easterners' attention is easier to distract by contextual information. In their experiment, while participants were asked to focus their attention to the central circle and disregard four interference circles, Easterners tried to pay attention to the target but failed to only focus on the target circle. Easterners' quantity of fixation and deviation of eye-movement from center within the 30 second period were both significantly larger compared to Western counterparts.

Another example of contextual interference was found in Petrova, Wentura, and Fu's (2013) study. They implemented a target tracking task and recorded eye-tracking data from German and Chinese participants, where a distractor might appear from either of the four corners. They found that Chinese had eye movements toward detailed, irrelevant information, compared with German participants who were able to maintain their focus on the target. They claimed that cultural background is a validated, modulating factor in human attention processing as shown by saccade trajectories.

2.6 Differences in Visual Attention: the Number of Distractors

Another perspective worth considering is how the number of distractors impact information search by two distinct cultures (Choi et al., 2003; Wang et al., 2012). Wang, Masuda, and Ito (2012) investigated peoples' preferred amount of information on their own cultural products, including posters on a conference, and portal pages in government and university websites between East Asian and North American students. The results suggest that, compared to Americans, Asians prefer information-rich products. Asians prefer a larger amount of information (1186.86 words, compared to Americans' 901.89 words) in viewing multiple conference posters; Asians favor more links, words, and bytes in looking at portal pages in university and government websites. Specifically, the words are on average 1000.23 and 311.72, and the recommended links are 64.72 and 55.02 in university pages in East Asia and North American, respectively.

Wang et al., (2012) further developed an "information search task on mock webpages" to measure the information processing speed between North Americans and East Asians. The results indicate that East Asians were faster than North Americans in searching information on longer webpages, but there was no difference on shorter webpages. This implies that Easterners are better at suppressing information and disregarding distractors than Westerners when the task has a sufficient level of complexity in a meaningful context. This finding contrasts with the results on Masuda et al.'s (2008a) and Petrova et al.'s (2013) studies that Easternes could not suppress irrelevant distractors.

2.7 Differences in Visual Attention: Size of Display

Previous research suggests that Easterners allocate attention more broadly than Westerners (Choi et al, 1999; Boduroglu et al., 2009; Wang et al., 2012). For example, a study conducted by Boduroglu, Shah, and Nisbett (2009) investigated the "cultural differences in allocation of attention in visual information process" between Asians and Americans. The results show that, with five stimuli on the screen, Asians could better detect the difference between color-change and no-color change trials when the screen is a larger, expanded size, whereas Americans could better perform color change detection tasks while the screen is a smaller, shrunken size and the stimulus size stayed the same.

Millar et al. (2013) conducted a Flanker task manipulating two types of gap lengths to investigate useful field of view between Easterners and Westerners. In their study, Turks represented Easterners and Americans represented Westerners. There were two different gap lengths between the target and flankers, including 0.5° of visual angle in the near condition and 1.5° of visual angle in the far condition. The results showed that there was no RT difference between the two cultures under these conditions; however, there was a significant accuracy difference in the incongruent condition when the gaps were shorter in 0.5^0. This finding was inconsistent with the results on Boduroglu et al.'s (2009) study that Easterners were able to perform better than Westerners when the size of display was enlarged.

2.8 Differences in Visual Attention: Global vs. Local Advantage

Research has generally suggested that global versus local visual information processing might be influenced by individual, affective, developmental, situational, and cultural differences. However, there is no universal consensus on which culture, either Easterners or Westerners, possess a global or local advantage/bias.

Some research suggests that Easterners have a global advantage. For example, global advantage is defined as being able to identify a larger alphabetic letter constructed by smaller alphabetic letters faster than others. McKone et al. (2010) conducted experiments to investigate global versus local allocation of attention between East Asians and Caucasian Australians. The results of their first experiment showed that East Asians were more accurate and faster in the global condition compared to Caucasian Australians, implying that Easterners had global advantage compared to Westerners.

In the second experiment, McKone et al. (2010) expanded their study by adding another group, which was the second generation of East Asian immigrant families, Asian-Australians. The results suggested that the second generation of East Asians raised and educated in Australia, unlike the first generation, had no global advantage compared to Caucasian Australians. In their experiments, gender had no effects on allocation of attention. They concluded that race/culture cannot be ignored while investigating visual attention with different spatial stimuli.

However, there is also research that does not support the idea of global advantage in Easterners. For example, Caparos, Ahmed, Bremner, de Fockert, Linnell, & Davidoff (2012) found that there was no East-West cultural difference on global vs. local visual processing. Caparos et al. (2012) used Novan-like symbols as stimuli (e.g., X or □) to investigate subjects' responses on whether a test trial more closely resembled the global symbol or the local symbol of the previous shown trial (in terms of global bias or local bias) and used correct ratios as the dependent factor. Their main finding was there was a local bias in a remote Himba tribe, but members of that tribe that have been urbanized, as well as British and Japanese people, possess a much more global advantage. Their study suggests that natural environment is a main issue in terms of local bias. Nevertheless, their study also revealed that there was no cultural difference between British and Japanese in global/local visual attentional processing using accuracy as a measure in their-own-designed global-local task (RTs were not investigated in their task, though), which was inconsistent with a hypothesized East-West difference.

It is critical to clarify the difference between global information processing and holistic information processing. While holistic processing works on "processing of relationships between components and/or contexts" (Miyamoto, 2013), global processing means “processing of properties at a hierarchically higher (global) level of structure than properties at a hierarchically lower (local) level” (Miyamoto, 2013; Navon, 1977). Thus, Asian’s holistic processing, on one hand, can be related to a global processing when contextual information resides on a higher, global level. On the other hand, holistic processing sometimes can be interconnected with a local processing when contextual, detailed information resides on a lower, local level of the structure (Miyamoto, 2013). This is to say, a global advantage can be found for Easterners if contextual information resides in the global level of a structure and vice versa for a local advantage for Easterners when contextual information is located at the local level. A further discussion on the existence and allocation of contextual information can be found in Chapter 4.2.1.3.

2.9 Differences in Change Detection

Previous research on change detection supports the idea that Westerners tend to pay more attention to focal, salient objects, and emphasize analysis of categorical data and elements/attributes, while Easterners distribute attention to broader, contextual information and the relationships among the objects (Masuda & Nisbett, 2001; Nisbett & Norenzayan, 2002; Nisbett & Masuda, 2003 Chua, Boland, & Nisbett, 2005).

For instance, Masuda and Nisbett (2001) asked Americans and Japanese to watch, on a computer, underwater scenes and describe the contents. The results showed that Americans were more accurate when the original scenes had been changed to novel scenes; however, Japanese explained more about the context and relationship (i.e., fish, rocks, water’s color, and nonmoving items) and were more accurate when the scenes remained in the original settings than in the novel settings. This indicates that Americans’ attention is more object-focused while Japanese's attention is more contextual-related and the manipulation of the contextual information has more impact on Japanese than Americans.

However, other research is inconsistent with this finding. Terziyan and Gilkey (2010) conducted a change blindness test with Turkish and American participants to examine whether Turks' attention is more similar to Easterners or Westerners. The authors failed to find any significant difference between the Turks and Americans. Turks were more like Westerners having more focused, object-oriented, analytic attention than East Asians.

2.10 Bilingual Advantage

Previous literature in developmental psychology suggests that children with a bilingual advantage are better at performing interference suppression and/or response inhibition than monolingual children in visual attentional tasks such as the global-local task (Bialystok, 2010), the card sorting task (Bialystok & Martin, 2004; Bialystok, 1999), the Attentional Networks Test (Rueda et al., 2004; Mezzacappa, 2004; Carlson & Meltzoff, 2008; Costa, Hernández, & Sebastián-Gallés, 2008), the Eriksen Flanker Task (Martin-Rhee & Bialystok, 2008, Yang, Yang, & Lust, 2011), the Simon task (Bialystok, et al., 2004), the Stroop task (Bialystok, Craik, & Luk, 2008), and the bivalent shape task (Esposito, et al., 2013).

For example, in Yang et al.'s (2011) study, they conducted a flanker task to examine whether the bilingual effects of executive attention and cognitive functioning exist in young children, including groups of English monolinguals, U.S. Korean monolinguals, ROK Korean monolinguals, and Korean-English bilinguals. The task used fish as stimuli for both the target and the flankers. The results showed a flanker effect (RTs were faster in the congruent trials than in the incongruent trials) and that bilingual children were more accurate and faster than the other three monolingual groups. However, this bilingual advantage may disappear when people grow older, and it may be overemphasized due to file drawer problem (de Bruin, Treccani, & Della Sala, 2015).

2.11 Conclusion

Previous literature supports cultural differences in human visual attention, including that Westerners are more object-oriented, locally-focused, analytic, independent, and individualistic, whereas Easterners are more context-oriented, globally-focused, holistic, interdependent, and collectivistic. This literature helps us narrow down the important mechanisms to look into and find the relevant tests to implement in order to measure the cross-cultural attentional differences between Westerners and Easterners. As mentioned, past literature did not test human visual attention consistently across a wide range of attentional tasks; instead, most studies included only one or two tasks to assess the cultural differences. To investigate these differences more broadly, nine classic validated attentional tasks were selected in Experiment 1. Four were reexamined and one more task was added in Experiment 2 to further investigate the potential cultural mechanisms underlining attentional differences between Westerners and Easterners.

Chapter 3: Rationale & Hypotheses

Research in cultural difference in the area of human visual attention has not been methodologically consistent and has never included a wide range of attentional tasks. If there are East-West cultural differences, what might they stem from? There are some approaches that can be used to identify cultural mechanisms. For example, general attentional differences, general philosophical differences, and bilingualism provide possible explanations for the observed cultural differences. The following mechanisms may account for Eastern and Western differences.

- Interference Suppression: the ability to suppress irrelevant interference on a display.
- Response Inhibition: the ability to inhibit natural, habitual responses and focus on the stimuli to which subjects were asked to react.
- Detail vs. Object Configuration: the ability to deploy visual attention to contextual detail or bigger object configuration.
- Centrality vs. Eccentricity: the ability to allocate attention more narrowly, or to distribute attention more broadly, perhaps reflecting a larger useful field of view.
- Visual Distractors: the ability to deal with the tasks that are designed to involve great amount of visual distractors or clutter, and others.

Five hypotheses are developed based on past research findings on these cultural mechanisms.

There are two types of cognitive control that may be involved in one's ability to avoid task interference, including interference suppression and response inhibition (Bunge et al., 2002; Esposito et al., 2013). Interference suppression is defined as being able to ignore salient objects while required to distribute attention to less salient information and to suppress irrelevant information. Response inhibition refers to the ability to make a less favored or less dominant response, at the same time inhibiting a more natural, habitual, and dominant response. The multiple Stroop tasks, the Simon task, the flanker task, and the BST are used to measure both interference suppression and response inhibition. These two types of abilities to control interferences are referenced in Hypotheses 1 and 2.

I expect that Easterners will be better at interference suppression (H1) and response inhibition (H2), will focus more on details rather than bigger object configurations (H3), will paying more attention to eccentricity (H4), and will be more easily distracted by larger numbers of distractors (H5), compared to Westerners. Support for each of these hypotheses is listed below

3.1 Hypothesis 1: Interference Suppression

Most of the attentional tasks selected in the present study involve congruent and incongruent conditions, which can be used to test H1. RT differences between these two conditions provide a measure of interference cost (i.e., RTs in incongruent conditions minus RTs in congruent conditions). In the global-local task, an example of the congruent condition is a big object H made out of small Hs or a big object S made out of small Ss. The incongruent condition may include a big object H made out of small Ss or a big object S constructed by small Hs. In the Eriksen flanker task the flankers point to the same direction as the central arrow in the congruent condition, and the flankers point to the opposite direction of the central arrow in the incongruent condition. In both tasks, lower interference cost represents the ability to perform interference suppression. Previous research on bilingualism suggests that bilingual people are better at interference suppression and response inhibition (Bialystok, 1999; Rueda et al., 2004; Mezzacappa, 2004; Bialystok & Martin, 2004; Bialystok, et al., 2004; Carlson & Meltzoff, 2008; Costa et al., 2008; Martin-Rhee & Bialystok, 2008; Bialystok, Craik, & Luk, 2008; Bialystok, 2010; Esposito, et al., 2013). Thus, bilingualism may drive the cultural difference between Easterners and Westerners and can be used to test H1.

The holistic vs. analytic viewpoint may also support the building of H1. Research on attention suggests that Westerners are more objected-oriented, analytical viewers with a focus on salient, big, focal unique objects while Easterners are more contextual-oriented, holistic viewers with a focus on group relationships and contextual details in order to form a clear picture of the whole story (Masuda & Nisbett, 2006; McKone et al., 2010). These above-mentioned attributes lead the study to hypothesize that Easterners are better at suppressing interference and directing attention to the holistic, contextual relationships, leading to lower interference cost and faster response times compared to Westerners in the global-local task ad the flanker task. Thus, H1 predicts that Easterners will perform better at suppressing irrelevant information compared to Westerners, which can be investigated using the response patterns, including RTs and accuracy, in the incongruent condition to compare with those in the congruent condition. I expect that both cultures will show congruency effects, but Easterners will show a lower interference cost (incongruent – congruent).

3.2 Hypothesis 2: Response Inhibition

Hypothesis 2, which tests participants' ability to inhibit their habitual action against a target stimulus, can be assessed in the multiple Stroop tasks, the Simon task, the flanker task, and the BST. These tasks require participants to inhibit their habitual, natural responses and focus on the required responses simultaneously. For example, in the flanker task, participants are presented with a series of arrows and they must respond based on the central arrow, simultaneously ignoring the other four arrows, which point to the same direction as each other. This kind of incongruent condition can be used to investigate response inhibition. Previous literature in developmental psychology suggests that children with a bilingual advantage are better at performing response inhibition than monolingual children in visual attentional tasks such as the global-local task (Bialystok, 2010), the card sorting task (Bialystok & Martin, 2004; Bialystok, 1999), the attentional networks test (Rueda et al., 2004; Mezzacappa, 2004; Carlson & Meltzoff, 2008; Costa et al., 2008), Eriksen Flanker Task (Martin-Rhee & Bialystok, 2008), Simon task (Bialystok, et al., 2004), and Stroop task (Bialystok, Craik, & Luk, 2008).

Taken together, these mentioned studies motivates H2: Easterners (represented by bilingual, international students at MTU) will be better at response inhibition, compared to Westerners (represented by American students). To test this hypothesis, I will examine participants' response patterns by comparing the incongruent condition with the neutral conditions. I hypothesize that both Easterners and Westerners will show a congruency effect, but Easterners will show a lower cost of response inhibition (incongruent –

neutral).

3.3 Hypothesis 3: Detail vs. Object Configuration

Research has suggested that individuals with a focus on accomplishment, advancement, and promotion tend to associate with global information processing, while persons centered on prevention, responsibilities, safety, vigilance, and security do more to local, detailed information processing (Förster & Higgins, 2005). In Förster and Higgins's study (2005), they first identified subjects with either promotion focus or prevention focus, based on the test results of the measure of "strength of guide" developed by Higgins, Shah, and Friedman (1997). Then the authors implemented a global-local task and the results indicated that participants with promotion focus had a global advantage, while those with prevention focus had local advantage. This aligns with the general concept described in Chapter 2.1: *Differences in General Cultural Manner or Philosophy* that Western culture is more individualistic (i.e., focusing on independence and self-achievement resulting in competition at the expense of the group goal-achievement) and Eastern culture is more collectivist (i.e., emphasizing interdependence and family or group responsibilities: Triandis, 1993; Skillman, 2000; Desai, 2007; Imada, 2012). Western culture is regarded as individualistic with the focus of self-achievement, which can map onto Förster & Higgins's (2005) promotion focus with better attending to big, global object configuration in the global-local task.

Some attentional research on cross-cultural differences supports the above philosophy. For example, previous research indicates that Westerners center their focus on salient objects, self-relevant information, and category-related data, while Easterners pay more attention to group-related information, relationships, contextual details in surrounding (Masuda & Nisbett, 2001; Boduroglu, et al., 2009; Freeth et al., 2013).

Therefore, Hypothesis 3 predicts that Westerners will direct attention to salient, big object configuration; in contrast, Easterners will pay attention to more detailed context information and relationships. The global-local task (i.e., using the global pure letters to measure the object configuration and the local mix letters minus the global mix letters to measure the detail configuration) and the change detection/flicker tasks (i.e., asking participants to find a changed stimulus, happened in either background or foreground scenes, which can be used to assess detail configuration) will test this hypothesis. I expect that Easterners will pay attention to the detail level of a structure and show a local advantage while Westerners will focus attention to the big, salient object and show a global advantage in the global local task. In the flicker tasks, I expect that Easterners will be better at background changes while Westerners will be better at foreground, salient changes and show stronger salient effect than Easterners.

3.4 Hypothesis 4: Centrality vs. Eccentricity

Research on cross-cultural differences of human visual attention has suggested that Westerners are more object-oriented. In contrast, Easterners are more context-oriented in their perception of their surroundings (Masuda & Nisbett, 2006; McKone et al., 2010). In addition, previous research on attention suggests that Easterners allocate attention more broadly and pay attention to more complex, contextual stimuli than Westerners (Choi et al, 1999; Boduroglu et al., 2009; Wang et al., 2012). Thus, H4, Eccentricity vs. Centrality assumes that Westerners allocate attention more narrowly, while Easterners distribute attention more broadly, perhaps reflecting a larger useful field of view.

There are several potential mechanisms which may account for the individual differences in the visual attention or detection in centrally vs. peripherally located objects. Most of these mechanisms fall under two major categories: retinal-mapped field-of-view (also useful field of view; see Ball, et al., 1988), and environmentally-mapped peripheral breadth of attention (Boff, Kaufman, & Thomas, 1986). The useful field of view, is defined as the visual field from which a person can acquire information (for example, a target's location or identity) at a single glance/fixation (Ball et al., 1988; Cosman, et al., 2012). Thus, a wider breadth of attention may suggest a person has a larger useful field of view.

Each of these could be influenced by a number of factors that may correlate with culture-of-origin, including: 1. genetic/physiological differences in the visual system, including differences in visual acuity, density of photoreceptors, or need to correct vision (Boff et al., 1986); 2. preferences or resources for correcting vision, including preferred degree of correction; size of corrective lenses, and use of contact lenses or surgery for vision correction; and 3. experience and habit in attending to different parts of the visual field, either because of differences in the natural or human environment; 4. personality differences associated with ego-centric versus allocentric perspectives (a distinction used both in cultural personality and spatial representation). In many cases either primary mechanism would produce similar or identical results in a given paradigm, so these above mentioned mechanisms might not be distinguishable.

Here I would only investigate the effects of breadth of attention or useful field of view in the global-local task and the Eriksen Flanker task. The eccentricity effects in these tasks can be measured using target and distractor location, although these tasks may not be able to distinguish between the two possibilities (retinal- or environmentally-mapped field-of-view). For example, if the gap lengths in the Eriksen Flanker task or the eccentricity of the target location in the global-local task impacts performance, this would be consistent with either explanation. If performance is impacted differentially across culture, this may indicate a potential explanation for cultural differences.

In addition, since people have generally been seen with global advantage and, in the global-local task, RTs were short (roughly 400 to 500 milliseconds in the global condition) with a response time that is essentially flat with eccentricity, it is the evidence that global information processing can be done in a single fixation/glance to the target, and this would be a possible measure for H4. Here, eccentricity effects can be assessed by target locations and calculated as the RTs and accuracy for eccentric distributed trials minus the central located trials. The global-local task, the Simon task, the Eriksen Flanker task, and the Dot flicker task in this task battery can be used to investigate eccentricity effects as these tasks record the positions of the stimuli/targets. I expect that Easterners will show an effect of wider useful field of view than Westerners (eccentric – central trials)

3.5 Hypothesis 5: Number of Distractors

Literature indicates that Easterners have difficulty ignoring interference from contextual information (Choi et al, 1999; Boduroglu et al., 2009; Wang, et al., 2012).

Pashler (1987) suggests that the intrinsic task difficulty is due to the similarity between the target(s) and distractors and the number of distractors in a task trial. A large number of distractors refers to more than 16 distractors presented simultaneously on the screen; on the other hand, in the tasks of smaller number of distractors, there are between 1 and 16 distractors (Pashler, 1987; Huang & Pashler, 2005).

Therefore, Hypothesis 5 tests whether Easterners' attention is more easily distracted by the contextual environment, and if Easterners have more difficulty focusing their attention compared to Americans when performing an attentional task with a greater number of distractors, when the target(s) and the distractors are similar (or even dissimilar), such as the global-local task, the visual search task, and the dot flicker task. Hypothesis 5 can be tested by calculating the RT and accuracy differences between the condition with a greater amount of distractors and the condition with a smaller amount of distractors in the visual search task and the dot flicker task, as well as by examining the relationship between clutter (i.e., measuring the file sizes of the images) and RTs in the image flicker task.

In summary, this study tests the hypotheses that

- H1: Interference Suppression - Easterners are better at suppressing irrelevant interferences compared to Westerners.
- H2: Response Inhibition - Easterners are better at inhibiting their natural, habitual responses and focusing on the responses required, compared to Westerners.
- H3: Detail vs. Object configuration - Easterners are better at detail

configuration while Westerners are better at big, salient object configuration.

- H4: Centrality vs. Eccentricity - Easterners distribute attention more eccentrically with wider useful field of view, while Westerners distribute attention more narrowly.
- H5: Number of Distractors - Compared to Easterners, Westerners can do a better job in dealing with a great amount of distractors.

A summary of the tasks and the hypotheses used to test each task are included in Table 1.

Table 1: The hypotheses testing in nine attentional tasks

Tasks/ Hypotheses	Interference Suppression (H1)	Response Inhibition (H2)	Detail vs. Object Configuration (H3)	Centrality vs. Eccentricity (H4)	Number of Distractors (H5)
Global-Local	✓	✓	✓		
Visual Search					✓
Victoria-Stroop	✓	✓			
Color-Stroop	✓	✓			
Number-Stroop	✓	✓			
Simon	✓	✓		✓	
BST	✓	✓			
Erikson Flanker	✓	✓		✓	
Dot Flicker			✓	✓	✓
Image Flicker			✓		✓

Chapter 4: Experiment 1

4.1 General Method

This section discusses the general method used for the tasks in Experiment 1. The discussion include the introduction and background theory, previous cross-cultural studies using the tasks, and the methods and results for each task. Tasks were selected from the PEBL test battery. Finally, a future plan for each task is also discussed.

4.1.1 Participants

Thirty-eight American students (mean age = 20.45, male = 21, female = 17), representing the Westerners, were recruited from Michigan Technological University (MTU) via the SONA system. They participated in this study to fulfill course requirements from several courses, such as Introduction to Psychology and Behavior Psychology, in September, 2014. Sixty-six Taiwanese students (mean age = 20.68, male = 19, female = 47), representing the Easterners, were recruited from multiple sites in Taiwan, such as University of Taipei and National Chiao Tung University in May and June, 2014. They voluntarily participated in Experiment 1 without any compensation. Participants in Taiwan were recruited through the help of the faculty and class leaders of the schools. Participants reported normal color vision and normal to corrected vision before they started the tasks. They did not have previous experience with these kinds of psychological experiments. Two American participants were left-handed.

I used the "pwr" package in R to calculate the Cohen (1988) effect size. With 66 (n_1) and 38 (n_2) participants in each group, the effect size (d) is .5452, a medium effect size. In addition, sensitivity tests (i.e., Welch two-sample t tests) are used to compare group performance in each task and can be found in Appendix A. According to the t-test power calculation in R, the power of t test is 0.7628 ($n_1 = 66$, $n_2 = 38$, $d = 0.55$, and significance level = 0.05).

It is worth noticing that gender had no impact on the results in this study. For example, in the global-local task, I tested the absolute RT variances between male and female in both groups, and the results showed that there were no gender differences in either the American group ($F(20,16) = 0.7883$, $p = 0.6074$) or the Taiwanese group ($F(19,47) = 1.1814$, $p = 0.6322$).

4.1.2 Design and Procedure

The experiment used a within-subjects design where all the participants in these two groups ran through the nine tasks in the same task sequence. The study also employed repeated measures as most of the trial conditions had multiple replicates in the tasks. The use of fixed order to run tasks maintained the same fatigue for each task in each group. The participants were separated into two experimental groups based on nationality. It took about 45 minutes to complete the entire task battery. The participants were informed to respond as soon as possible in a trial.

The demographic variables include gender, age, race, and educational level. The dependent variables are RTs and accuracy. The specific independent variables for each task will be discussed in the next chapter.

During the study, participants were required to turn off their cellphones and to sign the consent form in their native language, before they took part in the tasks. Both the English and Chinese consent forms were approved by the IRB at Michigan Tech in April, 2014. The instructions of how to perform the tasks and practice trials were presented to participants before the initiating of the test trials in each task.

4.1.3 Apparatus, Materials, and Stimuli

All of the tasks were conducted on computers with color monitors. Participants in the US completed the study using Dell Precision T1600 and Planar PX2230MW monitors with a screen size of 21.5 inches. In the Taiwanese sites, the desktop models are either Asus T14D766E7402E5 or Dell OptiPLEX745 both with ASUS VW193DG 19-inch color screens. Participants were asked to maintain one arm in viewing distance from their heads to the screens in front of them (approximately 20 inches). Participants' demographic data and response patterns, including response times and accuracy, were collected through PEBL (Mueller, 2014). PEBL is a free, open source, psychological programming language with more than 100 prebuilt tests which can be operated in three main operating systems, namely Linux, Mac OS, and Microsoft Windows.

The tasks in this experiment used pre-built PEBL 0.14 version with some modification. PEBL has a platform for developing and modifying a test (Mueller, 2014). I translated the English introduction and guidance into a Mandarin version by either providing the translation to the PEBL scripts or inserting pictures of Mandarin instructions into the codes. I did the Chinese translation and had an independent proficient bilingual speaker double check the equivalency of the two versions. The test translation aimed at providing a Mandarin version test for Taiwanese participants which was comparable and equivalent to the original English version for Americans.

4.2 Nine Visual Attentional Tasks & Results

In this section, I discuss the nine attentional tasks implemented in Experiment 1, including the introduction and background theory, previous relevant cross-cultural studies, design and procedure of the tasks, results, and analyses for each task (see Appendix A for detailed group comparisons between Americans and Taiwanese). These tasks were selected from the PEBL test battery. Finally, a future direction section motivating the development of Experiment 2 is provided at the end of each section.

4.2.1 Task 1: Global-Local Task

There are various versions of stimuli for the global-local task, such as the traditional Navon letters (1977 & 1981), hierarchical abstract shapes (Kimchi & Palmer, 1982), as well as objects such as faces (Fink et al., 1997; Dale & Arnell, 2013). The present global-local task in the PEBL battery is modeled from Navon's global-local task (Mueller, 2014). Navon's task uses smaller (local) letters to construct a larger (global) letter configuration, known as Navon figures or Navon shapes (e.g., H and S). Typically, humans process visual information hierarchically, initially from a global object configuration and moving towards more detailed, fine-representations in terms of global precedence. Accordingly, the response times are faster and accuracy is higher for responding to global figures versus local figures.

4.2.1.1 Prior Literature

McKone et al.'s (2010) study suggests that Easterners have a global advantage compared to Westerners in a Navon-like global-local task, which was designed with eight to twelve identical, local letters to construct a global, big letter image. It was a Go/No-Go task for which in the global conditions, subjects were asked to respond “present” to indicate the presence of a bigger configuration letter (e.g., big T and H made out of smaller T or H letters), and for which in the local condition, they were required to respond to smaller letters (e.g., small T and H to make up a bigger T or H letter). The three groups in this study included Caucasian-Australians, East Asians, and Asian-Caucasians. The results showed that there were no group differences in absolute RTs and accuracy, but East Asians showed a global advantage in RTs compared to Caucasians. McKone et al.’s study of Asians’ global advantage was supported first by cognitive neuroscience evidence in Lao, Vizioli, and Caldara’s (2013) study, which implemented electroencephalogram (EEG) in a Navon-like global-local task. The main finding was that stronger EEG responses associate with global figures during the early stage for East Asian participants compared to Westerner Caucasian ones.

Additional supporting evidence of Asians’ global advantage is from Kiyokawa, Dienes, Tanaka, Yamada, and Crowe’s (2012) study. Their experiments used a string of sequencing small (local) letters to make a bigger (global) letter. Participants had to respond to the sequences of either the global level or the local level. The results showed that Japanese subjects were more accurate than British subjects in the global, big object responses, but there was no difference in the local level. When subjects were asked to participate in just one level, either globally or locally, there were no differences in accuracy between these two groups, suggesting that the global advantage is largely subject to preference instead of subjects’ ability. In their last experiment, Japanese kana characters were used to substitute Roman letters, and the results showed that Japanese still had greater global advantage, indicating that familiarity of the elements does not account for cultural difference.

In contrast, other studies have found no cultural difference in global/local processing. For example, Caparos, Ahmed, Bremner, de Fockert, Linnell, & Davidoff (2012) used Navon-like symbols as stimuli (e.g., X or □) to investigate subjects' decision-making on whether a test trial more closely resembled the global symbol or the local symbol of the previously shown trial (in terms of global bias or local bias) in four cultural groups, including Japanese, British, urbanized Himba, and traditional Himba. The results showed no East-West difference between Japanese and British. As a side note, both traditional Himba and urbanized Himba showed a greater local advantage than the Japanese and British. Moreover, urbanized Himba (who had been to a big city, namely Opuwo, at least once in their lives) showed less local bias compared to traditional Himba who had never been to a big city. Similar to Berman, Jonides, & Kaplan's (2008) study, Caparos et al.'s (2012) study suggests that being exposed to an urbanized neighborhood, rather than a natural environment, would reduce the visual attentional bias toward local, detailed information.

4.2.1.2 Design, Stimuli, and Procedure

The global-local task employed a 2 (global, local) x 3 (congruent, neutral, incongruent) x 2 (central, eccentric) mixed factorial design. There were two cultural groups, including Easterners, represented by Taiwanese, and Westerners, represented by Americans. All the participants completed the task with the same block sequence and randomized trials.

Local stimuli included small, single symbols (h, s, or ■) with visual angle subtended 0.5° × 0.3°. Global stimuli were either big H (6.2° × 4.3°), S (6.2° × 4.3°), or ■ (8.2° × 5.0°) constructed by small h, s, or ■ (See Figure 1 for example). Seven blocks included a single letter block (one single, small h or s character), a local pure block (small h or s letters to construct a big rectangular, global image), a global pure block (consisting of a big H or S made out of many small rectangular blocks), a local mixed block (responding to small letters located at the center of the screen), a global mixed block (responding to a big letter located at the center of the screen), a local eccentric block, and a global eccentric block. Eccentric blocks mean the stimuli are randomly, horizontally distributed with a distance of 2.7° - 10.6° from the center of the screen. The task contains three congruency conditions including congruent (e.g., a big S was made out of small S's), neutral (e.g., only global or local stimuli were presented), and incongruent (e.g., a big S was made out of small H's) conditions in the last four blocks. The dependent variables in this task are RT and accuracy.

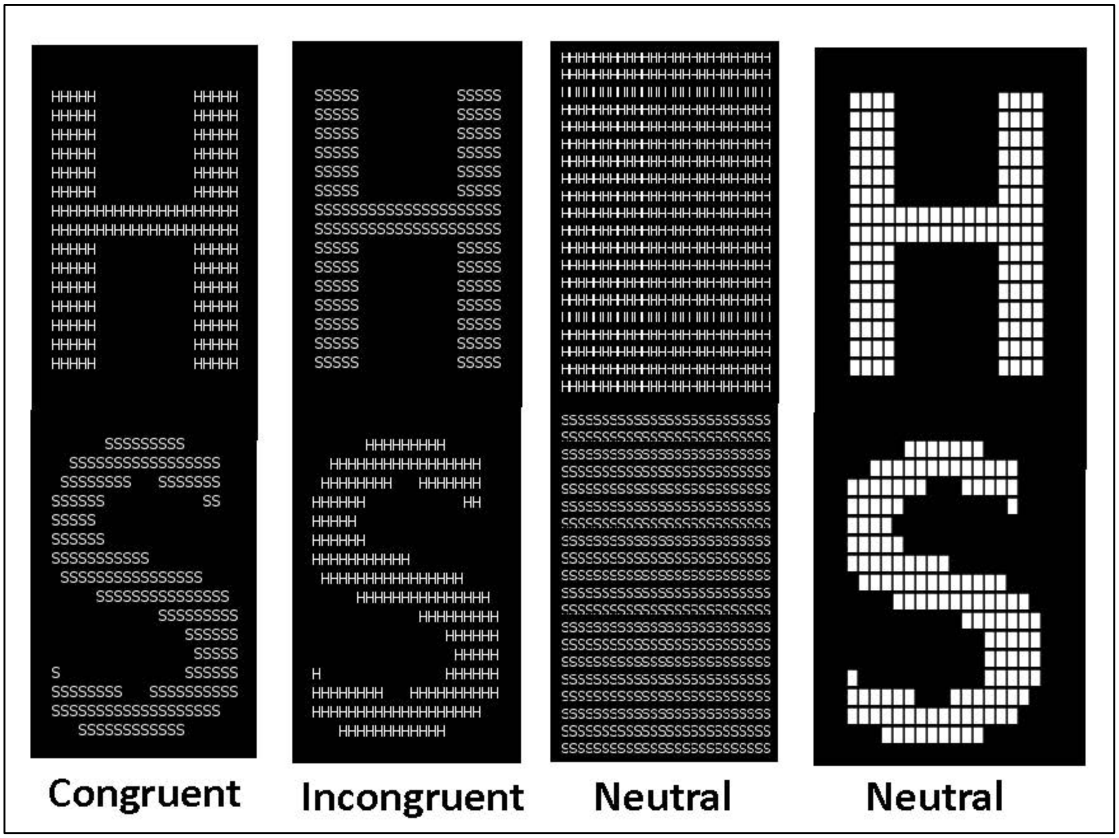

Figure 1: Examples of global-local task, including the congruent, incongruent, and neutral conditions.

There were 300 trials per subject in this task. Ten trials per condition in each block. In this global-local task, the pre-created stimuli, serving as a preview section, were presented to participants before they started to respond to the test trials as a means for them to be familiar with the stimuli later in the test section. Participants were required to respond either to a larger letter in the global condition or to smaller letters in the local condition in the test section. The present task was a two-alternative forced choice task. If they chose to respond with S, they would be instructed to press the right shift key, and if they chose to respond with H, they were required to press the left shift key (see Figure 2 for example). The stimuli remained on screen until the participant pressed the answer key. Feedback was provided after each trial, either “correct” or “incorrect,” at the center of the screen for 500 milliseconds, which was also served as a fixation point for the next trial.

Figure 2: Screenshot of the global-local Task. This task is performed by pressing the left shift key while responding to H and the right shift key while responding to S.4.2.1.3 Results and Analysis

4.2.1.3 Results and Analysis

RTs larger than 2000 milliseconds and less than 300 milliseconds were excluded from the analysis (.4% of Taiwanese data vs. .3% of US data). The analysis of the global-local data, averaged across all conditions indicated no significant difference in absolute RTs (Welch two-Sample t-test: 580 vs. 575 ms, *n.s.*, d = 0.0873) and accuracy (95.84% vs. 96.378%, *n.s.*, d = 0.2004) between Americans and Taiwanese, respectively. Results, as seen in Figure 3, revealed that global conditions had shorter RTs than local conditions, including in pure, central (mixed), and eccentric blocks. These results were consistent with the previous research finding that participants first attend to bigger global configuration then inspect the smaller local configuration (Navon, 1977), with significantly faster mean RTs in the global conditions than local conditions across groups (Table 2).

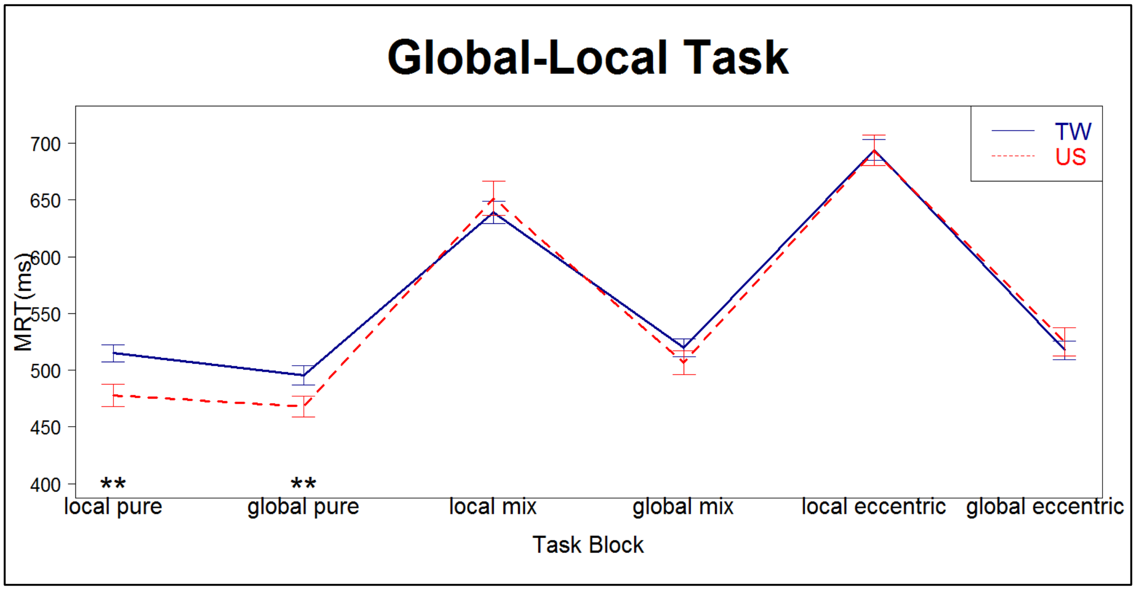

Figure 3: Mean RTs across different task blocks in global-local task. Blue solid line represents Taiwanese data while red dash line indicates American data. ** denotes the significant difference between Taiwanese (TW) and Americans (US). Americans were significantly faster in both local and global pure blocks than Taiwanese.

Table 2: The results of Welch two-sample t tests in the global-local task

Hypothesis/Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost (incongruence-congruence)			
	TW mean	US mear	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	580	575	0.42	0.675	0.96	0.96	-1	0.31	30.78	41.77	-1.69	0.095
Interference Suppression (Congruent - Incongruent)	31	38	-1.13	0.265	0.04	0.04	0.43	0.67				
Response Inhibition (Incongruent - Neutral)	-43	-45	0.33	0.741	0.04	0.03	0.37	0.71				
Eccentricity (global)	523	531	-0.49	0.623					-5.961	20.83	-1.99	0.051
Eccentricity (local)	702	703	-0.01	0.991					57.79	41703	1.36	0.177
Detail vs. Object Configuration (Detail - Object)	497 (G pure)	465	2.57	0.012*					116.06	150.9	-2.49	0.015*

Next will be the discussion of the hypotheses testing results. Neither H1 nor H2 were supported by this task. H1: Interference Suppression was calculated as the RT/accuracy in the incongruent condition minus congruent condition. The results did not reach statistical significance based on the Welch two sample t-test, including interference costs in both mean RTs ($t = -1.1339$, $df = 74.184$, $p = 0.265$) and accuracy ($t = 0.427$, $df = 94.087$, $p = 0.6703$). This study also failed to support H2, calculated as the RT or accuracy in the incongruent condition minus the neutral condition, in both mean RTs ($t = 0.3321$, $df = 69.353$, $p = 0.7408$) and accuracy ($t = -0.3743$, $df = 97.163$, $p = 0.709$).

H3: Detail vs. Object configuration was measured using RT/accuracy for the local, detail trials to compare with global, big object trials in the central (mixed) conditions. Hypothesis 3 predicts that Easterners are able to perform better at searching for local mixed letters (RT difference between detail and big object conditions), which is equivalent to being able to locate attention to identify detailed contextual information and relationships, while Westerners are better at processing visual information globally, which is equivalent to being able to pay more attention to the salient object configuration. As for the interference cost for detail/object configuration, the results showed that Taiwanese have a significantly lower interference cost (116 vs. 151 ms, respectively, $t(88) = -2.4863$, $p = 0.01479$, $d = 0.4949$) compared to Americans (i.e., the difference between processing the local mix letters and the global mix letters; Figure 4). This supports H3 that Taiwanese are better at paying attention to detail configurations, compared to Americans.

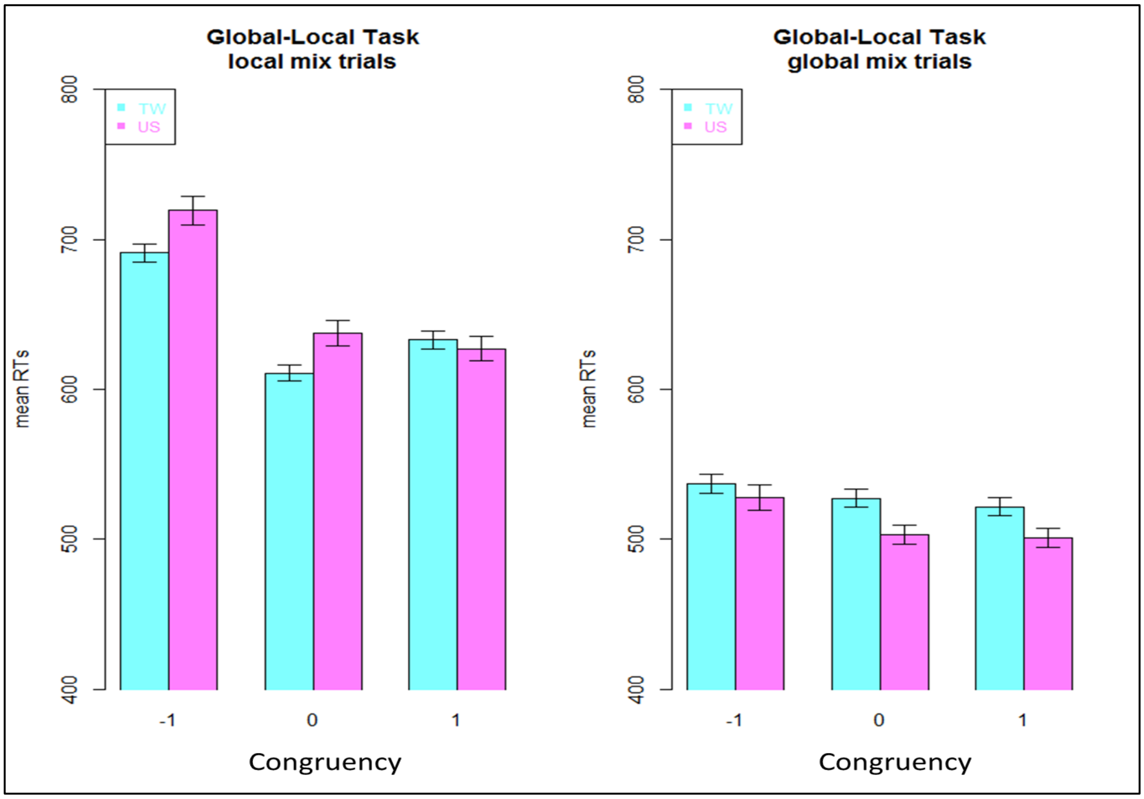

Figure 4: Mean RTs as a function of consistency in conditions of local mixed letters (left) and global mixed letters (right) in the center condition. "-1" denotes incongruent trials where global and local letters are different. "0" denotes neutral trials. "1" denotes congruent trials where global and local letters are identical. There was no significant difference between the two groups in the global centered condition. Both groups responded slower in the incongruent condition than both the congruent and the neutral condition in the local center block.

Further supporting H3, "detail/object configuration", is that Americans had faster absolute mean RTs in the block of global pure letters than Taiwanese (497 ms vs. 465 ms, respectively, t (85) = 2.5715, p = 0.01186, d = 0.5151), which indicates that Americans are better at paying attention to the large object configuration than their Taiwanese counterparts. These results seem to stand in conflict with the results of McKone et al (2010), which suggest that Asians have the global advantage over Westerners in this case. Both research studies use the same formula to derive the findings (i.e., local trials minus global trials), even though the terminology used is different. McKone et al.'s big letter (global) configuration was made out of sparse, few local letters (e.g., 8 smaller letter E's to construct a big T or 12 smaller T's to construct a big H) compared to the local configuration in the present study (See Figures 1 & 2); thus, McKone et al.'s global condition were time-consuming and effortful for participants to attend and discriminate, while their local stimuli were effortless to process. This was the evidence that their detailed information existed in the global level of a structure.

According to Miyamoto (2013), contextual information is an important mechanism to explain East versus West cultural differences (discussed in Chapter 2.8). Miyamoto suggests that a global advantage can be found for Easterners if contextual information resides in the global level of a structure and vice versa for a local advantage when contexts are located at the local level. McKone et al's (2010) study demonstrated that detail information resided in the global level of a structure, as it took time to locate and process global visual information, resulting in global advantage for Easterners. However, their global structure was the level the contextual detailed information resided, meaning that both their study and the present study were consistent with each other that Easterners were good at paying attention to detailed information.

Another demonstration that detailed information may reside in either the global or local level of a hierarchical structure can be found in Kimchi et al.'s (2005) study. The authors conducted a global-local task with 2 (Many vs. Few elements) * 2 (Global vs. Local response) conditions to assess subjects' information processing ability in a hierarchical structure. The local stimuli were either circles or squares to build a big square or a big diamond. The results showed that the Many-Global condition (i.e., many local, detailed elements to construct a global image and responding globally) was the fastest, the Few-Local condition (few local elements and responding locally) was the second fastest, the Few-Global condition (few local elements and responding globally) was the third fastest, and the Many-Local condition (many local elements and responding locally) was the slowest. Kimchi (2014) stated that, depending on the relationship between the global and local level, a global level can be more time-consuming and effortful if it is constructed with few, sparse local figures, resulting in local advantage, and a global level can be efficient and effortless, if it is made out of many, dense local elements, resulting in global precedence. The authors also specified that familiarity, codability, complexity, and identifiability are four important attributes, which form the basis to manipulate the interactions and interrelations among the global vs. local figures (Kimchi, 2014).

In conclusion, the results support H3: Detail vs. Object Configuration that Taiwanese are better at looking into detailed configuration while Americans are better at focusing on big object configurations. H1: Interference Suppression and H2: Response Inhibition were not supported by the results of this task. H4: Centrality vs. Eccentricity was not examined as we did not record the positions in the eccentric blocks. H5: Number of Distractors was not assessed in this study as it is not designed for testing H5.

4.2.1.4 Future direction for Experiment 2

Experiment 1 did not record eccentric positions. This would be revised in Experiment 2. In conclusion, significant cross-cultural differences are found in the global-local task regarding detail vs. object configuration (H3). This task will be included in Experiment 2 and modified to record eccentric positions.

4.2.2 Task 2: Visual Search Task

Visual search tasks (Treisman & Gelade, 1980) are popularly used to measure human ability to perform pre-attentive, feature search and conjunction search (e.g., Treisman, 1985 & 1988; McLeod, Driver, & Crisp, 1988; Plude & Doussard-Roosevelt, 1989; Dehaene, 1989; Zohary & Hochstein, 1989; Treisman & Sato, 1990; McLeod, Driver, Dienes, & Crisp, 1991; Cohen & Ivry, 1991; Cohen, 1993; Wolfe, 1994; Theeuwes & Kooi, 1994; Tales et al., 2002).

In a typical laboratory search task, participants are asked to search for a target displayed on the computer screen. Generally, measures are taken across hundreds of trials, with both target present and target absent conditions, in order to obtain a reliable measure. RTs and accuracy of trials are recorded. The slope in a linear regression model, predicting RT by display set size (number of distractors plus the target stimulus), is regarded as a measure of search efficiency. Participants' search times in conjunction search typically linearly increase as the set size becomes larger and larger. In addition, the search slope for target absent trials are twice as steep or more, compared to target present trials (Wolf, 1998; Townsend, 1990). Much more time is needed if the items are more difficult to search through. The intercept of the RT x set size function is typically at least several hundred milliseconds long, whether or not it is a simple search. The accuracy of a search task when stimuli remain visible throughout the trials is relatively high, typically more than 90 percent, so accuracy is not ideal for group comparison (Palmer, Verghese, & Pavel, 2000; Dukewich & Klein, 2005).

Previous research (Treisman & Gelade, 1980; Wolfe, 1994; 1998; Itti & Koch, 2000) has suggested a two-stage model of visual search task. In the first stage, parallel processing, the target has a unique feature and enables "popout" search. The target can be registered early and automatically. Search time for pop-out items will stay the same such that the search slope will be shallow even with the increase of the number of distractors. In the second stage, serial processing, several features (e.g., color, shape, size and orientation) are bound together, creating binding problems in terms of similarities for attention. This will require participants to shift their attention to search a target. (Treisman & Gelade, 1980; Treisman, 1985, 1988 & 1998). Focused attention will be demanded for potential more detailed, fine-grained target and the search slope will be steeper with the increase of display set size. However, Huang and Pashler (2005) indicated that "display-set size effect" and "target-distractor similarity" have significant impacts on pop-out search, when there is only a subtle difference between targets and distractors.

4.2.2.1 Prior literature

Little research has focused on the cross-cultural study of visual search task for adults. For example, Ito, Masuda, & Li (2013) conducted a cross-cultural study focusing on using visual search to perform face recognition out of other distracting faces, but their study did not examine feature search as the present study did. In addition, another cross-cultural study focused on examining children's performance in visual search task and revealed that Japanese children performed better in a relational match task while U.S. children were better in object search (Kuwabara & Smith, 2012). While this study was focused on children rather than adults and the task was much simpler, it still revealed the cultural differences between two distinct cultures in terms of object search.

4.2.2.2 Design, Stimuli, and Procedure

The visual search task was a 3 (set size) x 3 (number of targets) x 2 (target color) x 2 (target character) mixed factorial design implemented using PEBL. It was a short version with only 31 trials (due to a coding error) and trial sequence was randomized. There were four types of factors, including number of targets (0, 1 or 5), display set size (including targets and distractors: 10, 20, or 30), target color (white or green), and target character (either “X” or “O”). All the distractors were white and randomly distributed.

Stimuli were “O”, “X”, “U”, “D”, “G”, “C”, and “Q”, each with 0.7° × 0.6° of visual angle. The stimuli displayed within the range of 17° × 17° of visual angle from the outside edge of the field to the center of the screen.

In the PEBL visual search task, participants were asked to search for one or more targets (letters with particular color and shape combinations). Each trial, a target was presented for 800 ms, then disappeared, and then a screen appeared for participants to search for the target (see Figure 5). After participants completed the search, they would click on the mouse and all the targets would be replaced by empty circles. They had to click on the location of the target if the target was present, or they would press the “None” button if the target was absent. Participants were asked to respond as quickly as possible. Both participants’ RTs and accuracy were recorded and served as dependent measures for further analysis.

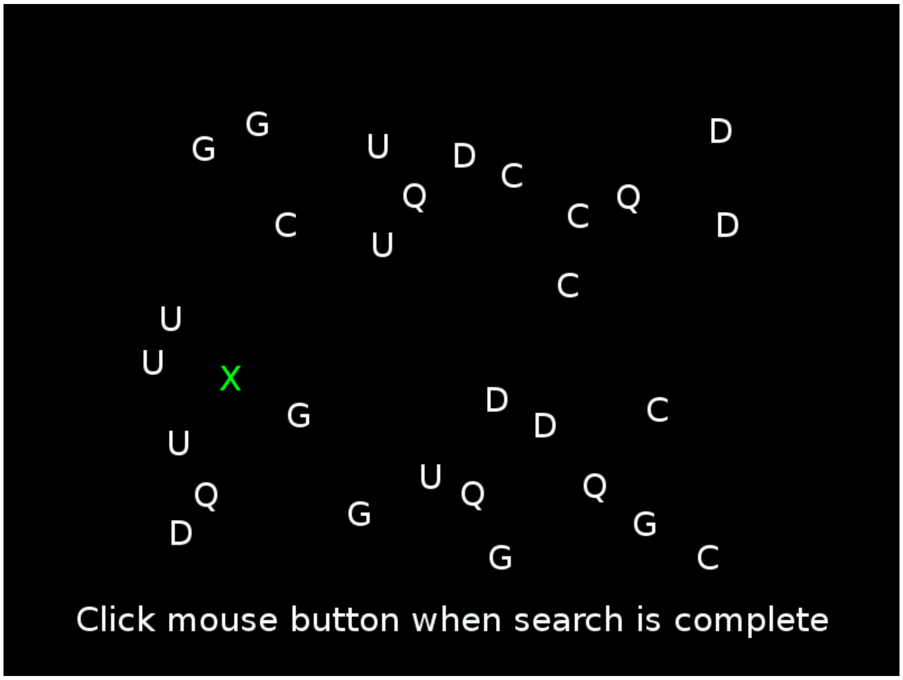

Figure 5: Screenshot of PEBL visual search task. This is an example of feature search where green X is the target.

4.2.2.3 Results and Analysis

Due to the coding issue while translating the task into mandarin, the task would end unexpectedly without completing the full vision of 180 trials. The visual search task had 3 (display set size) *3 (number of target) *2 (target color) *2 (target character) factors designed in this study but only 31 trials per subject were obtained. Unfortunately, it was difficult to derive meaningful results such that the data analysis would only limit to preliminary results, such as RTs and accuracy. In addition, the RT by set size effects were plotted in order to obtain an overall visualization of the task. The data would not be employed for hypotheses testing.

Four Taiwanese participants were eliminated from data analysis due to lower than 80% accuracy (i.e., 31%, 47%, 66%, and 71%). RTs longer than 10000 ms were removed from analysis. The RT analysis in this task excludes error responses. There was no difference in accuracy between the two groups (97.2% vs. 96.6%, in Taiwanese and American groups respectively, $t(61) = 0.56$, $p = 0.576$). Regarding RTs, Taiwanese (1,605.24 ms) were significant faster than Americans (1962.30 ms) based on Welch two sample t-test ($t(63) = -2.92$, $p = 0.005$).

Aligned with previous literature (Treisman & Gelade, 1980; Wolfe, 1994 & 1998; Itti & Koch, 2000), the results showed that with the increase of display set size, RTs increased linearly in both American and Taiwanese groups, except American group in the five target present feature search condition (Figure 6).

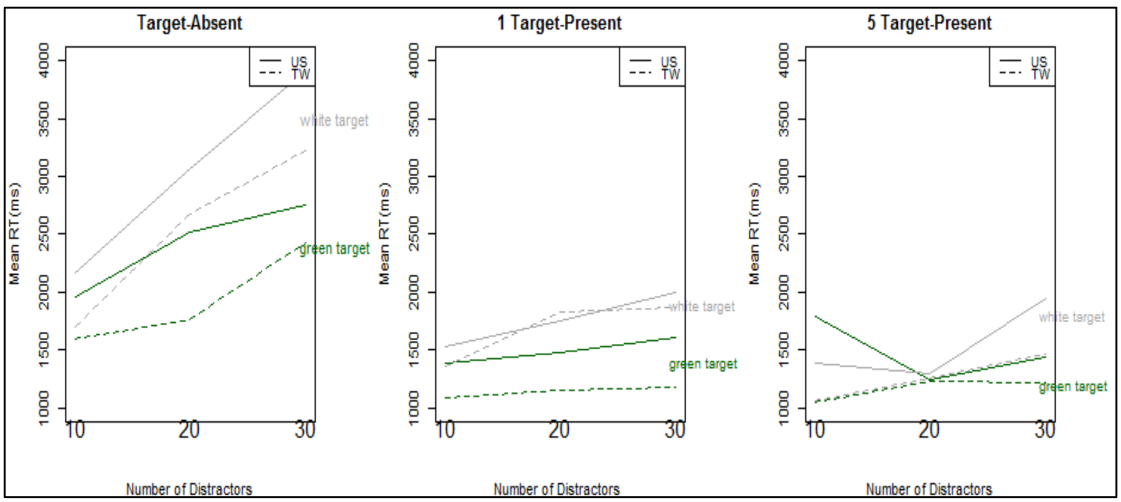

Figure 6: PEBL visual search task: mean RTs (ms) as a function of stimulus set size in target absent, one target, and five targets conditions (from left to right). Green lines represent feature search where green targets popout of white distracting stimuli. White lines denote conjunction search where both targets and distractors are white. RTs became larger as number of distractors increased. The target absent trials took longer to respond compared to the target present trials and RTs level off when target size increases from 1 to 5 targets (right).

4.2.2.4 Future Direction for Experiment 2

Understanding how people perform visual search in various conditions are important for cross-cultural study in visual attention. With the implementation of four factors, each with multiple levels, the design of this visual search task is very unique and deserves further investigation. In the Experiment 2, I would continue to investigate this task and use a full version, a total of 180 trials, in Experiment 2.

4.2.3 Task 3: Color-Stroop Task

The Stroop task was named after John Ridley Stroop (1935) to investigate attentional interferences of Stroop effect, referred to as "color-word interference effect" (Stroop, 1935; Alansari & Baroun, 2004). The basic Stroop task (Stroop, 1935) involves three different kinds of subtasks, including naming the color of a given square, naming color words in black ink, and naming color words printed in incongruent ink color. Participants are asked to verbally respond to either the name or color of a stimulus at the same time ignoring the word. The general finding is that verbally naming the color of a word takes longer and was more error-prone in the incongruent condition (e.g., naming the word "green" printed in red ink) than in the congruent condition.

The Stroop effect can be measured and explained in multiple ways, including processing speed (i.e., reading words is faster than recognizing colors), selective attention (i.e., recognizing colors requires more attention than reading words), automaticity (i.e., reading words is habitual, and automatic processing while recognizing colors requires more attention and is not automatic), and parallel processing in both relevant (color) and irrelevant (word) dimensions.

4.2.3.1 Prior Literature

The results of cross-cultural differences in Stroop effect are inconsistent in the literature. Alansari and Baroun (2004) employed the Stroop color / word test to investigate the interference effect. Participants were college students from Kuwait and Britain. The results showed that there was no gender difference in Stroop effect between these two cultures but cultural variation did exist. Kuwaiti students exhibited higher interference than British students. In Biederman and Tsao's study (1979), Chinese-speaking participants had higher interference cost than their English-speaking counterparts. Additionally, Kiyak (1982) found an overall lower interference for bilingual Turks than Americans and within-language interference was higher for Americans.

As for bilingual study in Stroop task, previous literature concluded that the Stroop effect provides evidence for the hypotheses in their studies in terms of bilingual advantage in cognitive flexibility and substantial experience of selective attention (Mägiste, 1985; Rosselli, et al., 2002; Esposito, et al., 2013). Language proficiency and language similarity are the reasons why interference for bilinguals in Stroop task is lower than monolinguals. Typically, the interference decreases with language familiarity. However, some studies suggest that this bilingual advantage is not found in bilingual preschoolers for Stroop task (Martin-Rhee & Bialystok, 2008; Siegal, Iozzi, & Surian, 2009). In a recent study, Esposito, Baker-Ward, and Mueller (2013) developed a Stroop task adaptation, termed bivalent shape task, which was also implemented in Experiment 1. They found that Spanish-English bilingual children performed better than English monolingual children, which suggested that the diverse results of Stroop variant tasks could be attributed to the different characteristics of Stroop task adaptation, instead of developmental cognitive differences.

4.2.3.2 Design, Stimuli, and Procedure

The color-Stroop task employed a within-subject design. There were 96 trials in three conditions (see Figure 7), each with 32 replicates. The conditions included congruent, incongruent (e.g., responding “red”, when seeing the word “yellow” in red ink), and neutral conditions (e.g., responding “red”, when seeing the word “when” in red ink.

In this color-Stroop task, keyboard responses were implemented, unlike a typical Stroop task which collects vocal responses. The same sequence of stimuli was used every time. The dependent variables in this task were RT and accuracy.

Before starting the test, participants go through practice trials to be familiar with the mapping between keyboard number and color (i.e., 1= red, 2=blue, 3=green, 4=yellow). In the test, participants were asked to determine the color of the written words. They were asked to respond as quickly as possible.

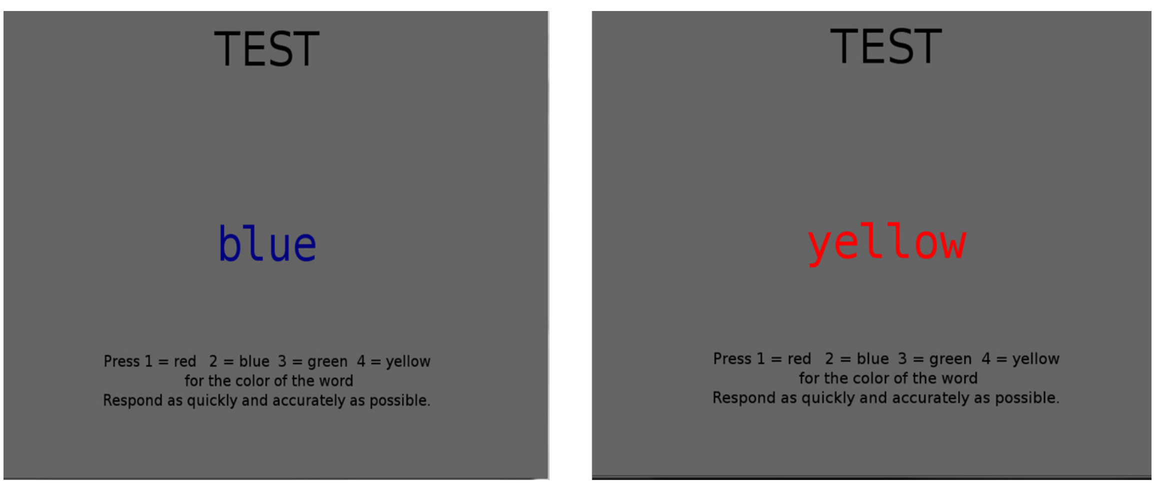

Figure 7: Color-Stroop task: congruent (left) and incongruent (right) conditions.

4.2.3.3 Results and Analysis

Two Taiwanese and one American participant were eliminated from the analysis due to their low accuracy (<60%). RTs larger than 2000 ms were eliminated as it was clear that participants were simply not paying attention. The accuracy was similar between Taiwanese and Americans (93.9% vs. 93.7%, respectively, d = 0.0478). The absolute RTs showed a trend that Taiwanese responded faster (non-significant) than Americans (735 vs. 750, respectively, d = 0.1503). See Table3 for detailed t test results.

Regarding three congruency conditions (see Figure 8), the only significant difference measured between Taiwanese and Americans was in the incongruent conditions (766 vs. 841 ms, respectively, t (57) = -2.5289, p = 0.0142, d = 0.5505). This indicates that Taiwanese are better at response inhibition as they were able to inhibit the habitual response against naming the word and respond to the color of the words printed faster than Americans.

Table 3: Welch two-sample t tests in the color-Stroop Task

Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost (Incongruence-Congruence)			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	735	750	-0.704	0.484	0.939	0.937	-0.232	0.817	43.88	154.1	-6.78	4.572e-09*
Congruent	723	687	1.7	0.093								
Incongruent	766	841	-2.53	0.014*								
Neutral	715	724	-0.44	0.663								

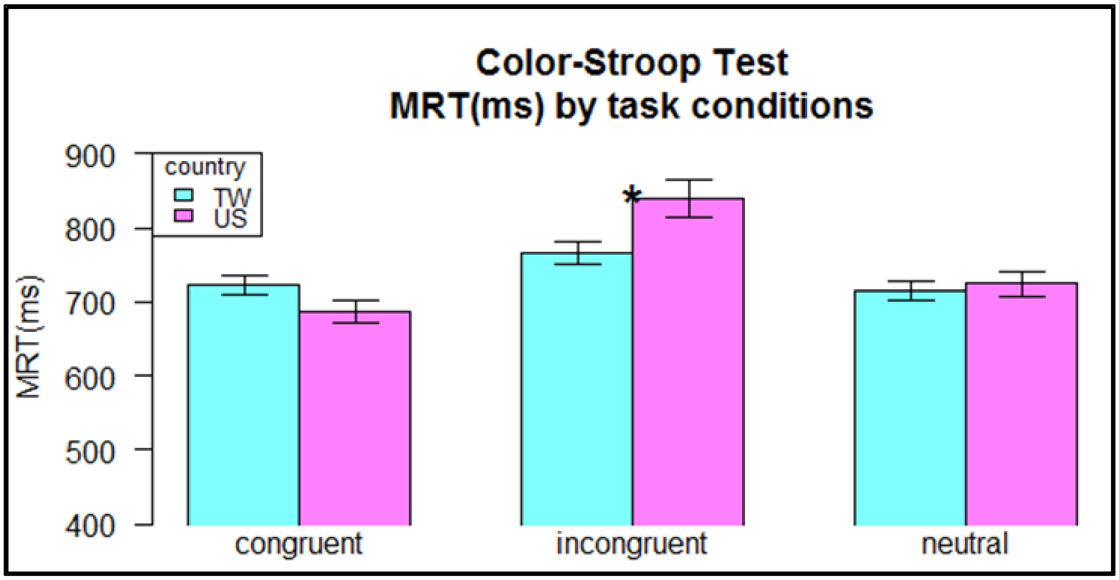

Figure 8: Mean RTs as a function of task condition in color-Stroop task. * denotes the significant differences in RTs in the incongruent condition between Taiwanese (TW) and Americans (US).

Next will be the discussion of the hypotheses testing.

H1: Interference Suppression, which was calculated as RTs in the incongruent condition minus the congruent condition. Taiwanese showed a significantly lower interference cost than Americans (43.88 vs. 154.10 ms, respectively, t (64) = -6.7838, $p <$ .001, d = 1.4558), which indicates that Taiwanese have better ability to suppress interference.

H2: Response Inhibition was measured using RTs in the incongruent condition minus the neutral condition. The results of H2 testing showed that there was a significant difference between Taiwanese and Americans (51.36, 117.45 ms, respectively, t (58) = -3.98, $p <$ .001, d = 0.865), indicating that Taiwanese were better at response inhibition than Americans.

4.2.3.4 Future direction for Experiment 2

The results supported H1 and H2 that Taiwanese are better than their American counterparts in interference suppression and response inhibition. However, in the neutral condition, only the English words (e.g., when, hard, and, & over) were implemented. I did not translate them into Chinese words, which may cause biased results in assessing cultural difference. There were multiple tasks in this study which can be used to test H1 and H2. Therefore, the color-Stroop task would not be implemented in Experiment 2.

4.2.4 Task 4: Victoria-Stroop Task

Victoria-Stroop task is one type of Stroop variant tasks (Troyer et al., 2006). This test requires subjects to perform color-naming against habitual responses at three conditions (from simplest to most difficult): name the colors of dots at the first round, then name the colors of neutral words, and finally name the colors of color names which are printed in contrasting color inks. Victoria-Stroop test can be used to test the relationship of color interference and cognitive slowing.

4.2.4.1 Design, Stimuli, and Procedure

The Victoria-Stroop task employed a within-subject design as all the participants completed the task with the same block sequence and randomized trials. There were 24 trials in each condition. There are three blocks, including naming the color of the dots, words, and words printed (see Figure 9 for example). In each of the blocks, there are two types of conditions: congruent and incongruent.

In the PEBL Victoria-Stroop task, a specific stimulus categorized either by name or by color is presented and participants are given the option of four responses (i.e., pressing 1, 2, 3, or 4 key on the keyboard, respectively, for green, blue, red, or yellow color). The dependent variables, RTs and accuracy, were recorded during the test period.

Before the beginning of the test, participants were introduced to learn the mapping between the keyboard responses and the colors. In the first block, participants were asked to name the colors of the dots. In the second block, they were required to name the colors of the words. In the last block, they were asked to respond to the color in which the word is printed (e.g., responding "green", when seeing the word yellow printed in green). Participants were asked to respond as quickly as possible.

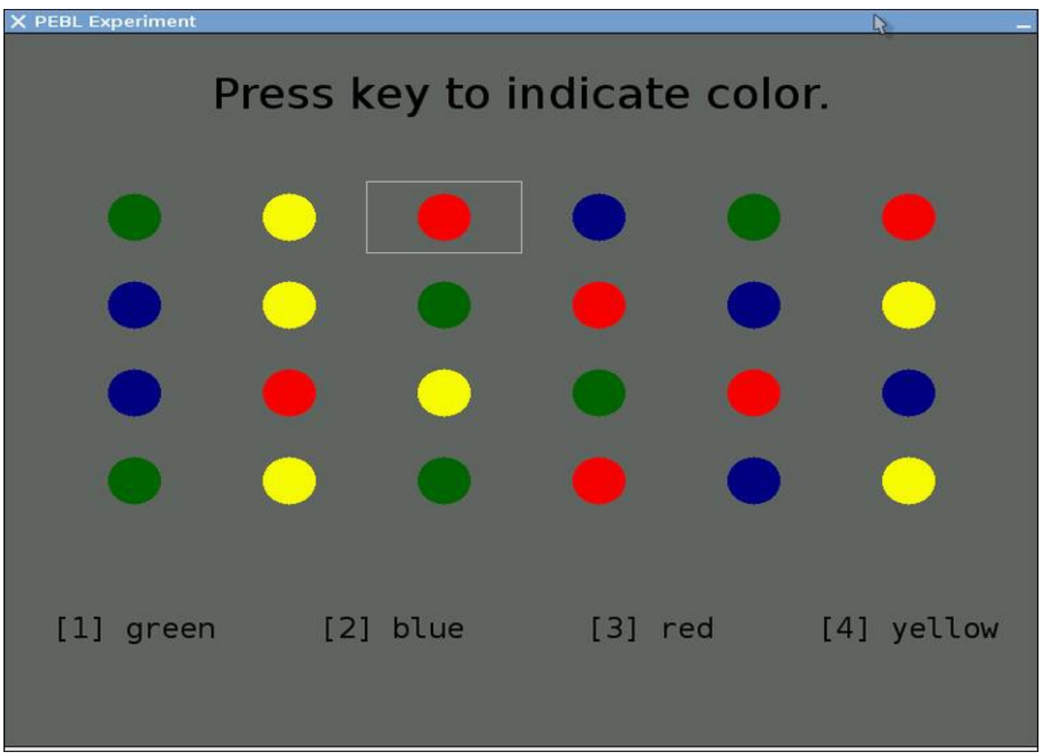

Figure 9: PEBL Victoria-Stroop task: naming the color of the dots as it appears on the screen.

4.2.4.2 Results and Analysis

One American participant was eliminated from this task analysis due to low accuracy (77%). The trials with RT larger than 4000 ms were excluded from further analysis (1.93%). Neither the absolute RTs nor the accuracies showed a significant difference between the two groups. All the conditions (Figure 10), including, color, dot, and word conditions, did not achieve statistical difference between the two groups (see Table 4 for Welch two-sample t test).

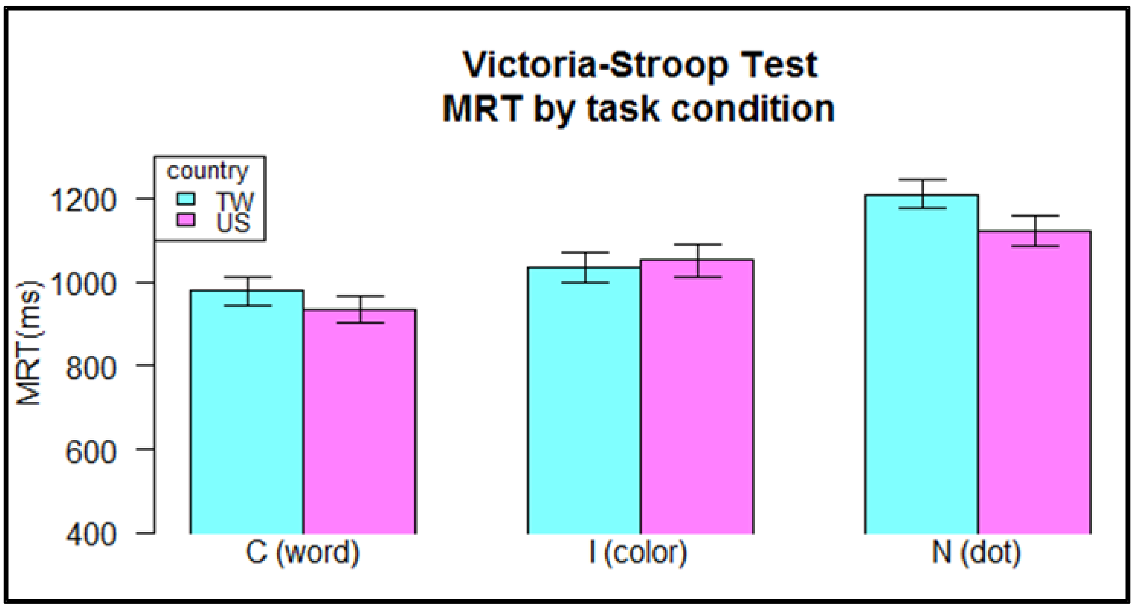

Figure 10: Mean RTs as a function of task conditions in Victoria-Stroop task.

Table 4: Welch two-sample t test in Victoria-Stroop task

Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	1116	1054	1.4	0.17	0.96	0.96	0.27	0.79	57.56	115.7	-1.47	0.146
Word Condition	978	935	0.93	0.35								
Color Condition	1035	1051	-0.3	0.76								
Dot Condition	1217	1124	1.79	0.08								

Next will be the discussion of the hypotheses testing. Note that only H1 was tested in this task as there were only congruent and incongruent conditions in each block.

H1: Interference Suppression, which was calculated as RTs in the incongruent condition minus the congruent condition, collapsed across the blocks. The results showed that there were no significant difference between Taiwanese and Americans (57.56 vs. 115.66 ms, respectively, t (87) = -1.47, p = 0.146, d = 0.292), indicating that there was no cultural difference in interference suppression.

4.2.4.3 Future Direction for Experiment 2

The results of Victoria-Stroop task did not support H1 and did not evaluate the remaining hypotheses. Therefore, it may be considered a culture-free cognitive task. This study would be excluded from Experiment 2 in order to focus on the tasks which would provide more meaningful attentional differences cross-culturally.

4.2.5 Task 5: Number-Stroop Task

Number-Stroop is one adaptation of the Stroop task, which was employed by Hernandez et al. (2010). In this task, participants are required to respond to the number of digits which are presented using the numbers (1, 2, or 3) either in congruent condition (e.g., asking to respond “2” while presenting 22), incongruent condition (asking to respond “3” while presenting 111), or neutral condition (e.g., asking to respond “2” while presenting letters such as GG). This task is commonly used in examining the Stroop effect and Stroop interference in bilingual study.

4.2.5.1 Design, Stimuli, and Procedure.

The number-Stroop task employed a within-subject design. There are two blocks and 84 trials in this task. All the participants completed the task with the same block sequence. The three conditions, including congruent (e.g., see “22” and respond 2) incongruent (e.g., see “33” and respond 2), and neutral conditions (e.g., see “GG” and respond 2), were randomly presented with equal number of times on the screen.

Before the test, participants were asked to take a training of 24 trials. A central fixation cross represented for 1000 ms and followed by the target stimulus lasting for 2000 ms or until participants gave a response. During the task, either 1, 2, or 3 characters were displayed on the screen and participants were required to press the 1, 2, or 3 keys on the keyboard to determine how many letters or numbers appeared on the screen (Figure 11). Participants were asked to respond as soon as possible. Both participants’ response time and accuracy were collected in this task.

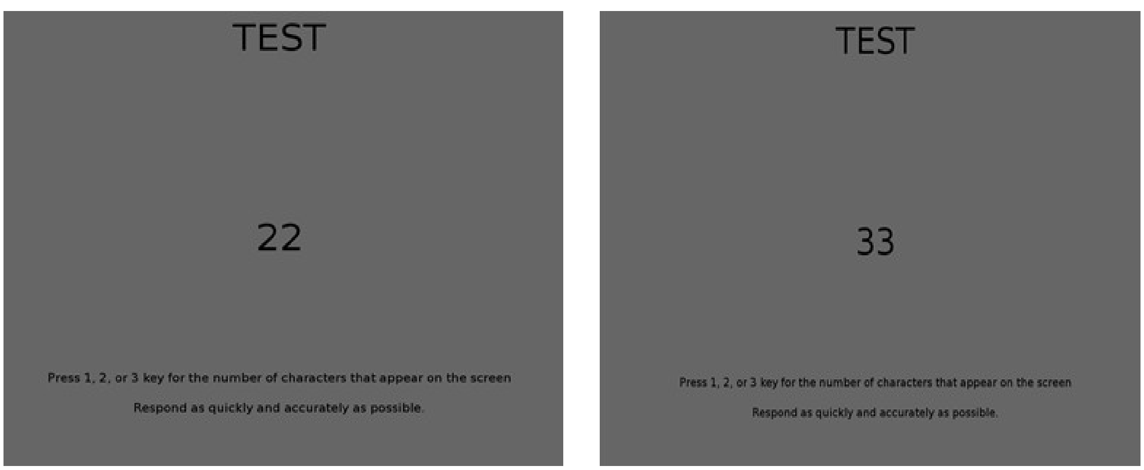

Figure 11: Number-Stroop task: congruent condition (left) vs. incongruent condition (right).

4.2.5.2 Results and Analysis

There were four Taiwanese and two American participants eliminated from data analysis due to low accuracy (<75%). The trials with RT larger than 2000 ms were excluded from further data analysis (0.28%). Number-Stroop task has similar results as Color-Stroop task. For example, there were no significant differences between the two groups in terms of absolute RTs and accuracy (see Table 5). As for the Stroop effect, the results revealed a trend similar to previous literature that incongruent trials on average took longer to respond to than congruent trials (Figure 12).

In addition, the mean RTs in the incongruent trials showed a difference between two groups as Taiwanese responded faster, compared to their American counterparts, when the number of characters differed from the numbers appeared (645 vs. 680, respectively: $t\ (79) = -2.2803$, $p = 0.0253$, $d = 0.4846$).

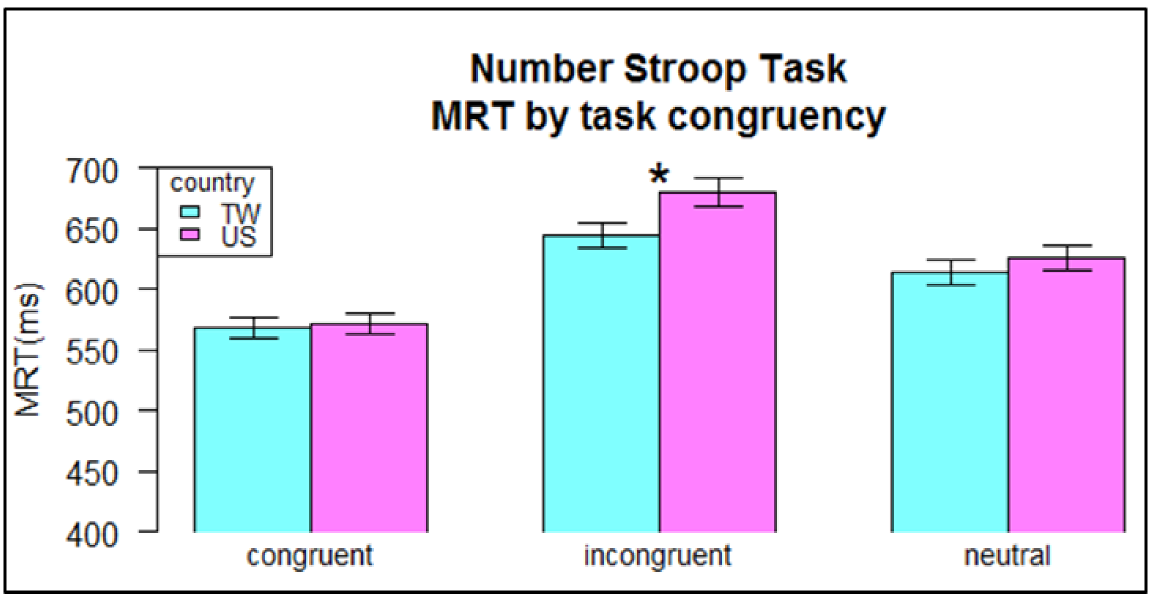

Figure 12: Mean RTs as a function of task condition in number-Stroop task. * denotes a significant differences between two groups.

Table 5: Welch two-sample t test in number-Stroop task

Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	609	626	-1.28	0.204	0.95	0.94	0.76	0.45	76.76	107.93	-4.27	<0.001
Congruent	568	572	-0.33	0.786								
Incongruent	645	680	-2.28	0.025*								
Neutral	614	626	-0.83	0.409								

Next will be the discussion of the hypotheses testing.

H1: Interference Suppression, which was calculated as RTs in the incongruent condition minus the congruent condition. The results showed that Taiwanese had on average 31 ms lower interference costs compared to Americans (76.76 vs. 107.93 ms, respectively, t (73) = -4.27, $p < .001$, d = 0.918). This indicates that Taiwanese were better in interference suppression than Americans.

Hypothesis 2: Response Inhibition was calculated as the RTs in the incongruent condition minus the neutral condition. The results showed that there was cultural difference between Taiwanese and Americans in H2 (30.94 vs. 54.19 ms, respectively, t (71) = -4.27, p = 0.007, d = 0.602), revealing that Taiwanese were better at response inhibition compared to Americans.

4.2.5.3 Future direction for Experiment 2

The results supported two hypotheses, including H1: Interference Suppression and H2: Response Inhibition. Since there were multiple stroop and flanker tasks to choose from in Experiment 1, we have decided to implement the Flanker task in Experiment 2.

This is because there is room for modifying the design in the flanker task, in terms of eccentricity effects. Using the flanker task could measure the congruency effect and eccentricity effect simultaneously.

4.2.6 Task 6: Simon Interference Task

The PEBL Simon task originated from Simon (1969), who examined a directional (left/right) Stimulus-Response compatibility effect, (now often referred to as the Simon effect). In addition to large compatibility effects, Yamaguchi & Proctor (2012) showed that when the stimulus location is closer to the targeted response key, the RT will be faster, even though participants are instructed to pay attention to the color and at the same time disregard stimulus location. The stimulus might appear from different locations with different sizes and subjects have to decide whether its color is blue or red by responding with the right or left shift key. It can be used to measure choice RT with interference of size and location (Yamaguchi & Proctor, 2012) as well as response inhibition against the habitual responses (Bialystok, Craik, Klein, & Viswanathan, 2004).

4.2.6.1 Prior Literature

The Simon task was popularly administered to investigate the bilingual advantage of response conflict. For example, Bialystok Craik, Klein, & Viswanathan, (2004) utilized magneto encephalography (MEG) to examine the correlation of neutral activities to bilingual advantage in bilingual French-English, bilingual Cantonese-English, and monolingual English speakers. The results showed that faster RTs were obtained in the congruent condition than in the incongruent condition. Among all the groups, Cantonese exhibited fastest RTs, but these results were not significantly different. Also, the MEG results suggest that bilinguals had larger activity in the left hemisphere such as superior and middle temporal pole, inferior and superior frontal lobe, and cingulate cortex, while monolinguals had greater brain activity in middle frontal lobes. In general, with regards to bilingual advantage, literature suggests that adult bilinguals generally respond faster than monolingual participants (Bialystok et al., 2004; Bialystok et al, 2005; Costa et al., 2009; Martin-Rhee & Bialystok, 2008; Esposito et al., 2013), exhibit lower interference (Bialystok et al., 2004; Costa et al., 2009), and maintain higher inhibition control (Bialystok, 2010; Martin-Rhee & Bialystok, 2008). However, these mentioned bilingual advantages did not find in MEG study.

4.2.6.2 Design, Stimuli, and Procedure

The Simon interference task employed a within-subject design. There are 140 trials and two conditions (congruent and incongruent), randomly distributed in this task. The dependent measures were RTs and accuracy, and the independent measure was the congruency.

Stimuli were either one blue or one red circle (2.8° × 2.8° of visual angle), appearing at a right or left location from a central fixed point (Figure 13). The stimuli displayed eccentrically at 1.4° to 7° of visual angle from the center of the screen.

Participants were required to respond to the color and ignore the location. Practice trials were given before participants started the task. They were asked to respond as soon as possible.

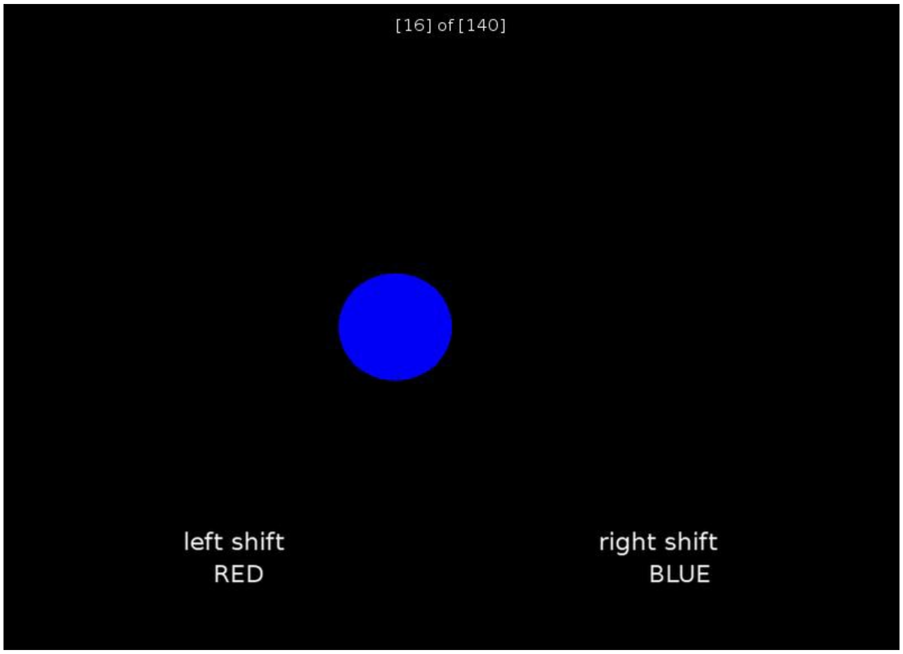

Figure 13: Screenshot of PEBL Simon Interference task.

4.2.6.3 Results and Analysis

One Taiwanese participant was eliminated from data analysis due to less than 80% accuracy (76%). The trials with RTs larger than 4,000 ms were excluded from further analysis (0.17%). There were no statistically significant differences between the two groups in either absolute RTs or accuracies between the two groups. In addition, Welch two-sample t tests found no RTs differences between Taiwanese and Americans in either the congruent or incongruent conditions (see Table 6). The results followed previous literatures' conclusion that RTs were faster when a stimulus appeared close to the response location, even if the location of the stimulus was irrelevant to the entire task. For instance, RTs were faster when blue stimuli were displayed in positions of 50, 100, and 200 pixels; on the other hand, when participants see red stimuli, participants responded faster in the positions of -50, -100, and -200 pixels (Figure 14). Overall, the results revealed that the interference costs between Taiwanese and Americans were very similar (28.8 vs. 27.2 ms, respectively, *d* = .0511).

Table 6: Welch two-sample t test in the Simon task

Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	486	465	1.66	0.1	0.94	0.96	-1.35	0.18	28.79	27.22	0.25	0.803
Congruent	473	452	1.51	0.13								
Incongruent	501	479	1.79	0.08								

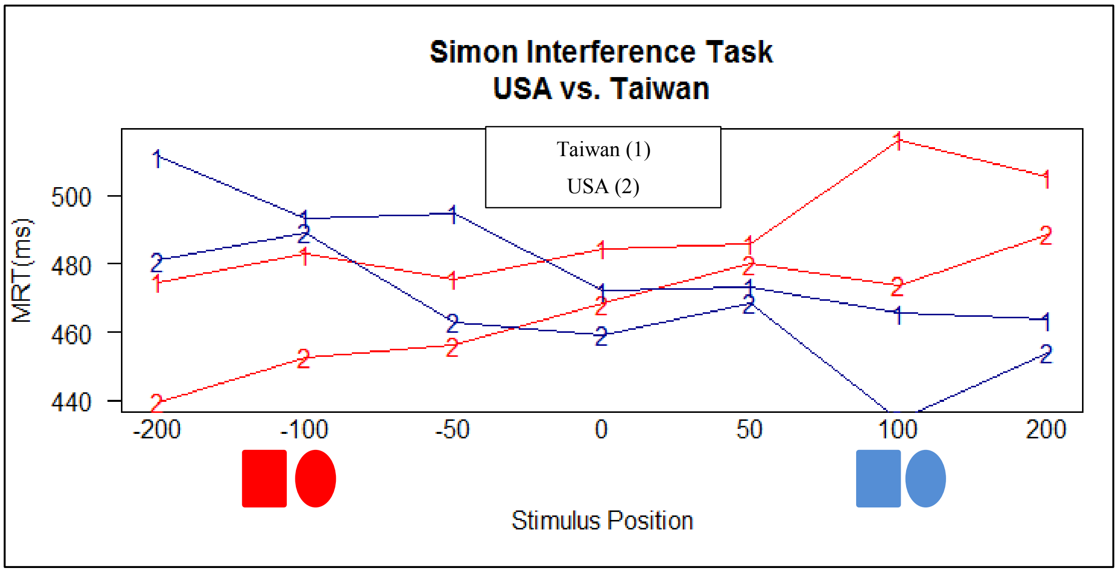

Figure 14: Mean RTs as a function of stimulus position and response type. Red lines represent the responses to stimuli in red color (using left shift key). The blue lines denote the responses to stimuli in blue coloFr (using right shift key).

Next will be the hypotheses testing.

H1: Interference Suppression was calculated as the RT in the incongruent condition minus the congruent condition. The results revealed that the interference costs between Taiwanese and Americans were very similar (28.8 vs. 27.2 ms, respectively, $t(78) = 0.25$, $p = 0.803$, $d = 0.051$).

H4: Centrality vs. Eccentricity was calculated where stimuli are presented at outer positions (greater than 50 or less than -50 pixels) minus the central position (greater than -50 and less than 50 pixels). Welch two-sample t tests do not reveal significant difference in H4 between Taiwanese and Americans (8.30, -1.67 ms, respectively, $t(101) = 1.41$, $p = 0.161$, $d = 0.271$). In conclusion, Simon interference task fails to support H1 and H4. This task does not evaluate H2, H3 and H5.

4.2.6.4 Future Direction for Experiment 2

Most of the literature focused on the discussion of human's executive function to the Simon effect, rather than centering on the component of visual attention. In addition, the results of the Simon task did not detect any cultural difference between two countries. This task would be excluded from Experiment 2 in order to focus on the tasks which would provide consistently significant attentional differences cross-culturally.

4.2.7 Task 7: Eriksen Flanker Task

PEBL flanker task is an implementation of Eriksen's version of flanker task. Eriksen and Schultz (1979) developed this task to examine the effect of distractor interference during the visual search process. Subjects are asked to respond to the central arrow out of five horizontal, equal sized arrows. The four flankers are either pointing to the same or opposite direction as the central targeted arrow (Stins et al., 2007). The general finding, referred to as flanker effect, is that RTs are shorter in the congruent condition (i.e., all arrows point to the same direction) than in the incongruent one (i.e., flanker stimuli point to the opposite position from the central target). Both selective attention and interference suppression can be investigated in this task.

4.2.7.1 Prior literature

Yang, Yang and Lust (2011) adopted the flanker test to examine whether the bilingual effects of executive attention and cognitive functioning exist in young children. The average age of the participants was four years. There were four groups in this study, including English monolinguals, Americans, Korean monolinguals, and Korean-English bilinguals. In order to be more child-friendly, the authors used fish as stimuli in their flanker test, rather than arrows. The results showed a flanker effect (RTs were faster in the congruent trials than in the incongruent trials) and that bilingual children were more accurate and faster than the other three monolingual groups.

A recent study on cross-cultural difference in Flanker interference was conducted by Millar, Uzundag, Gutchess, Boduroglu, and Sekuler (2013), where Turks represented Easterners and Americans represented Westerners. The authors manipulated two conditions, including gap length between the target and flankers (i.e., 0.5° of visual angle in the near condition vs. 1.5° of visual angle in the far condition) and the congruency (i.e., congruent, incongruent, & neutral conditions). The stimuli used in their task was either E or H. The results showed that there was no RT difference between the two cultures under these two gap length conditions; however, there was a significant difference in the incongruent condition when the gaps were shorter in 0.5°. Millar et al. (2013) suggested that “Americans are more likely to confuse neighboring positions, whereas East Asians make more random errors.” and “Americans may treat near letters as multiple items, while Turks group them as a gestalt.” They also indicated that there might be a cultural difference in terms of focal attention vs. contextual attention (Millar et al., 2013).

4.2.7.2 Design, Stimuli, and Procedure

The Eriksen flanker task employed a design with congruency as a within-subject factor. There were 24 trials in the four conditions, including a congruent condition (e.g., "← ← ← ← ←"), an incongruent condition (e.g., "← ← → ←←") (Figure 15), a neutral condition with one central stimulus only (e.g., "←"), and a non-flanker condition with one central target stimulus surrounded by four "-" (e.g., "- - ← - -").

The stimuli consisted of one central arrow (1.7° of visual angle), displayed at the center of the screen, and four flankers, either arrows (1.7° of visual angle) or lines (1.7° of visual angle) with two of them on each side of the central arrow. The gap length between each flanker and the central arrow subtended 0.4° of visual angle, and the field of the stimuli was 9.9° of visual angle.

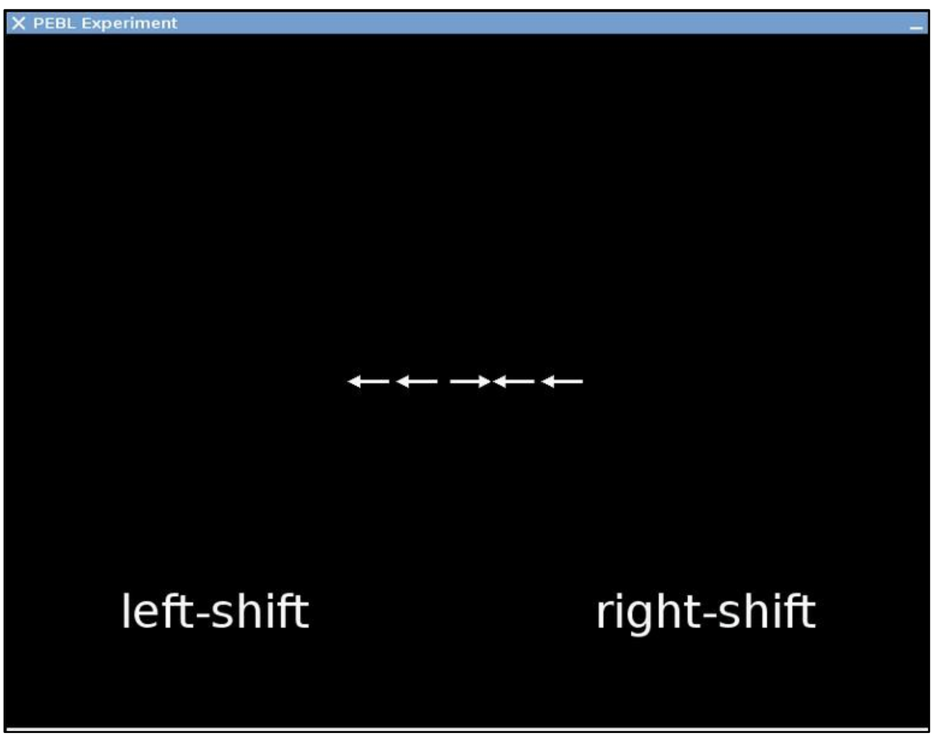

Figure 15: Screenshot of an incongruent trial in Erikson flanker task. The central arrow points to the opposite direction of the four flankers.

Participants were given eight training trials which were not analyzed. At the beginning of the task, a fixation cross appeared for 500 ms, and followed by a horizontal array of five equally-spaced arrows for 800 ms. Participants were asked to respond to the direction of the central arrow as quickly and accurately as possible. Participants were asked to pay attention to the central arrow and disregard the four flankers. When a central arrow was pointing to the right, participants were to respond to the right shift key, and vice versa. The dependent measures were RTs and accuracy.

4.2.7.3 Results and Analysis

Four Taiwanese and two American participants were eliminated from this task analysis due to low accuracy (< 80%). The results of paired t tests revealed that average RTs in Taiwanese group were significantly faster in the congruent condition than in the incongruent condition (457 vs. 500 ms, respectively, t (56) = - 6.5479, $p < 0.001$, d = 0.7728) and the same pattern was discovered for the American group (459 vs. 517 ms, respectively, t (37) = -6.8734, $p < 0.001$, d = 0.9906). Both absolute RTs and accuracies had no difference between two groups. All the conditions (Figure 16), did not achieve statistical difference between two groups (see Table 7 for Welch two-sample t test).

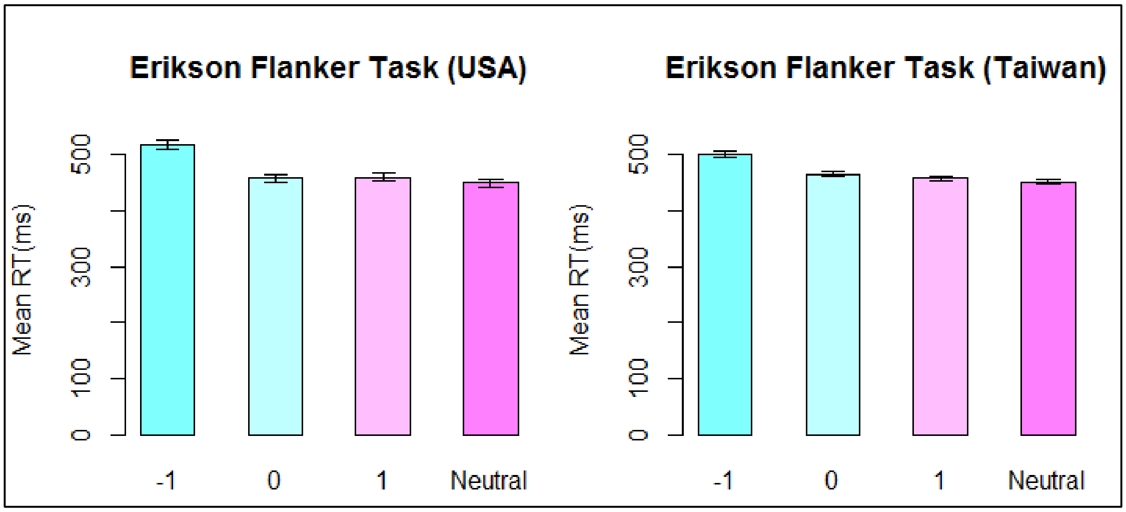

Figure 16: Mean RTs as a function of congruency in the Erikson flanker task. “1” denotes the congruent condition. “0” represents the condition of non-Flanker effect. “-1” denotes the incongruent condition. The results showed no difference between the two groups in either of the conditions.

Table 7: Welch two-sample t tests in the Eriksen flanker task

Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	468	471	-0.38	0.702	0.957	0.938	1.37	0.176	42.9	58.13	-1.42	0.159
Incongruent	500	517	-1.24	0.219								
Non-flanker	465	457	0.565	0.574								
Congruent	457	459	-0.189	0.851								
Neutral	451	449	0.151	0.881								

Next will be the discussion of the hypotheses testing.

H1: Interference Suppression was calculated as the RT or accuracy for incongruent condition minus the congruent condition, in terms of interference cost. Based on Welch two sample t-test, the results showed a trend that Taiwanese interference cost was 15 ms lower than American counterparts, but it did not reach significant difference in both accuracy (t (76) = 1.4875, p = 0.141) and in RTs (t (77) = -1.4215, p = 0.1592).

H2: Response Inhibition was measured using RT and accuracy in the incongruent condition minus the neutral condition. There was no difference between these two groups in either accuracy (t (70) = -1.4063, p = 0.164) or mean RTs (t (82) = -1.7472, p = 0.0844), indicating that these was no difference between the two groups in the abilities to suppression irrelevant visual information and to inhibit habitual, natural responses and to focus on the responses asked. Note that H3, H4, and H5 were not evaluated in this task.

4.2.7.4 Future Direction for Experiment 2

The results of the Erikson flanker task did not show any cultural difference between the two groups and did not support any hypothesis. However, this task may produce more promising results if the gaps between the target and the flankers can be manipulated as shown in Millar et al.'s (2013) study. They concluded that there was significant difference in accuracy between Americans and Turks when the gaps were narrowed. Thus, we would modify this task in Experiment 2 to include a wider range of gap widths.

4.2.8 Task 8: Bivalent Shape Task (BST)

BST is a non-verbal, Stroop-like, simple test developed by Esposito, Baker-Ward, and Mueller (2013). It tested participants' ability to respond to the shape of the stimulus while simultaneously ignoring the color. Both interference suppression and response inhibition can be measured in this task. In addition, this task has been used to assess bilingual children's ability to suppress irrelevant information (Esposito et al., 2013; Mueller & Esposito, 2014).

4.2.8.1 Prior Literature

In a recent study, Esposito, Baker-Ward, and Mueller (2013) used a newly developed BST to investigate bilingual children's ability to perform interference suppression. The results showed that Spanish-English bilingual children had lower cognitive interference than English monolingual children, indicating that bilingual children have better ability to suppress irrelevant information than monolingual ones.

4.2.8.2 Design, Stimuli, and Procedure

The bivalent shape task utilized a design with congruency as a within-subject factor. There were a total of 36 trials and three conditions, including congruent (i.e., matching the color of stimulus and response), incongruent (mismatching the color of stimulus and response), and neutral conditions (i.e., no color on the stimulus; see Figure 17 for the screenshot of these three conditions).

Stimuli were either a circle or a square at the center of the screen subtended 5.1° × 5.1° of visual angle. The answer keys were located at the bottom of the screen, including a circle on the left and a square on the right (both subtended 2.4° × 2.4° of visual angle), and separated with 4.8° of visual angle.

Before the task, participants were given six practice trials excluded from data analysis. Participants were first presented with a shape located in the screen's center. Then, they had to determine whether this shape matched the left-side or right-side shape. Participants were asked to click on the object that shared the shape with the central item. Both response times and accuracies were collected in this task. Participants were asked to respond as soon as possible.

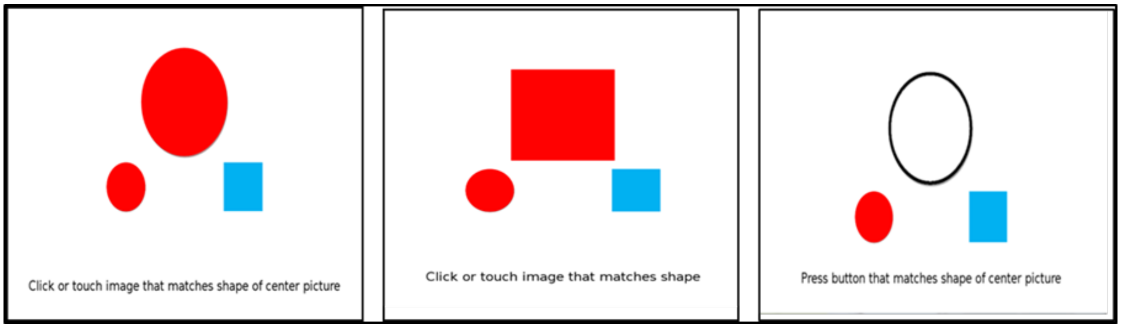

Figure 17: Screenshots of the congruent (left), incongruent (middle), and neutral conditions (right) in BST.

4.2.8.3 Results and Analysis

The results showed that the Americans' mean RTs in the congruent trials were significantly faster than the incongruent trials (762 vs. 833 ms, respectively, t (37) = -6.4649, $p < 0.001$, $d = 0.7047$; Figure 18). This significant difference between the congruent and incongruent conditions, termed congruency effect, was also exhibited in Taiwanese group (744 vs, 809, respectively, t (66) = -5.095, $p < 0.001$, $d = 0.5872$). However, absolute mean RTs and accuracies had no difference between two groups. None of the conditions, including, congruent, incongruent, and neutral conditions, achieved statistical difference between the two groups (see Table 8 for Welch two-sample t-test). Furthermore, the results showed a trend that Taiwanese has lower interference costs (5 ms, *n.s,* $d = .0589$) than American counterparts.

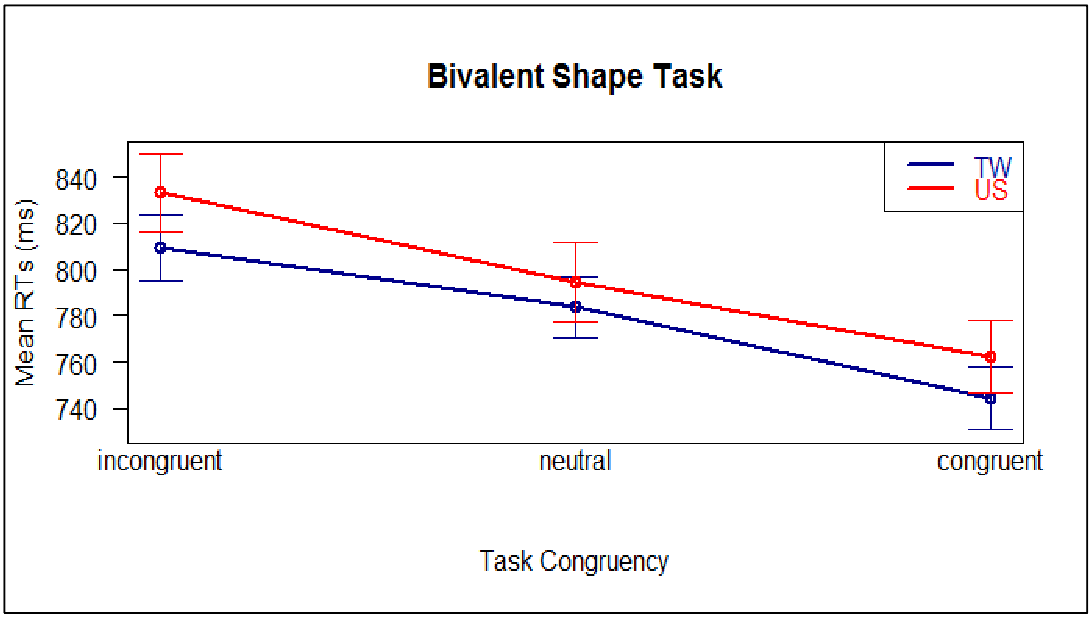

Figure 18: Mean RTs as a function of task congruency in BST. There was no difference between two groups.

Table 8: Welch two-sample T test in BST

Condition	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Overall	779	797	-0.92	0.359	0.989	0.992	-0.74	0.462	65.6	70.8	-0.31	0.758
Incongruent	809	833	-1.07	0.289								
Neutral	784	795	-0.5	0.621								
Congruent	744	762	-0.89	0.374								

Next will be the discussion of hypotheses testing.

Hypothesis 1: Interference Suppression was calculated as the RT/accuracy for incongruent condition minus the congruent condition. Based on Welch two sample t-test, the results showed a trend that Taiwanese interference cost was 5 ms lower than American counterparts, but it did not reach significant difference in both accuracy (t (101) = -0.85, p = 0.398, d = 0.166) and in RTs (t (101) = -0.31, p = 0.758, d = 0.059).

H2: Response Inhibition was measured using RT/accuracy in the incongruent condition minus the neutral condition. There was no difference between these two groups in both accuracy (t (63) = -0.58, p = 0.563, d = 0.122) and mean RTs (t (96) = 0.54, p = 0.593, d = 0.104), indicating that these was no difference between the two groups in their abilities to suppress irrelevant visual information and to inhibit habitual, natural responses, at the same time focusing on the responses required. Note that H3, H4, and H5 were not evaluated in this task.

4.2.8.4 Future Direction for Experiment 2

The analysis of BST did not reveal any cultural difference between two countries. It may be that the difference can be detected only in young children, like previous research (Esposito et al., 2013) in BST has shown, rather than in adults. Therefore, this task would not be included in Experiment 2.

4.2.9 Task 9: Dot Flicker Task

This task was an adaptation of Rensink, O'Regan and Clark's (1997 & 2000) change detection task using a flicker paradigm. Each trial, the original scene and changed scene appear in sequence, each for 400 milliseconds (they are interleaved with a blank screen for 100 milliseconds). Unlike Rensink et al.'s (1997 & 2000) using images as stimuli, this PEBL task uses symbols (i.e. dots) as stimuli. This task has four conditions, including changes in color, size, location, and even the disappearance of the target among 50 scattered background dots.

According to Pashler (1987), the number of stimuli in the display has an impact on self-terminating, conjunction search RTs. With 50 scattered circle stimuli, this dot flick task represents a high level of difficulty. Thus, this task can be used to investigate task difficulty as well as subjects' focused attention to search for the change and suppress background distractors.

4.2.9.1 Prior Literature

A study conducted by Boduroglu, Shah, and Nisbett (2009) investigated the "cultural differences in allocation of attention in visual information process" between Asians and Americans. Participants were asked to find the color change in two continuously scenes interleaved with a blank screen to mask the change. The results showed that Asians could better detect the color change in larger and expanded scenes when stimuli were displayed near the corners of the screen; on the other hand, Americans could better detect color change while the scene is minimized and stimuli were displayed closer to the center.

The study conducted by Masuda et al. (2008a) showed that Easterners' attention is easier to distract by contextual information than Westerners. In their stimuli, five circles evenly distributed on the screen; four distracting circles were presented symmetrically on the x and y axes, surrounding a central circle. The results showed that the number of fixations and deviations of eye-movement from the center within the 30 second period were both significantly larger for Japanese compared to Americans. The authors pointed out that while participants were asked to focus their attention to the central circle and disregard four interference circles, Japanese tried to pay attention to the central target but failed to only focus on the target circle. This study seems to indicate that while facing a more complex task with more stimuli on the screen, as seen in the present change detection task, Easterners might be more easily distracted compared to Westerners.

4.2.9.2 Design, Stimuli, and Procedure

The PEBL dot flicker task was an implementation of the flicker paradigm in which two (original and modified) images alternated one after the other, changing one specific area of the image, with a brief blank field in between. The task implemented symbols (i.e., dots) for participants to detect a change in the scene. It was a within-subject design. There were a total of 20 trials distributed randomly, each with 50 multicolor dot stimuli (Figure 19). The dependent variables in this task are RT and accuracy.

The dot stimuli had varied sizes and subtended from $0.6° \times 0.6°$ to $1.7° \times 1.7°$ of visual angles. The field of the visual stimuli subtended $12.5° \times 17.9°$ of visual angle. Four different kinds of target changes in this task include position change, color change, size change, and appearance/disappearance of a dot target.

Participants were presented with an example to learn how a dot target would move from one position to another at the beginning of the task. They were also reminded that only one dot would change (color, size, location, appear/disappear) among 50 dots. The presentations would rotate between an original scene (400 ms) followed by a flash blank (100 ms) and then the changed scene for another 400 ms. The scenes were presented until participants found the change location. Then, they were instructed to respond by clicking the space bar followed by clicking on the location where the scene had been changed. Participants were asked to find the change as quickly as possible.

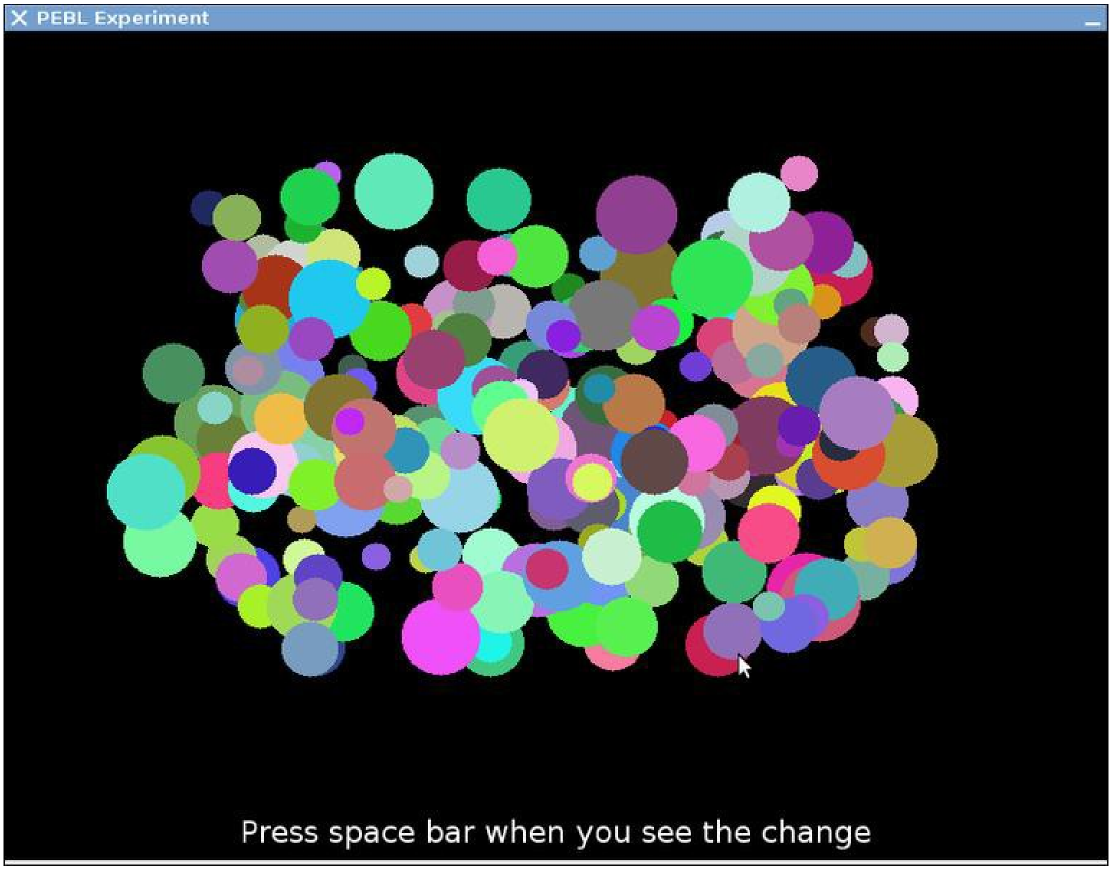

Figure 19: Screenshot of Dot flicker task

4.2.9.3 Results and Analysis

The trials with mean RTs greater than 3 minutes were excluded from this analysis. In addition, seven Taiwanese participants and one American participant were eliminated due to low accuracy (<50%). The reason to set the outlier criteria lower than the other eight tasks is because this task is much more difficult. This can be shown in two ways: first, the mean RTs of this dot flicker task (19,841 ms) drastically increased compared to the other eight tasks (Global-local task [578 ms], various Stroop tasks [647 ms], and visual search task [1,785 ms]). Second, the accuracy in this task was lower than the average of other remaining tasks (84% vs. 85%, respectively).

The results showed a trend that Americans were faster and more accurate compared to their Taiwanese counterparts (Table 9). Regarding accuracy, there was small difference between the two groups (84.97% vs. 83.96%, respectively in Americans and Taiwanese, $d = 0.0734$). Furthermore, Americans showed a trend of faster RTs than Taiwanese, using the correct trials only, but it did not reach significant difference (14,399 ms vs. 16,581 ms, respectively, $t\ (92) = 1.6135$, $p = 0.11$, $d = 0.3253$).

Table 9: Welch two sample t test in the dot flicker task

Condition	RT(ms)					Accuracy				
	TW mean	US mean	T-value	df	P-value	TW mean	US mean	T-value	df	P-value
Overall	16582	14399	1.61	92	0.11	0.84	0.85	-0.345	69	0.732
Position	11923	8400	3.06	86	0.003*	0.931	0.926	0.165	73	0.869
Absence	16085	15122	0.504	89	0.619	0.919	0.899	0.602	61	0.55
Color	22259	21741	0.174	79	0.862	0.628	0.682	-0.909	76	0.366
Size	17876	14203	1.95	91	0.055*	0.881	0.892	-0.252	81	0.802

While examining the four different conditions mentioned above, only the correct trials were used in the statistical sensitivity analysis. The results revealed a trend that Americans were faster than Taiwanese in all four conditions (Figure 20). In the position change condition, the difference was 3523 ms ($t\ (86) = 3.0567$, $p = 0.003$, $d = 0.5894$). In the size change condition, there was a 3673 ms difference ($t(91) = 1.9474$, $p = 0.0546$, $d = 0.3960$). In the color change condition, the results showed a non-significant difference between two groups where Americans were 518 ms faster than Taiwanese ($t(79) = 0.1741$, $p = 0.8622$, $d = 0.0368$). As for disappearance of a target condition, the difference between the two groups was 963 ms ($t(89) = .534$, $p = 0.616$, $d = 0.1027$). Mean RTs were significantly faster in the position change condition than in other conditions which suggest that participants were better at detecting moving targets than static targets. This results were expected as changing in position was somewhat equivalent to having two changes at two locations. Euclidian distance was also used to calculate the distance of the central targeted trials (within 150 pixels from the center of the screen) and the peripheral targeted (beyond 150 pixels from the center of the screen) trials. In the central condition, the results showed that there was no cultural difference between Americans (16,990 ms) and Taiwanese (17,280 ms) based on the Welch two sample t-test (t (76) = 0.10, p = 0.9193, d = 0.0229). In the peripheral condition, the RT results revealed that there was no cultural difference between Americans and Taiwanese (16,312 ms vs. 6,151 ms, respectively; t (64) = -0.1025, p = 0.9187, d = 0.0234.

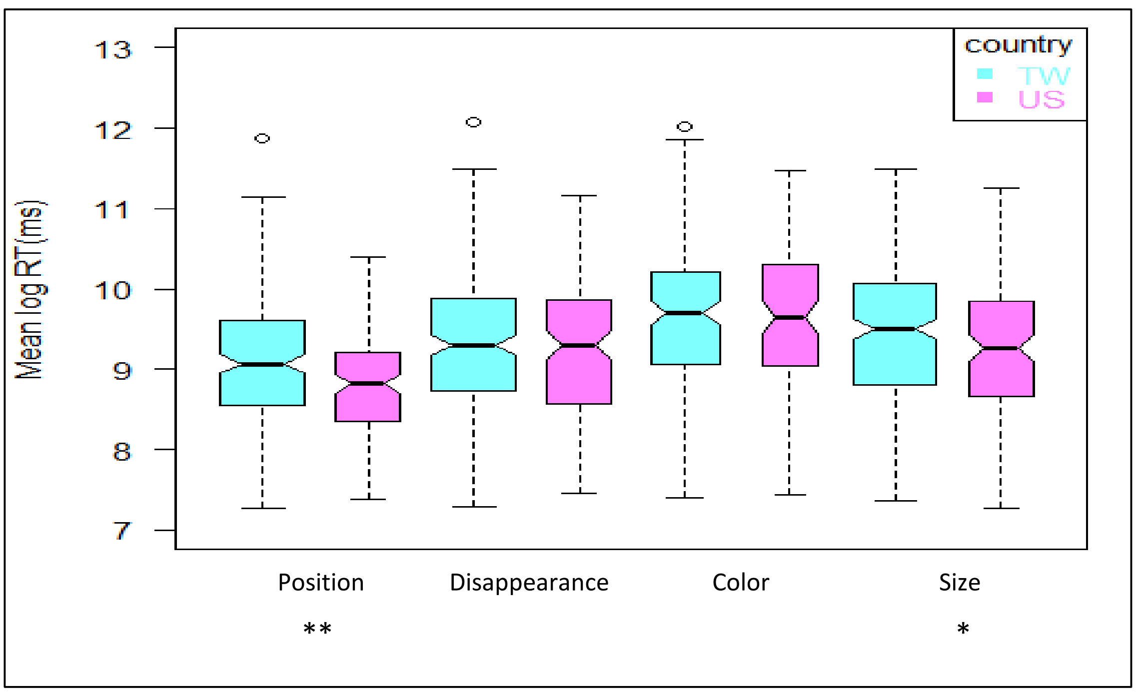

Figure 20: Mean log RTs as a function of task condition in dot flicker task. Black boxes represent the Taiwanese group and gray boxes represent the American group. "*" denotes statistical significance p = 0.05. "**" denotes statistical significance 0.01 > p > 0.001.

Next will be the discussion of the hypotheses testing.

The present task was designed to test H3 and H4 only. H3: Detail vs. Object Configuration is calculated as RT difference between the color change (demonstrating the change in the detail configuration where there were various colors displayed simultaneously and need a detailed search) and the size change (representing the change in the salient object configuration where only one dot had changed its size). Color change can be regarded as detailed change because subjects' RTs were the longest and accuracy was the lowest among all the change conditions, suggesting that additional attention and efforts were needed to detect a color change. In contrast, a dot/object change in size (subtended between $0.6° \times 0.6°$ to $1.7° \times 1.7°$ of visual angles) was easier to detect, which can be seen in both RTs and accuracy, compared to a color change. The Welch two sample t-test failed to support H3 (t (75) = -0.7662, p = 0.446), indicating that there was no cultural difference in participants' ability to search for object versus detailed changes on the screen.

H4: Centrality vs. Eccentricity was calculated as the RT/accuracy in the eccentric condition (beyond 150 pixels from the center) minus the central condition (within 150 pixel from the center of the screen). The results did not support H4 (t(75) = -0.1538, p = 0.8782), suggesting that there was no cultural difference in eccentricity vs. centrality.

4.2.9.4 Future Direction for Experiment 2

Huang and Pashler (2005) suggested that a difficult search task (greater than 16 stimuli in a scene) reduces search efficiency, and the present task is a complex task with a high level of difficulty. Even though Americans outperformed Taiwanese in the conditions of position change and size change, there was no difference in Hypotheses tested (i.e., H3 & H4). A plausible explanation might be that Taiwanese are more easily distracted by too many stimuli and detailed contextual information compared to Americans (Wang, et al., 2012).

In addition to the condition of 50 stimuli on the display as seen in Experiment 1, the conditions of 5 and 10 distractors would be added to Experiment 2. Additionally, an image flicker task was included in Experiment 2 as a means to further investigate the cultural difference in the real world scenes.

In conclusion, we have chosen the global-local task, the visual search task, the Eriksen flanker task and the dot flicker task to further assess Eastern and Western cultural differences in visual attention in Experiment 2. The basic criterion to select these tasks was based on whether the data supported the developed hypotheses. The primary focus to select tasks to implement in the Experiment 2 fell into three main considerations: 1. whether there was room to improve the design of the task (this would rely on whether we had the ability to modify computer codes); 2. whether there was previous literature which could prove to demonstrate cultural difference; and 3. whether there were other tasks better at addressing the hypotheses. Examples of the improvement included expanding gap lengths in the Flanker task, adding and recording the eccentricity effect in the global-local task, and reducing stimuli set size in the dot flicker task. Furthermore, we also tried to increase the task power by, for instance, increasing the trials from 31 to 180 per subject in the visual search task and from 24 to 128 in the flanker task. The efforts we put into programing algorithm and computer codes were in a hope to improve the tasks to better assess East-West cultural differences in visual attention.

Chapter 5: Experiment 2

Chapter 5 discuss Experiment 2, including the general method, the five visual attentional tasks, and their results. Furthermore, a predictive model which adapted Linear Discriminant Analysis (LDA: Fisher, 1936) and implemented cross validation is demonstrated at the end of this chapter.

5.1 General Method

This section consists of the general method used for these five tasks in Experiment 2. This discussion includes participants, design and procedure, apparatus, material, and stimuli. Four of the attentional tasks in Experiment 2 are modified versions of the tasks in Experiment 1, including global-local task, visual search task, Erikson flanker task, and dot flicker task. Experiment 2 also included the image flicker task, a task that was recently added to the PEBL platform. The introduction and prior literature review of image flicker task are discussed here. The other four tasks were discussed in detail in Chapter 4: Experiment 1.

5.1.1 Participants

A total of 135 participants were recruited from MTU. They were either volunteers with no pay recruiting from the psychological subject pool (the SONA system) or were paid $10 for one hour of participation. Three distinct cultures were recruited, including Americans (40%), Chinese (30.37%), and Indians (29.63%). These are the largest student groups in MTU. The main focus in Experiment 2 was the comparison of Americans (Westerners) and Chinese (East Asians), if the results have any discrepancy between

Indians and Chinese, because previous research tends to focus on the difference between East Asians and Westerners. There were 54, 41, and 40 American, Chinese, and Indian participants, respectively. Among the American participants, 31 were male and 23 were female students. There were 21 male and 20 female Chinese students who attended Experiment 2. In the Indian group, both genders had 20 students who took part in this study. The average ages among these three groups were 20.24 (ranged from 18 to 31), 25.68 (ranged from 18 to 32), and 24.19 (ranged from 21 to 45) in the American, Chinese and Indian groups, respectively. One American, three Chinese, and two Indians were left-handed. The self-reported, most recent, average TOEFL scores in the Indian group was 103.91, ranged from 91 to 120, while the average Chinese TOEFL score was 87, ranged from 60 to 107. These scores excluded those who did not know or could not recall their TOEFL scores. The languages participants can speak fluently were one, two, and three in the American, Chinese, and Indian groups, respectively. On average, Chinese participants had stayed in the U.S. for 2.5 years while Indian participants had stayed for one year. Three native languages were spoken in India, including Hindi, Marathi, and Telugu.

The “pwr” package in R was used to perform a power analysis and calculate the Cohen effect size. Cohen (1988) suggested that values of 0.1, 0.25, and 0.4 represent small, medium, and large effect sizes, respectively. Using medium effect size (0.3) and a power of 0.8, the common sample size needed in Experiment 2 is 37 in each group. With three groups and at least 40 participants in each group, the power in Experiment 2 is 0.84 ($k = 3$, $n = 40$, effect size = 0.3, significance level = 0.05), which reveals that the sample size in Experiment 2 is sufficient to find meaningful effects in the tasks.

It is important to note that gender has no impact on Experiment 2 as well.

According to the F variance analysis, the results of the absolute RT variances between male and female showed that there were no gender differences among the American group ($F(30,23) = 1.14$, $p = 0.7545$), Indian group ($F(19,19) = 0.8588$, $p = 0.7435$), and the Chinese group ($F(20,19) = 0.9642$, $p = 0.9335$).

5.1.2 Design and Procedure

A battery of five attention tasks, coded in the PEBL, was used to further investigate human visual attentional differences in Experiment 2, including global-local task, visual search task, Eriksen flanker task, dot flicker task, and the image flicker task. The participants were separated to three experimental groups based on nationality, including Americans, Chinese, and Indians. The experiment used the mixed factorial design where all the participants in these three groups went through the five tasks in the same task sequence. The entire Experiment 2 (i.e., the five tasks followed by a short survey of 12 questions) took about one hour to complete. The participants were instructed to respond as quickly and accurately as possible.

Demographic data was collected before participants began any tasks. The dependent measures included RTs and accuracy. The independent measures were tasks specific and will be discussed in the latter task sections.

5.1.3 Apparatus, Material, and Stimuli

The five tasks were conducted on computers with color monitors. All the participants completed the study using Dell Precision T1600 and Planar PX2230MW monitors with a screen size of 21 inches in an experimental psychology lab in MTU.

Participants were asked to sit on a chair in front of a computer screen and rested their heads on a chinrest, which maintained 20 inches viewing distance (29.6° × 50.3° of visual angle) from the screens in front of them.

Participants' demographic data and response patterns, including RTs and accuracy in each trial, were collected through PEBL (Mueller, 2014). Unlike translations to a native language for Experiment 1, participants in Experiment 2, regardless of their first language, used English to take these tests. This is because they were the students at MTU, indicating an ability to use English in an academic setting and to participate in this study. Also, as an experimenter, I was available to answer questions from participants.

All participants reported having normal or corrected-normal vision and no colorblindness. While attending the lab, participants were required to turn off their cellphones and to sign the consent form in their official language before they took part in the tasks. The consent forms were approved by the IRB at Michigan Tech. The instructions of how to perform the tasks and practice trials were presented to participants before participants started each task.

In addition to some demographic questions, such as age, gender, race, nationality, and major, some examples of post-test survey questions include,

1. Are you a right-hand user or a left-hand user?
2. Is your corrected vision normal?
3. When did you start learning English?
4. What is your most recent TOEFL score?

5. How many languages can you speak fluently?
6. What is your native language?
7. How long have you been speaking English daily?
8. How long have you lived in the United States?

5.2 Five Visual Attentional Tasks & Results

This section comprises the revised design, methodology, procedure, as well as the analysis of the results in the Global-Local task, Visual Search Task, Erikson Flanker task, Dot Flicker task, and Image Flicker task in Experiment 2.

5.2.1 Task 1: Global-Local Task

The global-local task was reinvestigated in Experiment 2 because of the promising results of the East-West difference in Experiment 1, where Taiwanese were better at looking into detail configuration, while Americans were better at focusing on salient, global, big object configuration. This is in line with the East-West cultural differences in general philosophy where Westerners have the tendency of analytic information processing, centering their attention to salient, focal objects, while Easterners tend to have a global viewpoint, focusing on relationships and detailed contexts (Nisbett, et al., 2001; Masuda & Nisbett, 2001 & 2006; Kitayama et al., 2003; Chua, Boland, & Nisbett, 2005; Miyamoto & Wilken, 2013). Moreover, the goal of reexamining the global-local task is to improve the design of this task as well as increase the reliability and validity of the task results.

5.2.1.1 Design, Stimuli, and Procedure

The global-local task employed a 2 (global, local) x 3 (congruent, neutral, incongruent) x 2 (central, eccentric) mixed factorial design. The design, stimuli, and procedure of the global-local task in Experiment 2 were identical to Experiment 1 (see Section 4.2.1.2), except that additional stimulus positions were added along the x axis in the last two eccentric conditions and the stimulus position was recorded for each trial. At the beginning of the task, the stimuli appeared at the center of the screen (540 pixels on the Y position and 960 pixels on the X position) for the first six blocks, and then stimuli appeared eccentrically (ranging from 675 to 1258 pixels randomly in X position, 2.1° to 10.6 ° of visual angles from the outside edge to the center of the screen) aiming at increasing eccentricity in the last two uncertain/eccentric blocks in Experiment 2. However, the block order was not randomized, which might cause confounding issues, such as practice effect or fatigue due to staying on the same block too long.

5.2.1.2 Results and Analysis

In this section, I first discuss the effect size, gender analysis, overall RTs and accuracy, and then perform hypothesis testing of the five hypotheses discussed in Chapter 3. As was done in Experiment 1, RTs larger than 2000 milliseconds or less than 300 milliseconds were excluded from the analysis (0.98% of USA data, 1.70% of IND data, & 1.75% of CHN data). Regarding accuracy, a chi-squared test, using the logit regression model with block, congruency, and nationality factors, yielded no significant difference among three groups ($\chi^2 = 0.45$, $df = 2$, $p = 0.8$), revealing that the overall effect of nationality on accuracy is not statistically significant.

A mixed factorial ANOVA with factors of nationality and congruency yielded significant effects of nationality ($F(2,399) = 49.81$, p <- 0.001) and congruency ($F2,399$) = 29.86, $p < 0.001$) on RT; however, these was no significant interaction of nationality by congruency ($F(4,399) = 0.028$, $p = 0.99$). A post-hoc Tukey HSD comparison revealed that Americans ($M = 553$ ms) were significantly faster than the other groups ($p < 0.001$) at the 0.05 level of significance. Chinese (M= 607 ms) lay in between and were faster than Indian ($M = 649$ ms, $p < 0$ .001). See Figure 21 for a comparison of the RT results of each block in each group of both experiments.

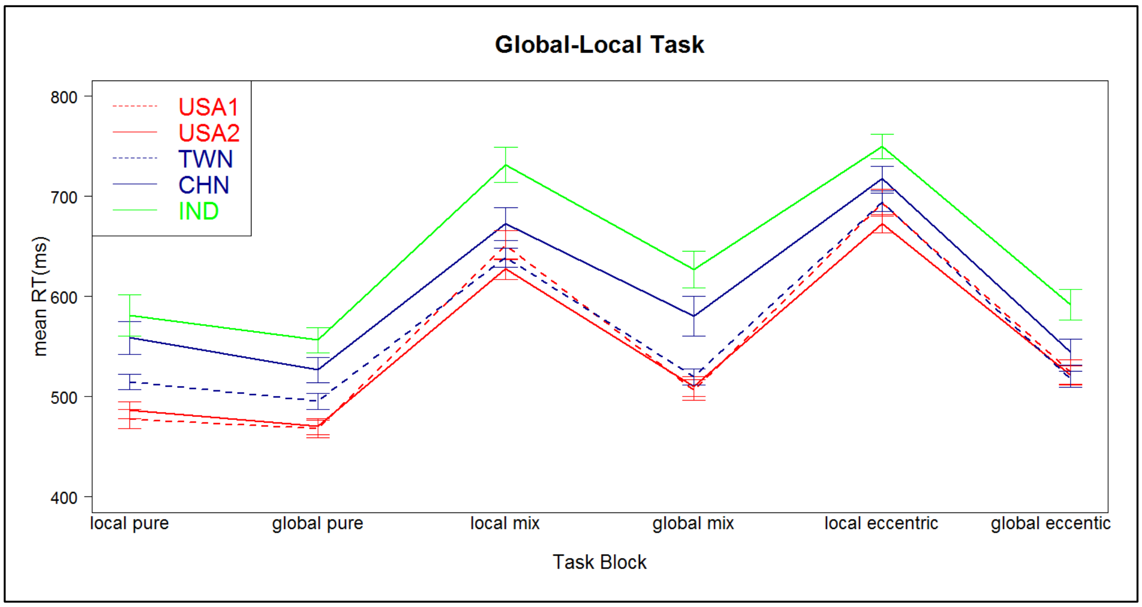

Figure 21: Mean RTs in six blocks. The dashed lines represent data in Experiment 1, and the solid lines denote data in Experiment 2. American, Chinese (including Taiwanese), and Indian groups are displayed in red, blue, and green lines, respectively. Error bars represent 95% confidence intervals within the groups.

Next, I will discuss about the results of hypothesis testing.

Hypothesis 1: Interference Suppression was calculated as RT in the incongruent condition minus congruent condition, in terms of interference cost. As seen in Experiment 1, the results did not support H1 based on the Kruskal-Wallis rank sum test (which is applicable for long-tailed, independent samples, rather than a normal distribution), including interference costs in both RT ($\chi^2 = 0.1665$, $df = 2$, $p = 0.9201$) and accuracy ($\chi^2 = 0.5363$, $df = 2$, $p = 0.7648$).

Hypothesis 2: Response Inhibition was measured using RT and accuracy in the incongruent condition minus the neutral condition. A Kruskal-Wallis rank sum test was performed to examine the relationship between response inhibition and nationalities. Consistent with Experiment 1, the results were not significant; the mean ranks of response inhibition per nationality are not significantly different among the three nationalities in both RT ($\chi^2 = 0.956$, $df = 2$, $p = 0.62$) and accuracy ($\chi^2 = 0.8886$, $df = 2$, $p = 0.6413$).

Hypothesis 3: Detail vs. Object Configuration is defined as RTs and accuracy in the detailed (local) condition minus the object (global) condition. The results of the Kruskal-Wallis test demonstrated that nationality had a significant impact on RTs to details vs. objects visual information processing ($\chi^2 = 10.0048$, $df = 2$, $p = 0.0067$) and an approaching significant effect on accuracy ($\chi^2 = 5.8065$, $df = 2$, $p = 0.0549$) (Figure 22). The results indicate that Easterners are slightly better at attending to contextual details while Westerners are better at focusing on big object configuration.

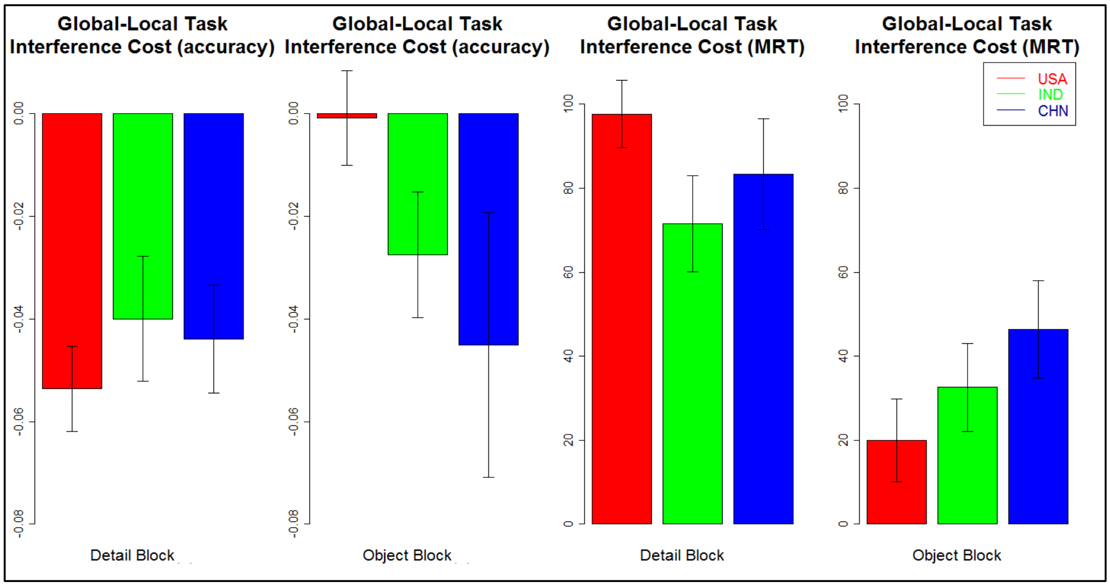

Figure 22: The results of H3: Detail vs. Object Configuration testing. Americans are denoted by red bars; Indians are represented by green bars, while Chinese are shown in blue bars. Error bars represent one confidence interval. The y axis represents the interference cost of either accuracy or mean RT formats. Americans had higher interference cost in detailed (local) blocks but lower interference cost in big object (global) blocks, compared to Easterners. The opposite is true for the other two groups.

Hypothesis 4: Centrality vs. Eccentricity was measured as the RT difference between central trials (100 pixel radius around the center of the screen) and eccentric trials, measured in Euclidian distance. There are two ways of examining H4, including the local measure (block 6 - block 4) and the global measure (block7 – block 5) (Figure 23). In the local condition, the results in all the groups were consistent with previous main finding of eccentricity effects, as participants responded faster while the stimuli were at the center of the screen and were slower while eccentricity increased, as the x axis shows in the left panel of Figure 23.

The hypothesis testing results, based on Kruskal-Wallis test, failed to support H4 in the local condition ($\chi^2 = 2.4867$, $df = 2$, $p = 0.2884$), suggesting that there was no difference in eccentricity costs in the local condition among the groups. However, there was a significant cultural difference in global condition ($\chi^2 = 6.851$, $df = 2$, $p = 0.0325$). Notably, the effect was in the opposite direction of assumed hypothesis that Americans had lowest eccentricity cost (-7.4643 ms), Chinese had second lowest cost (12.4788 ms), and Indians had highest cost (13.575606 ms). This suggests that Westerners were better at paying attention to salient object global configuration, even when eccentricity was increased, resulting in negative interaction cost.

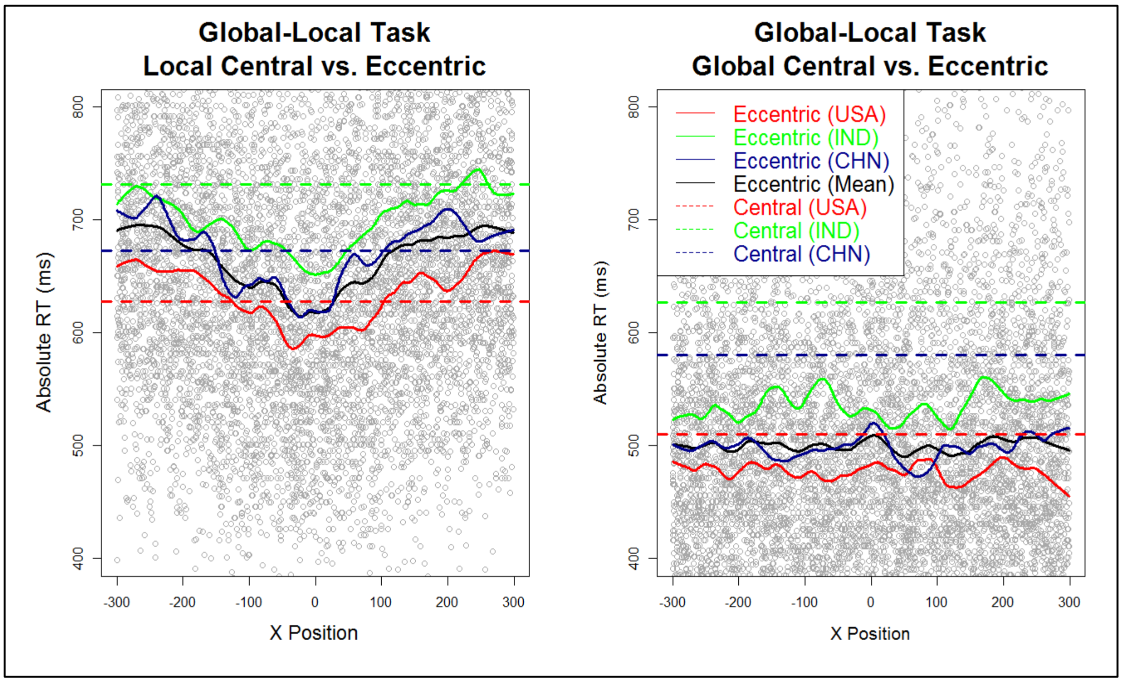

Figure 23: Central vs. Eccentric conditions. The local condition is on the left where the three groups showed a similar trend that the eccentric block, as shown in the solid lines, exhibited a typical eye movement shape. The global condition is on the right, which shows a flattened shape in both central and eccentric conditions.

The data in the Global-Local task were not relevant to H5: Number of Distractors.

5.2.1.3 Conclusion and Future Direction

Overall results in the global-local task in Experiment 2 support H3: Detail vs. Object Configuration, revealing that Westerners were better at focusing their attention to salient, focal, big object configuration, while Easterners were better at looking into small, detailed configuration. This is inconsistent with McKone et al.'s (2010) study which concluded that Easterners have a global advantage; however, in the present study, we have shown a global advantage for Westerners and a local bias for Easterners consistently in Experiment 1 and 2.

Due to the confounded issue of not randomizing the blocks/trials in this task, there could be a problem of level-repetition effect, resulting in participants' faster responses to consecutive trials, which required them to direct their attention to only a global (object) or local (detail) level (Ward, 1982; Lamb & Yund, 1996; Hubner, 2000). Thus, there is a need to design blocks with counterbalanced order within groups to account for learning effects and level-repetition effect. In the future, the task can be modified by counterbalancing the block order, increasing the difficulty of recognizing and distinguishing between the global and local figures, using more neutral stimuli like symbols or faces, or even using Chinese characters as stimuli, to reexamine H3 in depth.

5.2.2 Task 2: Visual Search Task

Understanding what mechanisms the Eastern and Western cultural groups utilize to visually search and process information and how these can be applied to real world situations is important for mutual understanding between Easterners and Westerners. This can be beneficial for industries in website and user interface design, video game design, advertisement campaigns, and more. In Experiment 1, we have seen significant differences in search speed and feature search; compared to Americans, Taiwanese searched for targets faster overall and did a significantly better job in their search for popout targets out of 10 stimuli in the situation of one or five targets present. In Experiment 2, we have expanded the search task to a full version to obtain a more reliable measure and have performed statistical testing on five hypotheses built to examine the cultural mechanisms consistently across multiple tasks.

5.2.2.1 Design, Stimuli, and Procedure

The visual search task was a 3 (set size) x 3 (number of targets) x 2 (target color) x 2 (target character) mixed factorial design. Except for the difference in trial size (where the trials were extended from 31 to 180 trials), the design, stimuli, and procedure in Experiment 2 were identical to Experiment 1 (see Chapter 4.2.2.2). Unfortunately, the x and y coordinates were not recorded in either Experiment 1 or 2, which hinder a thorough investigation of the impact of target location to cultural performance.

5.2.2.2 Results and Analysis

None of the subjects were eliminated from the data analysis as their accuracy was all above 80%. Similar to Experiment 1, RTs longer than 10,000 ms were removed from analysis, and the error responses were excluded in data analysis. A chi-squared test of accuracy was employed using the logit regression model where the factors of target number, set size, target character, target color, and nationality were included. The results of the Chi-squared test was highly significant (χ^2 (2) = 46.4, $p < 0.001$) indicating the overall effect of nationality on accuracy was statistically significant. Americans were more accurate than Indians and Chinese (99.14%, 97.89%, & 98.27%, respectively).

This task can be separated to target absent, one target present, and five target present conditions. Analysis of target absent data revealed that there were significant effects of countries, including the effect of culture on intercept ($F(2,133) = 3.58$, $p = 0.0321$), the effect of culture on search slope ($F(2,133) = 4.321$, $p = 0.0152$), the set size effect, indicating that RT increased with set size ($F(2, 133) = 8.266$. $p = 0.0004$), and the target color effect, indicating that RT increased from searching for the absent green target to searching for the absent white target among white distractors ($F(2,133) = 3.37$, $p = 0.0374$). In one-target present condition, ANOVA revealed a significant effect of culture on intercept ($F(2,133) = 4.764$ $p = 0.01$), and a significant set size effect, indicating that RT increased with set size ($F(2,133) = 3.149$, $p = 0.0461$), but there were no differences in the effect of culture on search slope ($F(2,133) = 2.778$, $p = 0.0658$) and the target color effect ($F(2,133) = 0.779$, $p = 0.461$). As for five-target-present condition, ANOVA showed that there was a significant effect of culture on intercept ($F(2, 133) = 7.343$, $p = 0.0009$), and a significant set size effect ($F(2, 133) = 4.933$, $p = 0.0086$), but there were no differences effect of culture on search slope ($F(2, 133) = 2.508$, p = 0.0853) and no significant target color effect ($F(2, 133) = 2.005$, $p = 0.139$).

A repeated measure of two-way ANOVA was employed to evaluate the effects of number of target (with two levels: one target present and target absent) and nationality upon RTs. The results showed statistically significant effects of number of target, indicating that RT increased with target size ($F(1, 266) = 213.61$, $p < 0.001$, $\eta^2 = 0.413$), as well as significant effect of nationality, indicating that Americans were faster than Chinese and Indians ($F(2, 266) = 16.82$, $p < 0.001$, $\eta^2 = 0.065$). However, the interaction between number of target and nationality was not significant ($F(2, 266) = 2.02$, $p = 0.14$,

$\eta^2 = 0.008$). Further employing the post-hoc Tukey HSD test, the results revealed that the effect of target presence on RTs was significantly different from that of target absence (*diff* = -603.21, *lwr* = -684.47, *upr* = -521.95, $p = 0$).

Further considering the nationality effect on search slope in six different conditions, it is represented in the Table 10 and visualized in Figure 24. First, I employed linear regression model of RTs by size, coded as lm (rt ~ size) in six different conditions. Second, I utilized two-way ANOVA model to examine the effects of set size and nationality o slope. The results revealed that interaction between set size and nationality were significant in two conditions, including target absent feature search and one target present feature search. Finally, post hoc tests were employed to examine set size effects among nationalities in these two conditions. In the target absent feature search condition, the results of Kruskal-Wallis test revealed that Americans were significantly faster than Chinese (1,130 vs.1,359 ms, respectively, *diff* = 229, *lwr* = 120, *upr* = 338, $p < 0.001$)) and Indians (1,130 vs. 1,751 ms, respectively, *diff* = 621, *lwr* = 511, *upr* = 731, $p = 0$); Chinese were significant faster than Indians (1,359 vs. 1,751 ms, respectively, *diff* = 392, *lwr* = 510, *upr* = 274, $p = 0$). In the one target present feature search condition, the results of Kruskal-Wallis test revealed that Americans were significantly faster than Chinese (624 vs. 828 ms, respectively, *diff* = 204, *lwr* = 149, *upr* = 260, $p = 0$)) and Indians (624 vs. 905 ms, respectively, *diff* = 281, *lwr* = 225, *upr* = 337, $p = 0$); Chinese were significant faster than Indians (828 vs. 905 ms, respectively, *diff* = 76, *lwr* = 137, *upr* = 17, $p = 0.007$).

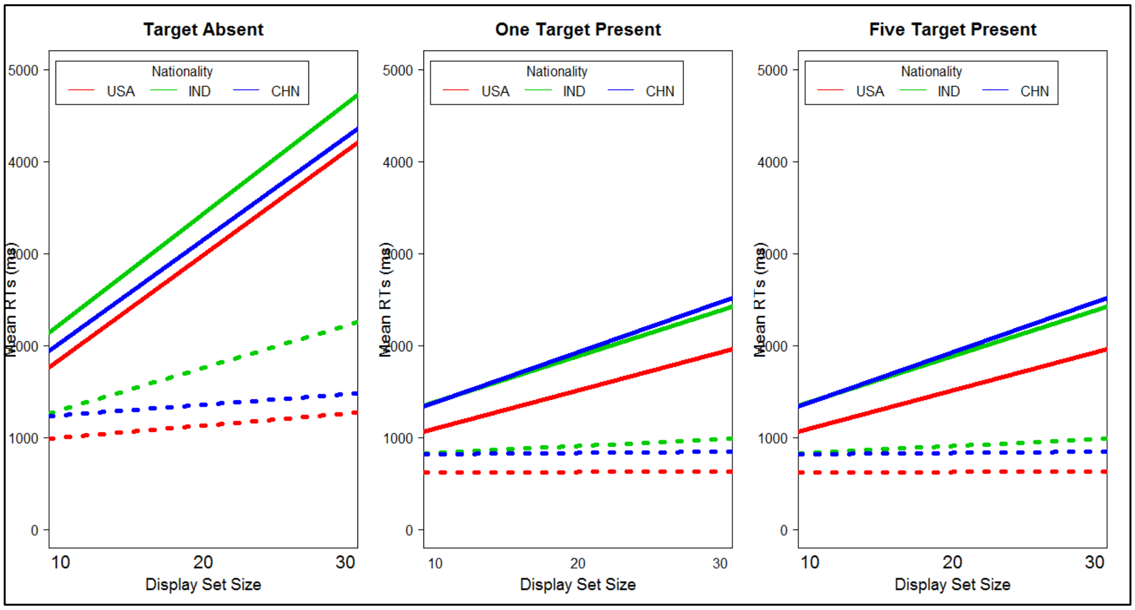

Figure 24: Slopes of mean RTs by display set size. The solid lines represent conjunction search, while the dash lines represent feature search.

Table 10: Search slopes in six conditions and the results of ANOVA analysis

Visual Search Task Experiment 2	Slope (ms/item)			Model: anova(lm(rt~size*nationality))			
	USA mean	IND mean	CHN mean	Df value	Residuals value	F value	P value
TA-Feature Search	15.23	55.64	15.17	2	391	5.81	0.003*
TA-Conjuction Search	122.43	125.36	128.45	2	1884	0.46	0.633
1TP-Feature Search	0.52	8.12	1.50	2	3937	2.93	0.054*
1TP-Conjunction Search	41.16	50.61	54.30	2	1933	2.08	0.125
5TP-Feature Search	2.65	7.30	1.32	2	3930	1.18	0.306
5TP-Conjunction Search	8.74	9.07	6.33	2	1950	0.05	0.955

Taken together, all the subjects have shown similar trends as seen in previous research (Treisman & Gelade, 1980; Wolfe, 1994 & 1998; Itti & Koch, 2000). For example, the, feature search, the RT was faster than the conjunction search (like white O among other white distractors), meaning that additional attention was required for conjunction search; the slopes for the feature search were flattened compared to the conjunction search; and the set size did not affect RTs in the feature search but did impact RTs in the conjunction search in the one target present condition (see Figure 25).

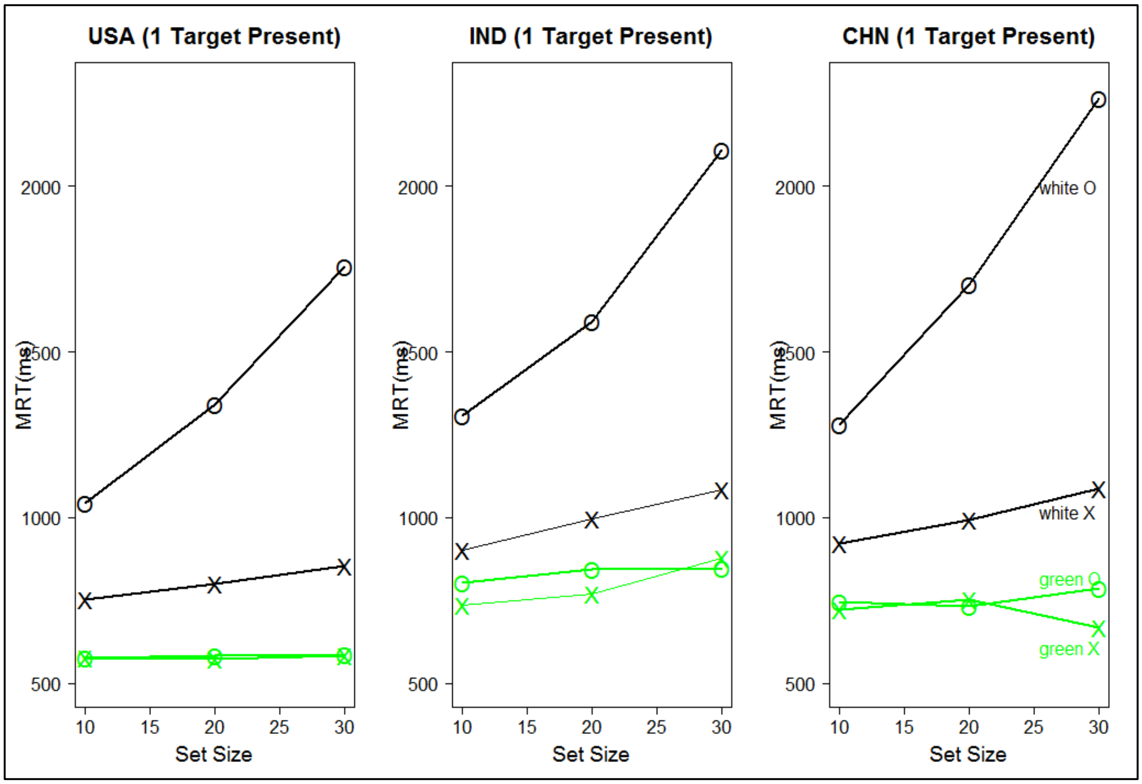

Figure 25: the target present condition of mean RT by set size (i.e., 10, 20, or 30). The American, Indian, and Chinese groups are presented in the left, middle, and right plots, respectively. The green lines represent the search for either green O or green X among all the white distractors, while the black lines exhibit the search for white O or X among distractors with the same color. The top lines of each of the three plots are regarded as conjunction search, while the bottom three lines are more like a feature search.

Note that all groups have shown a similar trend that search slope for the conjunction search for the white X had a slope in between that of the conjunction search for the O and the two feature searches. This implies that the conjunction search for the X was more efficient than the conjunction search for the O.

As seen in Figure 26, subjects took more time to search for a target absent trial than a target present trial. It is important to note that, unlike searching for the white X regarded as a feature search in the target present condition, searching for a white X resembled a conjunction search in the target absent condition, reflecting a conservative stopping strategy.

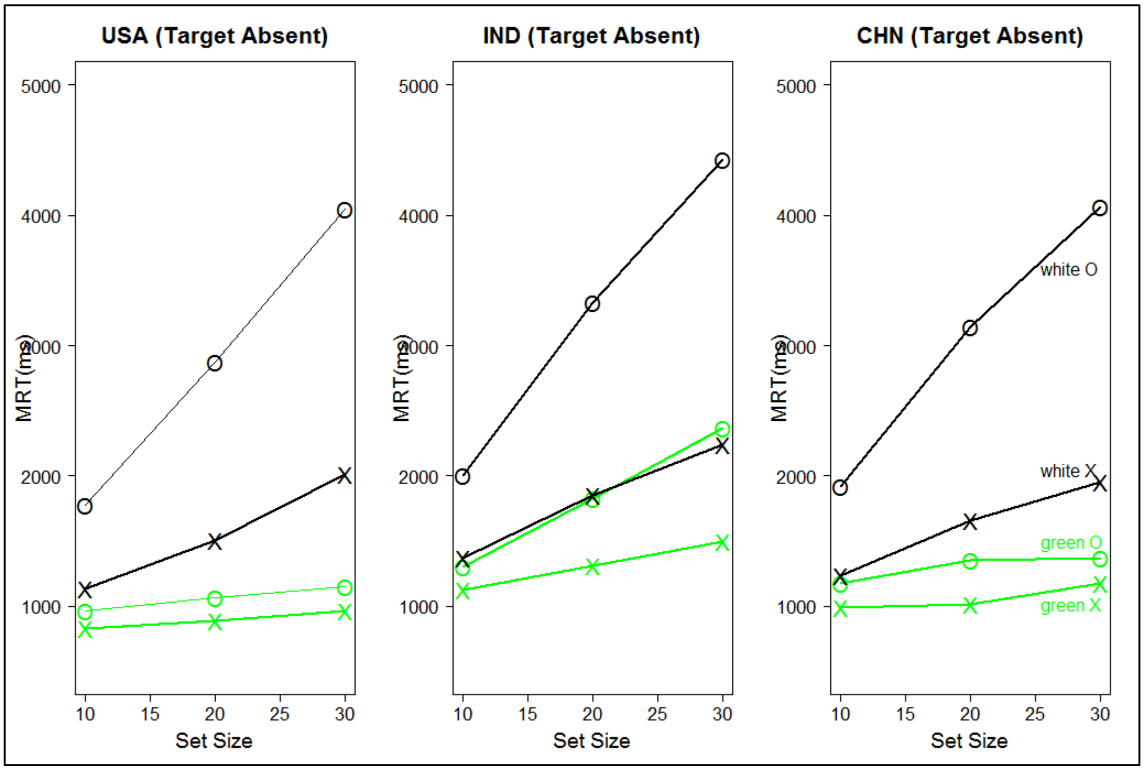

Figure 26: the target absent condition of mean RT by set size (i.e., 10, 20, or 30) in American, Indian, and Chinese groups (left, middle, and right, respectively). Searching for a white X among other distractors more resembled a conjunction search. Also, unlike other groups, Indians' green O search was more similar to conjunction search rather than a feature search.

Next, the discussion centers on the testing of H5. Note that H1 H2, H3, and H4 will not be included in the testing because the present visual search task is not designed to assess these hypotheses.

H5: Number of Distractors was measured as the RTs and accuracy difference between 30 distractors and 10 distractors on the display. The task can be divided into 4 different conditions: feature search in one target present condition (FS * TP), conjunction search in one target present condition (CS * TP), feature search in the target absent condition (FS * TA), and conjunction search in the target absent condition (CS * TA). The testing of H5 on the Kruskal-Wallis test revealed that these were significant differences among groups in the feature search for both the target present and target absent conditions, as well as conjunction search in the target absent condition (but this was not supported in Tukey HSD test which may be due to the high variation in the data to support pairwise Tukey test) (Table 11). Both the Kruskal-Wallis and the Tukey HSD tests failed to support H5, although some significant differences have been found between Americans and Indians but they pointed to the opposite direction where Americans had lower interaction cost of H5 than Indians. In addition, there was no significant cultural interaction between Americans and Chinese based on Tukey HSD test. Since the present study has mainly focused on the comparison between Americans (representing Westerners) and Chinese (representing Easterners), if there is an inconsistency between the results of Chinese and Indian data, these tests indicate that there is no cultural difference between Easterners and Westerners in H5. The testing results were consistent with Experiment 1 where no cultural difference was found regarding H5.

Table 11: Testing of Hypothesis 5: Centrality vs. Eccentricity

Testing of Hypothesis 5									
	Interaction Cost (ms)			Kruskal-Wallis rank sum test			Tukey HSD test		
	USA	IND	CHN	χ^2	df	p	USA-IND	USA-CHN	IND-CHN
FS*TP	9.1297	142.1688	28.4187	7.3462	2.0000	0.0254	0.0638	0.9413	0.1690
CS*TP	458.8073	601.6416	614.0730	3.9246	2.0000	0.1405	0.2381	0.1500	0.9904
FS*TA	271.4089	910.7568	232.2159	20.7714	2.0000	0.0000	0.0000	0.9544	0.0000
CS*TA	1578.8510	1613.2480	1498.6220	12.0483	2.0000	0.0024	0.9639	0.8165	0.7004

5.2.2.3 Conclusion and Future Direction

The results in Experiment 2 have shown effects which were consistently aligned with previous research, including set size effect, target present vs. target absent effect, as well as the slower RTs of the conjunction search compared to the faster RTs of the feature search. However, the results failed to support H5, indicating that there were no difference in handling large numbers of distractors between Easterners and Westerners. Since this task did not record the position of the cued target, H4: Centrality vs. Eccentricity cannot be tested and this issue will need to be addressed in future testing. It may be worthwhile to use language-free, more neutral symbols or figures, rather than English letters to examine the Eastern and Western differences in the future.

5.2.3 Task 3: Eriksen Flanker Task

Even though there was no significant cultural interaction in the Erikson Flanker task in Experiment 1, the goal of reexamining this task is to add an additional condition to further investigate the cross-cultural difference by manipulating the gap length between the target and the flankers as done by Millar and his colleagues in 2013. Overall, this section will include the discussion of the modified design, results and analysis, and a conclusion.

5.2.3.1 Design, Stimuli, and Procedure

The Eriksen flanker task employed a design with congruency as a within-subject factor. The design, stimuli, and procedure in Experiment 2 were identical to Experiment 1 with two exceptions. For example, the independent variable, gap length, was added here, resulting in three consecutive blocks of 2, 100, and 200 pixels gap lengths, unlike Experiment 1 where the gap length was only 2 pixels throughout the whole task. In the 100 pixel gap length condition, the gap length between each flanker and the central arrow subtended 2.5° of visual angle, and the range of the whole set of the stimuli subtended 20.5° of visual angle. In the 200-pixel gap length condition, the gap length subtended 5.7° of visual angle and the five stimuli spanned a range of 34.3° of visual angle. There used to be four types of congruency conditions in Experiment 1, but the control condition was removed from Experiment 2. Accordingly, only the congruent, incongruent, and neutral conditions were presented here. This is because the control condition and the neutral condition were quite similar, and it is unnecessary to have these two comparable conditions in one task.

5.2.3.2 Results and Analysis

There were six subjects (i.e., three Indians and three Chinese) eliminated from data analysis due to accuracy below 80%. With regards to accuracy, there was no cultural difference among the three groups in a Chi-squared test using the logit model with gap length, congruency, and nationality as independent factors ($\chi^2 = 5.4$, $df = 2$, $p = 0.068$).

Pertaining to RTs, a mixed factorial analysis of variance (ANOVA) revealed that gap length, congruency, and nationality had impacts on RTs ($p < 0.001$ for all the factors). Further on, a post-hoc Tukey HSD test showed that there were significant differences between Americans and Indians ($p < 0.001$), American and Chinese ($p < 0.001$), and Chinese and Indians ($p < 0.001$), where Americans were the fastest (mean RT = 423.7 ms), Chinese were the second fastest (mean RT = 432 ms), and Indians had the slowest RTs (mean RT = 460.6 ms).

Research on bilingualism reveals that bilingual people are better at interference suppression and response inhibition than monolinguals (Martin-Rhee & Bialystok, 2008; Bialystok, et al., 2004; Esposito et al., 2013). In Experiment 2, participants' recent TOEFL scores were analyzed to determine whether subjects' English ability (as an indicator of bilingualism) would affect their accuracy and RTs. The logit model in accuracy and the mixed factorial ANOVA in RTs were employed to assess subjects' English ability on RTs. Subjects' English ability was divided into three categories: native speakers (i.e., Americans in this study) were coded as 1; nonnative speakers with the most recent TOEFL scores above 100 were coded as 2 (i.e., all Indians and 34 out of 41 Chinese fall in this category); the rest nonnative speakers (i.e., 7 Chinese) were coded as 3. The results revealed that there was no significant effect of English ability on RTs, suggesting that nonnative speakers with higher English ability (coded as 2) had the fastest mean RTs (435.2 ms), and native speakers were the second fastest in mean RTs (437.2 ms), while the nonnative speakers with lower English ability (coded as 3) were the slowest (466 ms). The post-hoc pair-wise comparison of RTs using the Tukey HSD test showed that there was no difference between native speakers and nonnative speaker with higher English ability ($p = 0.4359$), but significant differences were found between native speakers and nonnative speakers with lower English ability ($p < 0.001$), as well as between nonnative speakers with high English ability and low English ability ($p < 0.001$). However, the logit model did not derive a significant impact of English ability on accuracy ($p = 0.788$). In the present task, international subjects, who can be regarded as bilinguals, had either no difference with native speakers or performed poorer than them, thus the task failed to support previous finding on bilingual advantage, which is the main basis for building H1 and H2, indicating the failure to support these two hypotheses.

Similar to Experiment 1 and previous research findings, in Experiment 2 all the groups have shown flanker effect as their accuracy was higher and RTs were faster in the congruent condition than in the incongruent condition (Figure 27).

When the gaps between the targets and arrows were enlarged to 100 pixels, participants showed diminished interference by the flankers compared to 2 pixel gap in between, which can be seen in both accuracy and mean RTs. (Figure 28). This was probably because the flankers in 100 pixel gap length fell outside of participants' attention spotlight. Similar results can be seen when gap length increased from 2 pixels to 200 pixels.

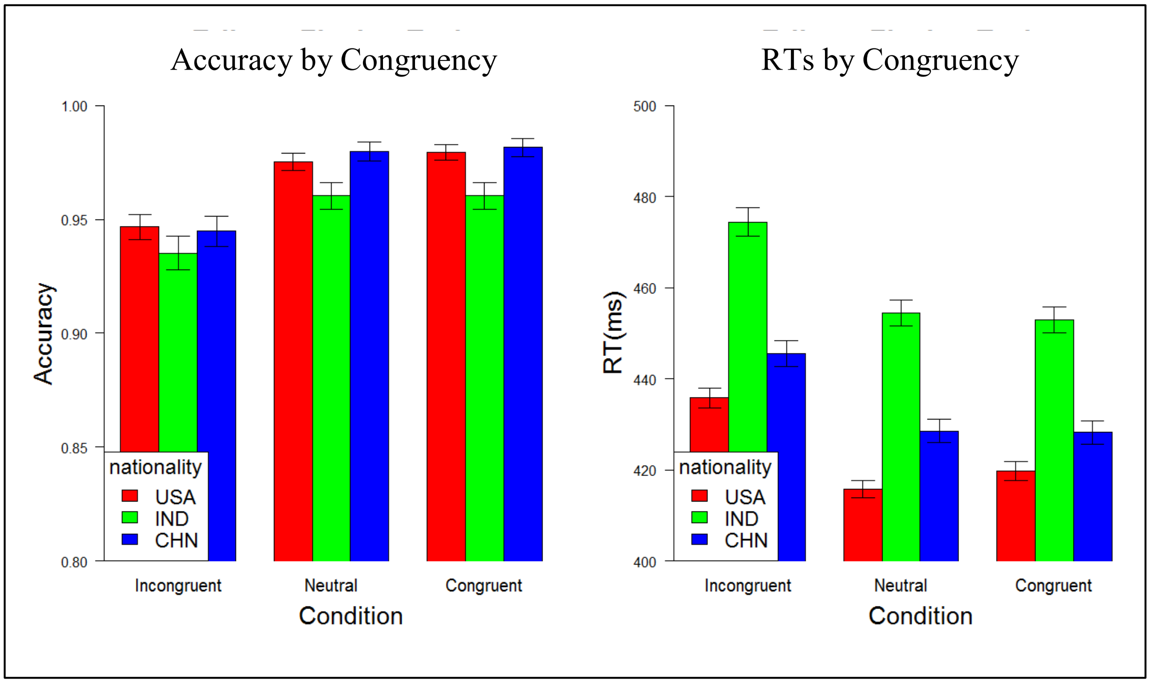

Figure 27: Flanker effect: the left panel shows accuracy as a function of task condition, and the right panel exhibits mean RTs as a function of task condition. Three conditions include incongruent, neutral, and congruent conditions shown in the left, middle, and right of each panel. The Flanker effect is confirmed because the congruent condition had more accurate and faster responses compared to the incongruent condition. The error bars represent the confidence intervals.

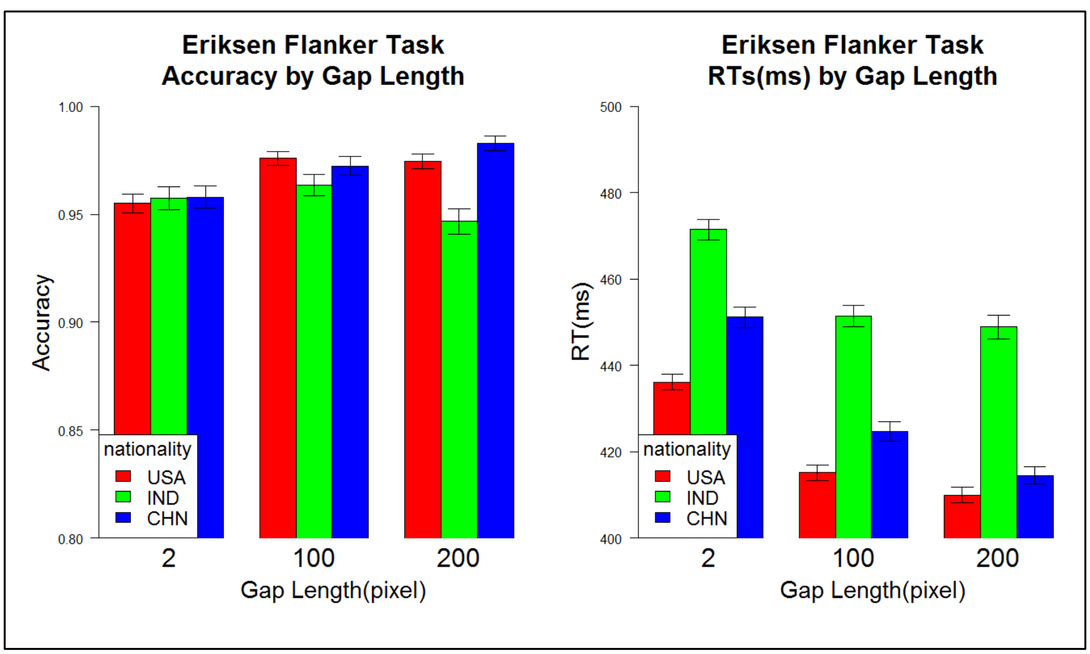

Figure 28: Accuracy as a function of gap length in the left panel and mean RTs as a function of gap length in the right panel. Three lengths of gap include 2, 100, and 200

pixels shown in the left, middle, and right of each panel. Accuracy was high in all the gap length conditions for all the groups, except for Indians in gap length 200 pixels where the accuracy was 94%. The gap lengths were significantly different among these three countries. Regarding RT, the gap length of 2 pixels impacted subjects' performance more than those of 100 pixels and 200 pixels.

Next will be the discussion of the hypothesis testing.

Hypothesis 1: Interference Suppression was calculated as the RTs and accuracy for incongruent condition minus the congruent condition. Consistent with Experiment 1, the results failed to support H1 based on the Kruskal-Wallis rank sum test (which is applicable for long-tailed, independent samples, rather than a normal distribution), including RT ($\chi^2 = 0.8097$, $df = 2$, $p = 0.6671$) and accuracy ($\chi^2 = 0.2517$, $df = 2$, $p = 0.8817$). This indicates that there was no cultural effect on RTs and accuracy regarding the ability to suppress irrelevant information.

Hypothesis 2: Response Inhibition was measured using RTs and accuracy in the incongruent condition minus the neutral condition. Two Kruskal-Wallis rank sum tests examined the interaction between response inhibition and nationalities. Consistent with Experiment 1, the results were not significant; the mean ranks of response inhibition per nationality did not significantly differ among the three nationalities in both RT ($\chi^2 = 0.7027$, $df = 2$, $p = 0.7038$) and accuracy ($\chi^2 = 1.103$, $df = 2$, $p = 0.5761$). This suggests that there is no cultural difference in response inhibition where subjects did not differ in their ability to inhibit their natural, habitual responses and to focus on the responses required.

Hypothesis 4: Centrality vs. Eccentricity was calculated using the RTs and accuracy in the block with 100 pixel gap length minus 2 pixel gap length. The results showed a trend that Americans had a lower interference cost while the gaps were narrowed to 2 pixels compared to Chinese in both accuracy and mean RTs; the opposite is true that Chinese had a lower interference cost compared to Americans while the gaps were 100 or even 200 pixels (Figure 29). This seems to imply that Westerners are better at focusing on central objects while East Asians were better at ignoring interference. However, the Kruskal-Wallis test revealed no significant difference between 100- and 2-pixel conditions in either accuracy ($\chi^2 = 0.7622$, $df = 2$, $p = 0.6831$) or mean RT ($\chi^2 = 0.302$, $df = 2$, $p = 0.8598$).

Neither H3 nor H5 were assessed using this data set.

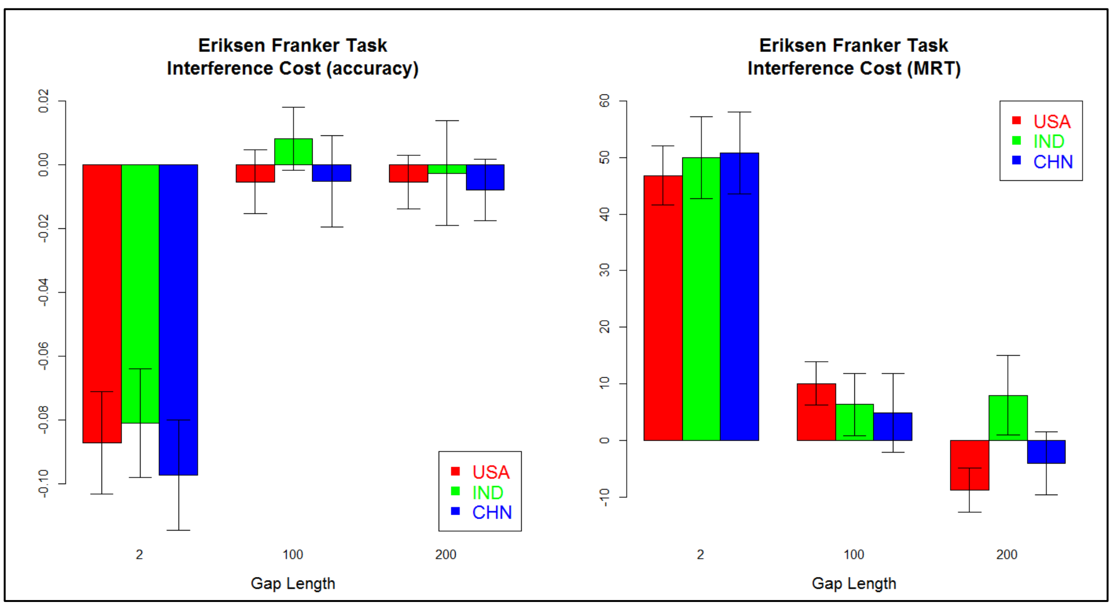

Figure 29: Interference cost by gap length. The left panel is the measure of accuracy, while the right one is for mean RTs. All the groups showed almost diminished evidence of interference costs past 2 pixel gap length.

5.2.3.3 Conclusion and Future Direction

The overall results revealed that Americans were significantly faster in three gap length conditions and three congruency conditions in Experiment 2; however, there were no cultural differences in interference suppression, response inhibition, or centrality vs. eccentricity. In addition, the results did not support previous research findings that bilinguals have higher advantage on interference suppression and response inhibition than monolinguals (Martin-Rhee & Bialystok, 2008; Bialystok, et al., 2004; Esposito et al., 2013).

In the future, a possible change to improve the design is to narrow the gaps between the target and flankers. Since we have observed almost no interference costs with a gap length past 100 pixels, it signals the need to modify the present task. For example, we can use 5 or 10 pixel gaps in between to better examine cross-cultural differences.

5.2.4 Task 4: Dot Flicker Task

In Experiment 1, the American performance outweighed the Taiwanese in absolute RTs, as well as in conditions of change position and change size, but there was no difference in Hypotheses tested (i.e., H3 & H4). A plausible explanation might be that, even though Easterners tend to have a more holistic viewpoint and look closer into contextual information and relationships, they are more easily distracted by too many stimuli and contextual information (Wang, et al., 2012). In Experiment 2, the issue of visual distractors is closely investigated by manipulating the number of distractors on the screen.

5.2.4.1 Design, Stimuli, and Procedure

The dot flicker task employed a within-subject design. The design, stimuli, and procedure in Experiment 2 are identical to those in Experiment 1, except that two more blocks were added to this task, one with 5 distractors and another one with 10 distractors to compare with 50 distractors on the screen. There were 10 trials in each of the three blocks. It took about 15 minutes for subjects to complete this task. It is worth noting that in Experiment 2, if a subject could not find the change on the display, the trial would be terminated automatically after 30 seconds and a following trial would be presented. This is different from Experiment 1, in which a trial would be ended only after a participant clicked on the change location he or she had seen and sometimes it took 2 to 3 minutes for participants to complete a trial.

5.2.4.2 Results and Analysis

Six participants, including one American, three Indians, and two Chinese, were excluded from this analysis due to low accuracy (less than 70%). Only the correct trials were included in the data analysis. A chi-squared test using the logit model with number of distractors, change conditions, and nationality as independent factors ($\chi^2 = 5.1$, $df = 2$, $p = 0.076$) revealed no cultural differences in accuracy among the three groups (88.94%, 86.99%, and 86.82%, in American, Indian, and Chinese groups, respectively). A three-way analysis of variance (ANOVA) revealed that number of distractors, change type, and nationality all had significant main effects on RTs ($p < 0.001$ for all the factors). Furthermore, a post-hoc Tukey HSD test showed that there were significant RT differences between Americans and Indians ($p < 0.001$), American and Chinese ($p <$

0.001), and Chinese and Indians ($p < 0.01$), where Americans were the fastest (mean RT = 5,048 ms), Chinese were the second fastest (mean RT = 5,699 ms), and Indians had the slowest RTs (mean RT = 6,231 ms).

Furthermore, looking into the blocks with 5, 10, or 50 dots presented, the results showed that there were no differences in accuracy among the three nationalities in any of the conditions; however, Americans were significantly faster than Indians and Chinese in the 5 distractor condition (Kruskal-Wallis rank sum test: $\chi^2 = 31.3157$, $df = 2$, $p =$ 1.584e-07) and the 10 distractor condition (Kruskal-Wallis rank sum test: $\chi^2 = 13.5837$, $df = 2$, $p = 0.0011$) (Figure 30). RTs were increased and accuracy decreased when more and more dots came into play.

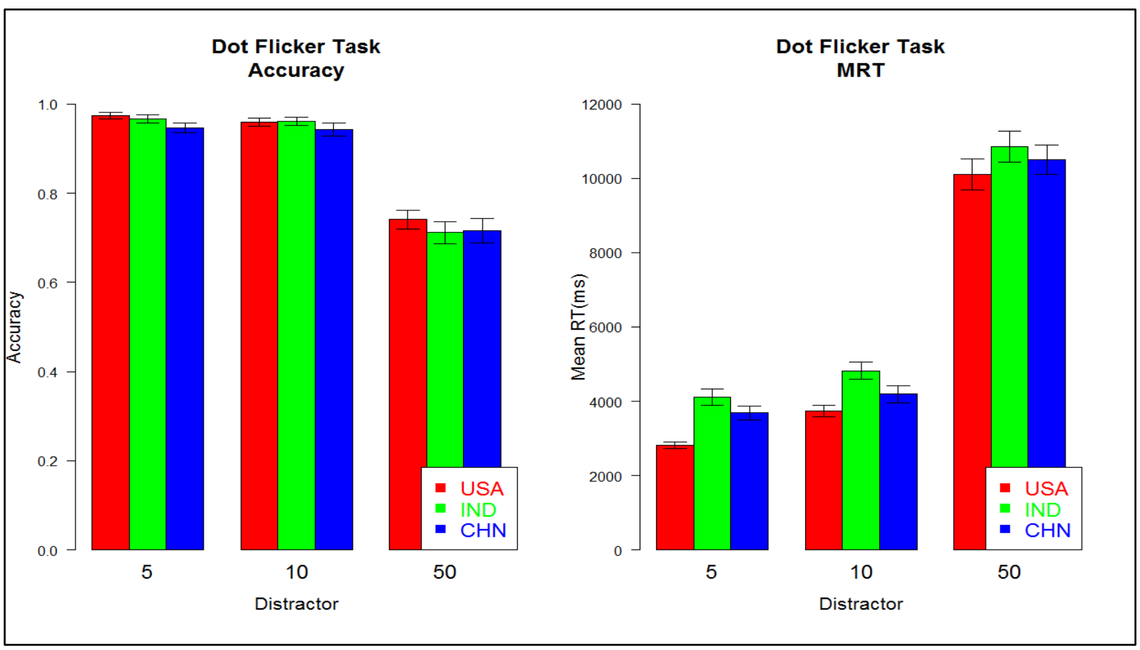

Figure 30: Accuracy (left panel) and mean RTs (right panel) by number of dots on the screen. There are conditions of five (left), 10 (middle), and 50 (right) dots presented on the screen. Error bars present confidence intervals.

Four types of changes were included in the task, including changing in position, in color, in size, and absence of a targeted dot. The results showed that there were no difference in accuracy among the groups in these four conditions, but Americans were significantly faster than Indians and Chinese in the position change (Kruskal-Wallis rank sum test: $\chi^2 = 11.947$, $df = 2$, $p = 0.0025$) and the size change (Kruskal-Wallis rank sum test: $\chi^2 = 18.3503$, $df = 2$, $p = 0.0001$) (Figure31).

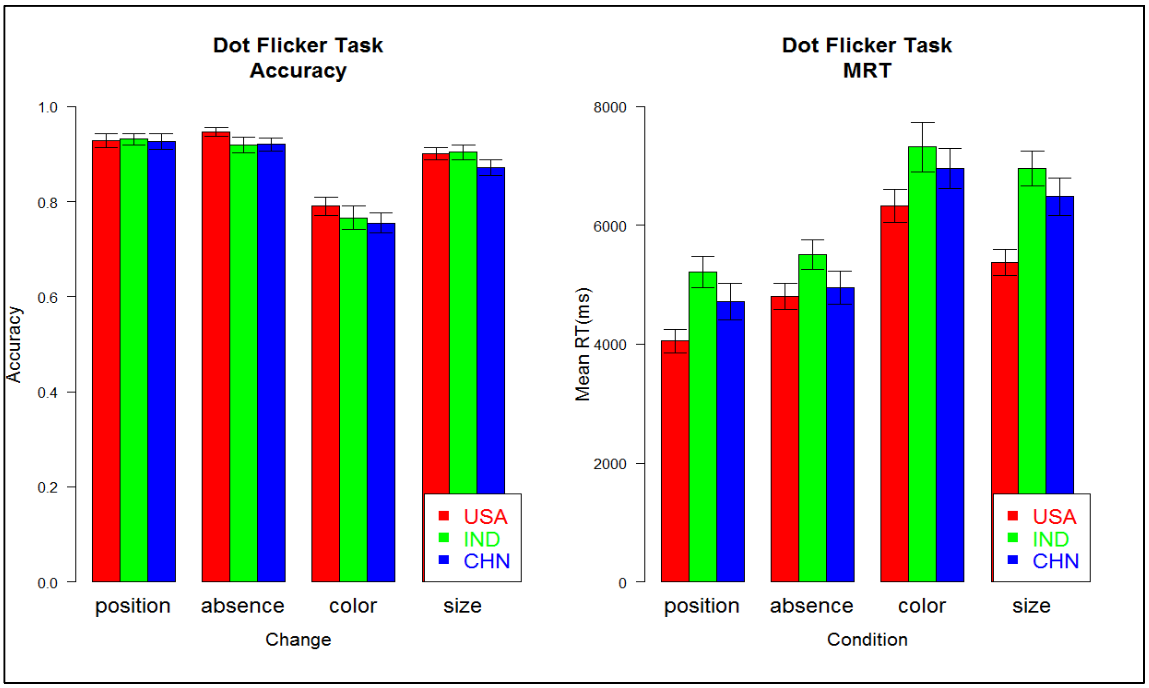

Figure 31: Accuracy (left panel) and mean RTs (right panel) as a function of change condition. Error bars present confidence intervals. Cultural differences can be seen in mean RTs of the position change and the size change.

The present task is designed to test H3 and H4.

Hypothesis 3: Detail vs. Object Configuration was measured as RTs and accuracy difference between the color change (demonstrating the change in the detail configuration where there were various colors displayed simultaneously and need a detailed search) and the size change (representing the change in the salient object configuration where only one dot had changed its size) in the dot changing condition (5 to 50 dot distractors) (Figure32). Color change can be regarded as detailed change because subjects' RTs were the longest and accuracy was the lowest among all the change conditions, suggesting that additional attention and efforts were needed to detect a color change. In contrast, a dot/object change in size was easier to detect, which can be seen in both RTs and accuracy, compared to a color change. This suggests color change is an appropriate variable to test H3. The Kruskal-Wallis test supports H3 that nationality had a significant effect on detail vs. object visual information processing (1653, -2029, -2835, respectively in the American, Indian, and Chinese groups: $\chi^2 = 7.6357$, $df = 2$, $p = 0.022$). The results indicate that Easterners are better at looking into detailed color changing while Westerners are better at detecting big, salient object size change.

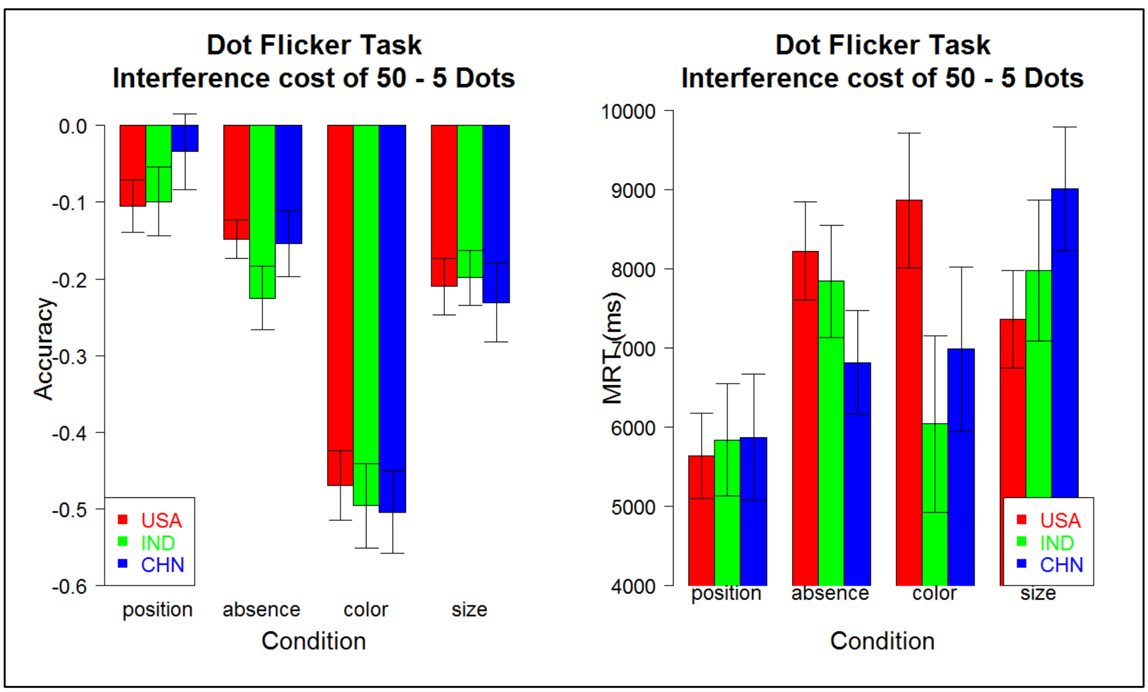

Figure 32: Accuracy (left panel) and mean RTs (right panel) of interference costs in the change conditions. TEach error bar presents one confidence interval. The accuracy plot showed that subjects had higher interference costs in the color change than other changes, suggesting that a color change was more difficult to find for all the groups.

Hypothesis 4: Centrality vs. Eccentricity was measured as the RTs and accuracy difference between the conditions of the central dot changes (within 150 pixel radius of the center of the screen would be calculated using Euclidean distance) and the eccentric dot changes (beyond 150 pixel radius). All of the groups show a trend that eccentric changes were easier to find than central changes (Figure 33). The results of a Kruskal-Wallis test failed to support H4 ($\chi^2 = 0.2163$, $df = 2$, $p = 0.8975$), revealing that there was no centrality vs. eccentricity differences among the three groups.

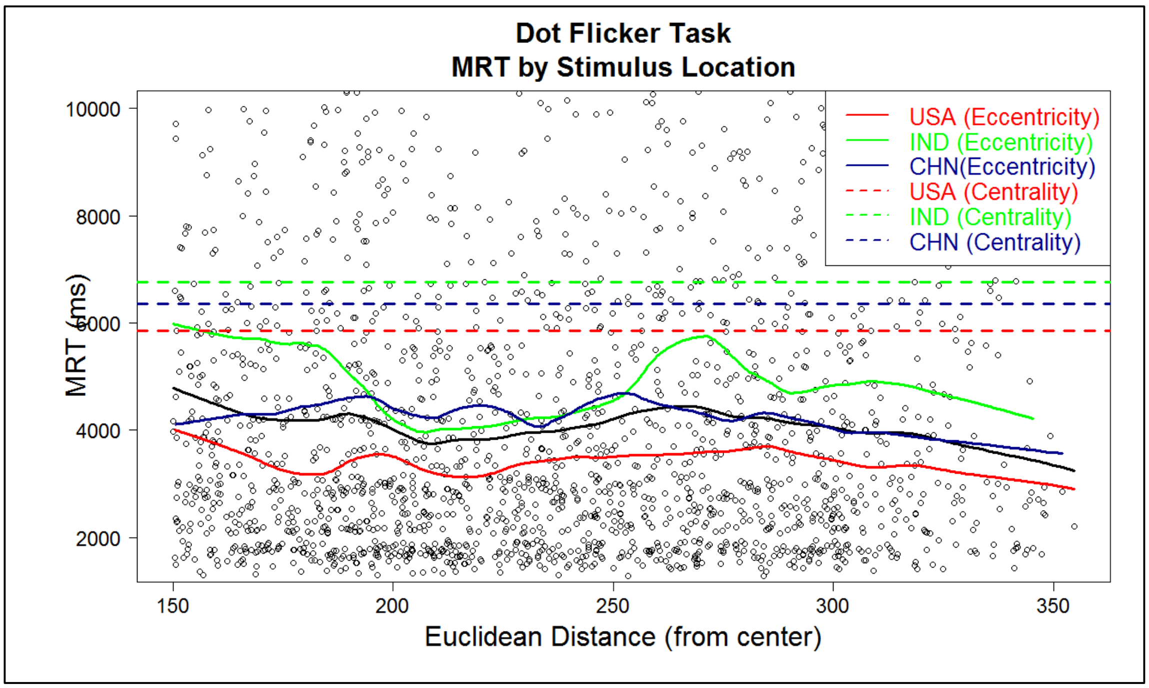

Figure 33: Mean RTs as a function of stimulus location. Solid lines represent mean RTs in the eccentric conditions, dash lines denote mean RTs in the central condition, and the black line represents the mean RTs in the eccentric condition among all the groups. Participants responded faster in the eccentric trials than in the central trials.

H5: Number of Distractors was measured as the RTs and accuracy difference between 50 distractors and 5 distractors in the display. The results failed to support H5 in both accuracy ($\chi^2 = 1.2152$, $df = 2$, $p = 0.5447$) and mean RTs ($\chi^2 = 1.001$, $df = 2$, $p =$

0.6062). The results demonstrate that there was no difference among Eastern and Western cultures when the visual distractors were increased in numbers and density.

5.2.4.3 Conclusion and Future Direction

As seen in Experiment 1, the results showed that Americans were significantly faster than Easterners in absolute RTs. However, an inconsistent result appeared in the H3 testing; the Kruskal-Wallis test in H3: Detail vs. Object Configuration supported H3 in Experiment 2, but not Experiment 1. Overall, the results of the dot flicker test in Experiment 2 are still encouraging as H3 is also supported by the global-local tasks of both Experiment 1 and Experiment 2.

As for the future direction, it may be of benefit to include different numbers of distractors (e.g., 5, 15, 25, 35, and 50) to investigate at which stage subjects will start to show a significantly increased cost of visual distractors.

5.2.5 Task 5: Image Flicker Task

Experiment 2 added the image flicker task that extended the flicker paradigm to real world scenes. The following section includes the introduction, prior research, design, stimuli and procedure, results and analysis, and conclusion and future direction.

5.2.5.1 Introduction

Humans commonly feel that they can immediately detect any changes while looking at the environment and surroundings. However, just looking is not sufficient. It is possible that people miss a great deal of details and changes unconsciously. Since the 1980s, change blindness, which refers to the failure to detect a change when the change has been occurred due to a blink, saccade, or other visual event that masks the visual transient, has been popularly discussed (Pashler, 1988). Research has shown that people are very poor at detection changes, and attention is needed while the display is complex; for example, when the scene is changing at brief intervals or during eye saccades, it is difficult to notice the changes (Pashler, 1988; McConkie & Currie, 1996; Rensink, O'Regan & Clark, 1997; 2000; Simons & Levin, 1998).

The image flicker task is an experimental paradigm used to study change blindness. The dot flicker task uses symbols such as dots or squares, but the new task used only lifelike, natural photos. The goal of the image flicker task is to further investigate whether the cultural differences between Easterners and Westerners observed in Experiment 1 (i.e., significant differences in size and position changes) can also be detected in more realistic scenes.

The change blindness phenomenon has hands-on applications in several areas. For example, in eyewitness testimonies, it is useful for wrongful conviction, identifying criminals, and eyewitness identification (Davies & Hine, 2007; Nelson, Laney, Fowler, Knowles, Davis, & Loftus, 2011). Other applications include military command personnel's reaction time and accuracy to combat information display (DiVita, Obermayer, Nugent, Linville, 2004), and driver's ability to detect the changes facing them at an intersection (Caird, Edwards, Creaser, & Horrey, 2005; Galpin, Underwood & Crundall, 2009).

5.2.5.2 Prior Literature

It is commonly noticed that participants are faster at searching for the change of a photo at the center of the screen than on the border of the screen (Rensink, et al., 1997; Simons & Ambinder, 2005, Simons & Rensink, 2005). Moreover, people are more likely to notice changes in focal, foreground, salient objects compared to peripheral, background, or contextual objects (Masuda & Nisbett, 2006). In addition, participants' attention is needed to detect the change; however, simple attention is not sufficient in this task, and subjects have to carefully encode and compare the change between original and altered scenes (Simons & Ambinder, 2005). Simons and Ambinder (2005) recognized that "our conscious awareness of our visual environment is sparse even if our representations of it might not be," which generally implies the difficulty of a change blindness task as well as the importance to explore the flicker search paradigm.

In Rensink, O'Regan and Clark's (1997 & 2000) studies, three change conditions were investigated in the photos, including present/absent image change, color change, and location change, either in images consisting of central interest (being significant to the subjects) or marginal interest targets. The results showed that participants were considerably faster at image changes of central interest compared to changes of marginal interest, no matter which change condition they were in. Moreover, the study also revealed that participants performed better with the assistance of verbal cues than merely visually searching for the changes. It is worth noting that RTs were quickest with color change, then present/absent change, and slowest with location change.

Mazza, Turatto, and Umilta (2005) were the first to classify photographs of an image flicker task into foreground and background images based on the regions of the images, called foreground-background segmentation. The results have shown that participants can detect smaller changes in the foreground images than in the background images. In addition, the color changes in the background photos were significantly more difficult and took longer to find compared to color changes in the foreground images.

The factors which affect human performance in change blindness have been explored. One factor is age; for instance, younger adults were faster to identify the visual changes compared to older adults (Veiel, Storandt, & Abrams, 2006; Caird, Edwards, Creaser, & Horrey, 2005). The second factor is attention to the location of the images. An example of this is when foreground images are easier to find than background images (Mazza, Turatto, & Umilta, 2005). Thirdly, the way the target object is presented is another factor in which a newly appearing target captures attention faster compared to a looming or a receding object (Cole & Liversedge, 2006). The fourth factor is familiarity with the target object, like an alcohol or drug abusers' attribution of more attention to the visual changes relevant to drug substances (Jones, Jones, Blundell, & Bruce, 2002; Jones, Bruce, Livingstone, & Reed, 2006). Moreover, perceived success from prior experience, such as feedback given and search duration, also affect the RTs of the image flicker task (Loussouarn, Gabriel, & Proust, 2011).

Regarding cultural difference, Masuda and Nisbett (2006) conducted three serial experiments to investigate whether East Asians have a more holistic viewpoint and pay more attention to relationship and contextual information while Westerners focus more on focal, salient objects and view things more analytically. Using the flicker paradigm, the authors presented photos with changes to either in focal scenes or contextual scenes. The results of Experiment 1 showed that East Asians detected contextual changes faster than Americans; however, there was no difference in finding focal, salient objects. Also, the RTs for East Asians were similar in the focal and contextual change conditions. In

Experiment 2 and 3, the authors used animated vignettes as images for detecting changes. The results showed that Americans found more focal changes while East Asians detected more contextual changes, regardless if these images were culturally specific or neutral.

5.2.5.3 Design, Stimuli, and Procedure

The image flicker task employed a within-subject design. It was designed using PEBL Cued Flicker-Paradigm Test v2.0 which was revised in 2015 by my advisor, Dr. Mueller, and myself. The first version which tested un-cued flicker performance was created by Olivier Harris in 2007, and the original scene imagery was taken and copyrighted by Harris (see Mueller, 2014).

The task consisted of 45 stimuli. The stimulus images were 21 inches wide and 16 inches long (16.6° × 21.4° of visual angle). All of the images were naturalistic, realistic pictures. For examples, pictures were taken inside a grocery store, in front of a shop, street scenes with people passing by, parking lot, images of houses and cars, in the gas station, on the beach, in a park or a square with people standing.

There were three types of changes for participants to detect. The first change condition was the appearance/disappearance condition. For example, in a picture of a bar with some people sitting and drinking, the image on the TV screen appeared and disappeared. The second change condition was a color change. For example, in a picture of a grocery store display, one of the wine bottles changed color. The third change was a location change. For example, the position of a number painted on the side of a bus changed from the right to the left.

In the image flicker task, an original image appears and is then followed by a whiteout interval (40 ms) and then modified version of the original image. This sequence continues, flick for 30 seconds or until the participant responds. Both the original image and the modified one are each displayed for 500 milliseconds. If participants could not find the change target after 20 seconds, the flicker time was decreased to allow for easier detection.

All the participants were tested on 45 identical naturalistic, colored images that were presented in a random order.. Participants were asked to respond as quickly as possible. When participants detected the changes, they were instructed to click the mouse (the ending point of their response time since they saw the change) and then continue to use the mouse to click on the changing image. Clicking on the target within 25 pixels threshold is considered a correct trial. After the trial ended (either due to finding the target or reaching the 30 second limit), they would be instructed to click the mouse again to continue the next trial. The 30 second limit was set to prevent participants from fatigue, which might in turn impact their performance. Also, we wanted to encourage participants to perform the task effectively and did not want to overwhelm the participants with the visual load and the complexity inside a trial.

5.2.5.4 Results and Analysis

Before performing any data analysis, the accuracy of trials was examined, and 5 out of 45 trials were eliminated due to low accuracy (i.e., ranging from 18% to 53% accuracy). In addition, four participants, including three Indians and one Chinese, were excluded from this analysis due to low accuracy (i.e., 7%, 8%, 11% & 11%), because it appeared that these participants were trying to complete this task as soon as possible, rather than fully demonstrating their abilities. Also, there would be 14 subjects removed from data analysis, if choosing 50% accuracy as a criteria instead, suggesting that this was a difficult task and required thorough attention. After eliminating the low accuracy trials and participants, there was a significant cultural effect of nationality on accuracy in these three groups (86%, 76%, and 79%, respectively in American, Indian, and Chinese groups, $\chi^2 = 69.5$, $df = 2$, $p < 0.001$), where Americans (86%) were the most accurate, Chinese were the second most accurate (79%), and Indians (76%) were the least accurate.

Similar to Musuda and Nisbett's (2006) change blindness study, the present study only used participants' correct responses within 30 seconds for data analysis. The average RTs in Musuda and Nisbett's (2006) study were about 9,300 ms and 9,750 ms in the salient and the contextual changes, respectively. However, in the present task, the mean RTs of salient changes were 13,337 ms, 15,328 ms, and 13,172 ms in American, Indian, and Chinese groups, respectively, and the mean RTs of background changes were 14,334 ms, 16,875 ms, and 14,988 ms, respectively. These slower RTs than those in Musuda and Nisbett's (2006) study suggest that the present task was a complicated flicker task with a high level of difficulty. It should be noted that, as shown in Musuda and Nisbett's (2006) study, the categorization of salient vs. background images in the present task were arbitrary: the foreground, large, obvious changes were categorized as salient changes, while the background, obscured changes were classified as background changes. The categorization of the present task was double verified by two independent investigators.

A mixed factorial ANOVA tested for main effects of saliency, nationality, and their interaction on mean RTs. The results suggested that the effects of both saliency

($F(1, 258) = 12.07$, $p < 0.001$, $\eta^2 = 0.04$) and nationality ($F(2, 258) = 10.28$, $p < 0.001$, $\eta^2 = 0.07$) were statistically significant. The interaction between saliency and nationality was not statistically significant ($F(2, 258) = 0.29$, $p = 0.75$, $\eta^2 = 0.002$). The post-hoc Tukey HSD test revealed that both Americans and Chinese were significantly faster than Indians (both *ps* < .001); there was no difference in RT between Americans and Chinese ($p = 0.93$).

The change conditions can also be classified into three types of changes, including appear/disappear, color change, and location change. Adding the change condition into the mixed factorial ANOVA model, the results revealed that similar to other factors, change condition also had significant impacts on search speed ($F(2, 784) = 78.91$, $p < 0.001$, $\eta^2 = 0.001$). The results showed that Americans were significantly faster in the appear/disappear condition and most accurate in the appear/disappear and color change conditions, compared to the other two groups (Figure 34). Notice that location changes had the highest accuracy and their RTs were also the shortest among all the changes in all the groups, which indicates that the location change was easier to find compared to other changes.

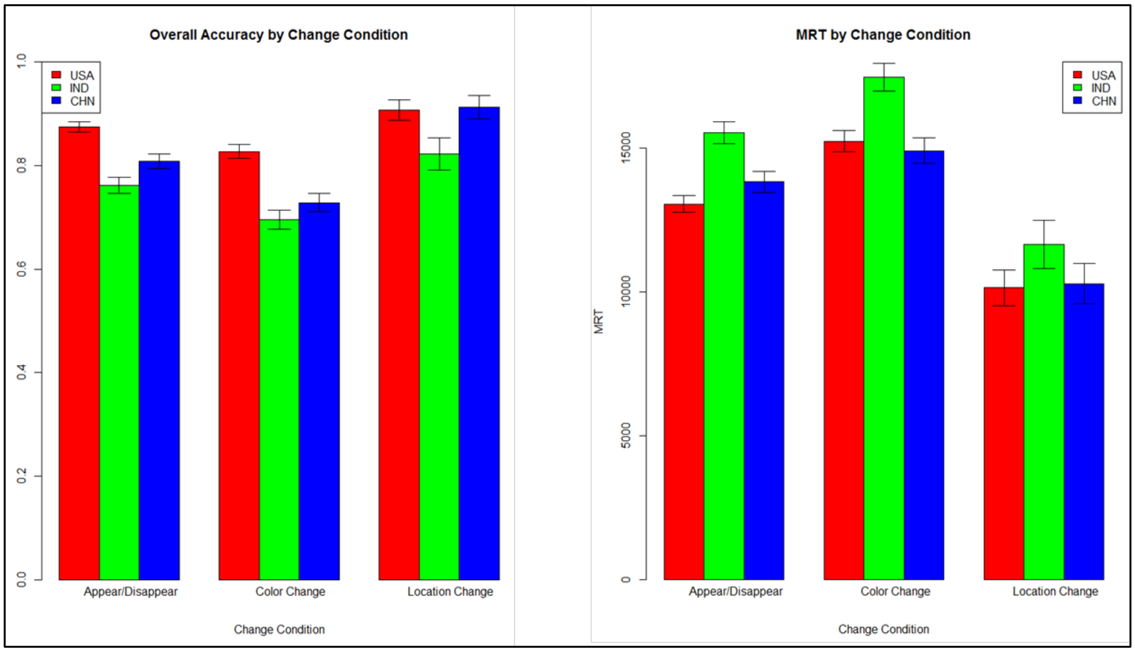

Figure 34: Accuracy (left) and mean RTs (right) by change condition. From the left to the right in each panel are the conditions of appear/disappear, color change, and location change. Americans were the most accurate and fastest, and the Chinese were the second accurate and fastest, while Indians were the least accurate and slowest among the three groups. Location change was the easiest change for subjects to find as the accuracy was the highest and the mean RTs were the fastest among all the groups.

The next will be the hypotheses testing. Note that H1, H2, and H4 were not tested here as the present task is not designed to test these hypotheses.

Hypothesis 3: Detail vs. Object configuration was tested using the RTs and accuracy difference between background and salient changes. Based on the Kruskal-Wallis tests, the results failed to support H3 in both mean RTs ($\chi^2 = 1.9394$, $df = 2$, $p = 0.3792$) and accuracy ($\chi^2 = 0.2968$, $df = 2$, $p = 0.8621$), suggesting that there was no significant cultural differences in searching for the salient vs. the background changes (Figure 35).

Hypothesis 5: Number of Distractors was measured based on the file size of the images. A larger file size represents more cluttered image, which might interfere subjects' search efficiency, compared to a smaller file size of image. A medium split method was held and 212 image size was the threshold. A Kruskal-Wallis rank sum test failed to support H5 in both mean RTs (χ^2 = 2.3728, *df* = 2, *p* = 0.3053) and accuracy (χ^2 = 2.2493, *df* = 2, *p* = 0.3248), revealing that there was no interaction with cultures in terms of the amount of visual distractors.

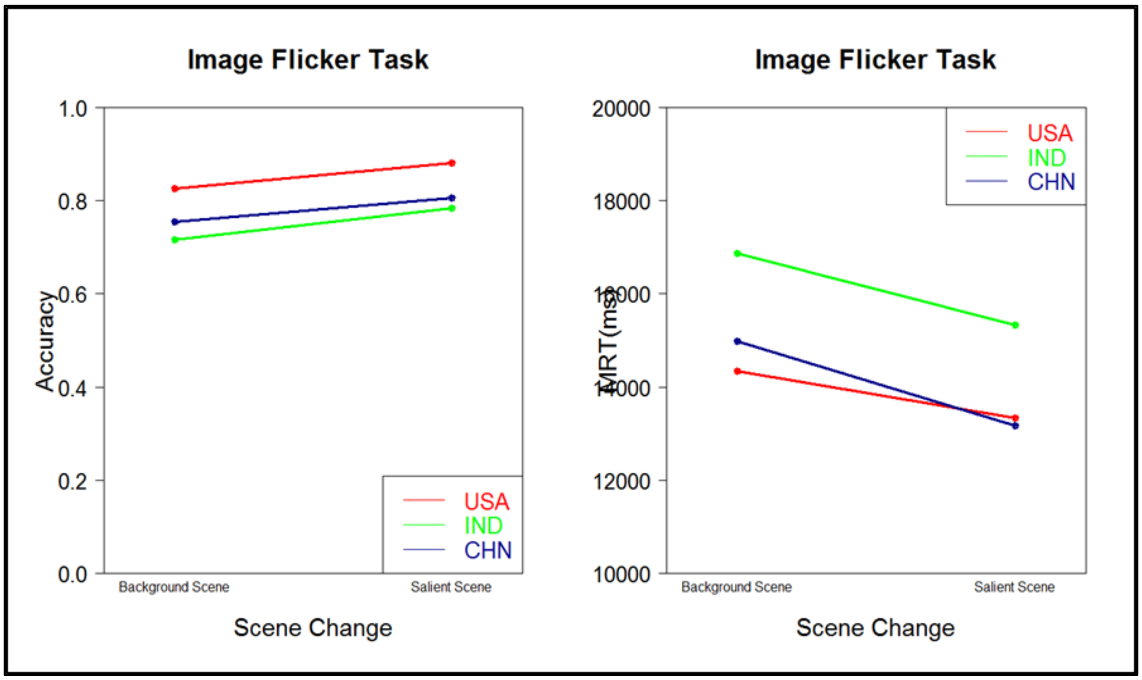

Figure 35: Accuracy (left) and mean RTs (right) by scene change. The background scene changes are on the left of each panel, while the salient scene changes are on the right of each panel. It seems that there was an interaction with cultures between Americans and Chinese in the right panel; however, based on a Welch two-sample t-test, it did not reach a significant difference ($t(78) = -1.2287$, $p = 0.2229$).

5.2.5.5 Conclusion and Future Direction

In the present task, the results revealed that Americans were significantly more accurate, but no faster at detecting changes than East Asians (i.e., Chinese). The overall comparison using both the dot flicker task in Experiment 1 and Experiment 2 and the flicker task showed an interesting trend that Americans' performance was getting better in accuracies with the results from no difference in the dot flicker tasks to reaching significant difference in the realistic image flicker task compared to Easterners; however, RTs showed an opposite trend that Americans were significantly faster in the dot flicker tasks and dropped to no difference in the image flicker task. This indicates that Americans were better in change detection task, as indicated by better accuracy in the image flicker task and faster response times in the dot flicker task.

Note that none of the hypotheses built for testing the cultural mechanisms between Easterners and Westerners were supported in this present task. In the future, the use of an eye tracker is essential to examine subjects' search performance in terms of eye movement, the number of fixations, and deviation in an image flicker task. In addition, culturally specific, unique pictures should be considered to further investigate whether familiarity can influence change detection performance in the image flicker task. Alternatively, this task can use culturally-neutral images exclusively to avoid biased familiarity effects.

5.3 Predictive modeling

Data mining, machine learning, pattern recognition, classification, clustering (and more) are popular methodological techniques in statistics used to describe the learning procedure and algorithms to uncover and predict factors, patterns, and regularities in the data set. This chapter will introduce a predictive model we have built adapting linear discriminant analysis (LDA) with the use of cross validation. We did implement cultural mixture modeling (CMM: Mueller & Veinott, 2008; Tan & Mueller, 2015) and factor analysis as an attempt to build a predictive model, but were unsuccessful. This might be due to the noise in the data and some of the Eastern participants might exhibit Westernized visual attention patterns. Thus, it increased the difficult to successfully identify group membership without knowing their cultural identities in advance while using CMM to develop a predictive model. However, using LDA might be promising as its primary function is to select the best predictors during the process of model selection to fit the provided answer key.

Linear Discriminant Analysis (LDA)

Linear discriminant analysis has been popularly implemented as a technique to perform dimensionality reduction for various classification/clustering problems in the areas of face recognition and speech recognition (Yu & Yang, 2001), bankruptcy prediction (Altman, 1968), marketing strategy (Feinberg, 2010), eye movements in clinical neurological study (Tseng et al., 2012), biomedical study (David, et al., 2010), as well as earth science (Tahmasebi et al., 2010). Fisher (1936) introduced LDA, a technique aimed at using the linear components of multiple measurements to classify populations or events. LDA was further demonstrated by Ripley (1996) using a neural network as one of various classification tools for recognizing consistent patterns in the dataset.

We propose a methodological approach of machine learning schema for modeling accuracy and RTs as a Gaussians distribution, which adapts LDA with cross validation to predict cultural identities. There were 104 features in the data set using the five tasks in Experiment 2, while there were only 129 samples in either of the cultural groups. This represents an issue of too many features in a limited sample size. Thus, adapting LDA seems a reasonable approach to reduce the features and produce optimal classifications simultaneously (Ripley, 1996; Tseng et al., 2012).

A comprehensive feature set included 32 features derived from the global-local task, 14 from the visual search task, 24 from the Eriksen flanker task, 22 from the dot flicker task, and 12 from the image flicker task. These variables are either mean RTs or accuracy of interference cost, congruency, eccentricity, and the aggregation using the task conditions specified in the tasks. For example, the features in the visual search task include the multiple of three parameters: set size (10, 20, or 30), target effect (target present or target absent), and search condition (feature search or conjunction search), in addition to absolute mean RTs and accuracy.

To deal with the issue of having too many features in the LDA model, the feature set was separated into three subsets, including big feature set (104 features approaching almost complete list), medium set (57 features, that includes more important features chosen discretionarily), and small set (24 features with statistically significant difference). The next step would be to develop a method to randomly select the features from the feature sets to model features that can be used to predict maximum classification of cultural identities.

The methodological approach developed to run LDA is described and listed as following and the codes (developed using R programming language) are provided in Appendix C.

First, we developed a partition method for feature (filter) extraction (20% TRUE vs. 80% FALSE), which would randomly select 20% of the features in every round of LDA. Then, the model would add the current best filter to the previous selected random features to create a random initial configuration for the next round. We also tried to improve the current best filter by using a staircase of up to 100 steps (implementing the same algorithm for 100 rounds) and keeping track of each neighboring model on bigger or smaller filter sets. This staircase procedure would go through each neighboring model and update the neighbor filter based on the current best filter. Finally, the model should produce the goodness of fit (GOF) of each neighboring model. It is important to note that cross validation was implemented in every iteration of the predictive model as a means to find more reliable filters and classifications, even though the results were produced with lower correct classification rates, compared to the model without using cross validation.

The algorithm randomly picks up features and then, in each round of the LDA, the algorithm keeps the better feature for the next round of testing, which happens over 100 times. And after this, a new randomly-selected feature set is used to repeat the procedure all over again. In totality, the whole algorithm is repeated over 1000 times to yield the best features and classification results at the end of the algorithm (See Figure 36 for flowchart visualization).

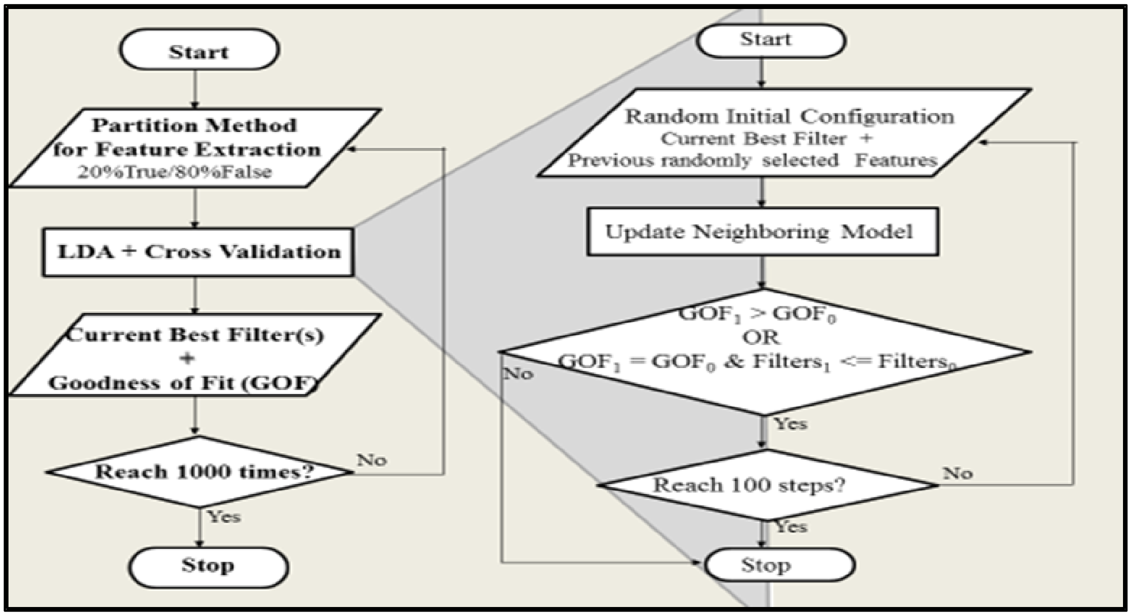

Figure 36: Flowchart of the Predictive Model

The most important functions of the algorithm are that (1) if the current model beats the previous model using GOF as the criteria, it would pick one of the best current models at random as there might be more than one qualified; (2) if the model fails to produce better results, but there were smaller models that did not make it worse, it would continue to rerun the model within the loop of 100 rounds; and (3) if there are models which made it worse, it would break the loop and start a new random feature set all over again. In order to find a maximum classification with the use of the minimum feature set, the model was programmed to run the entire algorithm multiple times (e.g., 1,000 times per feature set) aiming to derive a maximum classification along with the shrinkage estimators. That is to say that LDA was run maximally 100,000 (100 repetitions of 1,000 tries) times in order to find an optimal classification with reduced feature extraction for each of the three feature sets.

This predictive model produced two results, including best GOF and length of best filters in the best found model. In addition, the number of rounds (out of 100 rounds in a random feature set), classification results, and the filters used to derive the best found results were also recorded. The confusion matrix used to represent the overall classification results of participants' cultural identities was shown in Table 12. Six plots for visualizing the classification results between actual groups and predicted group in three filter sets are shown in Figure 37. The starting filters were reduced from 104, 57, and 24 to 35, 21, and 9 in the large, medium, and small filter sets, respectively (Table 13). Using the large feature set, the model yielded the largest predictors, but with most noise compared to the other filter sets, even though it could produce a higher GOF than others.

Table 12: Confusion Matrices of Classification Results

		Predicted								
		104 Filters			57 Filters			24 Filters		
		G1	G2	G3	G1	G2	G3	G1	G2	G3
Actual	USA	49	2	3	47	2	5	45	4	5
	IND	5	30	2	9	25	3	9	23	5
	CHN	5	3	30	6	4	28	13	9	16

Table 13: The outputs of LDA Modeling

Filter Set	Try	Time	Starting Filter	Ending Filter	GOF	Correct Ratio
Large	1000	13	104	35	109	85%
Medium	1000	6	57	21	100	78%
S.D.	1000	2	24	9	84	65%
Random(L)	1000	11	104	37	90	70%
Random(M)	1000	8	57	21	79	61%
Random(S.D)	1000	3	24	7	66	51%

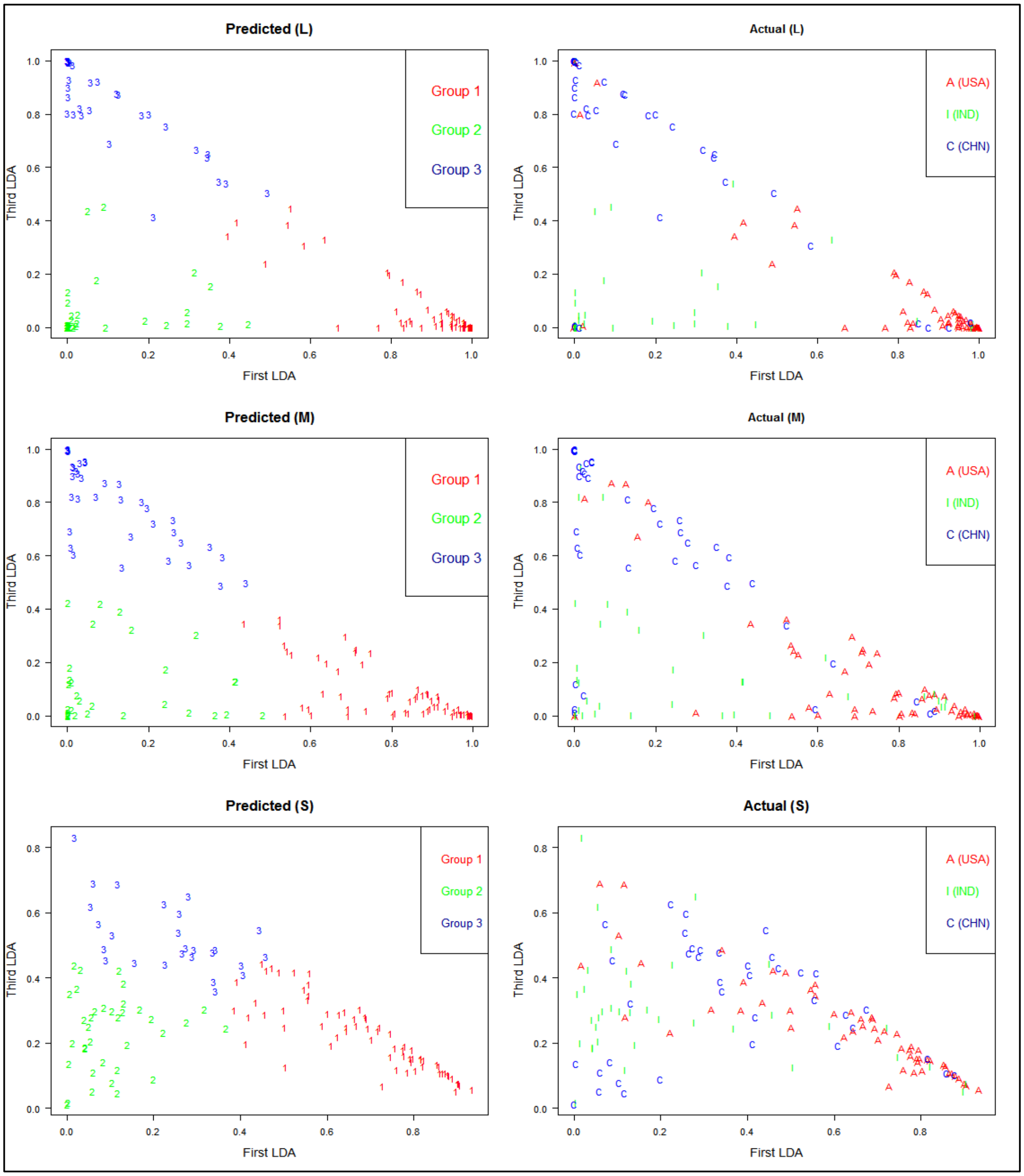

Figure 37: The classification results in the predictive model. The x axis represents the first LDA posterior parameters and the y axis represents the third LDA posterior parameters. The predicted group membership are on the left and the actual group membership is on the right. The modeling results using large filter set, medium filter set, and small filter set are shown in the top, middle, and bottom plots, respectively. With the increase of filter sizes, the predictive model yielded increased correct classification rates. However, since the classification advantages are consistently higher than the chance models in these three filter sets, it seems that a larger filter set simply produced more noise compared to smaller filter sets.

We also used this model to run randomly generated normal distribution data sets with the same construction as seen in three feature sets (i.e., 104 x 129, 57 x 129, and 24 x 129). The overall results revealed that the model predicted the classification with 85%, 78%, and 65% accuracy, while random models produced the classification with 70%, 61%, and 51% accuracy. This indicates that even though this predictive model produced imperfect classification results, it still beat the random model. This imperfect results might be because multivariate variances in the data are somehow sensitive to the noise in the data (e.g. outliers). Most importantly, the predictive model produced about a 15% advantage compared to the random model systematically in three filter sets (see Table 13). This implies that these nine ending filters in the small data set have the same capability to predict classification of cultural identities like the other two larger filter sets. Thus, these nine ending filters were used to interpret the task results.

The nine filters the predictive model ended up with in the small filter set consist of: (1) four filters in the global-local task, such as absolute mean RTs, mean RTs in both local and global centered condition (used to test H3: Detail vs. Object Configuration and it derived a significant difference among cultures), and mean RTs in the global eccentric condition; (2) two filters in the dot flicker task, including absolute mean RTs and mean RTs in the color change condition (regarded as detailed change for testing H3 and it has yielded a significant difference among cultures); (3) three filters in the image flicker task, including overall accuracy, mean RTs in both salient and background change conditions (which were used to test H3, but it didn't reach a significant difference).

The overall results of the predictive model suggest that H3: Detail vs. Object Configuration was the most important predictor to capture the cultural differences between Easterners and Westerners. This predictive result is consistent with the hypotheses testing and suggesting that attention to detail drives cross-cultural differences in visual attentional tasks.

Chapter 6: Discussion and Future Direction

6.1 Summary of the Results

This study initiated by using nine visual attentional tasks to explore the cultural differences between Westerners (represented by Americans) and Easterners (represented by Taiwanese) in Experiment 1. Additionally, we have developed five hypotheses which were built upon the mechanisms derived from the cultural differences in general philosophy, studies in visual attention, and bilingualism. , Experiment 1 identified five tasks with marginal cultural differences. So, Experiment 2, we revised and implemented these five tasks and added a new image flicker task.

Both experiments tested five hypotheses: H1: Interference Suppression, H2: Response Inhibition, H3: Detail vs. Object Configuration, H4: Centrality vs. Eccentricity, and H5: Number of Distractors. The next section summarizes the current findings for each of the five hypothesis based on the results of the current experiments and the results of previous studies (Table 14).

Table 14: The summary of hypotheses testing and the comparison to previous studies

HYPOTHESES / TASKS	H1: Interference Suppression	H2: Response Inhibition	H3: Detail vs. Object Configuration	H4: Centrality vs. Eccentricity	H5: Number of Distractors
Global-Local 1	X	X	✓	-	-
Global-Local 2	X	X	✓	X (global) X (local)	-
McKone et al. (2010)			✓*East Asians vs. AUS		
Kiyokawa et al. (2012)			✓* (global) X (local) JPN vs. GBR		
Caparos et al. (2012)			X JPN vs. GBR		
Visual Search 1	-	-	-	-	X
Visual Search 2	-	-	-	-	X
Flanker 1	X	X	-	-	-
Flanker 2	X	X	-	X	-
Yang et al. (2011)	✓ (KOR vs. USA)				
Millar et al. (2013)	✓ (TUR vs. USA)				
Dot Flicker 1	-	-	X	X	-
Dot Flicker 2	-	-	✓	X	X
Boduroglu et al. (2009)				✓ (JPN vs. USA)	
Masuda et al. (2008)					✓ (JPN vs. USA)
Image Flicker	-	-	X	-	X
Masuda & Nisbett (2006)			✓ (JPN vs. USA)		

Hypothesis 1: Interference Suppression tested that Easterners are better at suppressing irrelevant interferences compared to Westerners, and was measured by comparing the RT and accuracy differences between the incongruent and congruent conditions. H1 was assessed in the global-local task Experiment 1 and 2 and the Eriksen Flanker task Experiment 1 and 2. Results failed to support H1 across the experiments and

tasks, revealing that there were no cultural difference in people's ability to suppress irrelevant interferences. Notably, the results of the current studies did not support previous studies' finding on bilingualism. For example, Yang et al. (2011) conducted a flanker task using fish as stimuli to test on 4 year-old preschool kids and found that Eastern bilingual kids were faster and more accurate than Western monolingual children. However, this bilingual advantage might disappear when people grow older, as some research has shown no bilingual advantage on adults (de Bruin, Treccani, & Della Sala, 2015). Another example was from Millar et al.'s (2013) study in which stimuli were implemented using E and H characters and gap lengths were manipulated in a flanker task. The results showed that there was no cultural difference in RTs in terms of congruency and gap length, but Turkish people were significantly better in accuracy for incongruent trials with narrowed gap length compared to Americans. However, whether Turkish people can represent Easterners or Westerners is a debate.

Hypothesis 2: Response Inhibition predicted that Easterners can do a better job of inhibiting their natural, habitual responses and focusing on the responses required, compared to Westerners. H2 was assessed by calculating the RTs and accuracy differences between the neutral and the congruent conditions. H2 testing was employed in both the global-local task and flanker task in Experiments 1 and 2. The results failed to support H2, suggesting that there was no cultural difference in response inhibition. The bilingual advantage was not observed in either study.

Previous studies on global-local task (Bialystok, 2010), Eriksen Flanker Task (Martin-Rhee & Bialystok, 2008), Simon task (Bialystok, et al., 2004), and Stroop task (Bialystok, Craik, & Luk, 2008) indicate that bilinguals are better at performing response inhibition than monolinguals, but these mainly focused on preschool children in developmental psychology, rather than adults. When comparing this present study to previous ones, it suggests that the bilingual advantage for response inhibition may be limited to children.

Hypothesis 3: Detail vs. Object Configuration predicts that Easterners are better at looking into detailed configurations, while Westerners are better at focusing on salient, big object configurations. H3 was assessed by measuring the RT and accuracy differences between detail configuration and big object configuration. H3 was tested in the global-local task Experiments 1 and 2, the dot flicker task Experiments 1 and 2, as well as the image flicker task. The results supported H3 consistently in the global-local tasks in both experiments and in the dot flicker task Experiment 2, suggesting that looking into detail configuration drives the difference between Easterners and Westerners. It indicates Easterners had an easier time at responding to detailed configuration while Westerners had an easier time focusing on big object configuration.

The current results are consistent with previous studies, like McKone et al. in 2010 and Kiyokawa et al. in 2012. Their main finding was that Easterners have global advantage, which means Easterners were better at the global level. In their studies, their Navon-like figures were constructed with sparse, local symbols and additional efforts were needed to allocate and identify them, meaning that the detailed information exists in the global level. Thus, these studies and the present study all revealed that Easterners were better at looking into detailed information, while Westerners were better at focusing on big object configuration.

Hypothesis 4: Centrality vs. Eccentricity predicts that Easterners distribute attention more broadly while Westerners distribute attention more narrowly. H4 was assessed by comparing the RT and accuracy difference between eccentric and central trials in the global-local task Experiment 2 and the dot flicker task Experiments 1 and 2. The results did not support H4, suggesting that there was no cultural difference in eccentricity effects.

Boduroglu et al. (2009) examined cultural difference in allocation of attention between Asians and Americans. Participants were asked to find a color change in two continuously changing scenes interleaved with a blank screen. The results showed that Asians could better detect the color change at the corner of the screen in the condition of larger and expanded scenes; on the other hand, Americans could better detect color change while the scene is narrowed and stimuli were displayed closer to the center. This suggests that Easterners allocated attention more broadly compared to Westerners. However, the results in the present study was inconsistent with their findings.

Hypothesis 5: Number of Distractors predicts that Westerners can deal with a greater amount of distractors, compared to Easterners. To test H5, we the RT and accuracy differences between a greater and a smaller amount of distractors. H5 was assessed in the visual search task Experiment 2, the dot flicker task Experiment 2, and the image flicker task. The results showed that H5 was not supported in any of the tasks tested, suggesting that there was no cultural difference in dealing with a greater amount of distractors.

Overall, H3 was the only hypothesis consistently supported by the present and previous studies, suggesting that detail (vs. object) processing may drive cultural differences between Easterners and Westerners. In order to further assess cultural differences, we developed a predictive model using potential predictors designed in the five tasks. The machine learning schema of this predictive model adapted LDA using cross validation as a means to select proper parameters and best predictions of cultural classification. Starting with more than 100 predictors, three types of filter sets were chosen to run this model. We found that the predictive model did a better job and obtained a 15 percent advantage no matter which filter set size was used, compared with the random predictor model. Specifically, using the small filter set (starting with 24 filters which were marginally significant in cultural comparison), the best model produced nine predictors (i.e., overall RTs, and mean RTs in the local, global central, and global eccentric conditions in the global-local task; overall RTs and mean RTs in the color change condition in the dot flicker task; and the overall accuracy and the mean RTs in the salient and background conditions in the image flicker task), which mapped well onto H3, indicating that detail vs. object information processing drives the East-West cultural difference. The results suggested that the predictive model was better than a chance model, though not perfect. This was evidence that the model signaled something in the data which can distinguish culture. Therefore, the conclusion is that we can use this machine learning schema to predict cultural differences.

In summary, H3: Detail vs. Object Configuration is consistently supported by the hypotheses testing in the global-local tasks Experiment 1 and 2, the dot flicker task Experiment 2, the predictive model, and previous studies. It reveals that Westerners tend to focus on global, salient objects, while Easterners tend to pay attention to local, small, detailed information. These results are aligned with Eastern/Western general philosophical differences; Westerners tend to have analytic cognitive processing with a focus on salient, global, and categorical objects, while Easterners tend to have holistic cognitive processing with a focus on detailed components, group relationships, and contextual information in order to understand the whole picture (Nisbett, et al., 2001; Masuda & Nisbett, 2001 & 2006; Kitayama et al., 2003; Chua, Boland, & Nisbett, 2005; Miyamoto & Wilken, 2013).

6.2 Discussion of the Results

One of the plausible explanations of cultural differences on H3: Detail vs. Object Configuration can be associated with the written systems residing within cultures. Tan et al., (2005) and Han and Northoff (2008) suggested that Chinese words are more complex, (constructed by sophisticated strokes with mono-syllable) such that people need to pay attention to detailed strokes in order to recognize a word correctly. This might encourage Chinese to cultivate the habit of paying attention to details and contexts. Similar to Stoesz et al.'s (2007) study, it has showed that musicians have a tendency to look into detailed information compared to normal individuals.

"Habit" can contribute to cultural differences as seen in Kitayama, Duffy, Kawamura, and Larsen's (2003) study that Japanese could draw more accurately when the length of line was identical to the previous line of a square, whereas Americans did a better job when the line differed from the previous line of a square. They concluded that cultures might be bound by habits in some way or another.

Moreover, ecological/environmental factors, such as the environmental complexity, socialized factors, as well as other gene factors might also play roles in cultural differences in human visual attention. Previous research has shown that having exposure to an urban neighborhood, rather than a natural environment, would reduce the visual attentional bias toward local, detailed information (Caparos et al., 2012; Davidoff et al., 2008; Berman et al., 2008). Even though environmental affordances contribute to cultural differences in human attention as shown in previous research, it should not be regarded as a whole story because cultural differences have been found through a variety of attentional tasks and reasoning tasks as mentioned by Masuda and Nisbett, (2006).

6.3 Implication of the study

Just as Hofstede's (2011) cultural dimension theory assesses how values in the working environment are impacted by national cultures, the five cultural mechanisms in the present study may serve as a framework to guide future research that examines visual attentional differences in different cultures/nations. Hofstede's cultural dimensions initially included only four dimensions: power distance, individualism vs. collectivism, masculinity vs. femininity, and uncertainty avoidance in 1980, and the fifth dimension, long-term vs. short term orientation, and the sixth dimension, indulgence vs self-restraint, were added in different phases through the efforts of different researchers (Hofstede, 2011). Hofstede's cultural dimensions have had wide impacts on business practices, such as international communication, negotiation, management, and marketing (Builtjens & Noorderhaven, 1996; De Mooij & Hofstede, 2010).

The evolving dynamics of the cultural dimensions/mechanisms give rise to opportunities for future research in multiple areas, including visual attention. Unlike

Hofstede's utilization of self-report surveys, the present study implemented empirical lab research to measure human subjects' RT and accuracy. Because PEBL is implemented as a free, open-source, reliable psychological testing software, the cultural mechanisms examined in the present study can easily be cross-validated in different timeframes, nations, and cultures.

The current work also has practical implications. The fundamental cultural mechanisms discussed here can serve as a framework for human factor work or principles for applications in areas like video game design, user interface design, website design, and even advertisement campaigns. For example, the cultural difference driving from the detail vs. object information processing could be used to inform the design of signs, labels, signals in a radar displays, and in-vehicle technologies for individuals in different cultures. This study can also benefit the area of marketing strategy. For example, to boost sales on-line, understanding customers' preference and tendency in visual information processing is beneficial to product designers, marketing research analyst, as well as customers. In this regard, Eastern customers should be provided with detailed description, guidance, pros and cons, as well as offered with various choices for their decision-making, while Westerner customers should be provided with distinctive, succinct description and guidance in a salient manner with fewer filtered choices to make.

6.4 Limitation

In the present study, the sample sizes are small, around 40 in each group, so it is difficult to approximate our samples to the entire Eastern and Western population. Also, there might be file-drawer problems in which researchers didn't publish their findings if their data didn't obtain significant differences or causal relationship. So, it's difficult to know the whole story while trying to compare the current results with previous studies. In addition, to my understanding, more than 90% of the Chinese and Taiwanese are near-sighted especially in the younger generation. This might be an unaccounted for factor in our Eastern participants and may have affected their performance in ourvisual attentional tasks. The present study screened out subjects based on their self-reported corrected or correct-to-normal visual acuity and normal color vision. In future studies, it will be important test participants' visual acuity and vision in the lab, rather than relying on self-report.

6.5 Future Direction

As mentioned in Chapter 5, there are some potential ways to improve the design of the study in order to better examine cultural differences. For example, randomizing the block order and constructing fewer figures at the local level to increases the task difficulty in the global-local task as done by McKone et al.'s (2010) study. In the visual search task, an eye-tracker can be used to investigate subjects' eye movements and fixation points to verify the task results. It may be worthwhile to add a block with language-free, more neutral symbols to examine the Eastern and Western differences in the visual search task in the future. As for the Eriksen flanker task, adding 5- or 10-pixel gap conditions may better elicit cross-cultural differences. In the dot flicker task, it would be interesting to explore at which stage subjects will start to produce significant interference costs with the increase of distractors. In the image flicker task, it is necessary to use images which can be divided into salient change and background change without ambiguity to better examine the interaction cost between these two changes. Most important of all, the tasks should be modified to validate whether looking into details drives the cross-cultural differences and allow us to investigate when and how detail information starts to show an effect.

Evidences from neuropsychology also supports the notion of cultural differences between Easterners and Westerners. Evidence in the cognitive neuroscience field indicates that an individual's sociocultural context may influence their own neural mechanisms (Han & Northoff, 2008). On one hand, people in both Eastern and Western cultures show similar neural activity in certain brain regions; for example, object-processing tasks seem to activate activities in lateral occipital cortex (Goh et al., 2007). On the other hand, an individual's cultural background strongly accounts for differential neural activity in other brain regions; for instance, the activity in the premotor cortex while performing mental calculation differed between Easterners and Westerners (Tang et al., 2006). However, as seen in previous research in visual attention, research in the cognitive neuroscience also just used one or two tasks to examine the cultural differences In the future, it would be nice to collaborate with cognitive neuroscience researchers using this developed task battery to collect neuroimaging to facilitate the examination cultural differences. In addition, eye tracking may facilitate the interpretation of the cultural differences that may be found in behavioral measures like RTs and accuracy.

In addition to identifying whether cultural differences in human visual attention exist and which mechanisms cultural differences stem from, it will be of benefit to explore questions, such as when and how cultural mechanisms affect cultural differences. This will help avoid too generalized or too dispersed understanding of this topic

(Miyamoto, 2013). Furthermore, this study did not address the issue of strategic differences among cultures, so future research can add a questionnaire or eye tracking to understand this issue.

6.6 Conclusion

The current study assessed cross-cultural differences in visual attention between Easterners and Westerners. In spite of what is often reported about cross-cultural attentional differences, such as Asian's global advantage, bilingual advantage on interference suppression and response inhibition, Asian's preference (inclination) but vulnerability in dealing with visual distractors, the results in previous research sometimes appear inconsistent with each other, or they lack clear predictions from underlying theories. For example, evidence for a preference for cluttered displays (Wang et al., 2012), evidence for being vulnerable to peripheral distractors (Masuda et al., 2008a), as well as evidence for greater sensitivity to distraction by global information (McKone et al., 2010) are all taken as evidence for East-West cultural difference, even if they may be inconsistent with one another (i.e., Easterners prefer displays that are likely to lead to more distraction). In full view of these inconsistencies, the study has sought to answer the following two questions:

1. What potential cultural mechanisms are responsible for these differences?
2. Can cultural differences between Easterners and Westerners be shown consistently across tasks?

To overcome the inconsistent findings as shown in past research, this study has used three approaches:

1. **Identified cultural mechanisms** for hypotheses testing, which stemmed from cultural differences on general philosophy, visual attention, and bilingualism.
2. **Implementing two empirical research studies** using multiple visual attentional tasks cross two experiments to consistently validate the findings.
3. **Developing a predictive model** to validate the test results and predict the classification of cultural membership through machine learning algorithm**.**

Despite some limitations in this study and an imperfect (but qualified) classification in the predictive model, the overall results consistently pointed to one cultural mechanism, Hypothesis 3: Detail vs. Object Configuration that suggesting that looking into detailed information drives the cultural differences between Easterners and Westerners. Easterners tend to distribute attention to detailed background information and relationship, while Westerners tend to focus on salient, focal object configuration.

The results of this dissertation were cross-validated in multiple experiments and a predictive model that support the cultural mechanism that attention to details drives cultural difference between Easterners and Westerners. These overall findings suggest that, instead of focusing on high-level descriptive accounts of cultural difference, future research should attempt to investigate how specific attention mechanisms and strategies may differ across cultures.

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Appendix A: Welch Two Sample T-test Table

Table A1: The results of the Welch Two Sample T-tests in Experiment 1

Tasks/Conditions	Absolute Differences								Implicit Differences			
	RT(ms)				Accuracy				Interference Cost			
	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value	TW mean	US mean	T-value	P-value
Global-Local	580	575	0.4206	0.6754	0.958	0.964	-1.020	0.312	30.782	41.774	-1.690	0.095
1. Interference Suppression	31	37.8535	-1.1339	0.265					0.040	0.040	0.427	0.670
2. Response Inhibition	-43	-44.7	0.3321	0.7408					0.039	0.028	0.374	0.709
3. Eccentricity (global)	523	531	-0.49	0.623					-5.961	20.830	-1.990	0.051
4. Eccentricity (local)	702	703	-0.01	0.991					57.790	41703.000	1.360	0.177
5. Detail vs.Object Configuration	497	465	2.570	0.012*					116.060	150.920	-2.490	0.015*
Visaul Search	1607	1962	-2.920	0.005	0.972	0.966	0.611	0.543	116.060	150.920	-2.490	0.015*
1. TA-Feature Search (10s)	1530	1974	-1.584	0.118								
2. TA-Conjuction Search	1803	2135	-1.408	0.163					42.990	63.200	-1.943	0.057
3. TP-Feature Search (10s)	1013	1385	-2.056	0.043								
4. TP-Conjunction Search	1376	1549	-1.120	0.267								
5. TA-Feature Search (20s)	1961	2417	-1.453	0.150								
6. TA-Conjuction Search	2897	3362	-1.275	0.206								
7. TP-Feature Search (20s)	1150	1394	-1.086	0.281								
8. TP-Conjunction Search	1804	1807	-0.013	0.990								
9. TA-Feature Search (30s)	2312	2823	-1.667	0.099								
10. TA-Conjuction (30s)	3256	3965	-1.857	0.068								
11. TP-Feature Search (30s)	1224	1645	-1.561	0.124								
12. TP-Conjunction Search	1980	1999	-0.075	0.940								
Victoria- Stroop	1116	1054	1.400	0.165	0.961	0.959	0.272	0.786	57.558	115.660	-1.470	0.146
1. Color	1035	1051	-0.300	0.764								
2. Dot	1217	1124	1.790	0.076								
3. Word	978	935	0.933	0.353								
Color- Stroop	735	750	-0.704	0.484	0.939	0.937	-0.232	0.817	43.880	154.100	-6.780	<0.001*
1. Congruent	723	687	1.700	0.093								
2. Incongruent	766	841	-2.530	0.014*								
3. Neutral	715	724	-0.440	0.663								
Number- Stroop	609	626	-1.280	0.204	0.946	0.940	0.761	0.450	76.757	107.930	-4.270	<0.001*
1. Congruent	568	572	-0.330	0.786								
2. Incongruent	645	680	-2.280	0.025*								
3. Neutral	614	626	-0.830	0.409								
Simon	486	465	1.660	0.101	0.936	0.957	-1.345	0.183	28.700	27.220	0.250	0.803
1. Congruent	473	452	1.510	0.134								
2. Incongruent	501	479	1.790	0.077								
BST	779	797	-0.920	0.359	0.989	0.992	-0.738	0.462	65.598	70.811	-0.310	0.758
1. Incongruent	809	833	-1.070	0.289								
2. Neutral	784	795	-0.500	0.621								
3. Congruent	744	762	-0.890	0.374								
Flanker	468	471	-0.380	0.702	0.957	0.938	1.371	0.176	42.917	58.125	-1.420	0.159
1. Incongruent	500	517	-1.240	0.219								
2. No flanker effect	465	457	0.565	0.574								
3. Congruent	457	459	-0.189	0.851								
4. Neutral	451	449	0.151	0.881								
Dot Flicker	21527	18155	2.050	0.043*	0.840	0.850	-0.345	0.732				
1. Position	11923	8400	3.060	0.003*	0.931	0.926	0.165	0.869				
2. Absence	16085	15122	0.504	0.619	0.919	0.899	0.602	0.550				
3. Color	22259	21741	0.174	0.862	0.628	0.682	-0.909	0.366				
4. Size	17876	14203	1.950	0.055*	0.881	0.892	-0.252	0.802				

Appendix B: R Codes of the Predictive Model

```
##
###  Program of the Predictive Model
###
tmp <- data.frame(Rando2)

ll <- lda(new$nat~as.matrix(tmp[,bestfilter]),CV=T)

bestgof <- sum(diag(table(ll$class,new$nat)))

tries <-  1000

for(try in 1:tries)
{

 ##choose a random filter
 filter <- sample(c(T,F),replace=T,prob=c(.2,.8),size=ncol(Rando2))

 filter[bestfilter]<-T

 lastmax <- 0

 tmp <- data.frame(Rando2)

 for(times in 1:100)

 {

  fits <- rep(0,ncol(tmp))

  ll <- lda(new$nat~as.matrix(tmp[,filter]),CV=T)

  gof0 <- sum(diag(table(ll$class,new$nat)))

  for(i in 1:ncol(tmp) )

  {

   tmpfilter <- filter

   tmpfilter[i] <- !tmpfilter[i]

   ll <- lda(new$nat~as.matrix(tmp[,tmpfilter]),CV=T)
```

```
  gof <- sum(diag(table(ll$class,new$nat)))

  fits[i] <- gof

}

max <- max(fits)

bests <- (1:length(filter))[fits==max]

if(max > lastmax)

{

  ##if so, pick _one_ of the best models at random
  best <- bests[order(runif(length(bests)))][[1]]

  filter[best] <- !filter[best]

} else if(max==lastmax)

 {

   bests2 <- (1:length(filter))[fits==max & filter==TRUE]

   if(length(bests2)==0)

 {

   break

   best <- bests2[order(runif(length(bests2)))][[1]]

   filter[best] <- FALSE

  } else

   {

     break
    }

if(max>lastmax)

  lastmax <- max
```

```
 }

 if(lastmax>=bestgof)

 {

   bestfilter <- filter
   bestgof <- lastmax

  }

}
```