THE EFFECT OF CULTURE ON LOAD AND DISTRACTOR PROCESSING

RONDA LO

A THESIS SUBMITTED TO THE

FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE DEGREE OF MASTER OF ARTS

GRADUATE PROGRAM IN PSYCHOLOGY

YORK UNIVERSITY

TORONTO, ONTARIO

August 2017

Abstract

The present study examined perceptual load capacity as a potential mechanism that may contribute to visual attention differences between East Asians and North Americans. Participants identified targets in a low or high load display while ignoring distractors that are compatible or incompatible with the target. Previous research suggests North Americans do not experience reaction time difference between compatible and incompatible trials under high load because high load uses up perceptual load capacity before distractors can be processed. If East Asians possess a higher perceptual load capacity than North Americans, they should be slower than North Americans to react in incompatible trials compared to compatible trials under high load. Results revealed that both cultural groups performed similarly, suggesting no cultural difference in perceptual load capacity. Results also revealed that East Asians were significantly slower under high load, but more accurate across all loads, than North Americans. Implications and limitations are discussed.

Acknowledgements

I would like to thank my supervisor Joni Sasaki, not only for her support and insightful feedback on my research, but for encouraging the pursuit of my own academic interests and the growth of my professional skills. It is with her mentorship that has allowed me to enjoy graduate school so much. I would also like to thank Adam Cohen for his expertise on cognitive psychology research and PsychoPy.

I would like to thank Kerry Kawakami for helping me make sense of my hypotheses and strengthening my overall argument throughout this thesis. Her comments on my drafts have shaped this paper into the best version it could be. I would also like to thank Raymond Mar and James Elder for their insightful comments on my study design, analysis, and discussion.

I would like to thank Joshua Guilfoyle and Michael Friendly from York's Statistical Consulting Service for their expertise and help on analyzing my data. I would also like to thank my research assistants Isabella Lim and Shasanji Lingaratnam for helping me run my (arduous) study.

I would like to thank my academic friends for the ongoing support of my research and grateful companionship throughout our long journey of becoming slightly smarter. I would also like to thank my non-academic friends for their encouragement of completing my graduate program in the hopes that one day they can finally call me Dr. Lo.

Lastly, I would like to thank my loving and supportive parents and brother, all of whom are not quite sure what I'm studying, but believe that I know what I'm doing anyway.

TABLE OF CONTENTS

LIST OF FIGURES

The Effect of Culture on Load and Distractor Processing

Cultural psychological research on attention has shown that North Americans tend to use an analytic attention style that focuses more on objects than the surrounding context. East Asians, on the other hand, tend to use a more holistic attention style that focuses on object and context relatively equally (Nisbett, Peng, Choi, & Norenzayan, 2001). Although research on cultural differences in attention is plentiful, there is little research on the specific cognitive mechanisms that may contribute to cultural differences in attention. One potential mechanism of interest is perceptual load capacity (Lavie & Cox, 1997; Lavie, Hirst, de Fockert, & Viding, 2004), which influences the extent to which distractors are processed under varying levels of perceptual load (i.e., how difficult or demanding it is to process). The current research aims to examine basic differences in perceptual load capacity between cultures using the perceptual load paradigm.

Culture and Attention

There is a wealth of research documenting cultural differences in aspects of perception and attention, including how much attention is allocated to focal and contextual information. While North Americans tend to allocate most of their attention to focal information, East Asians tend to broadly allocate attention to include both focal and contextual information. Relative to North Americans, East Asians have been found to make more eye movements to the background of visual scenes (Chua, Boland, & Nisbett, 2005; Lee, Greene, Tsai, & Chou, 2016), produce more descriptions of contextual information (Masuda & Nisbett, 2001), and be more sensitive to visual changes in the wider contextual scene (Boduroglu, Shah, & Nisbett, 2009; Masuda & Nisbett, 2006).

Evidence also suggests that East Asians may necessarily process contextual information together with focal information, whereas North Americans seem to more easily process focal information independent of the context surrounding it. One study found Japanese participants experienced difficulty recognizing focal objects from previously viewed scenes that were pasted on novel backgrounds, whereas American participants showed little difficulty (Masuda & Nisbett, 2001). Another study found that although both Europeans and East Asian participants performed equally on target tasks, East Asians processed and remembered distractor information to a greater extent than Europeans, even when knowing that distractors were irrelevant to the task (Amer, Ngo, & Hasher, 2017). When reproducing a previously viewed line within a square frame, East Asians were better than North Americans at reproducing a line that was proportionally similar to the previous line within the context of the frame, whereas North Americans were better at reproducing the exact length of the line, regardless of how different the new frame was (Kitayama, Duffy, Kawamura & Larson, 2003). This finding suggests that while North Americans seemed to process the length of the line independently of the square frame, East Asians processed the length of the line within the context of the square frame. Taken together, this area of research has produced robust evidence that the allocation of attention is different between North Americans and East Asians.

Although this broad difference in attention between the two cultures has been widely studied, less is known about exactly why this is the case. Nisbett et al. (2001) postulate that the differences in attention may stem from the different social systems within North American and East Asian cultures. Compared to North American culture, East Asian culture emphasizes the importance of relationships, drawing more attention to relational and contextual information in general. This emphasis on context and relationships may facilitate processing of both focal and contextual information. Research has corroborated on this idea, where relative to North Americans, East Asians tend to allocate more attention to the greater social context, such as to emotional expressions (Masuda, Ellsworth, Mesquita, Leu, Tanida, & De Veerdonk, 2008) and eye gaze directions (Cohen, Sasaki, German & Kim, 2017) of background faces surrounding a central face.

Yet beyond this more distal explanation for cultural differences in attention, little is known about the proximal cognitive mechanisms that underlie cultural differences in attention processes. Beyond sensitivity to context, another process that could potentially play a role is perceptual load capacity, a cognitive mechanism known to have consequence for attention shifting (Lavie & Cox, 1997). Differences in the amount of information one can perceive in the visual field can influence whether or not attention can shift. Smaller capacities can limit the amount of contextual information processed, leading to more focused attention on focal information. On the other hand, bigger capacities increase the amount of both focal and contextual information processing, and can subsequently shift attention between focal and contextual information. Differences in perceptual load capacities have been found in populations that typically diverge in attention tendencies (e.g., video gamers versus non-video gamers; Green & Bavelier, 2006). Thus, it is possible that there will be cultural differences in perceptual load capacity since East Asians and Europeans typically diverge in attention tendencies as well.

Research suggests that East Asians tend to structure context-rich environments around them (e.g., physical environments, Miyamoto, Nisbett, & Masuda, 2006; communicative products and media, Wang, Masuda, Ito, & Rashid, 2012). Exposure to these context-rich environments may allow East Asians to develop a larger *capacity* to process more information in the visual field than North Americans. In order to test this, the current study utilizes theoretical and methodological approaches from perceptual load research.

Perceptual Load

The perceptual load theory of selective attention proposed by Lavie (Lavie & Cox, 1997; Lavie, Hirst, de Fockert, & Viding, 2004) explains that, at least within Western European populations, the perception of information is an automatic, but limited process. When a visual display is low load (i.e., perceptually easy to process), perceptual load capacity allows processing of both the display and any distractors. However, when a visual display is high load, (i.e., perceptually difficult to process), the display takes up the perceptual load capacity, leaving little capacity for processing any distractors. The perceptual load task involves measuring the reaction time (RT) of participants locating a target within a visual display that is either low or high load, while ignoring a flanking distractor that is either compatible (same shape) or incompatible (different shape) with the target. Research conducted with this task has found that North Americans (Green & Bavelier, 2006; Proksch & Bavelier, 2002) and Western Europeans (Lavie & Cox, 1997; Maylor & Lavie, 1998; Thoma & Lavie, 2013) typically experience more interference from the incompatible distractor compared to the compatible distractor under low load, termed as "interference effect" (i.e., the magnitude of difference in RT between compatible and incompatible trials). However, North Americans and Western Europeans are able to ignore the distractors during high load trials, and thus there is no interference effect. The explanation for this effect is that after processing the target during low load trials, there is enough capacity leftover to process the distractors. However, during high load trials, processing the target requires the maximum perceptual load, and thus there is not enough capacity to process distractors.

We know that East Asians, compared to North Americans, pay more attention to contextual information (e.g., Ishii, 2013; Masuda & Nisbett, 2001; Masuda & Nisbett, 2006; Nisbett et al., 2001). One possible reason for these known differences in attention styles is that East Asians have a larger perceptual load capacity than North Americans, allowing them more resources to attend to both focal and contextual information, and being able to process and remember contextual information to a greater extent than North Americans. Specifically for the current task, a larger perceptual load capacity than North Americans would allow East Asians more resources to process both the target and distractors in the perceptual load task, even under conditions of high load. Comparing East Asians to North Americans on the perceptual load task would reveal whether a basic cognitive mechanism, such as perceptual load, might underlie the different cultural tendencies to attend to contextual versus focal information.

The Present Study

If East Asians (henceforth referred to as Asians) have a larger perceptual load capacity than North Americans (henceforth referred to as Europeans), then there will be a 3-way culture x load x compatibility interaction.

Under low load, the pattern of results for both Asians and European should be consistent with what has been shown in past research (Green & Bavelier, 2006; Lavie & Cox, 1997; Lavie, Hirst, de Fockert, & Viding, 2004), in which there is a main effect of compatibility. Both Asians and Europeans will experience more interference from the incompatible trials relative to the compatible trials (termed a “high interference effect”) under low load.

Under high load, there should be a culture x compatibility interaction. In line with previous research, Europeans under high load should experience no interference from distractors, and thus exhibit no RT difference between compatible and incompatible trials (termed a "low interference effect"). Asians should experience more interference in incompatible trials relative to compatible trials (i.e., a "high interference effect") because their larger perceptual load capacity is still capable of processing distractors even under high load.

Given that previous perceptual load research also typically reports task accuracy, I will also report effects on accuracy. However, there is no particular prediction for how culture, load and compatibility should interact to affect accuracy in this task.

Method

Participants

Initial power analyses conducted on G*Power (Faul, Erdfelder, Lang, & Buchner, 2007), with statistical test selected as "ANOVA: Repeated measures, within-between interaction", indicated that a total sample size of 98 participants would yield an approximate power of 95% to detect a Cohen's $f = 0.15$. This effect size was chosen because it is between the value of small (i.e., $f = 0.10$) and medium (i.e., $f = 0.25$) effect sizes, and previous research using the perceptual load task reported effect sizes that ranged from small to medium (Green & Bavelier, 2006). Participants were recruited from York University's Undergraduate Research Participant Pool. In order to qualify for the study, Europeans had to identify themselves as "White/European" and indicate that they were born in North America (i.e., Canada or the United States). Asians had to identify themselves as East Asian and only indicate that their parents were born in East Asia. The qualification rules for Asians and Europeans differ for pragmatic and theoretical reasons. East Asian participants did not need to be born in East Asia themselves, since many East Asians at York University were born in Canada, and thus it would limit the Asian sample recruitment. As long as both of the Asian participant's parents were born in East Asia, this would ensure that they would have sufficient exposure to their East Asian cultures through their parents. Similarly, parents of European participants did not have to be born in North America, as many Europeans at York University have at least one parent born in Europe, and this would have limited the European sample recruitment.

One hundred and forty-eight undergraduate students from the Undergraduate Research Participant Pool from York University were initially recruited. However, due to technical issues in the experiment task and survey, the first 9 participants' data were improperly collected. Research assistants noted an additional 7 participants as inattentive, and thus they were also removed from the data. Thirty-three participants indicated that they were not East Asian or White/European in the survey and were removed from the data. As a result, 49 participants were removed, and the total number of participants that remained in the sample was 99: 49 Asians and 52 Europeans. Out of the 49 Asians recruited, 32 were not born in Canada (M = 4.70 years living in Canada, SD = 4.67 years).

Apparatus

The experiment was presented on a desktop computer, running Windows 7 64-bit, with an Intel Core i7-4770 Processor, at 3.40 GHz 4GB RAM with Service Pack 1. The computer monitor measured exactly 47.5cm in length by 29.5 cm in width. The perceptual load task was programmed on PsychoPy (Peirce, 2007), version 1.84.1. The average refresh rate across all trials was 59.94 Hz, ranging from 59.39 Hz to 60.55 Hz. Monitors were positioned 60 cm away from participants' faces, and keyboards were placed so that both hands could comfortably reach the arrow keys.

Stimuli

The perceptual load task measured RT to identify a target in 1 of 6 circles while ignoring a distractor under varying levels of load of the visual display. The background colour was neutral grey, while stimuli were presented in black.

Load. In addition to the target in 1 of the circles, the other 5 circles in the visual display remained either blank (low load; see Figures 1 and 2) or filled with miscellaneous filler shapes (high load; see Figures 3 and 4). In low load conditions, the display should not be cognitively taxing because there is only one shape in the display (the target), and it should not be cognitively taxing because there is only one shape in the display (the target), and it should be easily located and processed. High load suggests that the display would be cognitively taxing because there would be more shapes in the display to search through in order to locate the target. The size of the display circles subtended 1.35°, and the sizes of the target and non-target shapes subtended an average of 0.8°. The target could be either a square or diamond shape, and non-targets were pentagons, upside-down pentagons, triangles, upside-down triangles, and hexagons.

Distractor. There were trials where a distractor was either a shape compatible with the target (i.e., if the target is a square, the distractor is a square as well), incompatible with the target (i.e., if the target is a square, the distractor is a diamond), a neutral shape (i.e., triangle), or there was no distractor, and appeared on the left or right side of the visual display. Trials with neutral distractors and no distractors were added to the task in order to make sure participants do not always anticipate a compatible or incompatible distractor appearing in every trial. Each block of experimental trials had 25% compatible trials, 25% incompatible trials, 25% neutral distractor trials, and 25% no distractor trials. The size of the distractors were presented at an average of 1.01 visual degree angles vertically and horizontally (1.06 cm x 1.06cm, or 30 x 30 pixels), and were positioned 4.4 visual degree angles (4.60 cm, or 131 pixels) to the left or right of the fixation cross.

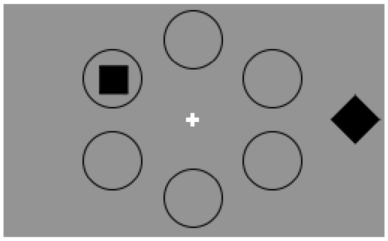

Figure 1. Low load trial with incompatible distractor (target = square, distractor = diamond).

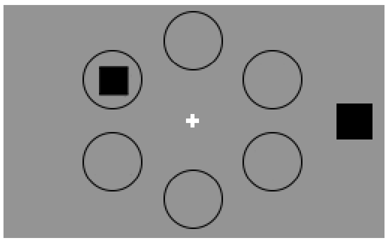

Figure 2. Low load trial with compatible distractor (target and distractor = square).

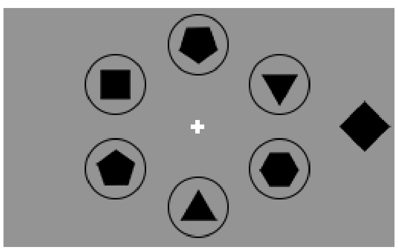

Figure 3. High load trial with incompatible distractor (target = square, distractor = diamond).

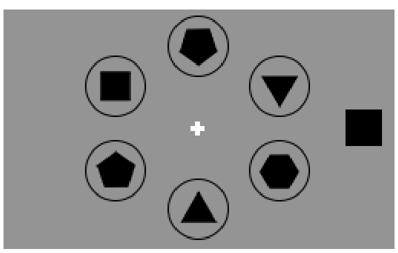

Figure 4. High load trial with compatible distractor (target and distractor = square)

Perceptual load task overview. The perceptual load task required participants to identify one of two possible targets within a visual display. Distractors could flank the visual display on the left or right side, and could take the form of either possible target shapes (square or diamond) presented in the visual display, creating trials where the target and distractor would be of compatible (e.g., both the target and distractor are squares) and incompatible (e.g., the target is square and distractor is diamond) shapes.

During low load trials, incompatible distractors should induce more interference than compatible distractors. Load theory of perception states that because the task (identifying what the target's shape is in the circles) does not require the full capacity of attention, there is leftover attention that can process the distractor. Incompatible distractors should be more interfering than compatible, and they should distract the participant's attention from the target (Lavie & Cox, 1997). To illustrate, the participant is asked to locate a square or diamond in a low load display (see Figure 1); a square appears in the display, but a diamond appears as a distractor (incompatible). Since diamond is also a possible target shape, the diamond is perceived to be a viable response that interferes with the correct response (square). If the distractor is compatible, it facilitates the response time, and there is less conflict about what the identity of the target is and how the participant should respond. For example, if a square appears in the display, and a square appears as a distractor (compatible), then square is the only response possible, whether responding to the target, or accidentally responding to the distractor (see Figure 2). We can index this interference effect by subtracting compatible trial RTs from incompatible trial RTs. Thus, on low load trials, participants tend to experience a high interference effect (large magnitude of RT difference between incompatible and compatible trials, as incompatible trials take longer to respond to, and compatible trials are faster to respond to).

During high load trials, the display should be cognitively taxing. Load theory of perception states that when the current task requires full capacity of attention, there is little to no attention left to process the distractor. In this case, response times for high load incompatible and high load compatible trials should not differ from each other because participants should ignore the distractor regardless of its shape. Thus, on high load trials, participants should typically experience a low interference effect (small magnitude of RT difference between incompatible and compatible trials). If Asians possess a larger perceptual load capacity than Europeans, Asians, but not Europeans, may experience an interference effect during high load trials, since there is left over capacity to process the distractors.

Procedure

To complete the perceptual load task, participants were seated behind a desktop computer and instructed to respond to either a square or diamond target that appeared in 1 of 6 circles that were displayed around the fixation cross. Although there may be other shapes that appear in the circles, they were only required to respond to either a square or diamond. Instructions emphasized that participants should aim to be as quick and accurate as possible, and to ignore any shapes that may appear in the periphery of the circles (distractors).

Each trial began with a fixation cross presented for 1000 ms, followed by the visual display for 100 ms. Afterward, participants were given up to 3000 ms to respond to what shape the target was in the visual display. Half of the participants were randomly assigned to instructions that indicate that the left arrow key represents square, and the right arrow key represents diamond. The other half of the participants were randomly assigned to instructions that indicate that the left arrow key represents diamond, and the right arrow key represents square. This was done in order to minimize bias that may occur from pressing the right arrow key faster than the left arrow key (Zhang et al., 2016). Participants were instructed to use the pointer finger of their dominant hand for completing trials, and to rest their finger on the down arrow key in between trials. Participants completed one block of 40 randomly chosen practice trials, followed by four blocks of 192 experimental trials each, totaling 768 experimental trials. Each block took approximately 6 minutes to complete. At the end of the study, participants completed a short, online demographics questionnaire before debriefing.

Results

Data Preparation

Data preparation and analyses were completed in R, and were across all participants. RT was recorded in milliseconds as the unit. In order to analyze RT, all incorrect trials (Asian: 12.08%; European: 16.70%) were first removed. Trials that were greater than 2 standard deviations from the mean (M = 744.87 ms, SD = 392.26 ms) were excluded (2.56% of total correct trials). Following the procedure from Green and Bavelier (2006), trials that were less than 300 milliseconds (1.11% of remaining trials) were also excluded.

The remaining filtered data was initially modeled in a 2 x 2 x 4 mixed ANOVA with culture (levels: Asian, European) as a between-subjects factor, and load (levels: high, low) and distractor compatibility (levels: compatible, incompatible, neutral, no distractor) as within-subjects factors. Assumptions of sphericity and homogeneity of variance were satisfied, but the assumption of normality was violated. Residual visualizations revealed the data as highly bimodal. Further investigations revealed a coding error associated with key assignment two (i.e., those assigned to press left arrow key for diamond, and the right arrow key for square), where RT was measured at the onset of fixation cross (i.e., at 0 ms) rather than onset of display (i.e., at

1000 ms), causing all trials in key assignment two to be off by 1000 ms. All RTs in key assignment two were corrected by subtracting 1000 ms from RTs. After correction, the normality assumption was satisfied.

Accuracy proportion was also calculated. Proportion of accuracy ranges from 0 (where no trial was answered correctly) to 1 (all trials were answered correctly). Accuracy proportions were similarly modeled in a 2 x 2 x 4 mixed ANOVA with load (levels: high, low), distractor compatibility (levels: compatible, incompatible), and culture (levels: Asian, European) as factors[1].

Main Analyses

Reaction time. The RT data was modeled in a 2 x 2 x 4 mixed ANOVA with load (levels: high, low) and distractor compatibility (levels: compatible, incompatible, neutral, no distractor) as within-subjects factors, and culture (levels: Asian, European) as a between-subjects factor.

A main effect of load was observed, $F_{1,97} = 464.19$, $p < .01$, $\eta_G^2 = .35$. For both cultures, RTs in the high load conditions (M = 758.68 ms, SD = 100.17 ms) were greater than in the low load conditions (M = 631.57 ms, SD = 71.66 ms). A main effect of culture was also observed,

---

[1] The data distribution for accuracy proportion were left skewed (towards 0, from 0-1), and typically polynomial transformations can improve left-skewed distributions. A squared transformation was applied to resolve non-normality, and an identical model was defined using the transformed accuracy proportion data as a dependent variable. Given that both ANOVA models with transformed and untransformed data revealed the same significant effects, only the model with the untransformed data is reported in order to maintain clear interpretation.

$F_{1,97} = 4.89$, $p = .03$, $\eta_G^2 = .04$. Overall Asians exhibited slower RTs (*M* = 713.43 ms, *SD* = 111.79 ms) than Europeans (*M* = 678.57 ms, *SD* = 101.37 ms). A main effect of compatibilitywas also observed, $F_{3,291} = 11.25$, $p < .01$, $\eta_G^2 = .001$. Using the Holm-Bonferroni method, I conducted pairwise comparisons of compatibility conditions. RTs in trials with no distractors (*M* = 690.21 ms, *SD* = 109.80 ms) were faster than trials with compatible distractors (*M* = 694.42 ms, *SD* = 108.95 ms), *t*(197) = 2.49, *p* = .04, incompatible distractors (*M* = 696.43 ms, *SD* = 106.58 ms), *t*(197) = 3.43, *p* < .01 and neutral distractors (*M* = 699.43 ms, *SD* = 106.42 ms), *t*(197) = 5.62, *p* < .01. RTs in trials with compatible distractors were faster than trials with neutral distractors, *t*(197) = 2.99, *p* = .01. RTs in trials with incompatible distractors were not significantly different from compatible distractors, *t*(197) = 1.18, *p* = .24, and neutral distractors, *t*(197) = 1.76, *p* = .16.

A significant interaction of load x compatibility, $F_{3,291} = 5.06$, $p < .01$, $\eta_G^2 = .0008$, was observed (see Figure 5). To decompose the interaction, the effect of compatibility was examined separately by load.

Within the low load, there was a significant effect of compatibility, $F_{3,294} = 27.59$, $p < .01$, $\eta_G^2 = .006$. I used the Holm-Bonferroni method to conduct pairwise comparisons of compatibility conditions. Compatible trials (*M* = 627.88 ms, *SD* = 72.05 ms) had faster RTs than incompatible trials (*M* = 635.41 ms, *SD* = 70.65 ms), *t*(98) = 4.71, *p* < .01, and neutral trials (*M* = 638.09 ms, *SD* = 70.93 ms), *t*(98) = 6.10, *p* < .01. RTs in compatible trials were not significantly different from RTs in trials with no distractors (*M* = 624.88 ms, *SD* = 73.26 ms), *t*(98) = 1.61, *p* = .17. Trials with no distractors also had significantly faster RTs than both incompatible trials, *t*(98) = 6.56, *p* < .01, and neutral trials, *t*(98) = 7.64, *p* < .01. Incompatible trials were not significantly different than neutral trials, *t*(98) = 1.73, *p* = .17.

In high load conditions, the compatibility effect was not significant, $F_{3,294} = 1.63$, $p = .18$, $\eta_G^2 = .0005$.

A significant interaction of load x culture was also observed, $F_{1, 97} = 18.24$, $p < .01$, $\eta_G^2 = .02$ (see Figure 5). To decompose the interaction, the effect of culture was examined separately by load. Within the low load condition, there was no significant cultural difference in RTs, $F_{1,97} = 0.43$, $p = .51$, $\eta_G^2 = .004$, whereas in the high load condition, there was a significant cultural difference, such that Asians (*M* = 790.36 ms, *SD* = 87.94 ms) had longer RTs than Europeans (*M* = 730.05 ms, *SD* = 102.11 ms), $F_{1,97} = 10.02$, $p < .01$, $\eta_G^2 = .09$.

The predicted 3-way interaction of load x culture x compatibility was not significant, $F_{1,96} = 0.71$, $p = .55$, $\eta_G^2 = .0001$.

Despite the overall significant main effect of culture in the omnibus ANOVA, it is likely that this effect was only driven by the stronger effect of culture within high load from the load x

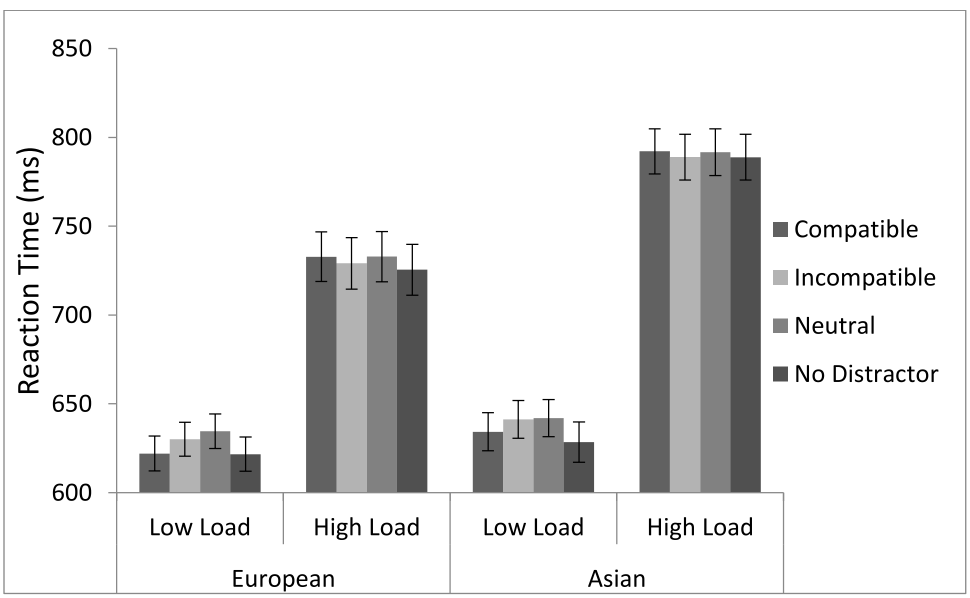

Figure 5. Bar plot of mean reaction time (in milliseconds). Standard error bars are indicated. Larger y-values indicate slower reaction time.

culture interaction, since within the low load, the effect of culture was not significant. The main effect of load in the omnibus ANOVA represents the overall higher task difficulty in high load trials, and is reflected in slower RTs for both cultural groups in high load trials, compared to low load trials. The main effect of compatibility is likely driven by the compatibility effect within low load trials, in which RTs in trials with compatible or no distractor were faster than trials with incompatible and neutral distractors. The load x compatibility interaction was driven by both cultural groups experiencing a compatibility effect under low load, but not under high load (see Figure 6). The load x culture interaction was driven by the lack of cultural differences in RT in low load, and the large cultural difference in RT in high load.

Accuracy. From the 2 x 2 x 4 mixed ANOVA, main effects of load, $F_{1,97} = 537.70$, $p < .01$, $\eta_G^2 = .48$, culture, $F_{1,97} = 7.43$, $p < .01$, $\eta_G^2 = .05$, and compatibility, $F_{3,291} = 3.05$, $p < .01$, $\eta_G^2 = .001$, on accuracy proportions were observed. As depicted on Figure 7, responses were more

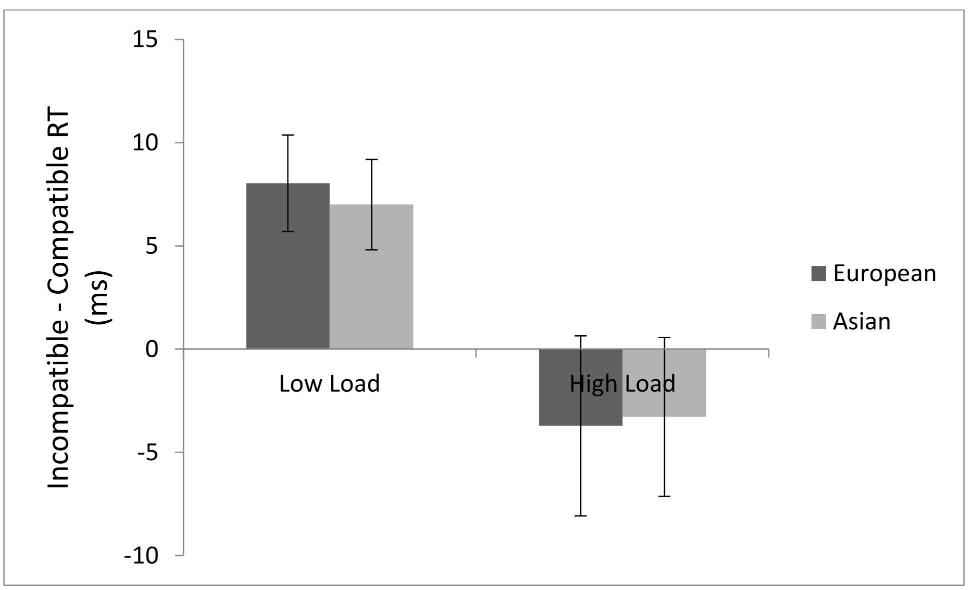

Figure 6. Bar plot depicting the interference effect, calculated by subtracting compatible RT from incompatible RT (in milliseconds). Standard error bars are indicated. Larger y-values indicate a higher interference effect.

accurate under low load (*M* = 0.95, *SD* = 0.08) than under high load (*M* = 0.76, *SD* = 0.11). Asians (*M* = 0.87, *SD* = 0.12) were more accurate than Europeans (*M* = 0.83, *SD* = 0.15) across both load conditions. The Holm-Bonferroni method was used to conduct pairwise comparisons of compatibility conditions. Within the compatibility conditions, trials with no distractors (*M* = 0.86, *SD* = 0.14) were more accurate than trials with incompatible distractors (*M* = 0.85, *SD* = 0.14), $t(197) = 2.94$, $p = .02$. Other pairwise comparisons with compatible trials (*M* = 0.85, *SD* = 0.14) and neutral trials (*M* = 0.85, *SD* = 0.14) were not significant (*p*s ranged from .17 to .72).

Exploratory Analyses

Video game experience. Previous research has found that action video game experience (Green & Bavelier, 2001, 2006) significantly influences performance in the perceptual load task, where video gamers tended to experience an interference effect from distractors in high load

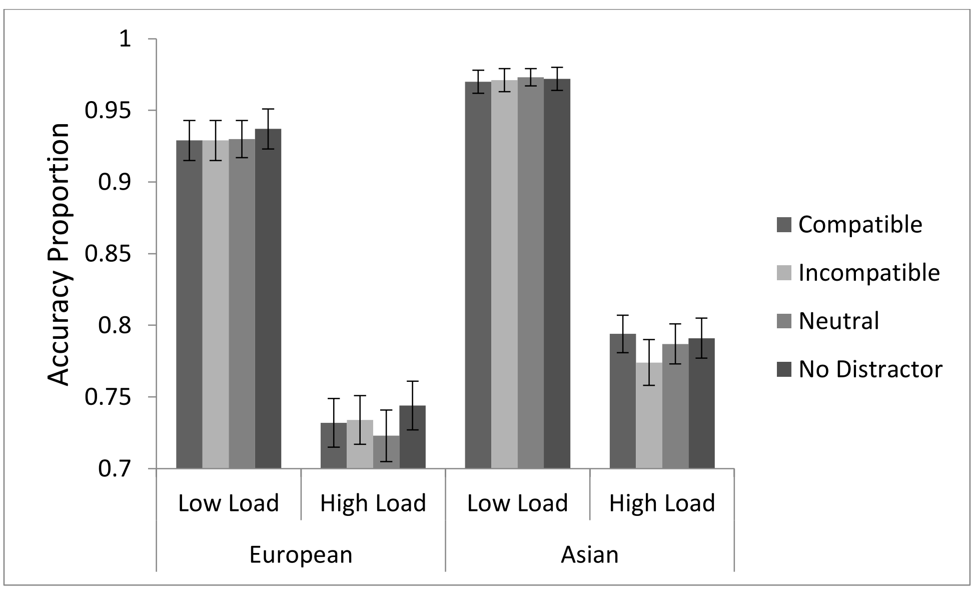

Figure 7. Bar plot of mean accuracy proportions. Standard error bars are indicated. Larger y-values indicate higher proportion of correct trials.

because long-term action video game experience encourages development of a larger perceptual load capacity. In the low load, video gamers tend to perform similarly to non-video gamers. Gamer status (action video game player vs. non-action video gamer player) was added as a between-subjects variable to the ANOVA to examine if gamer status had interacting effects with the other variables in the model. Participants qualified as a video gamer if they had been playing action video games for more than 6 months and at least several times a week (Green & Bavelier, 2006). From the ANOVA, gamer status came out as a significant main effect, $F_{1,95} = 5.74$, $p = .02$, $\eta_G^2 = .05$, where video gamers (M = 650.90 ms, SD = 107.48 ms) were faster to respond than non-video gamers (M = 700.09 ms, SD = 106.77 ms). Gamer status did not interact with any other variable in the model, and additional steps were taken to ensure that gamer status did not contribute to the cultural differences found on RTs.[2]

Discussion

The current study provides evidence that Asians do not have a larger perceptual load capacity than Europeans. In my hypothesis, I described that within low load trials, there should be a main effect of compatibility, and that within high load trials, there should be a culture x compatibility interaction. The current results have instead replicated the standard perceptual load

[2] Since Europeans were found to be overall faster than Asians, I investigated whether there were more video gamers within the European sample than Asian sample. There was no significant difference between the number of video gamers in the Asian group (14.89% of Asians were given the status of action video gamer) versus the European group (5.77% of Europeans were given the status of action video gamer), $\chi^2 = 1.37$ (1, N = 99), $p = .24$. Since gamer status did not interact with other variables in the ANOVA, this suggests that having more gamers in the Asian sample did not drive the differences between Asians and Europeans. It is also implausible that gamer status had any effect on the cultural differences found in RT because if there were significantly more gamers in the Asian sample, the Asian sample would have been faster in overall RT than Europeans, instead of slower.

effect (i.e., the load x compatibility interaction) that was not qualified by culture, suggesting that Asians may not have larger perceptual load capacities than Europeans. Both cultural groups under high load did not experience an interference effect, suggesting that, as a result of a maxed out perceptual load capacity, neither the incompatible or compatible distractor was processed. If Asians do not have a larger perceptual load capacity than Europeans, then it is likely that another mechanism may contribute to the known cultural differences in attention.

It is possible that, although perceptual load capacities between cultural groups are similar, how each cultural group processes and remembers the information may differ. There is attention research that shows both Europeans and Asians performing similarly on trials where they have to detect changes in either focal object or background, with culturally divergent eye movements emerging only on trials where nothing in the image changes, forcing participants to search for a change in the image (Masuda, Ishii, & Kimura, 2016). Similarly, research on Europeans and Asians tracking moving objects has found that there was no cultural difference in eye movements when simply tracking the moving objects, but eye movement patterns diverged between cultural groups when required to construct a narrative while observing the objects (Senzaki, Masuda, & Ishii, 2014). Both of these studies suggest that the performance on attention tasks may not differ between cultural groups when investigating scenes shallowly, but that culturally divergent strategies of attention are recruited when requiring deep processing of scenes. There is also evidence that cultural differences are not necessarily reflected in performance, but in underlying neural activity (Kitayama & Murata, 2013). Similarly, if there are no cultural differences when measuring perceptual load capacity, this may signal that load processing may actually be similar, but if both cultural groups were given instructions to engage in the task with deeper processing (e.g., if they were asked to recall previous distractor shapes), culturally divergent strategies to process information may have been recruited. This is in line with studies that have found no cultural differences in eye movements when simply viewing naturalistic scenery (Evans, Rotello, Li, & Rayner, 2009; Rayner, Castelhano, & Yang, 2009; Rayner, Li, Williams, Cave, & Well, 2007). It could be that studies that do observe cultural differences may be recruiting and measuring processes that are more malleable to cultural influence, such as memory (Paige, Ksander, Johndro, & Gutchess, 2017). This would also explain why cultural influences on social attention processes have been observed (e.g., faces processing, facial emotion, eye gaze) (Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Caldara, 2017; Cohen, Sasaki, German, & Kim, 2017; Masuda et al., 2008) since the nature of processing social information likely recruits culture-specific top-down processes. Because the mechanisms underlying cultural differences in attention is unknown, it is still important to use tasks known to measure specific mechanisms to compare cultural groups. However, studies in the future should explicitly test comparable bottom-up strategies alongside top-down strategies of attention allocation in order to differentiate what is being influenced by culture.

The significant culture x load interaction was an unexpected finding. The cultural difference in RTs under high load relative to low load suggests that high load incurred significant RT costs for Asians that were not experienced by Europeans. This pattern of results is consistent with research using similar visual search paradigms that show Asians, compared to Europeans, were slower at locating targets when surrounded by irrelevant information, similarly to how Asians in the current study were much slower than Europeans to locate the target within a high load display that contains irrelevant non-target shapes (Kuwabara & Smith, 2012).

It may be that Asians in the present study may have valued being accurate over being fast. This is evidenced by Asians demonstrating higher accuracy rates than Europeans across all conditions. Being more accurate than Europeans under low load did not incur RT costs for Asians because the low load was likely easy to process. However, high load processing was likely difficult, and thus Asians took more time than Europeans to respond correctly This is in line with speed–accuracy tradeoff effects (Heitz, 2014), in which faster RTs typically result in lower accuracy rates, and is also in line with known cultural differences in motivation (Heine et al., 2001). Given that research on culture and motivation suggests that Asians persist on difficult tasks for longer than Europeans (Heine et al., 2001), the findings of the present study suggest that the perceptual load task may have recruited top-down processes that were influenced by culture, and thus reflected in the culture x load interaction. However, this is not likely related to the load x compatibility effect found for both cultural groups.

Another explanation for the culture x load interaction is that there are features of the high load display (i.e., non-target shapes within the display circles) that Asians are coding as relevant, whereas Europeans are coding the same features as irrelevant. Visual attention research has shown that the extent to which irrelevant information distracts people from relevant information depends on how featurally similar it is to the relevant information (Becker, Folk, & Remington, 2010; Folk, Remington, & Johnston, 1992). In the current study, there is no cultural difference in overall RT under low load between both cultural groups. This could be due to how easy it is to determine whether the low load display has any relevant information for the task, since the display circles without the target are blank. However, the large magnitude of difference between Europeans and Asians under high load suggests that 1) Europeans may have considered some parts of the display to be irrelevant, and thus easier to ignore in order to locate the target, and 2) Asians may have considered some parts of the display to be relevant, and thus harder to ignore in order to locate the target. This may mean that Asians may be more inclusionary when regarding information as relevant, than Europeans. This may be related to culture-specific ideas regarding the relevance and importance of contextual information. Research has found that people from East Asian cultures regard contextual information to be as important as focal information, not only in visual processing, but in social attribution and reasoning (Ji, Peng, & Nisbett, 2000; Morris & Peng, 1994). For example, Asians may pay more attention to contextual details surrounding the behaviour of the people around them because these contextual details are perceived to add significant information about the behaviour of interest. Similarly, research suggests that Asians, relative to Europeans, pay more attention to potentially relevant contextual information in order to complete present goals (Lee, Shin, Weldon, & Sohn, 2016), and future goals (Amer et al., 2016).

If Asians in this study are considering features of the non-target shapes to be similar to the target shapes more so than Europeans, Asians may be biased towards perceiving information based on relational similarity. Relational theory of attention (Becker, 2013; Becker, Folk, & Remington, 2010) suggests that when determining if peripheral cues contain relevant or irrelevant information for locating a target within a cueing task, the cue's features are processed within the context of the *relative* features the target possesses, rather than the *specific* features the target possesses. For example, in order to locate a red coloured target, not only are red coloured cues paid more attention to, more attention is also paid to cues that are "reddish", such as an orange cue, relative to less "reddish" coloured cues, such as blue and green cues. In the context of the current study, Asians may have exhibited slower RTs, relative to Europeans, because they perceived that some, or all, of the non-target shapes (i.e., triangles, pentagons, hexagons) were relatively similar to the target they were searching for (i.e., squares, diamonds). This unexpected finding that high load differentially affects people from different cultural groups is nevertheless an important finding for understanding how selective attention is influenced by culture. Further research is required to examine why high load is eliciting this cultural difference in RT. One way to test this is to have a range of gradually similar and different distractors (relative to the target) to determine at what point are the distractors considered similar enough to the target to be significantly distracting for each cultural group, and to determine any relative differences in RT between each cultural group.

One possible limitation of this study is the sample of Asians recruited. It has been found that East Asian countries, compared to North American countries, have visually complex environments that contain many features, and exposure to these environments may have encouraged perception of contextual information (Miyamoto, Nisbett, & Masuda, 2006), and perhaps, the development of a larger perceptual load capacity. Although there is evidence that Asians living in Western countries have attention tendencies that differ from their European counterparts (Goto, Ando, Huang, Yee, & Lewis, 2010; Ji, Peng, & Nisbett, 2000; Miyamoto, Nisbett, & Masuda, 2006; Wang et al, 2012), there is a possibility that Asians living in a Western country for several years may have reduced the context sensitivity needed to process distractors under high load in the task. In the current study, 46.9% of the Asian sample lived in Canada for 5 years or less. Since approximately half of the Asian sample did not grow up in an Asian context for the majority of their life, it is possible that there was not enough exposure of these context-rich environments that are found in East Asian countries that may allow development of a larger perceptual load capacity. If I had recruited only Asians that grew up in an Asian country for the majority of their life, cultural differences in perceptual load capacity may have been detected.

Another limitation of this study is that with only the low and high load conditions to compare, it is hard to determine if minor cultural differences in perceptual load could still exist.

It may be that if Asians have a larger perceptual load capacity than Europeans, this task's high load condition is particularly taxing on their capacity. If there were cultural differences in interference effect within several medium load conditions in between low and high load, this would indicate that there may be cultural differences in perceptual load capacity that may simply be capped at this task's particularly high load. Future studies should include several different load conditions to examine this possibility.

Overall, this research examined a novel mechanism in order to explain the robust cultural differences found in visual attention research. Although the data suggests that there is no cultural difference in perceptual load capacity, this may just be a step forward into investigating how culture seems to be influencing attention shifting and information processing. As mentioned before, it seems pertinent that this field continues to not only test basic attention and perception mechanisms with different cultural groups, but to also step back and examine the possibility that culture has differential impact on bottom-up and top-down strategies of attention shifting and allocation. The current study examined a well-known effect of load processing on distractors for two cultural groups and found both cultural groups replicating it. These results should be informative for future research using the perceptual load paradigm, visual attention literature and the area of culture and cognition.

References

Amer, T., Ngo, K. W. J., & Hasher, L. (2017). Cultural differences in visual attention: Implications for distraction processing. *British Journal of Psychology, 108*(2), 244-258.

Becker, S. I., Folk, C. L., & Remington, R. W. (2010). The role of relational information in contingent capture. *Journal of Experimental Psychology: Human Perception and Performance, 36*(6), 1460-1476.

Becker, S. I. (2013). Why you cannot map attention: A relational theory of attention and eye movements. *Australian Psychologist, 48*(6), 389-398.

Boduroglu, A., Shah, P., & Nisbett, R. E. (2009). Cultural differences in allocation of attention in visual processing. *Journal of Cross-Cultural Psychology, 40*(3), 349-360.

Chua, H. F., Boland, J. E., & Nisebtt, R. E. (2005). Cultural variation in eye movements during scene perception. *Proceedings of The National Academy of Sciences of The United States of America, 102(*35), 12629-12633.

Cohen, A. S., Sasaki, J., German, T. C., & Kim, H. S. (2017). Automatic mechanism for social attention are culturally penetrable. *Cognitive Science, 41*(1), 242-258.

Evans, K., Rotello, C. M., Li, X. S., Rayner, K. (2009). Scene perception and memory revealed by eye movements and receiver-operating characteristic analyses: Does a cultural difference truly exist? *Quarterly Journal of Experimental Psychology, 62*(2), 276-285.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Folk, C. L., Remington, R. W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human*

Perception and Performance, 18(4), 1030-1044.

Green, C. S., & Bavelier, D. (2006). Effect of action video games on the spatial distribution of visuospatial attention. *Journal of Experimental Psychology: Human Perception and Performance, 32*(6), 1465-1478.

Goto, S. G., Ando, Y., Huang, C., Yee, A., & Lewis, R. S. (2010). Cultural differences in the visual processing of meaning: Detecting incongruities between background and foreground objects using the N400. *Social Cognitive and Affective Neuroscience, 5*(2-3), 242-253.

Heine, S. J., Lehman, D. R., Ide, E., Leung, C., Kitayama, S., Takata, T., & Matsumoto, H. (2001). Divergent consequence of success and failure in Japan and North America; An investigation of self-improving motivations and malleable selves. *Journal of Personality and Social Psychology*, *81*(4), 599-615.

Heitz, R. P. (2014). The speed-accuracy tradeoff: History, physiology, methodology, and behavior. *Frontiers in Neuroscience, 8*, 150. doi:10.3389/fnins.2014.00150

Ishii, K. (2013). Culture and the mode of thought: A review. *Asian Journal of Social Psychology, 16*(2), 123-132.

Ji, L. J., Peng, K. P., & Nisbett, R. E. (2000). Culture, control and perception of relationships in the environment. *Journal of Personality and Social Psychology, 78*(5), 943-955.

Kitayama, S., Duffy, T., Kawamura, T., & Larson, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. *Psychological Science*, *14*(3), 201-206.

Kitayama, S. & Murata, A. (2013). Culture modulates perceptual attention: An event-related potential study. *Social Cognition, 31*(6), 759-769.

Kuwabara, M. & Smith, L. B. (2012). Cross-cultural differences in cognitive development: Attention to relations and objects. *Journal of Experimental Child Psychology, 113*(1), 20-35.

Lavie, N., & Cox, S. (1997). On the efficiency of visual selective attention: Efficient visual search leads to inefficient distractor rejection. *Psychological Science, 8*(5), 395-398.

Lavie, N., Hirst, A., de Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology – General, 133*(3), 339-354.

Lee, Y. J., Greene, H. H., Tsai, C. W. & Chou, Y. J. (2016). Differences in sequential eye movement behavior between Taiwanese and American viewers. *Frontiers in Psychology, 7*(697). doi: 10.3389/fpsyg.2016.00697

Lee, D., Shin, H. J., Weldon, R. B., & Sohn, M . H. (2016). Cross-cultural differences in consistent mapping effects of targets and distractors. *Journal of Cross-Cultural Psychology, 47*(4), 525-539.

Masuda, T., Ellsworth, P. C., Mesquita, B., Leu, J., Tanida, S., & De Veerdonk, E. V. (2008). Placing the face in context; Cultural differences in the perception of facial emotion. *Journal of Personality and Social Psychology, 94*(3), 365-381.

Masuda, T., Ishii, K., & Kimura, J. (2016). When does the culturally dominant mode of attention appear or disappear? Comparing patterns of eye movement during the visual flicker task between European Canadians and Japanese. *Journal of Cross-Cultural Psychology, 47*(7), 997-1014.

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology, 81*(5), 922-934.

Masuda, T., & Nisbett, R. E. (2006). Culture and change blindness. *Cognitive Science, 30*(2), 381-399.

Maylor, E. A., & Lavie, N. (1998). The influence of perceptual load on age differences in selective attention. *Psychology and Aging*, *13*(4), 563-573.

Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment. *Psychological Science, 17*(2), 113-119.

Morris, M. W. & Peng, K. (1994). Culture and cause: American and Chinese attributions for social and physical events. *Journal of Personality and Social Psychology, 67*(6), 949–971.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, *108*(2), 291-310.

Paige, L. E., Ksander, J. C., Johndro, H. A., & Gutchess, A. H. (2017). Cross-cultural differences in the neural correlates of specific and general recognition. *Cortex, 91*, 250-261.

Peirce, J. W. (2007). PsychoPy – Psychophysics software in Python. *Journal of Neuroscience Methods, 162*(1-2), 8-13.

Proksch, J., & Bavelier, D. (2002). Changes in the spatial distribution of visual attention after early deafness. *Journal of Cognitive Neuroscience, 14*(5), 687-701.

Rayner, K., Castelhano, M. S., & Yang, J. M. (2009). Eye movements when looking at unusual/weird scenes: Are there cultural differences? *Journal of Experimental Psychology – Learning Memory and Cognition*, *35*(1), 254-259.

Rayner, K., Li, X. S., Williams, C. C., Cave, K. R., & Well, A. D. (2007). Eye movements during information processing tasks: Individual differences and cultural effects. *Vision Research, 47*(21), 2714-2726.

Senzaki, S., Masuda, T., & Ishii, K. (2014). When is perception top-down and when is it not?

Culture, narrative, and attention. *Cognitive Science, 38*(7), 1493-1506.

Thoma, V., & Lavie, N. (2013). Perceptual load effects on processing distractor faces indicate face-specific capacity limits. *Visual Cognition, 21*(8), 1053-1076.

Wang, H. T., Masuda, T., Ito, K., & Rashid, M. (2012). How much information? East Asian and North American cultural products and information search performance. *Personality and Social Psychology Bulletin, 38*(12), 1539-1551.