Abstract

The current study aimed to explore cultural differences in the covert spatial distribution of attention. In particular, we tested whether those born in an East Asian country adopted a different distribution of attention compared to individuals born in a Western country. Previous work suggests that Western individuals tend to distribute attention narrowly and that East Asian individuals distribute attention broadly. However, these studies have used indirect methods to infer spatial attention scale. In particular, they have not measured changes in attention across space, nor have they controlled for differences eye movements patterns, which can differ across cultures. To address this, in the current study, we used an inhibition of return (IOR) paradigm which directly measured changes in attention across space, while controlling for eye movements. The use of the IOR task was a significant advancement, as it allowed for a highly sensitive measure of attention distribution compared to past research. Critically, using this new measure, we failed to observe a cultural difference in the distribution of covert spatial attention. Instead, individuals from East Asian countries and Western countries adopted a similar attention spread. However, we did observe a cultural difference in response speed, whereby Western participants were relatively faster to detect targets in the IOR task. This relationship persisted, even after controlling for individual variation in attention slope, indicating that factors other than attention distribution might account for cultural differences in response speed. Therefore, this study provides robust, converging evidence that group differences in covert spatial attentional distribution do not necessarily drive cultural variation in response speed.

Key words: visual attention; spatial attention; attentional scale; inhibition of return; cultural differences; East Asian; Western

Humans use visual attention to filter visual information, triaging certain stimuli for enhanced processing at the expense of others (Carrasco, 2011; Desimone & Duncan, 1995; Posner, 1980; Posner & Cohen, 1984). Although there are many elements of visual attention, including spatial attention, object attention, and featural attention (Carrasco, 2011), here, we are interested in individual differences in one aspect of visual attention: the *covert* spatial attentional distribution (e.g. Lawrence, Goodhew, & Edwards, 2018). For example, spatial attention resources can be narrowed to focus on a small region of the visual field. Alternatively, they can be expanded to cover more of the visual field. This is an important function, as narrow attention improves performance on tasks requiring the processing of fine spatial detail (e.g. Balz & Hock, 1997; Eriksen & James, 1986; Eriksen & Yeh, 1985; Goodhew, Lawrence & Edwards, 2017, Goodhew, Shen, & Edwards, 2016; Mounts & Edwards, 2017), while broad attention improves our ability to process ensemble statistics, and detect changes in the environment (e.g. Chong & Treisman, 2005; Pringle Irwin, Kramer, & Atchley, 2001). Although objects of different sizes can play a critical role in changing the spatial distribution of attention, attentional scaling is not purely a form of object-based attention since the effects generalise beyond the object of induction to others within a given spatial extent (Goodhew & Edwards, 2017). Therefore, we conceptualise it as a form of spatial attention.

Broadly, research on spatial attentional scaling has focused on understanding the influence of scaling on visual perception (e.g. Goodhew et al., 2017, 2016), measuring the flexibility of attentional scaling, or understanding individual differences in how attention is distributed (i.e. narrowly or broadly). Flexibility refers to the capacity to expand and contract attentional resources across the visual field relative to task demands. It is typically indexed by measuring the efficiency of individuals to change their scale of attention from narrow to broad, or broad to narrow (Jefferies & Di Lollo, 2009; Jefferies, Enns, & Di Lollo, 2014). Cultural differences in attention flexibility have been shown between British and Himba observers (a group from remote Namibia), where compared to British observers, Himba people showed a greater ability to attend to global and local information in the presence of distraction (Caparos, Linnell, Bremmer, de Fockert & Davidoff, 2013). In contrast, spatial attention scaling is a measure of whether an observer distributes attention narrowly or broadly across a region when minimal task demands are imposed (e.g. Bennett & Pratt, 2001; LaBerge, 1983; Lawrence et al., 2018).

Measuring group and individual differences in spatial attentional distribution can give useful insight regarding how experience, cognition and vision interact. For example, Wilson, Lowe, Ruppel, Pratt, and Ferber (2016) found that stable individual differences in personality predicted spatial attentional distribution. Participants who scored highly on trait Conscientiousness tended to adopt a narrow spread of attention. In contrast, those who scored highly on an Openness to Experience scale tended to adopt a broad spread of attention. Furthermore, Lawrence et al. (2018) recently demonstrated that a reliable age difference in attentional spread exists, where older adults distributed attention narrowly compared to younger adults. In the current study, we were interested in understanding how another relatively stable factor, cultural background, influences spatial attentional distribution. In particular, we tested whether those born in countries with a predominantly East Asian culture versus those born in countries of predominantly Western culture differed in their spatial attentional distribution.

Over the past two decades, an accumulating body of research has demonstrated that there are cultural differences in cognitive processes (e.g. Boduroglu & Shah, 2017; Goh et al., 2007; Ketay, Aron, & Hedden, 2009; Masuda, 2017; Masuda & Nisbett, 2006; Masuda, Li, Russell, Lee, 2019; Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005). For example, Markus and Kitayama (1991, 2010) proposed that cultural variation in self-concept might influence cognition. Specifically, individuals from East Asian cultural backgrounds may adopt an interdependent self-concept, where connectivity is valued, while those from Western cultural backgrounds might adopt an independent self-concept, which values individuality. Furthermore, Nisbett., Peng, Choi, and Norenzayan (2001) identified that those from East Asian and Western cultural backgrounds might show differences in thinking styles. Specifically, those from East Asian cultural backgrounds were proposed to value role relations, and thus would show a holistic cognitive style, processing relational and contextual elements of the world. In contrast, those of a Western cultural background were more likely to process the world analytically, focusing on individual objects and their details.

More specifically, a number of cultural differences in visual attention processes have been demonstrated (e.g. Caparos, Linenell, Breenner, deFockert, & Davidoff, 2013; Gutchess, Welsh, Boduroglu, & Park, 2006; Hedden, Ketay, Aron, Markus & Gabrielli, 2008; Ji, Peng, & Nisbett, 2000; Ji, Zhang, & Nisbett, 2004; Doherty, Tsuji, & Phillips, 2008; Kitayama, Duffy, Kawamura, & Larsen, 2003; Nisbett & Miyomoto, 2005). For example, Kitayama et al. (2003) found that those of East Asian and Western cultural background differed in their performance of a framed line task. In this study, participants were shown two boxes of either the same, or differing size. One box contained a line, while the other was empty. In one condition, participants were asked to draw a line in the empty box that was exactly the same length as the line in the adjacent box. In another condition, participants were required to draw a line in the empty box that was the same relative size as the line in the adjacent box. Critically, Japanese participants were more accurate at drawing a line in the relative size condition compared to the American participants. This suggests that Japanese participants were more sensitive to context. Furthermore, a more recent neuroimaging study has found cultural differences in levels of activation of the frontoparietal attention network, which is involved in top-down cognitive control, when completing the framed line task

(Hedden et al., 2008). Specifically, when East Asian participants completed the absolute line condition, activation was higher in the frontoparietal network, whereas the opposite pattern of results was observed for Western participants. Finally, cultural differences have been observed in the processing of foreground and background objects which has been associated with related differences in eye movement patterns across varying cultures (e.g. Chua, Boland, & Nisbett, 2005; Goh et al., 2007), as well as in the way in which children construct pictures (Senzaki, Masuda, & Nand, 2014). Taken together, this provides strong converging evidence that cultural differences in attentional processing exist for visual attention.

The focus of the current study is on one aspect of visual attention: cultural differences in the covert spatial distribution of attention. To date, three key studies have broadly explored how culture might alter the covert spatial spread of attention. Firstly, Boduroglu et al. (2009) proposed that cultural differences in cognitive styles may be observed in both the spatial distribution of attention, and working memory processes. Specifically, due to their holistic thinking style, the authors proposed that East Asian individuals would tend to adopt a broad spread of attention, while Western individuals with a more analytical thought process would tend to adopt a narrow spread of attention. This idea was tested using a change detection task (Figure 1). Here, participants were shown four coloured blocks arranged cardinally around fixation across two time-intervals. In the second time interval, one of the blocks could change colour, and participants were required to detect this change. Critically, to measure the distribution of attention adopted by the two culture groups, between the two time intervals, the spatial area over which coloured blocks appeared was also manipulated. That is, the blocks either expanded out to encompass a wider spatial location (broad attention, Experiment 1), contracted to cover a smaller spatial location (narrow attention, Experiment 2), were displaced randomly, or remained in the same location (control conditions). Further to this, occasionally, a probe task was included in between trials, to measure response times to detect a centrally presented target. When the colour blocks expanded, East Asian participants outperformed American participants. In contrast, when the colour blocks contracted, American participants outperformed the East Asian participants. Finally, in the probe task, East Asians had slower response times to detect the central target. Taken together, this suggests that the two cultural groups utilised different distributions of spatial attention to complete the change detection task, where East Asians utilised a broad spread of attention, and Americans adopted a narrow spread of attention.

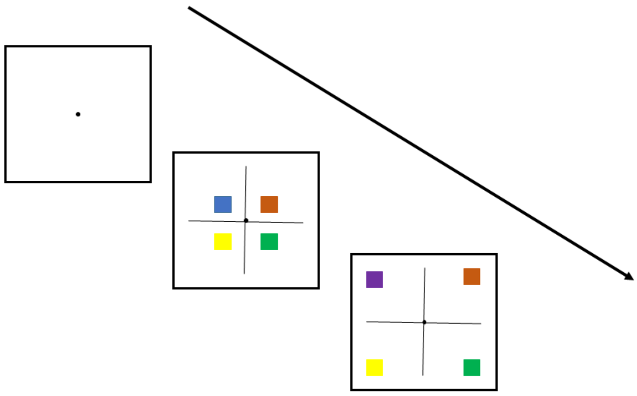

Figure 1. Example of the stimuli used in Boduroglu et al. (2009). The condition above is a change trial, where the location of the colour blocks expands (i.e. broad attention). Participants would have to determine which block changed colour.

Although the study by Boduroglu et al. (2009) provided a valuable framework for understanding cultural differences in attention distribution, a later study conducted by the same research group failed to replicate this finding (Boduroglu & Shah, 2017). Again, the authors used the change detection task with an East Asian and a Western cultural group. However, instead of finding East Asians to outperform Western participants in the "Expand" condition, performance in the Expand and Contract conditions did not vary across cultural groups. Although the authors suggest this may be due to lower overall performance in the task by both cultural groups, the lack of interaction between culture and performance on the different conditions of the change detection task suggests that this particular task may not be a reliable measure of differences in the spatial distribution of attention. Furthermore, a recent pre-registration study conducted by Hakim, Simons, Zhao and Wan (2017) only partially replicated Boduroglu et al. (2009). Indeed, in some instances, using Bayes analysis, the authors found evidence against the originally predicted cultural differences. Finally, across both studies using this paradigm, eye movements were not controlled for (i.e. participants were able to use overt attention). This is an important issue to consider, as some research has shown cultural differences in East Asian and Western participants eye movements when viewing a scene (e.g. Chua et al., 2005; Kelly, Miellet, & Caldara, 2010; Rayner, Li, Williams, Cave, & Well, 2007, although see Rayner, Castelhano, & Yang, 2009; Evans, Rotello, Li & Rayner, 2009 who found culture to have minimal influence on eye movement patterns). For example, Chua et al. (2005) found that while Chinese participants tended to fixate more on background objects in complex scenes, American participants moved their eyes more towards central objects. Therefore, based on this research, it is possible that in Boduroglu et al. (2009) differences in change detection performance may be due to the use of different eye movement strategies, rather than differences in covert spatial attention spread per se.

Given that the change detection task described above is not a typical method used to measure attentional distribution, and that the results using this paradigm have been conflicting, the implications of those results for cultural differences in attentional distribution remains unclear. A far more common stimulus type used to investigate attentional breadth are Navon letter stimuli (Navon, 1977, 2003). Navon letters are compound stimuli, where a larger letter is made up of smaller local letters (Figure 2) In a divided attention version of the task, participants respond to the presence of a target letter (which is presented at the global or local letter size). The assumption is that when responding to the global letter, an individual's attentional distribution is larger, and when responding to the local letter, attentional spread is narrow. An individual's attention spread is inferred by measuring response times to both global and local letter targets, and consequently, measuring whether each participant had a preference for processing stimuli globally or locally (i.e., a global preference is calculated by taking the local level response times minus global level response times. A positive number indicates a global preference).

McKone et al. (2010) used Navon letters to measure global and local processing preferences for those of Eastern and Western backgrounds. Note that the authors did not specifically intend to measure spatial attention; instead, they measured global and local preferences for Navon processing. Overall, the authors found East Asian participants to have a stronger global preference compared to Western participants. This suggests that East Asian participants spread their spatial attention across a relatively broader area, to the global level, while Western participants may have adopted a narrower spread of attention. Converging evidence for this conclusion came from another study in which participants were primed to think interdependently versus independently, and differences in Navon letter processing emerged. In particular, interdependent thinking styles predicted a global preference, and independent thinking styles predicted a local preference (Lin & Han, 2009). This distinction is important, as East Asian cultures are typically associated with an interdependent thinking style, and Western cultures with an independent thinking style (Gardner, Gabriel, & Lee, 1999; Markus & Kitayama, 1991).

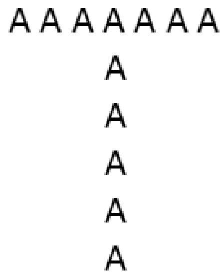

Figure 2. Example Navon Stimulus. The local level letters (As) are arranged to compose a global level letter (T)

Again, however, although these studies indicate that culture might shape spatial attention distribution, Navon figures may not be an optimal stimulus for directly inferring the spread of attention. The attentional mechanisms underlying Navon processing are diverse, and likely involve more than solely spatial attentional scaling (Flevaris, Bentin, & Robertson, 2011; Navon, 2003; Poirel, Pineau, & Mellet, 2008; Robertson, Egly, Lamb, & Kerth, 1993; although see Sasaki et al., 2001). Indeed, early work by Robertson et al. (1993) suggests that while attentional scale can influence which level of Navon letters are attended, categorical attention may also play a role. That is, while one could attend to different spatial regions that global and local elements encompass, for a Navon stimulus, one could also categorically attend to either the global, low spatial frequency elements of the stimulus, or the local, high spatial frequency elements, regardless of the distribution of attention (Shulman & Wilson, 1987). This is akin to selectively attending to features *within* an attended spatial region. Importantly, Robertson and colleagues work suggests that both categorical and spatial attention could influence the processing of Navon letters. Therefore, in McKone et al. (2010), as participants were allowed to view Navon stimuli freely, it is unclear whether the two groups used only spatial attention, categorical attention, or a combination of the two. Furthermore, similar to the change detection task, recent research has failed to replicate a cultural difference in Navon letter processing (Hakim et al., 2017). As such, the Navon task may not be the most appropriate tool to use when measuring cultural differences in spatial attention.

Finally, one recent paradigm which has been used to claim cultural differences in attention distribution is the functional field of view task. Specifically, Boduroglu and Shah (2017) demonstrated cultural differences in performance on a functional field of view task, which the authors conceptualised as a measure of attention spread and spatial resolution. Participants were required to identify the location of targets which were shown for short periods across a broad range of eccentricities, demarcated by 24 placeholder stimuli. Lower accuracy scores and longer response times were interpreted as participants adopting a broader spread of attention. This assumption is based on the zoom lens model. This model predicts that a larger attentional distribution leads to lower processing efficiency within the attended region (Eriksen & James, 1986). Therefore, worse performance in the functional field of view task was assumed to reflect a broader attention scale. Overall, Boduroglu and Shah (2017) found that across all eccentricities, East Asian participants were less accurate, and slower to respond than Western participants. These accuracy and response time differences were interpreted as East Asian participants adopting a broader attentional spread. Furthermore, the authors analysed the types of location identification errors participants made, finding that when Western participants made location errors, on average, the misidentified location was close to the actual target location. In contrast, when East Asian participants made location errors, the errors were more randomly distributed throughout the 24 placeholder locations. The authors took this as further evidence that East Asian participants adopted a broad spread of attention.

Nonetheless, this interpretation assumes that all targets within a task fall within the *attended region*. Although targets will be detected relatively efficiently within a narrow compared to broad attention distribution, targets falling outside of this region should also be detected relatively slowly and inaccurately. Therefore, an equally plausible argument in this paradigm is that East Asians were slower/less accurate to respond because they had a *narrow* distribution of attention which they randomly shifted across the visual field. In the functional field of view task, many targets may have fallen outside of the distribution of attention, leading to overall slower response times as participants shifted their attentional resources across the visual field. This distribution of attention could also lead to a higher proportion of random errors.

Furthermore, the utility of the functional field of view as a measure of attentional distribution has recently been questioned, with research suggesting that the task measures the speed of information processing and attentional control processing more generally rather than the spatial distribution of attention (Cosman, Lees, Lee, Rizzo, & Vecera, 2012; Lunsman et al., 2008; Matas, Nettelbeck, & Burns, 2014). Finally, a number of studies report stable differences in response time generally, which may not be linked to differences in spatial attention (e.g. Brebner & Cooper, 1974; Deary, Der, & Ford, 2001; Der & Deary, 2006; Edman, Schalling, & Levander, 1983; Goodhew & Edwards, 2019; Lahtela, Niemi, & Kuusela, 1985; Schmitz, Daly, & Murphy, 2007; Sheppard & Vernon, 2008). Therefore, while Boduroglu and Shah (2017) provide promising evidence of a cultural difference in attentional distribution, whereby East Asian participants adopt a broader spread of attention, a more nuanced method of measuring spatial attention is required for cleaner conclusions.

Taken together, the above literature review highlights the need for further examination of the potential role of culture in predicting covert spatial attentional spread. While Boduroglu et al.'s (2009) change detection task initially showed cultural differences in attentional distribution, two replications of this study produced conflicting findings, bringing into question to the reliability of the measure as a method to infer differences in attention.

Divided attention Navon tasks have also been used to tap into attentional processing (McKone et al., 2010), however, it is unclear whether differences in Navon letter processing relate to changes in spatial attention, feature-based attention, or both. Furthermore, a recent pre-registered study attempting to replicate the Navon letter effect failed to observe a cultural difference. The functional field of view task used by Boduroglu and Shah (2017) provides promising evidence that cultural differences in spatial attention and resolution exist, however, given that the functional field of view only measures overall response time and accuracy, a more direct measure of attention spread will allow for more definitive conclusions to be made regarding the distribution of attention across space. Finally, given that there potential cultural differences in eye movement patterns (Chua et al., 2005), as the studies described above did not control for eye movements, it is unclear whether culture influences overt attention, covert attention or both.

As an alternative to the tasks described above, a powerful method that can be used to tap into group differences in covert spatial attentional processes is the Posner cueing paradigm (Posner, 1980; Posner & Cohen, 1984; Posner, Rafal, Choate, & Vaughan, 1985). The Posner paradigm was initially developed to measure the processes of attentional facilitation and inhibition following a spatial *shift* of visual attention. The method is summarised in Figure 3. Participants are first required to fixate at the centre of the screen. An uninformative peripheral cue then briefly appears, which automatically attracts attention to the location of the cue. Finally, a target to be detected appears, either at the cued location or at an opposing location (uncued location). Target detection response times are calculated for cued, and uncued trials to measure the dynamics of spatial attention facilitation and inhibition. The key variable of interest is the time between the cue and target presentation. When the cue and target appear quickly after one another (less than 300ms), participants are quicker at detecting the target at the cued location. However, when there is a relatively long gap in time between the cue and target (greater than 300ms), response times at the cued location are slower compared to uncued location suggesting attentional inhibition.

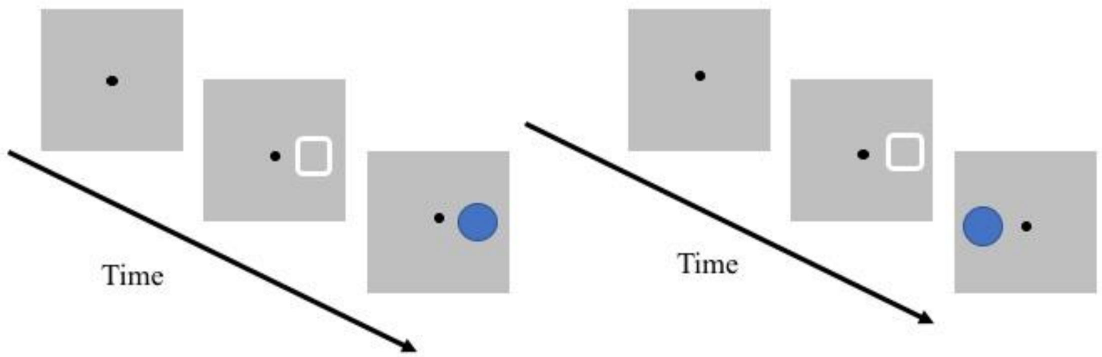

Figure 3. Example of the Posner Cueing Paradigm. Attention is attracted to the white square (the cue). A blue circle (the target) appears at either the cued (left) or uncued (right) location. Differences in response time for the two locations reflect attentional facilitation and inhibition.

While the Posner paradigm was designed to measure the influence of *shifts* of attention, it has since been adapted to measure group differences in attentional *spread* (e.g. Wilson et al., 2016; Lawrence et al., 2018). In order to do so, the spread of attentional inhibition around a cued location is mapped by measuring response times for targets appearing at varying distances from the cue (Figure 4). For example, when measuring attentional inhibition, response times are slowest as the cued location. However, as the distance between the cue and target gets larger, response times become gradually faster (e.g. Bennett & Pratt, 2001; Downing, 1988; Klein, Christie, & Morris, 2005; LaBerge, 1983; Taylor, Chan, Bennett, & Pratt, 2015). This release from inhibition across space can be used to infer the distribution of attention by exploring the rate of change in response times for different cue-target distances (i.e. the attentional slope). When response times decrease sharply across cue-target distance, an individual's attention resources are assumed to be distributed over a relatively small spatial region, suggesting they have adopted a narrow focus of attention. In contrast, when response times decrease relatively shallowly across cue-target distance, it is thought that an individual has distributed attention across a larger region of the visual field (Wilson et al., 2016). Previous research has used inhibition paradigms to measure attentional distribution, as the paradigm allows for a higher degree of sensitivity in measuring individual differences, giving enough time for somewhat sluggish attentional processes to develop (Lawrence et al., 2018; Wilson et al., 2016). This is particularly important for the current study, as previous work has observed cultural differences in attention flexibility, as well as response speeds in visual attention tasks (e.g. Borudoglu et al., 2009; Caparos et al., 2013)

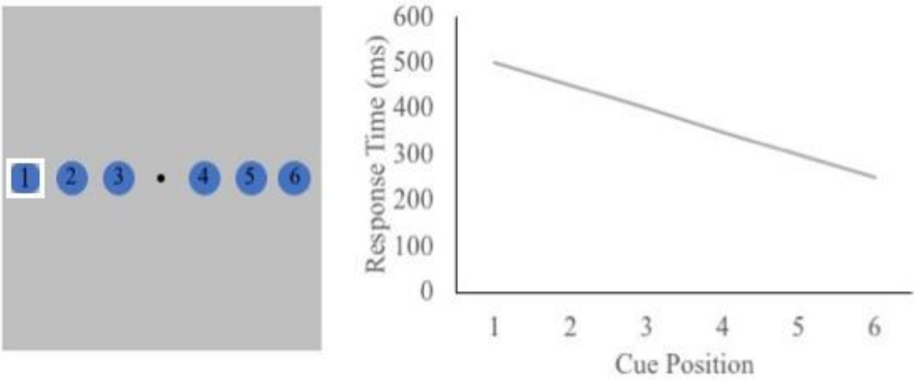

Figure 4. The relationship between distance and target detection speeds when measuring attentional inhibition. Left: experimental paradigm. The white square represents the cue. The blue circles represent different distances at which the target may appear. Right: Hypothetical results. As the distance between the cue and target increases, target detection speeds gradually decrease. The slope of this decrease is assumed to reflect attentional distribution.

A recent study conducted by Lawrence et al. (2018) used the attentional inhibition paradigm to test whether healthy ageing influenced spatial attention spread. Here, attention was directed to one of four potential locations, using a bright, briefly presented (100ms) ring. After 1315ms, a target appeared at varying distances from the cue. Participants responded to the target as quickly as possible by pressing the spacebar. Regression coefficients were calculated for each participant, which measured the change in response time across increasing cue-target distances. These coefficients were compared for the two age groups. Overall, it was found that older adults had a steeper slope of inhibition, suggesting that the older adult group adopted a relatively narrow focus of attention. This finding was replicated in a second experiment, suggesting that the paradigm is an appropriate tool for measuring individual differences in attentional distribution across different times and samples.

Given the robust nature of the attentional inhibition method to measure group differences in spatial attentional distribution, the current study aimed to measure the influence of cultural background on attentional inhibition, and thus, infer potential group differences in covert attentional spread. The attentional inhibition task was mostly similar to that used by Lawrence and colleagues (2018). During the task, participants were instructed to fixate their gaze on the centre of the screen. Further, their eye movements were monitored. This instruction allowed us to ensure that the participants were only using covert attention to complete the task. In line with similar research exploring differences in attentional inhibition with a younger sample, a cue-target interval of 803ms was adopted (Taylor et al., 2015; Wilson et al., 2016).

On each trial, there were four cue locations and 20 possible target locations. Response times for target detection were recorded across ten possible cue-target distances, and individual regression slopes were calculated for each participant, which reflected attentional distribution. Following completion of the attentional inhibition task, participants completed a demographic survey, and autism-like traits scale (Allison, Auyeung, & Baron-Cohen, 2012). This scale was included as those scoring higher in autistic-like traits tend to adopt a narrower distribution of attention (Mann & Walker, 2003).

Given that East Asian participants are thought to process information more holistically, and have an interdependent self-concept, we predicted that those who identify as such would have a relatively broad attention spread. In contrast, Western participants who are more likely to process information analytically, and have an independent self-concept, are predicted to adopt a relatively narrow attention spread (Boduroglu et al., 2009). Therefore, compared to Western participants, East Asian participants are likely to have relatively a shallower slope of attentional inhibition across increasing cue-target distances (Figure 5).

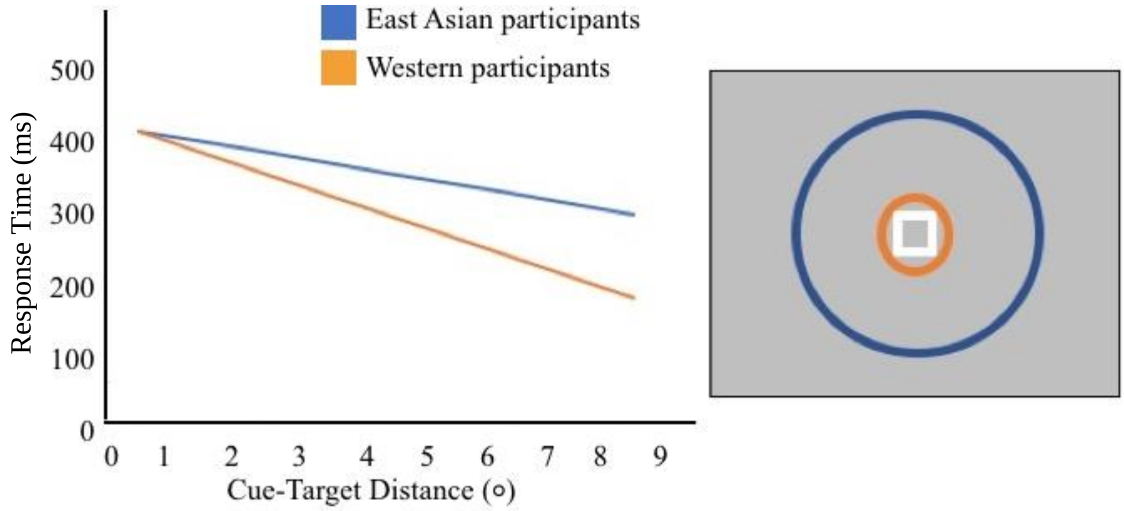

Figure 5. Predicted pattern of attentional inhibition (left), and thus, attentional spread around a cued location depicted by the white square (right), for East Asian versus Western participants. The distance between the cue and target is shown on the X-axis. Response time is shown on the Y-axis. A steeper attentional slope is assumed to infer a narrower distribution of attention (orange circle), while a shallower slope is assumed to infer a broader distribution of attention (blue circle).

Method

Participants

One hundred and twenty-eight individuals aged between 18-40 years participated in the current study. This sampled size was deemed adequate to compare cultural differences in cognition, with past research typically using approximately 30 participants in each group (e.g.

Boduroglu et al., 2009). All participants provided written informed consent, and had normal or corrected to normal vision. Participants were recruited on the basis that they self-identified as East Asian or Western. However, in the primary analyses, country of birth was used as the grouping variable for cultural background[1]. One participant did not provide demographic data following participation and was excluded from further analysis. A further six participants did not report their birth county. However, based on responses to other questions in the demographic survey (i.e. which countries have you lived in, and how for how long?), birth country was inferred as being of East Asian or Western origin, and these participants were included in our primary analysis. Finally, six participants were excluded due to experimenter and technical errors during the computer task (e.g., eye-tracker not calibrating). Following exclusions, this left a total sample of 121 participants.

Our culture variable, birth country, was categorised by determining whether a participant's birth country was predominantly of East Asian or Western culture. Participants who were born in Australia (82.7%), England (9.6%), the Netherlands (3.8%), New Zealand (1.9%), or the United States of America (1.9%) were classified as being from a predominately Western cultural background. Participants who were born in China (84.8%), Korea (13.6%) and Japan (1.7%) were classified as being from a predominantly East Asian cultural background. Eight participants who were born in South Asian, or South East Asian countries were not included in final analyses, nor was one participant who was born in South Africa, and one participant born in Morocco. Overall there was a final sample of 111 participants (52 Western, 59 East Asian). Demographic details of these participants are summarised in Table 1.

Table 1. Demographic details of the participant sample of the current study

	East Asian	Western	sig.

Gender	Female = 41, Male =16	Female = 42, Male= 10	.279
Age (years)	*M* = 21.05(*SD* =1.85)	*M* = 20.21(*SD* = 2.07)	.030
Handedness	RH = 53, LH =,1 A =3	RH = 47, LH =,4 A =1	. 230
Vision	Corrected = 37	Corrected = 12	<.001
Total Years Education	*M* = 16.47(*SD* = 2.64)	*M* = 14.90(*SD* = 1.80)	.001
Self-Identified Culture	East Asian = 56, Caucasian = 1, Other = 2	East Asian = 6, Caucasian = 46, Other = 0	<.001
Strength of Cultural Identity	*M* = 3.69(*SD* = 1.15)	*M* = 3.08(*SD* = 1.05)	.004
Multicultural Identity	N = 21	N = 11	.094
Number of languages Spoken	*M* = 2.27(*SD* =.61)	*M* = 1.35(*SD* =.65)	<.001
Time Spent Living in Australia (years)	*M* = 2.51 (*SD* = 2.90)	*M* = 18.11(*SD* = 5.31)	<.001
Autism Quotient -10	*M* = 3.59(*SD* = 1.60)	*M* = 2.58(*SD* = 1.82)	.002

Notes.
1. Self-identified culture reflected the group that the participant most strongly associated with throughout the survey. Strength of cultural identity and multicultural identity was measured using a five-point Likert scale adapted from the Mutual Intercultural Relations in Plural Societies (MIRIPS) questionnaire which captures levels of acculturation (Berry, 2014). The questionnaire asks participants to rate how much they see themselves as part of the cultural group they identify with (1 = Not at all, 5 = Very Much), and indicate if (and how strongly they felt) they belonged to a different cultural group to the one they identified as their primary culture (alternate cultural groups identified by the participants are not reported here).
2. The published cut-off score for AQ-10 is a score of 6 or higher (Allison et al., 2012).
3. Continuous variables were analysed using paired samples t-tests, and categorical variables were compared using Pearson Chi-square tests.[2]

Stimuli and Apparatus

The study was conducted with stimuli presented on an LCD monitor with dimensions 530mm by 300mm, and resolution 1920 by 1080 pixels. Participants were seated 850mm from the computer screen, and head movements were stabilised using a chin rest. The experiment was programmed using MATLAB, and the psychophysics and eyelink toolboxes (Brainard, 1997; Cornelissen, Peters, & Palmer, 2002). Throughout the study, to ensure the participants were using covert, and not overt attention to complete the task, participant's eye movements were tracked using an Eyelink 2000 eye tracker, with a sample rate of 1000Hz (SR-Research, 2005-2008).

Stimuli were shown on a grey background of luminance of 43 cd/m^2. There were four possible cue locations and 25 possible target locations. The possible cue and target locations were determined by creating an invisible 5 x 5 grid subtending approximately 10° x 10° of visual angle. Grid lines were evenly spaced, 2.5° apart, and cues and targets appeared where grid lines intersected. Therefore, there were ten possible cue-target distances to be sampled, ranging in distances from 0° to 10.6°. For the duration of a trial, a black fixation dot, subtending .01°, was presented at the centre of the screen. Participants were required to maintain their gaze on this fixation region. The cue was a white unfilled circle which had an average luminance of 253 cd/m^2, and the target was a filled, off-grey circle which had an average luminance of 28 cd/m^2. Both circles had a radius of .25°. Participants completed 240 trials, where 200 trials contained both cues and targets, and 40 trials contained only cues (catch trials). The cue was uninformative of the target location. Therefore, each cue-target combination was presented an equal amount of times.

Procedure

The overall procedure is shown in Figure 6. Firstly, participant's eye movements were initially calibrated using a standard nine-point calibration procedure. Following calibration, participants were given the attentional inhibition task instructions and completed ten practice trials. At the beginning of a trial, participants completed a drift-correct using the Eyelink drift-correction function to ensure that an accurate recording of gaze. Here, participants were required to fixate on a central fixation ring and to press space bar to begin the trial. The trial would only commence following successful drift correction. Participants were told to maintain their gaze on the central fixation dot. This instruction was given to ensure we measured covert, and not overt attention processes.

After the participant commenced the trial, a blank screen was shown for approximately 1000ms. Next, the fixation dot appeared alone for 501ms. The cue would then briefly appear for 100ms, followed by a blank interval of 801ms. In the target-present trials, following this blank interval, the target would appear for 1002ms, or until a participant had made a detection response. In the target-absent trials, no target appeared and was instead replaced by a longer blank interval, lasting 1803ms. Corrective feedback was given, where a message showing "CORRECT" appeared for one second if participants responded appropriately. If participants responded early, or during a catch trial, a warning message appeared for three seconds. After the practice trials, participants completed the experimental trials. This experimental block was similar to the practice block, except the "CORRECT" message did not appear if participants responded correctly. Participants were given a rest break every 40 trials. Throughout the experiment, recalibration of the eye tracker was conducted where necessary. Following completion of the computer task, participants completed a brief demographic questionnaire, a cultural identity scale (Berry, 2014), and the AQ-10, a self-report measure of autism-like traits (Allison et al., 2012).

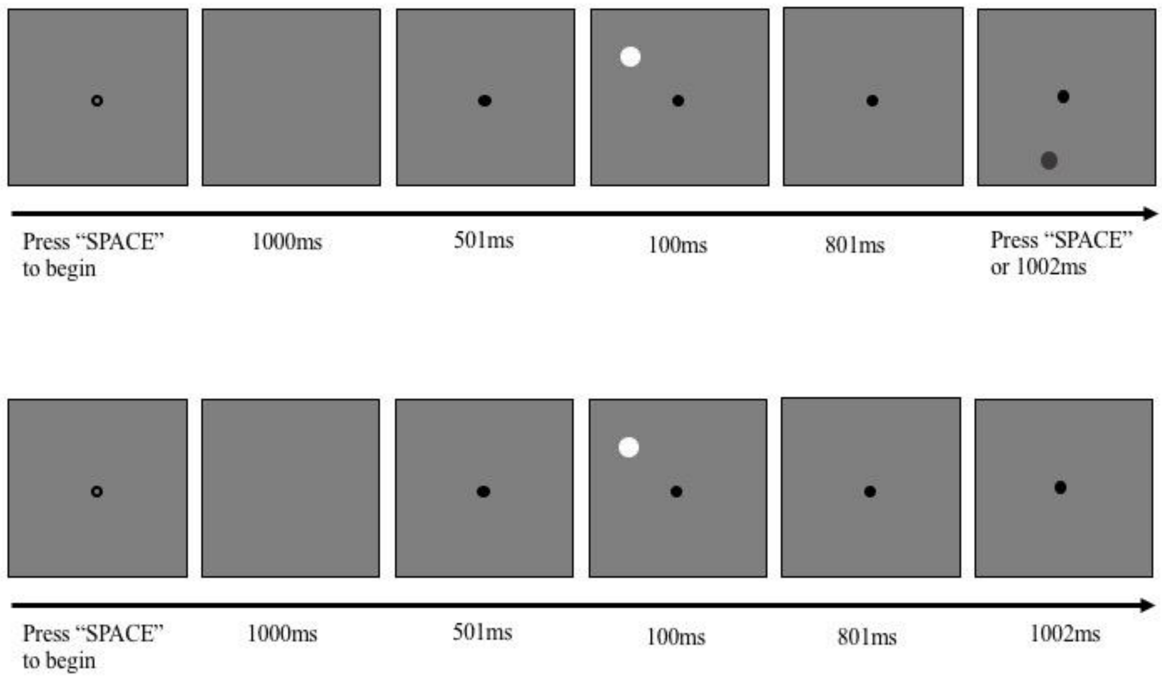

Figure 1. IOR task used in the current study. An example of a target-present trial is shown above, and a target-absent trial is shown below. On each trial, following a cue (the white circle), participants were asked to detect the presence of an off grey circle as quickly as possible.

Results and Discussion

Accuracy Data

First, we examined accuracy data to ensure that participants in both groups were actively engaged in the attentional inhibition task. Participants who scored below 90% accuracy for either the target present or target absent (catch trial) conditions were removed from further analyses. Three participants were removed from further analyses for this reason.

Eye Movement Data

Next, eye movement data was analysed to check whether participants shifted their gaze from the central fixation region during each trial. The aim here was to only include trials in our final analyses where participants used covert, and not overt attention to complete the

IOR task. We were primarily interested in the spatial distribution of covert attention. Thus, trials were excluded from further analyses if participants made an eye movement outside of the central fixation region. This region was defined as a 3.8 x 3.8° rectangular region centred on the fixation dot. A larger fixation region was chosen, as initial pilot testing suggested that with a smaller region of fixation trials were incorrectly being excluded from further analysis (e.g. glare from glasses, eye blinks). In particular, we wanted to be certain that any eye movements made by participants were genuine, rather than due to changes in fixation drift on a trial-by-trial basis. Further, if participants made a saccade outside of the central interest area on more than 30% of trials, the entire participant's data was removed from further analyses[3]. We chose this number because we wanted to ensure that we only included participants who were actively using covert attention to complete the task. Seven participants were removed from further analyses for this reason. Overall, this left a total sample of 101 participants (50 East Asian participants, 51 Western participants). For the remaining participants, overall accuracy, catch trial accuracy, and eye movement accuracy was high (Table 2). Interestingly, there was a significant difference in eye movement accuracy for the two cultural groups. In particular, East Asian participants shifted their gaze from the central fixation region more often than Western participants. This is consistent with work suggesting cultural differences in overt attentional processes (e.g. Chua et al., 2005).Nonetheless, as both groups maintained a high level of eye movement accuracy (greater than 90%), it appears that all participants were able to accurately engage with the task and use covert attentional processes.

Table 1. *Mean accuracy data (and standard deviations) for East Asian and Western participants in the IOR task.*

	East Asian	Western	sig.
Accuracy	98.37% (1.32%)	98.31% (1.49%)	.841
Catch Trial Accuracy	98.39% (2.18%)	98.43% (2.06%)	.922
Eye Movement Accuracy	91.51% (7.64%)	95.10 % (5.00%)	.006

Notes. Significance values were obtained by computing independent samples t-tests for each of the variables. The accuracy of eye movements reflects a participant's ability to maintain their gaze in the central fixation region of the screen during an experimental trial.

Response Time Data

Before analysing the influence of cue-target distance on response time, participant's raw response time data were examined for outliers. For each participant group, at each cue-target distance, outliers were defined as those response times with a Z-score exceeding +/-3.29. Following outlier exclusion, mean response times for each distance were recorded. Next, response time outliers at the group level were then identified as any response times at each distance which had a Z-score that exceeded +/- 3.29 for each cultural group. Participant's data violating this criterion were excluded from further analysis. One Western participant was removed for this reason, leaving a total sample of 50 East Asian, and 50 Western participants. Cue-target distance and birth country were then entered into a mixed ANOVA to check that both groups experienced IOR. This analysis was important, as differences in attentional slopes would only be meaningful if the main experimental manipulation actually influenced attention. Mauchly's test of sphericity was violated, χ^2 (44) = 190.78, $p < .001$, so a Greenhouse-Geisser correction was used (ε = .683). Overall, there was a main effect of cue-target distance on response time, F (6.15, 602.34) = 28.53, p < .001, η_p^2 = .23, suggesting that participants experienced inhibition around the cued location. As shown in Figure 7, responses were slower at closer cue-target distances compared to larger cue-target distances. There was also a main effect of birth country on response time, F (1, 98) = 9.09, p =.003, η_p^2 =.09, where compared to Western participants, East Asian participants had slower response times, regardless of cue-target distance (Figure 7). Finally, there was no interaction between cultural group and cue-target distance, F (6.15, 602.34) = 1.06, p = .385, η_p^2 = .01, suggesting that the magnitude of the cueing effect was similar for both participant groups.

Cultural differences in attentional slope

Next, we compared the influence of cultural group on participants' attentional slopes. Each participant's attentional slope was calculated by running a linear regression with cue-target distance as a predictor, and response time as the outcome variable. A greater magnitude attentional slope reflects a narrower distribution of attention (Figure 5). The slopes were then compared using an independent samples t-test. No outliers were detected, and the assumptions of normality and equality of variance were met. The effect of birth country on attentional slopes was non-significant, t (98) = 1.82, p = .072, d = .36 ($M_{\text{East Asian}}$ = -.11, $SD_{\text{East Asian}}$ = .12, $M_{\text{Western,}}$ = -.15, SD_{Western} = .10). Overall, this suggests that in the current study, cultural differences in attention inhibition, and thus covert spatial attention spread were minimal.[4]

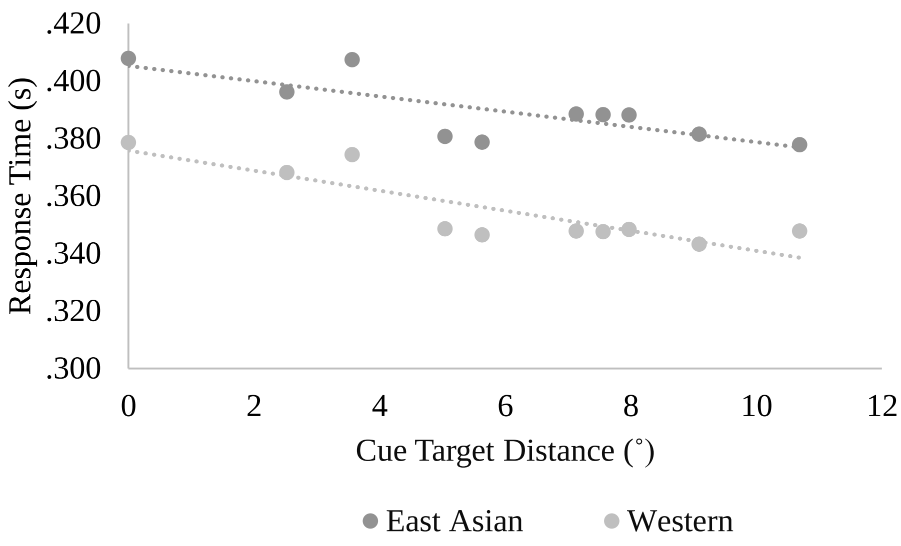

Figure 2. Average group data for East Asian and Western participants in the attentional inhibition task. The distance between the cue and target is shown on the X-axis, and average response time for target detection is shown on the Y-axis. The rate of change in response time (i.e. the attention slope) indicates the distribution of attention Overall, East Asian participant's had a shallower attentional slope, suggesting that during the task, they adopted a broader attentional distribution.

Exploring the relationship between cultural background, attention slope, and mean response time

Of particular importance, in the current study, East Asian and Western participants had different average response times. This response time difference is consistent with previous research, which has found that on average, East Asian participants are slower to respond than Western participants (e.g. Boduroglu & Shah, 2017). Nonetheless, past research has shown that controlling for overall differences in mean response time can help clarify individual differences in attentional slope for the IOR task (Lawrence et al., 2018). Therefore, we ran a multiple regression analysis, where cultural differences in mean response time were accounted for when testing the influence of cultural background on attentional slope.

For the multiple regression analysis, mean response time scores (i.e. mean response time across all cue-target distances), were screened for univariate outliers using Z scores exceeding +/-3.29 as a cut-off, and multivariate outliers were determined by checking participant cases where Mahalanobis distance values exceeded 13.82 with birth country and mean response times as predictors. No outliers were identified. The assumptions of multiple regression were then checked. Here, it is important to note that even though cultural background predicts mean response time, the variance inflation factor for the model was low (*VIF* = 1.10), suggesting that potential multicollinearity between the variables had minimal influence in the model. Overall, the regression model was significant, $R^2 = .17$, $F(2, 97) = 7.60$, $p = .001$. Further, there was a relationship between mean response time and slope, $b = .34$, $t(97) = 3.40$, $p = .001$, where slower response times were associated with a shallower slope of attention. However, cultural group alone did not show a relationship with attentional slope, $b = .08$ $t(97) = .77$, $p = .412$. Overall, this provides converging evidence that for the current task, there were minimal cultural differences in attention spread.

Although mean response time predicted slope and cultural group did not, it is important to note that the multiple regression should not necessarily be interpreted as differences in mean response time *causing* differences in attentional slope. Instead, it is equally plausible that differences in attentional slope predict slower response times overall. Indeed, a secondary multiple regression shows that both attentional slope, $b = .32$, $t(97) = 3.40$, $p = .001$, and cultural group, $b = .24$, t (97) = 2.56, $p = .012$, predict mean response time. Critically, this demonstrates that potential cultural differences in attention distribution cannot solely account for cultural variation in response time. Even though we found no evidence in favour of a cultural difference in spatial attention distribution, group differences in response time were still observed (where East Asian participants were slower to respond compared to Western participants), even after variation in attention slope was accounted for. This is crucial, as past research has often interpreted cultural differences in response time as reflecting variation in spatial attention distribution (e.g. Boduroglu et al., 2009; Boduroglu &

Shah, 2017). Therefore, the current study adds an important clarification to the literature, showing that cultural differences in response speed may also be explained by factors other than the covert spatial distribution attention.

Do other factors related to culture predict attention spread?

Finally, although our study suggests that birth country is not related to attentional slope, it is important to note that our sample also differed on a number of relevant demographic factors, such as age, number of languages spoken, self-identified culture, vision, multiculturalism, time spent living in Australia, and total years of education. It is therefore still unclear if, and what, other factors related to culture might be related to group differences in attention spread. To address this, we conducted a series of exploratory analyses, measuring whether any factors which significantly differed between the two cultural groups predicted attentional spread, regardless of the participant's cultural group. However, no factors predicted attention slope. Therefore, it appears that there is minimal evidence for a relationship between culture and the spatial spread of attention, as measured by the IOR task.

Although our analysis suggested that factors other than time spent in Australia (e.g. language), may not be necessary for defining cultural differences in the spatial distribution of attention, in the current study, all of these variables were measured via self-report. For example, for the variable: "number of languages spoken" participants were asked to state how many languages they were fluent in speaking. As participants may differ in their judgement of what constitutes fluency, a better measure of multilingualism would be more appropriate to measure whether language predicts attentional spread. Furthermore, our multiculturalism variable was determined by asking participants which ethnic groups they identified with (i.e. East Asian or Western), as well as how strongly they saw themselves as a part of these groups. However, during data collection it became apparent that different participants interpreted this question in various ways. For example, when participants reported other ethnic groups they identified with, some appeared to consider Australia as a separate ethnic group, whereas others did not. Likewise, some participants reported high levels of identification with sub cultures within the broader ethnic group they identified (e.g. people who speak a specific language). This made the coding of the multiculturalism variable challenging, and required a degree of interpretation from the research group. Thus, future research should endeavour to more directly measure which factors predict cultural differences in attention, be it language, multiculturalism, or another social factor often coinciding with culture in these studies.

It is also important to note the potential role of language instruction in the current study. Although participants did not complete the English-language demographic questionnaire until after completing the IOR task, all participants received instructions for the IOR task in English at the beginning of the study. The language in which participants are instructed may encourage a particular cultural style of thought, which in turn, might influence how attention is deployed in a given task (Imai, Kanero, & Masuda, 2016; Ji et al., 2004). For example, Ji et al. (2004) found that bilingual Chinese participants performance in word categorisation task varied as a function of whether the participants were instructed in English or Chinese. Furthermore, our East Asian participant group comprised mainly of International students who had moved to Australia to study. This distinction is important, as there is a possibility that the current study was measuring the influence of student status (i.e. an individual who chooses to be a domestic versus an international student), rather than culture on attention. Therefore, future work should also compare cultural differences in the spatial distribution of attention when participants from East Asian and Western cultures are instructed in their primary language, in their country of birth.

Finally, even though time spent living in Australia did not predict attention slope, within our East Asian participant sample, many individuals had lived in Australia for an extensive period (e.g. up to 21 years). This length of time differs markedly from other research exploring cultural differences in cognition, where participants are sometimes recruited on the basis of having lived in Australia for less than five years (e.g. Boduroglu et al., 2009). Therefore, it is possible that in the current study, the inclusion of East Asian participants who had lived in Australia for a substantial amount of time may have potentially weakened the measured relationship between culture and the spatial distribution of attention. In turn, this could have led to the null result observed.

Specifically, in the current study, acculturation processes may have led these participants to adopt a different cognitive style to that typically associated with those of an East Asian cultural background. For example, work conducted by Cheung, Chudek and Heine (2011) has shown that both age and the amount of time spent residing a new country of residence is related to the degree to which an individual identifies with that country. In particular, the younger an individual is when they moved to Australia, as well as how long an individual has been living in Australia, may influence the strength with which they identify with Australian culture, and consequently adopt attentional strategies similar to those prevalent in Western cultures (i.e. analytic processing styles, and a narrower slope of attention). To address this, we ran a secondary analysis comparing attention for East Asian and Western participants, which only included East Asian participants who had lived in Australia for less than five years. The value of five years was chosen as similar work as it allowed us to include enough participants from our East Asian sample for meaningful statistical analysis, while also followed the recruitment methods of relevant previous studies exploring cultural differences in attention breadth (i.e. Boduroglu et al., 2009 who measured cultural differences in change detection of East Asian participants who had lived in America for less than five years). This left a total sample of 94 participants (44 East Asian, 50 Western).

When defining culture by both birth country, and time spent in Australia, a similar pattern of results emerged to our original analysis. For the repeated measures ANOVA comparing the influence of distance and birth country on response time, again, Mauchly's test of sphericity was violated, χ^2 (44) = 194.88, $p < .001$, and a Greenhouse-Geisser correction was used (**ε** = .666). Overall, there was main effect of distance, F (5.99, 551.34) = 28.49, $p <$ .001, $\eta_p^2 = .24$, and a main effect of birth country, F (1, 92) = 11.93, $p = .001$, $\eta_p^2 = .12$. There was no interaction between birth country and distance, F (5.99, 551.34) = .89, $p = .499$, $\eta_p^2 = .01$. Again, this suggests that East Asian participants were slower to detect targets, regardless of cue-target distance. Finally, an independent samples t-test revealed a non-significant relationship between birth country and attention slope, where East Asian participants had a slightly shallower attention slope compared to Western participants, t (92) = 1.85, $p = .068$, g =.33 ($M_{\text{East Asian}}$ = -.11, $SD_{\text{East Asian}}$ = .12, $M_{\text{Western,}}$ = -.15, SD_{Western} = .10). Therefore, this analysis suggests that even after accounting for group differences in acculturation processes, and using a more sensitive measure of culture, there appears to be no reliable relationship between cultural background and attention slope, as measured in the current study.

General Discussion

The current study aimed to explicitly test whether cultural group predicted the covert spatial distribution of attention using an IOR task. Compared to previous research exploring cultural differences in spatial attention, the attentional inhibition task has notable strength because it allows for differences in attentional slope to be directly measured across space. Further, we were able to control for cultural differences in eye movement patterns, which some research suggests might differ between East Asian and Western participants in scene viewing tasks (e.g. Chua et al., 2005). Overall, when using a more direct measure of spatial attention, we found no evidence of a reliable relationship between culture and attention distribution. Critically, however, a reliable cultural difference in response time was observed. In particular, East Asian participants were slower to respond to targets across all cue-target distances in the IOR task. As such, it appears that in this task, group differences in response time may be driven by factors other than the spatial distribution of covert attention.

Culture and Attention Spread

In contrast to earlier research, which suggested that there may be cultural differences in the spatial distribution of covert attention, we found no reliable evidence that cultural group predicted attention slope in our specific IOR task. Instead, the results of the current study are similar to a recent body of work suggesting that some aspects of visual attention may be similar across cultures (e.g. Boduroglu & Shah, 2017; Evans et al., 2009; Hakim et al., 2017; Rayner et al., 2009). For example, a large scale replication study conducted by Hakim and colleagues recently found little evidence favouring a cultural difference in attention processing tasks similar to those used by Boduroglu et al. (2009) , McKone et al. (2010), and Kitayama et al. (2003).These were variants of the change detection task, Navon letter task, and framed line task respectively. Furthermore, there has been mixed evidence as to whether or not there are cultural differences in eye movement patterns (e.g. Chua et al., 2005; Evans et al., 2009; Rayner et al. 2007).

However, the null findings reported in the current study should not be interpreted as evidence for a lack of cultural variation in visual attention. Indeed, a large body of work has found reliable variation in many aspects of cognition across cultures. For example, early work suggests that those from East Asian cultures are more inclined to utilise holistic thought processes, and have an interdependent self-concept, while those from Western cultures are more inclined to use analytic thought processes and have an independent self-concept (see Masuda et al., 2019 for a recent review). These cultural differences are likely due to both environmental factors and sociocultural factors, emerging in ancient Chinese and Greek societies (Masuda et al., 2019; Nisbett, 2003; Nisbett et al., 2001; Nisbett & Masuda, 2003). Furthermore, a broad array of visual attention processes have been shown to vary with culture, such as patterns of eye movements, the way in which individuals describe and remember scenes, as well as rates of change detection and change blindness (e.g. Boland, Chua, & Nisbett, 2008; Chua et al, 2005; Boduroglu & Shah, 2017; Goh et al., 2007; Ketay et al., 2009; Masuda, 2017; Masuda & Nisbett, 2006; Masuda et al., 2019; Nisbett, 2003; Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005; Senzaki, Masuda, & Nand, 2014). Finally, studies which have directly manipulated self-concept within participant groups, have found independent versus interdependent self-concepts to alter visual attention processes (for a review, see Han & Humphreys, 2016).

In order to understand why the effect of culture on attention differs across studies, it is important to recognise the multifaceted nature of visual attention. Visual attention can be broken down into object, featural and spatial components (Carrasco, 2011). Furthermore, spatial attention can be shifted or split to varying locations simultaneously, as well as scaled to cover different sized areas of the visual field (Goodhew et al., 2017; Müller, Malinowski, Gruber, & Hillyard, 2003; Posner, 1980; Posner & Cohen, 1984). In the current study, we were interested in just one aspect of visual attention, the covert spatial distribution of attention. Therefore, while our results suggest that the covert spatial distribution of attention may not differ between East Asian and Western individuals, it is unlikely that this is the case for all aspects of visual attention processing. Instead, it is likely that previous studies observing cultural differences in visual attention might have been measuring variation in other aspects of visual attention, rather than the covert distribution of spatial attention.

For example, research has demonstrated that individuals from East Asian cultures deploy more attention resources to the background images, while those from Western cultures may deploy more attention to the foreground of images (e.g. Masuda & Nisbett, 2001, 2006). Specifically, in Masuda and Nisbett (2001), participants from both Japan and America were shown short videos of animated fish swimming through the ocean. The participants were then asked to describe the scene. Japanese participants were more likely to describe the background of the ocean scene compared to American participants. This suggests that the two groups differed in their attention to context, and level of 'field dependence'.

Critically, from this, one might assume that to attend to contextual information, Japanese participants adopted a broad spatial spread of covert attention, while American participants adopted a narrow spread of covert spatial attention. However, this does not necessarily have to be the case. Instead, participants might have differed in their use of another aspect of visual attention, such as attentional shifting. That is, in order to attend to more background, contextual information, Japanese participants might have shifted their attention resources to multiple locations in the visual field, whereas American participants may have kept their focus of covert attention in one location. Alternately, Japanese participants may have split their attention to more locations compared to the American participants. Finally, research by Senzaki, Masuda & Ishii (2014), suggests that while the total area over which attention is deployed in the ocean task might not differ between cultures, the amount of time fixating on salient foreground and background objects might differ.

Furthermore, it is important to consider the separate roles of top-down and bottom-up cognitive processes when studying cultural variations in visual attention (Senzaki, Masuda, & Ishii, 2014; Masuda, Ishii, & Kimura, 2016). While top-down (endogenous) attention encourages the use of internal, voluntary cognitive resources, bottom-up (exogenous) attention is driven by external changes in the environment (Carrasco, 2011; Müller & Rabbitt, 1989; Nakayama & Mackeben, 1989; Posner, 1980; Posner & Cohen, 1984; Turatto et al., 2000). Senzaki, Masuda and Ishii (2014) suggested that cultural differences in visual attention processes, and specifically, eye movements, might be more likely to emerge in situations which encourage the use of top-down attentional control, instead of automatic processes. In their study, Japanese and Canadian participants viewed ocean videos similar to those used in Masuda and Nisbett (2001). In Experiment 1, participants were asked to view the underwater scene, while in Experiment 2, participants were asked to complete a narrative task, describing the events of the ocean scene that they observed (similar to Masuda & Nisbett, 2001). During the both studies, eye movements were recorded. Critically, cultural differences in eye movements emerged in Experiment 2, but not in Experiment 1, whereby Japanese participants spent a relatively longer amount of time fixating on background objects, while Canadian participants spent more time fixating on objects in the foreground. The authors suggested that this was because Experiment 2 would have required participants to use top-down attentional resources to a greater extent than Experiment 1, which would require exogenous attention when tracking salient swimming fish.

Importantly, the inhibition of return task used in the current study measured the spatial distribution of covert attention, when attention was manipulated *exogenously,* requiring bottom-up attentional resources. In particular, a bright peripheral luminance change was used to automatically capture attention to a particular spatial location. If variations in visual attention across cultures are more likely to emerge when top-down attentional resources are required, this could account for the null effect observed in the current study. That is, regardless of cultural differences in top-down attention styles, the luminance change, utilising bottom-up attention, might have had a similar effect on visual attention for both East Asian and Western participants.

As such, rather than concluding that cultural background does not influence visual attention processes, what we can say is that, for the specific type of attentional processing tested in the current study, cultural different may be minimal. Therefore, future research should aim to systematically explore how culture might influence all the different aspects of basic visual attention processes, such as spatial attentional splitting, shifting, and scaling, the as well the influence of exogenous versus endogenous experimental manipulations. Indeed, the spatial distribution of covert attention can be measured when attention is manipulated *endogenously*. Here, instead of using exogenous luminance changes to capture attention, central, informative cues can be used to shift attention. These types of cues require participants to utilise a greater amount of top-down cognitive resources. Together, this will provide clarity as to exactly how culture might influence specific types of visual attention in tasks such as Masuda and Nisbett's (2001) scene viewing task.

Finally, the characteristics of the particular sample used should be taken into consideration when evaluating cultural differences in attention spread. In the current study, the majority of participants in the East Asian sample were born in China, and the majority of the Western sample was born in Australia. It is important to note that Chinese and Australian participants are not wholly reflective all aspects of East Asian and Western cultures. Indeed, there appears to be variation of cognition *within* specific cultural groups. For example, some research suggests that observed cultural differences in visual attention are smaller when comparing North American and Chinese participants as opposed to Japanese and North American participants (e.g. Rayner et al., 2009; Rayner et al., 2007; Senzaki, Masuda, & Ishii, 2014; Masuda et al., 2016).

One reason for this variation may be differences in the structure of language of English, Japanese and Chinese individuals (Senzaki, Masuda, & Ishii, 2014; Tajima & Duffield, 2012). Indeed, the way in which language is structured can shape attention. For example, Tajima and Duffiled (2012) noted that in Japanese language, sentences typically begin with background information, with information about central elements following this. Critically, the opposite is true for both English language, where foreground information precedes background information. If language can shape thought and cognition, the Japanese language may lead speakers to focus more on contextual information, compared to American participants, regardless of their cultural background (Senzaki, Masuda, & Ishii, 2014; Tajima & Duffield, 2012). To test this idea Tajima and Duffiled (2012) asked Chinese, Japanese and English participants to describe images, as well as complete memory task for the images. Given that Japanese and English language differ in structure, it was predicted that a strong difference in visual attention processes would emerge between these groups. Specifically, it was hypothesized that Japanese participants would remember more details about image backgrounds and describe background elements before focal objects compared to English participants. In contrast, Chinese language more closely resembles English language structure than Japanese language structure. As such, it was predicted that differences between English and Chinese speakers would be smaller. Overall, the performance of Japanese participants could be differentiated from Chinese participants, suggesting that language may play a part in driving cultural differences in visual attention. Therefore, it would be useful for future work to compare the performance on the IOR task between Japanese and Chinese participants to see if language plays a role in determining the covert spatial distribution of attention.

Culture and Response Time

Interestingly, although cultural differences in the spatial distribution of attention were not observed, the current study found a significant cultural difference in overall response speed, where Westerners were relatively faster to detect targets compared to East Asian participants. That group differences in response time were observed is consistent with previous research showing that on average, East Asian participants are slower to respond during target detection tasks (Boduroglu & Shah, 2017; Boduroglu et al., 2009). Although slower responding has previously been interpreted as reflecting cultural differences in attention distribution (Boduroglu & Shah, 2017), given the results of the current study, we believe that this is unlikely. In particular, even after controlling for variation in attention slope, group differences in response time remained.

One possible reason for cultural differences in response speeds are group differences in response biases. For example, East Asian participants may have used a more conservative response criterion compared to Western participants. In turn, this may have led East Asian participants to have slower overall responding, as participants may have waited for more perceptual evidence to accumulate before responding to the target. Indeed, recent research suggests that in perceptual tasks, participants from an East Asian cultural background may have a more conservative response bias compared to Western individuals (Hakim et al., 2017). Specifically, Hakim et al. (2017) compared cultural differences in participants' performance of the Boduroglu et al. (2009) change detection task (Figure 1). Critically, in both the ‘expand’ and ‘contract’ conditions of the task, Chinese participants were more likely to report “no change” compared to American participants, indicating that they adopted a more conservative response style (however, this difference was not observed when comparing Asian International student participants versus American student participants).

Furthermore, cultural differences in motivation and self-regulation may have influenced response styles, and subsequently overall target detection response times in the IOR task. In particular, East Asian individuals are thought to be motivated to avoid adverse outcomes, while Western individuals show stronger motivation to approach positive outcomes (e.g. Hamamura, Meijer, Heine, Kamaya & Hori, 2009; Heine et al., 2001). For example, Hein et al. (2001) found that persons from Japan and North American responded differently to feedback indicating success, versus feedback indicating failure. In particular, when given negative feedback regarding performance on a task, Japanese participants continued with the task for a longer amount of time compared to Western, participants, indicating they were more motivated by this form of feedback. In the current study, during the experimental block, participants were provided with corrective feedback if they performed the IOR task incorrectly (i.e. responded before the target appeared, or during a catch trial). Specifically, a warning message appeared in red text for 3 seconds which asked participants to wait for the target stimulus. Given that there are known cultural differences in motivation following negative feedback, the warning message presented in the current study may have had a different impact on motivation, and subsequently, completion of the IOR task. East Asian participants may have been more motivated by the ‘failure message' to avoid further errors, and thus responded more conservatively when searching for the target. Nonetheless, it is important to note that cultural background did not predict the number of ‘catch trial' errors made by participants. If East Asian participants were more conservative in responding, their catch trial accuracy should be higher compared to Western participants due to Western participants potentially responding more liberally. Nonetheless, given that catch trial accuracy was very high for both cultural groups, this might not be a sensitive enough measure of response bias.

Finally, a growing body of research suggests that stable differences in response time exist. For example, age, impulsivity and sex have been found to predict response time (e.g. Sheppard & Vernon, 2008; Der & Deary, 2006). However, similar to Boduroglu and Shah (2017), it is important to emphasise that the response time difference obtained in the current study does not reflect group differences in overall ability to complete the attentional inhibition task. The reasons for this are twofold. Firstly, overall accuracy scores for both groups were high, and the difference between the groups was not significant. Secondly, our participants were drawn from the same, highly educated, university sample. Taken together, this would suggest that the two groups were of equal ability.

Conclusion

In conclusion, the current study found that there are minimal cultural differences in the covert spatial attention distribution, as measured using an inhibition of return task which requires exogenous attention. Despite this, however, a reliable difference in target detection response time was observed, where East Asian participants were slower compared to Western participants. This difference in response time is not solely attributable to differences in attention distribution, and as such, future work should explore whether differences in response criterion or motivation might cause this effect.

Notes

1. Initially, we intended to create our East Asian and Western participant groups for analysis based on self-identified cultural background. To do so, in the demographic survey, we asked participants which ethnic group they most strongly identified with (Caucasian, East Asian, South Asian, Indigenous, or Other). We also asked participants if they identified with any other cultural groups and the strength of their identification with these groups. Inspection of responses to this question suggested that the question was a poor measure of culture, with some participants providing unclear responses. For example, some participants answered that they most strongly identified as being from an East Asian ethnic group, however, when prompted if they identified with another ethnic group later in the survey, they responded that they more strongly identified as Caucasian than East Asian. Furthermore, some participants self-identified equally as having many ethnic associations, making individual's responses hard to categorise into clear cultural groups. Therefore, we chose to use birth country as the main grouping variable for analysis, as it allowed for a cleaner demarcation of cultural groups compared to self-identified culture. This is consistent with previous research, which has used birth country as the grouping variable for cultural background (e.g. Boduroglu, Shah & Nisbett, 2009).
2. A subset of participants did not to respond to some demographic questions. This resulted in smaller participant numbers for the variables age, self-identified culture, and total years of education. Further, apart from the data reported in Table 1, the demographic survey also measured a) which countries a participant had lived in, as well as for how long they lived in those countries, b) countries in which the participant completed primary and secondary education, as well as the language spoken at those schools, c) the degree to which they saw themselves as Australian,

compared to their self-reported cultural group (using a 5 point Likert scale; Berry, 2014) and d) birth country of both of their parents . Variation in responses to these questions were highly variable, and often misinterpreted, and were thus, not included in our final analysis. Furthermore, our original survey asked participants their a) first language, b) what languages they were fluent in, and c) the main language they used now. However, for clarity, we condensed this into one variable, labelled “number of languages spoken” and recorded the number of separate languages participants reported speaking across these three questions.

3. We originally intended to exclude participant data if eye movements were made on more than 20% of target present trials. However, this meant that a high number of data sets were excluded. Therefore, to include as much data as possible, we lowered our accuracy cut off score to 70% (i.e. participants were excluded if they moved their eyes on more than 30% of trials). Nonetheless, both exclusion criteria led to a similar overall pattern of results.

4. In earlier version of this manuscript, we collected 82 useable data sets for final analyses (32 East Asian, 50 Western). The original analysis included in this manuscript found a marginally significant effect of birth country on attention slope, t (80) = 1.92, p = .058, d = .42. Further, in the original version of the manuscript, when East Asian participants who had been living in Australia for greater than 5 years were excluded from analyses, the effect of birth country on attention slope was significant, , t (75) = 2.14, p = .035, d =.49. However, upon the request of an anonymous reviewer, we collected a further 19 useable data sets, so that there were 50 East Asian, and 50 Western participants in our final sample, and revised manuscript.

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