Asia has the global advantage: Race and visual attention

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A R T I C L E   I N F O
Article history:
Received 6 July 2009
Received in revised form 24 April 2010

Keywords:
Attention
Global–local processing
Culture differences
Race differences

A B S T R A C T
In studies of visual attention, and related aspects of cognition, race (continent/s of ancestry) of participants is typically not reported, implying that authors consider this variable irrelevant to outcomes. However, there exist several findings of perceptual differences between East Asians and Caucasian Westerners that can be interpreted as relative differences in global versus local distribution of attention. Here, we used Navon figures (e.g., large E made up of small Vs) to provide the first direct comparison of global–local processing using a standard method from the attention literature. Relative to Caucasians, East Asians showed a strong global advantage. Further, this extended to the second generation (Asian Australians), although weakened compared to recent immigrants. Our results argue participants’ race should be reported in all studies about, or involving, visual attention to spatially distributed stimuli: to continue to ignore race risks adding noise to data and/or drawing invalid theoretical conclusions by mixing functionally distinct populations.

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1. Introduction

Studies investigating visual attention typically report neither participants’ physical race (which we here define as the continent/s of ancestry), nor the confounded variable of culture. However, a number of findings predict there could be important differences between East Asians and Caucasian Westerners in the relative preference for global versus local distribution of attention. A common idea in recent articles is that East Asians are better relative to Westerners at integrating across the entire stimulus including background context, while Westerners show a relative advantage at processing focal objects or regions and ignoring context. This idea is not without controversy but, overall, current evidence makes a good case for the existence of such a “culture difference in perception”. East Asians are more sensitive than Westerners to an illusory change in orientation of a rod caused by a surrounding tilted frame (Ji, Peng, & Nisbett, 2000). East Asians also show greater sensitivity to the centre-surround size illusion than Westerners (Doherty, Tsuji, & Phillips, 2008). East Asians also show more central and fewer distributed fixations on faces than Westerners (Blais, Jack, Scheckers, Fiset, & Caldara, 2008). East Asians are quicker than Westerners to detect a change in contextual information in a change blindness paradigm (Masuda & Nisbett, 2006). And, when viewing scenes with a focal object and a background, event-related functional magnetic resonance imaging (fMRI) reveals East Asians activate fewer of the neural regions implicated in object processing areas than Westerners (Gutchess, Welsh, Boduroglu, & Park, 2006). These five results appear methodologically robust in that the studies concerned used samples in which proportion of females was well matched across East Asian and Western groups. Matching is important because sex differences are known to exist on at least some tasks used to assess context sensitivity (e.g., rod-and-frame illusion, Ji et al., 2000; centre-surround size illusion, Phillips, Chapman, & Berry, 2004).

Findings are also largely consistent with culture differences in the framed-line task. In this task, participants remember either the relative or the absolute length of the line relative to the frame inside which it protrudes. Kitayama, Duffy, Kawamura, and Larsen (2003) found East Asians were better than Westerners at the relative task, while Westerners were better than East Asians at the absolute task, using a version in which subjects were free to choose their own processing strategy when first encoding the stimuli. In this study, proportion of females was well matched across the cultural groups in the first experiment. In a version in which processing strategy was controlled to be either relative or absolute on both the encoding and 1-back matching trials, Hedden, Ketay, Aron, Markus, and Gabrieli (2008) found no race/culture effects on behavioural performance, but found fMRI evidence arguing that achieving the equivalent levels of behavioural performance required more sustained attentional effort for the absolute task in East Asians, and the relative task in Westerners. Zhou, Gotch, Zhou, and Liu (2008) failed to replicate Kitayama et al.’s finding that Westerners more accurately estimated absolute than relative...
length in the framed-line task. However, we do not consider this compelling evidence against the existence of race/culture differences because: (a) in the version of the task that came closest to obtaining this finding in Westerners (stimuli with a perceptually weak frame, Experiments 3 and 4) they did not test an East Asian comparison group; (b) in another version (strong frame, Experiments 1 and 2) the means showed a strong suggestion that East Asians showed a stronger relative-over-absolute advantage than European Americans, but the interaction with group was only ever tested also including an Asian American group with an intermediate pattern which may have weakened the power of the test for detecting an interaction involving the two theoretically key groups; and (c) sex distribution across groups was not reported for experiments that allowed group comparison on the same tasks.

The only task in which the results pertaining to culture differences currently remain unclear is in studies that examined eye movements to, and/or tested memory for, focal objects versus backgrounds in scenes. Two studies found evidence that East Asians integrated the objects with the backgrounds and Westerners attended more to the focal objects (Chua, Boland, & Nisbett, 2005; Masuda & Nisbett, 2001), but two did not (Evans, Rotello, Li, & Rayner, 2009; Rayner, Li, Williams, Cave, & Well, 2007). The explanation of these conflicting results is unknown, although it is possible that the conflict could be due to confounds with sex: three studies did not report sex distribution, and the only one that did (Chua et al., 2005) had poor matching of proportion of females across race/culture groups.

In the present article, our aim is not to test possible explanations of the origin of the conflicting findings. Instead, we focus on the fact that, where so-called culture differences in perception have been found, they have commonly been explained in terms of an idea that East Asians are better than Westerners at “attending holistically” while Westerners are better than East Asians at “attending analytically” (e.g., Kitayama et al., 2003; Masuda & Nisbett, 2001; Nisbett & Miyamoto, 2005; Nisbett, Peng, Choi, & Norenzayan, 2001).

The starting point for the present research was that this idea can essentially be reduced to the claim that, although all groups need to attend globally in some perceptual situations and locally in others (Liechty, Pieters, & Wedel, 2003), East Asians attend more globally relative to Westerners, while Westerners attend more locally relative to East Asians. Crucially, however, there have been no previous studies comparing East Asian and Caucasian participants that have used direct tests of global–local processing, employing a standard technique taken from the visual attention literature.

Global–local processing is typically examined via Navon figures (Navon, 1977), namely hierarchical stimuli comprising a large global shape (e.g., the letter E) made up of small local shapes (e.g., letter Vs). There are many versions of the global–local processing task. In the divided-attention letter version, as used in the present study, the degree of global versus local preference can be measured by the extent to which participants detect target letters faster when they appear at the global level rather than at the local level.

Importantly, whether results show a global or a local preference in the Navon task, and the exact size of any global preference, is not fixed but instead varies substantially with many parameters of the experiment and stimuli (e.g., stimulus clarity, sparsity between local features, number and relative size of elements, visual angle, retinal location, exposure duration, eccentricity and masking; for reviews see Kimchi, 1992; Navon, 2003; Yovel, Yovel, & Levy, 2001). Thus, to compare the size of the global advantage across race/culture groups, it is necessary to conduct exactly the same experiment in both groups. There are extensive literatures on the Navon paradigm in both Western Countries, and in East Asian countries (e.g., Han, Fan, Chen, & Zhuo, 1999), but unfortunately these previous studies appear not to allow direct comparison across race/culture groups because we were unable to determine that any used exactly the same procedure in the East and the West. Also note that, even if it could be shown that some studies did use identical procedures, race was not reported, making any East/West differences merely suggestive of a race difference rather than compelling evidence. This is particularly the case given that many of the studies testing modern American undergraduates cannot be assumed to have tested only Caucasian subjects and indeed very likely tested quite a high proportion of subjects who were not Caucasian Westerners.

Only one previous study has used hierarchical stimuli to examine global–local processing between groups of different races/cultures using exactly matched procedures (Davidoff, Fonteneau, & Fagot, 2008). This study contrasted native English-speaking undergraduates at a British university with the nonliterate Himba people of northern Namibia (in Africa). Stimuli were comprised of geometric shapes, and participants made a similarity judgement to alternatives that matched a sample geometrical shape at either the global or local level. Results showed a global bias in the English–speaking undergraduates, but an extremely strong local bias in the Himba.

Here, we provide the first study to use Navon figures to compare global–local processing differences between East Asians and Caucasian Westerners.

2. Experiment 1: East Asians and Caucasian Westerners

In Experiment 1, our primary research question was whether East Asians showed a stronger global preference than Caucasian Westerners, as would be predicted by the theory of race/culture differences in spatial allocation of attention. The experiment also tested the role of several specific factors that might, theoretically, be the cause of any such difference.

We tested, for the first time, the idea that some form of hemispheric differences might contribute to perceptual differences between East Asians and Caucasians. Lateralised hemispheric specialisation for allocating visual attention is now well established: the right hemisphere plays a stronger role in global processing and the left in local processing (e.g., Heinke, Hinrichs, Scholz, Burchert, & Mangun, 1998; Hubner, 1997; Robertson & Lamb, 1991; Robertson, Lamb, & Zaidel, 1993; Sergent, 1982; Van Kleek, 1989). We developed three specific hemisphere-related hypotheses, any of which could potentially explain the stronger global preference in East Asians.

The first we refer to as the “right hemisphere” hypothesis. There is evidence (Green, Morris, Epstein, West, & Englar, 1992) that individual people can show characteristic differences in cerebral arousal asymmetry, and that individuals with baseline arousal stronger in one hemisphere (e.g., the right) show reaction time advantages for stimuli presented in the contralateral visual field (i.e., the left). Two studies have also raised the idea that group-level differences in hemispheric reliance could exist and predict global–local performance: Kramer, Ellenberg, Leonard, and Share (1996, p. 403) argued that, because “girls tend to do better on tasks associated with the left hemisphere . . . whereas boys tend to do better on tasks associated with the right hemisphere” that therefore “girls would be more perceptually biased towards local shapes and boys would be more perceptually biased towards global shapes” (also see Roalf, Lowery, & Turetsky, 2006). In the present context, the right hemisphere hypothesis would state that the cause of a stronger global preference in East Asians would be greater right hemisphere arousal in East Asians than in Caucasians. In our design, this would correspond to a finding that East Asians show a reaction time advantage for left visual field over right visual field presentations, relative to Caucasians, for both respond-global and respond-local trials (i.e., a group × visual field interaction).
The second hemisphere-related hypothesis we refer to as the “pattern of hemispheric organisation” hypothesis. This idea suggests that, without differences in overall hemispheric arousal, it may be that there is some difference in the relative strength of global versus local processing in the two hemispheres. East Asians, like Caucasians, show the basic global-right hemisphere/local-left hemisphere pattern of organisation (Yamaguchi, Yamagata, & Kobayashi, 2000), but it is possible the degree of hemispheric difference in global–local processing could differ between groups. In our study, this hypothesis would predict a three-way group × global–local level × visual field interaction.

The third idea we refer to as the “global advantage regardless of hemisphere” hypothesis. It may be that there are group differences neither in hemispheric arousal nor hemispheric organisation, but instead that, compared to Caucasians, East Asians favour global processing in both hemispheres. This idea predicts only a two-way group × global–local level interaction, with no two- or three-way group interactions involving visual field.

To test these hypotheses, we used a specific version of the global–local paradigm, in which participants were required to divide their attention between levels to monitor for target letters that could appear as either the global or the local level randomly from trial to trial (see Fig. 1). Combined with appropriate spacing of the small local letters relative to the global whole, and with presentation of the entire stimulus randomly just to the left or right of central fixation, and with post-stimulus masking, the advantage of using Navon figures in a divided-attention paradigm is that it allows us to assess hemispheric contributions to overall global or local preference. When tested in Western countries, this method produces the classic pattern of global processing advantages for the right rather than left hemisphere, and local processing advantages for the left rather than right hemisphere (Yovel et al., 2001).

3. Method

3.1. Participants

Experiment 1 tested two groups: (a) 22 Caucasian-Australians (13 females, i.e., 59.1% female) raised in Australia; and (b) 25 East Asians (15 females, i.e., 60.0% female) raised in Hong Kong, mainland China, Singapore, Malaysia, Indonesia, and Korea, who had recently moved to Australia as university students (mean duration of residence in Australia 7.8 months, range 5 days to 36 months; 84% ethnic Chinese). All participants were right-handed young adults.

Physical race was determined by self-report of continent of ancestry: all participants were (as far as they knew) of single rather than mixed physical-race descent (i.e., all reported as either 100% ancestry from Asia, or 100% ancestry from Europe). Note that all participants would be expected to be highly fluent at identifying single English letters: East Asians were studying at an English language university and had passed English exams in order to obtain visas; and the subset of East Asians raised in Singapore had English as a first language. The reason for equating percentage of female participants across the two groups was that it was important to ensure any group differences we observed in global–local processing could be attributed to race and not confounds with sex: Roalf et al. (2006) reported that global–local processing differs between men and women, although this result has not been observed in other studies (e.g., Kimchi, Amishav, & Sulitzeanu-Kenan, 2009; Poirol, Pineau, Jobard, & Mellet, 2008).

3.2. Stimuli and procedure for Navon figures task

Participants were asked to respond whenever they detected either of the target letters (E and H) as being present in the display. Targets could appear unpredictably as either the small local letter (0.4° × 0.5°) or the large global letter (2.3° × 3.9°; see Fig. 1), allowing the individual’s default (i.e., uninstructed) preference for one level or the other to be assessed. The measure was reaction time to respond “present”, for targets appearing at each level. The procedure on each trial was: central fixation cross (size 0.1°) for 500 ms; lateralised stimulus for 150 ms with inside edges 1.5° from fixation; pattern mask (8 × 9 array of letters each 0.15° × 0.1°) to both visual fields for 1000 ms. Stimuli were: Et Ev Hx Ht Xv Xt Ltv Tx Tl Vx Vl Lh Te Xh Ve (coded as GLOBALlocal); note all were “inconsistent” (i.e., different letters at global and local levels). The particular stimuli (number and spacing of small letters) were pilot tested to produce approximately equal reaction times for global and local levels (when collapsed across visual field) in Caucasian participants.

Number of trials per subject was 240: 50% target absent catch trials; 25% target present global; 25% target present local. There were 48 practice trials. Viewing distance was 57 cm. Responses were made with the right hand. If applicable, participants wore corrective glasses or contact lenses for testing; all then achieved 20/20 acuity on a Snellen eye chart. Criteria for excluding reaction times as outliers were <148 ms or >1000 ms (less than 1% of data). Race of experimenter was East Asian (for N = 19 East Asian participants and N = 19 Caucasian participants) or Caucasian (for the remainder).

4. Results and discussion

The key results, regarding race/culture effects on global-over-local advantage, are summarised in Fig. 2. Data are presented in more detail in Fig. 3 (reaction times) and Fig. 4 (error rates).

The primary data were reaction times to respond “present” on trials on which a target letter (E or H) was indeed present, divided into trials on which the target was present at the global level, and trials on which the target was present at the local level. We also examined error rates for these trials, i.e., failures to respond when the target was present at the global level, and at the local level.1 For both RTs and errors, we also calculated a global preference score (i.e., the global-over-local advantage), as localRT minus globalRT for reaction times, and as localError minus globalError for error rates.

Considering in Experiment 1 only the Caucasian and East Asian groups, several important findings can be seen (Figs. 2–4). We begin by describing these findings before presenting the statistical evidence that supports them.

First, collapsed across conditions, there was no difference in either average RT or average error rate across the two groups (Figs. 3B and 4B). This means that any differences in global preference scores – that is, the amount by which reaction times were faster, or errors lower, in global compared to local conditions – cannot

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1 Note that, following standard procedures in this field (e.g., Yovel et al., 2001), absent trials were considered merely catch trials: there are no usable reaction time scores to absent trials (because ideally no response is made), and analysing errors is also of no value given that absent errors cannot be divided into global and local conditions (i.e., when the target is absent, it cannot be assigned to being absent at the global level or absent at the local level). Mean error rate on absent trials was 4.99% for Caucasian-Australians, 7.28% for East Asians in Experiment 1, and 7.73% for Asian-Australians in Experiment 2.
be attributed to overall differences in the speed or accuracy with which East Asians found the target “E” or “H” compared to Caucasians. The result also implies that, as expected, the East Asians demonstrated no lack of fluency with the English letter stimuli: indeed, if anything, the (nonsignificant) trend was for East Asians to be slightly faster than Caucasian-Australians.

Second, both groups showed the established pattern of hemispheric organisation. That is, with both Caucasians and East Asians, there was a left visual field (right hemisphere) advantage compared to right visual field (left hemisphere) for global-level responses, together with a reverse right visual field advantage compared to left visual field for local-level responses. This pattern is revealed in the crossover interaction plots in Figs. 3A (RTs) and 4A (errors).

Third, East Asians showed a clear global preference in reaction times relative to Caucasians. That is, superimposed on the crossover interaction between level (global, local) and visual field (left, right), there was an overall “tilt” in favour of global processing in East Asians (Figs. 3A and 4A). The stronger global preference in East Asians than in Caucasians is summarised in Figs. 2A (RTs) and C (errors), where it can be seen that, relative to the very slight (nonsignificant) local preference in Caucasians, East Asians tended to be faster and more accurate at global processing. The relative global preference in East Asians compared to Caucasians was large in absolute terms: in the context of fast baseline RTs of approximately 420 ms, the mean global preference in East Asians (32 ms) was a substantial 38 ms larger than the mean global preference score in Caucasians (~6 ms).

Fig. 2. Key result of the article, showing effects of race/culture group on the amount of global-over-local advantage. Y-axes plot the amount by which target detection was faster (A and B) or more accurate (C) for the global level than the local level. Results illustrate: (A) on reaction times (RT in ms), East Asians showed a stronger global advantage than Caucasians, with Asian-Australians falling in between; (B) this result was not due to the presence of differences in overall accuracy between some groups (see Fig. 4B), because the same pattern was replicated for a subset of subjects who all had excellent task accuracy (overall error rate <5%); (C) on error rates (% misses to target-present trials), East Asians again showed a stronger global advantage than Caucasians, and Asian-Australians were similar to East Asians rather than Caucasian-Australians (note that a high-accuracy subset plot is not shown because, for these subjects, error rate is by definition at floor and so the global–local difference scores are not meaningful).

Fig. 3. Reaction time results. (A) Each participant group shows the same pattern of global–local × visual field interaction (i.e., global faster for LVF than RVF and local faster for RVF than LVF). (B) Collapsing all conditions, mean reaction time did not differ between the three participant groups. Error bars show ±1 SEM. (C) Collapsing across visual field, global preference was strongest in East Asians, intermediate in Asian-Australians, and absent in Caucasian-Australians. Error bars show ±1 SEM of global minus local difference scores, appropriate for within-subjects comparison of global and local. (D) Collapsing across global and local, data clearly rejected the hypothesis that East Asians were “more right hemisphere” than Caucasians: results in East Asians show significantly faster reaction times in the left hemisphere (RVF) than the right (LVF). Error bars show ±1 SEM of LVF minus RVF difference scores.
Fourth, regarding the cause of the global preference, results clearly refuted the “right hemisphere” explanation. Figs 3D and 4A show that, if anything, East Asians showed slightly more left hemisphere arousal than Caucasians, i.e., East Asians showed a relative advantage for right visual field (left hemisphere) compared to left visual field (right hemisphere), on both RT and errors.

Fifth, results showed no support for the “pattern of hemispheric organisation” hypothesis. That is, not only did East Asians, like Caucasians, show the standard right-hemisphere advantage for global and left-hemisphere advantage for local (Figs 3A and 4A), but the strength of the two-way interaction between visual field and global–local level did not differ between the two groups (i.e., no suggestion of any three-way interaction; see below for statistics).

Sixth, results supported the “global advantage regardless of hemisphere” hypothesis. That is, relative to Caucasians, East Asians showed a stronger global preference (Fig. 2A) that was apparent with both left visual field and right visual field presentation (Figs 3A and 4A).

Seventh, speed-accuracy tradeoffs could not account for any of the above results. That is, all theoretically important trends in a given direction on reactions times (Fig. 3) were also present in the same direction on error rates (Fig. 4).

Turning to the statistical evidence supporting these statements, reaction time results were as follows. A three-way ANOVA (group × global–local level × visual field) revealed: (a) no difference in overall reaction time between Caucasians and East Asians, $F < 1$, MSE = 24142.71, $p = .648$ (Fig. 3B); (b) a stronger global preference in East Asians than in Caucasians (significant group × global–local level interaction, $F(1, 45) = 4.191$, MSE = 3974.94, $p = .047$, see Fig. 3C); (c) no overall advantage for right compared to left hemisphere in either race (no main effect of visual field, $F(1, 45) = 2.889$, MSE = 1076.68, $p = .096$, and no group × visual field interaction, $F < 1$, MSE = 1076.68, $p = .488$, see Fig. 3D); and (d) a left visual field advantage (right hemisphere) advantage compared to right visual field (left hemisphere) for global–local level responses, and a right visual field advantage compared to left visual field for local-level responses (strong global–local level × visual field interaction, $F(1, 45) = 25.11$, MSE = 1216.94, $p < .001$), that showed no three-way interaction with race, $F < 1$, MSE = 1216.94, $p = .857$ (see Fig. 3A).

Additional analyses, considering only subsets of the conditions, were driven by the significant group × global–local level interaction, and/or the need to conduct a priori tests of specific hypotheses. Results showed the following. Regarding Fig. 3A, each group considered independently showed a clear global–local level × visual field interaction (East Asians: $F(1, 24) = 12.533$, MSE = 1398.31, $p = .002$; Caucasians: $F(1, 21) = 13.213$, MSE = 1009.67, $p = .002$). Regarding Fig. 3C collapsing over visual field, the global advantage relative to local was significant in East Asians (global versus local, $t(24) = 2.625$, $p = .015$), while Caucasians showed a small nonsignificant trend in the reverse direction toward a local advantage (global versus local, $t < 1$, $p = .677$). Regarding Fig. 3D collapsing over global–local level, there was a small but significant left hemisphere (right visual field) advantage in East Asians (left versus right, $t(24) = 2.407$, $p = .024$), in conjunction with no difference between hemispheres for Caucasians (left versus right, $t(21) = .553$, $p = .586$).

The same statistical analyses were conducted for error rates. Results were as follows. The three-way ANOVA (group × global–local level × visual field) showed no difference in mean error rates between East Asian and Caucasian groups, $F(1, 45) = 2.031$, MSE = 227.11, $p = .161$ (Fig. 4B). There was also the typical pattern of global–local level × visual field interaction (Fig. 4A, $F(1, 45) = 8.113$, MSE = 68.245, $p = .007$) in both groups (no three-way interaction with race, $F < 1$, MSE = 68.245, $p = .702$). On errors, in contrast to the results for reaction times, race differences in overall global preference were not significant (no group × global–local level interaction, $F < 1$, MSE = 56.778, $p = .802$). Thus, the relative global advantage in East Asians was apparent primarily in the speed at which the global level could be processed relative to the local, with effect on the accuracy only weak although in the same direction (Fig. 4C).

In a final analysis, we examined whether there was any effect of the particular letter appearing as the target. There seems no theoretical reason to expect that the race/culture effect on global advantage would be dependent on the particular letter/s used. Results of analysing data for E and H trials separately were consistent with this idea. We found no three-way interaction between group × global–local level × letter (E versus H), either for reaction times
and raised in Australia. For all participants, both their parents were again reporting 100% East Asian continent of ancestry), but born female; 70% ethnic Chinese). All were physically East Asian (i.e.,

5. Experiment 2: The second generation

In Experiment 2 we addressed whether our finding that East Asians have a strong global preference compared with Western Caucasians extended to the second generation; that is, to the Western-born children of East Asian immigrant families. We refer to this group as Asian-Australians. This group are physically 100% Asian, but have been born and raised in a country with a strongly Western culture; they have also had exposure to aspects of Asian culture, particularly during infancy (i.e., while under primarily parental care).

Note that the theory of race/culture differences in attentional allocation makes no specific predictions about what will happen for the second generation. Instead, results are relevant to the explanations of the effect. Testing the second generation can provide useful clues as to roles of heritable versus environmental and cultural factors (Han & Northoff, 2008). For example, a finding that Asian-Australians’ global preference is exactly like East Asians’ global preference would argue that (a) recently-experienced culture and physical environment have no effect, and that (b) amount of global preference is due either to genetics and/or to home culture experienced during early childhood (see Section 8 for more detail).

Testing the second generation is also relevant to the practical issue of whether researchers can assume that only country of birth need be reported in Method sections (e.g., ‘American”) or whether physical race (defined by continent/s of ancestry) must be reported as well. No previous studies related to attentional distribution have tested the second generation. (Although see Norenzayan, Smith, Kim, and Nisbett (2002), for a second-generation study of formal versus intuitive reasoning.)

Experiment 2 also tested an additional hypothesis about the origin of our race/culture effects on global preference. A common idea is that perceptual differences between Caucasian Westerners and East Asians derive from cultural differences in individualism–collectivism (e.g., Nisbett & Miyamoto, 2005), with individualist societies (i.e., the West) producing a preference for ignoring context, and collectivist societies (i.e., the East) producing a preference for integrating it. Therefore, in the present study we measured, for each Asian-Australian, their cultural affiliation as Asian and as Australian, and also their independent versus interdependent self-construal; we then tested the individualism–collectivism theory prediction that these variables should correlate with the magnitude of global preference within Asian-Australians. Note that cultural affiliation and self-construal were measured only within our Asian-Australian group, because testing the correlation prediction requires substantial variation in the predictor variables within the group (and little variability would be expected with Caucasian-Australians or East Asians.)

6. Method

6.1. Participants

Experiment 2 tested 22 Asian-Australians (13 females, i.e., 59.1% female; 70% ethnic Chinese). All were physically East Asian (i.e., again reporting 100% East Asian continent of ancestry), but born and raised in Australia. For all participants, both their parents were East Asian, from the countries listed in Experiment 1, and both parents had migrated to Australia as adults.

6.2. Design, stimuli, and procedure

Experiment 2 was identical to Experiment 1 in all ways except the following. First, in Experiment 2, race of experimenter was South Asian. Second, after completing the Navon task, Asian-Australians were given social questionnaires. Camerons (2004) social identity scale was administered twice to measure identification with Asian and then Australian culture. Example items are I have a lot in common with other Asians (Australians) and I often think about the fact that I am Asian (Australian). Independent versus interdependent self-construal was also measured, using Singelis’ (1994) scale. An example independent item is I enjoy being unique and different from others in many respects; an example interdependent item is If my brother or sister fails, I feel responsible.

7. Results and discussion

The Asian-Australian group again showed the typical pattern of global–local level × visual field interaction, on both reaction times (F(1, 21) = 15.159, MSE = 849.75, p < .001, see Fig. 3A), and error rates (F(1, 21) = 25.362, MSE = 2.011, p < .001, Fig. 4A). Asian-Australians showed no right-hemisphere (left visual field) advantage on reaction times (F < 1, MSE = 1157.30, p = .636, see Fig. 3D), or errors (F(1, 21) = 4.175, MSE = 1.440, p = .054, see Fig. 4D). Asian-Australians did not differ significantly in overall reaction time from the other two groups (Fig. 3B); no main effect of group in an overall ANOVA including all three groups, F < 1, MSE = 26806.32, p = .718). However, they were significantly more accurate (Fig. 4B; main effect of group in overall ANOVA including all three groups, F(1, 2) = 8.210, MSE = 164.223, p = .001), a result for which we have no specific explanation beyond the observation that Asian-Australians may have been slightly more cautious in their “present” responses than the other groups (i.e., their lower present error rate occurred in conjunction with a trend towards slightly longer present reaction times, and also a slightly higher absent error rate, see Footnote 1).

The major question then concerned global–local preference; that is, the extent to which second-generation Asian-Australians showed either East Asian or Caucasian-Australian patterns of global preference. Fig. 2 shows that, on reaction times, Asian-Australians had a global preference score (localRT minus globalRT) intermediate in size between the other two groups.2 The global preference in Asian-Australians only approached significance, t(21) = 1.730, p = .098 (Fig. 3C). Global preference in Asian-Australians did not differ significantly from that in either Caucasian-Australians or East Asians (both ps > .05), and direct support for the conclusion of an intermediate effect was that trend analysis revealed a significant linear trend in size of the global preference across the three ordered conditions of Caucasian-Australians (~6 ms), Asian-Australians (~22 ms), and East Asians (~32 ms), p = .040 (Fig. 2A). At the same time, however, we note Fig. 2A shows some suggestion that global preference for Asian-Australians was slightly more like that of East Asians, than like that of Caucasians, and there was some statistical support for this interpretation: A t-test comparing all subjects whose physical race was Asian (i.e., East Asian group plus Asian-Australian group, N = 47) to the Caucasian group (N = 22) found a significant difference in global preference, t(67) = 2.08, p = .041, while a t-test comparing all Australians

2 Note that we checked there was no evidence of a bimodal distribution of global preference scores amongst Asian-Australians: that is, it was not the case that some Asian-Australians retained the complete Asian pattern while others shifted completely to the Caucasian pattern. Instead, the distribution was unimodal, implying a general shift somewhat towards the Caucasian pattern. (For supporting data, see Fig. 2 of McKone, Animola Davies, & Fernando, 2008.)
(i.e., Caucasian-Australian group plus Asian-Australian group, \(N = 44\)) to the subjects born in Asia (East Asian group, \(N = 25\)), found no significant difference, \(t(67) = 1.535, p = .130\). Moreover, the same conclusion was suggested by examination of the global versus local preference on error rates. The global preference score within Asian-Australians was significantly greater than zero (Fig. 4C, \(t(21) = 4.582, p < .001\), and comparison to the other two groups showed global preference was similar to the East Asians and not to the Caucasians (Fig. 2C). Thus, considering the RT and error rate results together, our results imply that global preference in Asian-Australians is intermediate to that of the other groups, but somewhat more similar to the East Asians than to the Caucasians.

We next conducted an additional analysis to confirm that the major conclusion – that is, of a global advantage on reaction time that is strongest in East Asians, weakest in Caucasians, and intermediate in Asian-Australians – could not have been in some way produced by the difference in average overall accuracy across the groups that is apparent in Fig. 4B. Logically, there seems no reason why the fact that Asian-Australians showed lower error rates averaged across all conditions than the other two groups could produce a false finding regarding the difference score for the global-over-local advantage on the reaction time measure. However, given that the Asian-Australians unexpectedly showed better overall accuracy on the task, we felt it was important to check. To do so, we performed an analysis including all three subject groups, but excluding any subjects with an all-condition error rate of greater than 5%. This procedure meant that only high-accuracy subjects were included, and that the mean all-condition error rate was now, as would be expected, very low and almost identical for the three groups (2.5% Caucasians, 2.0% Asian-Australians, 2.5% East Asians). Crucially, analysis of the global advantage RT scores for this subset of participants (Fig. 2B) showed that, despite the potentially reduced power from the reduced sample size (\(N = 8\) Caucasians, \(N = 16\) Asian-Australians, \(N = 10\) East Asians): (a) in a three-way group \(\times\) global–local level \(\times\) visual field ANOVA there remained a significant interaction between race/culture group and global–local level, \(F(2, 31) = 3.954, MSE = 2570.80, p = .03\); and (b) this still took the form of a significant linear increase in global advantage across the three ordered groups of Caucasians (\(-12\) ms), Asian-Australians (+25 ms), and East Asians (+55 ms), \(p = .008\).

Turning to the social measures, Table 1 shows no correlations between any of the various self-constructual measures and the amount of global preference in Asian-Australians. This could not be attributed to lack of range: in all cases, scores ranged from approximately 3.5–6.5 on the 1–7 rating scales of agreement. Also, there is no suggestion that there were effects in the direction predicted by individualist–collectivist theories that were nonsignificant merely due to lack of power: instead, half of the correlations were in the opposite-to-predicted direction.

### 8. General discussion

Our primary findings were that (a) there was a strong global preference in East Asians relative to Caucasians, and (b) this extended in slightly weakened form to the second generation of immigrant families (i.e., individuals who were physically Asian but born and raised in a culturally Western country). We also tested several specific theories of the origin of the race/culture difference in global preference. Results supported the view that Asians show a stronger global preference regardless of visual field of presentation, with no support for three other hypotheses (individualism–collectivism, greater right hemisphere arousal in Asians, or different patterns of hemispheric organisation). Also note that our results are robust in that they cannot be attributed to confounds with sex of the participants (i.e., all three race/culture groups had the same ratio of females to males). The major implication of our findings is that race cannot be ignored in studies that involve allocation of attention to spatially distributed stimuli.

#### 8.1. Free choice versus directed attention

Before turning to interpretation and implications in more detail, we note one important qualification on our results. The task we used allowed participants free choice of whether to attend more globally or more locally – that is, we investigated a situation where there was no explicit instruction to attend to either the global or local level, and where attention to each level was potentially equally useful (i.e., participants could not anticipate whether a global or a local target would be presented). This “divided attention” situation is the most naturalistic in terms of everyday vision (Roalf et al., 2006). However, our results cannot be taken as a guarantee that the same race/culture effects in global–local processing would be present either where the participant is explicitly instructed to attend to a specific level (as in a “directed- or focussed-attention” version of the global–local processing task), or in real world tasks where one level is intrinsically more useful than others (e.g., it could be argued that local attention is intrinsically most valuable while reading, and global while driving).

#### 8.2. Origins of the race/culture differences in global–local processing

We now consider a number of factors that might contribute to race/culture differences in global versus local distribution of attention. The most common theory of race/culture differences in perception has been that individualist cultures produce a relative ability to ignore context while collectivist cultures produce a relative ability to incorporate context, with the presumption that Western cultures are more individualist and East Asian cultures are more collectivist (Ji et al., 2000). However, as we will see below, the current evidence argues more against this specific theory than in favour of it. Also, the almost universal focus on this one theory has tended to lead researchers to ignore other factors which could, a priori, play a role in global–local processing differences between East Asians and Caucasians. We now raise several possible explanations, and evaluate them in turn with respect to evidence from the present experiments and previous studies.

#### 8.2.1. Genetic differences

Currently, we cannot rule out the possibility of a heritable genetic contribution to global–local differences. There are two things
that would comprehensively rule out a genetic explanation. The first would be if there were simply no reliable way of distinguishing genetics of Caucasians from those of East Asians – but, recent multivariate cluster analyses of single-nucleotide polymorphisms from across the DNA show extremely clear grouping based on continent of ancestry (including between Europe and East Asia; Jakobsson et al., 2008; Li et al., 2008; also see Rosenberg et al., 2002). Second, a genetic contribution could be ruled out if, in the present study, the second-generation Asian-Australians had moved completely to the Caucasian-Australian pattern of global–local effects – but, this did not occur, with Asian-Australians instead showing a global preference more similar to that of the East Asian group. Thus, while the present results by no means support or imply a genetic cause of the differences in global–local preference, we mention it here because it is at least an a priori possibility, and no data currently rule it out.

8.2.2. Individualism–collectivism

Turning to potential environmental and cultural factors, we first consider the theory that differences in individualism–collectivism between cultures account for group differences in attentional allocation. In the previous literature on “cultural differences in perception”, this theory has been so pervasive that cultural differences have largely become synonymous with cultural differences in individualism–collectivism (although of course there are many other aspects of culture that differ between groups).

So what is the empirical evidence? The potential for collectivism to play a role in group differences in global–local processing is indicated by findings that priming with “we/our” can produce a more global preference on Navon figures than priming with “I/mine” (Kühnen & Oyserman, 2002; Lin & Han, 2009), and can also alter occipital P1 amplitude in event-related potentials (ERPs) correspondingly (Lin, Lin, & Han, 2008).

However, there is little direct support for the idea that individualism–collectivism differences between societies or individuals are actually responsible for global–local differences. In attention and perception studies, the only positive evidence of which we are aware is that Hedden et al. (2008) found that, in the relative versus absolute framed-line test, blood-oxygenation-level-dependent (BOLD) responses indicating amount of sustained attentional effort correlated significantly in the predicted direction with an individual’s level of independence–interdependence (American sample) or degree of acculturation to American values (immigrant East Asian participants). In contrast to this, however, our own results showed no suggestion of the expected correlations in Asian-Australians involving strength of Australian versus Asian identity, nor independence–interdependence (despite our study using a larger sample size than Hedden et al.). In addition, important evidence against the individualism–collectivism explanation has been obtained from the Namibian Himba. This group has a highly collectivist society, yet show an extraordinarily strong local bias on Navon figures relative to native English-speaking participants tested in Britain (Davidoff et al., 2008) and also weaker sensitivity than English speakers in Britain to the centre-surround size illusion (de Fockert, Davidoff, Fagot, Parron, & Goldstein, 2007). Both these results are exactly opposite to the theory’s predictions. Finally, we also note Matsumoto (1999) has argued the claimed differences in collectivism do not necessarily apply to modern Asian cultures, and that not all studies find clear evidence that East Asians are more collectivist and Westerners more individualist.

8.2.3. Hemispheres

Our present results argue that the global–local differences between East Asians and Caucasians do not derive from hemispheric differences. In particular, the stronger global preference in East Asians could not be attributed to greater right hemisphere arousal (indeed, East Asians showed, if anything, a slightly more left-hemisphere advantage than Caucasians). It could also not be attributed to any variation in hemispheric organisation: groups did not differ in the extent to which global processing was performed more efficiently by the right than left hemisphere and local processing was performed more efficiently by the left than right hemisphere. In terms of hemispheres, our results instead showed that relative global preference in East Asians reflected stronger global processing in East Asians than Caucasians regardless of hemisphere.

8.2.4. Myopia

Another environmental and/or cultural factor (Morgan & Rose, 2005) is differences in myopia (short-sightedness). Myopia is rare in Caucasian-Australians, more common in Asian-Australians, and almost universal and often at extreme levels in East Asians raised in Singapore and Hong Kong (Morgan & Rose, 2005). In the present study, participants wore corrective lenses during experimental testing, but it could potentially be argued that East Asians could still have acquired a global bias across development if they did not permanently wear their glasses or contact lenses. This proposal rests on the idea that, in blurring the visual world, myopia would produce individuals who show a global advantage in distribution of attention. However, while this might seem the obvious prediction, in fact the limited experimental evidence available to date suggests exactly the opposite: that is, myopia leads to either no changes in global–local attention or an enhanced ability to attend locally under instruction (i.e., visual attention becomes trained to compensate for blurred visual input). We discuss this evidence in McKone et al. (2008); also see Turatto et al. (1999). Of most direct relevance to the present study, McKone et al. (2008) reported that, in the same sample of Asian-Australians tested here, there was substantial variation in level of myopia (correction ranging from 0 to −6.25 diopters), yet no correlation between level of myopia and global preference scores on the present Navon figure task ($r = -0.04$). Thus, overall, we think a myopia explanation of our race differences in global–local processing is unlikely.

8.2.5. Degree of visual complexity in the physical environment

East Asian cities are more visually complex than Western cities (e.g., photographs taken from post office locations contain a larger number of discrete objects in Tokyo than in New York) and short-term priming with Japanese versus American scenes affects context sensitivity in a change blindness task (Miyamoto, Nisbett, & Masuda, 2006). In principle, therefore, it is possible that the global preference differences we observed in Experiment 1 between our East Asian and Caucasian-Australian groups could be attributed to differences in complexity of the physical environment, at least if there are effects of extended lifetime exposure (note that the recent environment to which all participants had been exposed was Western). Our results for Asian-Australians argue physical environment was not the sole contributing factor: both Caucasian-Australians and Asian-Australians had been raised in a Western country (and all had spent only brief holiday visits in Asia), yet global preference scores for Asian-Australians were more similar to those for East Asians than those for Caucasian-Australians. However, it remains possible that physical environment could play some role, and fully or partially explain the small difference we observed in global preference between East Asians and Asian-Australians.

8.2.6. Cultural differences in parents’ direction of babies’ attention during infancy

One factor that could plausibly play a role is different language exposure in infancy. East Asian mothers direct babies’ attention less to naming single objects in a complex scene than do Western mothers, and, correspondingly, English-speaking toddlers know
many more nouns than verbs while Japanese and Chinese toddlers have a more balanced ratio (Fernald & Morikawa, 1993; Tardif, Gelman, & Xu, 1999). Thus, it could be that being raised by a culturally East Asian mother produces a bias towards global attention while being raised by a native English-speaking mother produces a relative bias towards local attention. This idea could explain not only our differences between East Asian and Caucasian-Australian groups, but also the fact that the Asian-Australians did not shift fully to the Caucasian pattern. Note, however, that it cannot be the only factor in that it does not explain why Asian-Australians did not show fully the East Asian pattern.

8.2.7. Situational social variables

Finally, we note a possibility that has received no exploration in the culture differences in perception literature, namely that global preference could be affected by situational social variables. Priming of a participant’s perceived group membership has been shown in other domains to affect cognition (e.g., in the United States, female Asians perform better on a mathematics test if their Asian identity is primed than if their female identity is primed; Shih, Pittinsky, & Ambady, 1999). In terms of attentional processing, an interaction between the race of the participant and the race of the experimenter could possibly prime participants to adopt a more global or more local focus.

8.2.8. Summary

Regarding the origin of greater global/“holistic” processing in Asians and local/“analytic” processing in Caucasians, several conclusions can be drawn. First, factors that currently do not seem likely to be involved are individualism–collectivism, hemispheric differences, and myopia. Second, a genetic contribution (i.e., based on physical race) cannot be rule out. Third, plausible environmental/cultural variables that may contribute include complexity of physical environment, parents’ direction of infants’ attention via early language exposure, and situational social variables. Finally, rather than one single factor being capable of explaining the full set of results, it seems more likely that two or more factors interact.

More generally, our discussion implies that the causal origin of group differences in perception and attention should not automatically be assigned solely to differences in individualism–collectivism between cultures. Instead, future studies need to consider a rather more complex picture of potential variables.

8.3. A need to report race of participants in studies about, or involving, visual attention

Despite the fact that the literature on culture differences in perception has become highly visible and well established in the last 5–10 years, this literature has as yet had little impact on studies within the visual attention field. Traditionally, it has been presumed (incorrectly as it turns out) that race/culture are irrelevant to basic cognitive and perceptual processes. The continuation of this presumption is reflected in the fact that, even in very recent visual attention research, researchers do not report the race (or culture) of their participants in their method sections. We suspect that one factor contributing to continuing ignorance of relevant group differences has been the universal use of the term “culture” rather than “race” in previous culture differences studies. It is partly for this reason that we have deliberately chosen to employ “race” in the present article.

The need to report race is also relevant specifically to the culture differences literature itself. Perhaps because the individualism–collectivism theory is so pervasive, even culture differences studies often do not state the race of their participants; for example, participants are commonly described simply as “American”. However, the inability of any extant evidence to rule out a contribution of genetic differences, and most importantly the present finding that all individuals raised in a Western country are not the same (i.e., Asian-Australians differ from Caucasian-Australians) indicates a need to report race in addition to the dominant culture in the country of birth (e.g., “Western”). Our arguments in the previous section imply it would also be of value to report other information about participants, such as language exposure in infancy.

We then believe some of the most important implications of our results are as follows. First, we suggest that all studies about, or involving, visual attention should report race of their participants (i.e., continent/s of ancestral origin). Second, we suggest that authors should seriously consider limiting reported results to data from participants of one racial/cultural group except where resources permit deliberate investigation of two or more groups. This is an approach successfully taken, for example, in the face recognition literature, where race of observer is known to affect results (because it interacts with race of face). Third, we argue that researchers should not assume that all participants born in a Western (or East Asian) country will perform a given task in the same way regardless of whether they are racially Caucasian or East Asian (or, potentially, any other race, or of mixed racial heritage).

The practical disadvantages of continuing to combine the data of two functionally distinct populations is that this is likely to, at the least, add noise to the data and could, at the worst, lead to false theoretical conclusions. The magnitude of the race effect on global–local preference was 75% as large as the well-known effect of hemisphere on global–local preference (that is, race produced a 38 ms change in global preference, from −6 ms in Caucasians to +32 ms in East Asians, while visual field produced a 51 ms change in global preference). Thus, the mixing of data from Caucasians and East Asians is a significant current issue given the present race distribution of the undergraduate and graduate students who Typically make up the participant pool in many research laboratories in Western Countries. For example, in many universities in the United States, Canada, and Australia, our guess is that this distribution could be as high as 50:50 Asian:Caucasian.

In studies directly about visual attention, we argue that problems caused by mixing data from Caucasians and East Asians could arise in any research using spatially distributed stimuli, including classic methods such as visual search and flanker paradigms. In these cases, the advantage of coding for race is that it may improve our understanding of attention by removing both noise and conflicting findings in theoretically important results.

We also emphasise that race/culture differences in attention could affect many other studies in cognition and perception which, while not about spatial attention per se, employ tasks that make implicit assumptions about the way in which visual attention is distributed in space. This might include, for example, studies of memory that use visually-divided attention during the encoding phase. As another example, a common task in the face perception literature, namely the composite test (Young, Hellawell, & Hay, 1987) presumes that, except where subjects’ attention is forced beyond a target half of the face by a special configural processing mechanism, subjects are able to rapidly and accurately localise their attention to the target half of the global whole; the present results, however, suggest that this assumption may be less valid for Asian subjects than it is for Caucasians.

We thus argue that all studies of, or making assumptions about, visual attention routinely need to report the race of participants. This is partly to avoid combining data of functionally distinct populations, and partly to allow the field of visual attention research to properly recognise the diversity of all peoples.
Acknowledgments
Supported by Australian Research Council Grants DP0450636 and DP0984558 to EM. We thank Kate Crookes for assistance with testing some participants in Experiment 1.

References