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Cultural Differences in Allocation of Attention in Visual Information Processing

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Abstract

Previous research has shown that when processing visual scenes, Westerners attend to salient objects and East Asians attend to the relationships between focal objects and background elements. It is possible that cross-cultural differences in attentional allocation contribute to these earlier findings. In this article, the authors investigate cultural differences in attentional allocation in two experiments, using a visual change detection paradigm. They demonstrate that East Asians are better than Americans at detecting color changes when a layout of a set of colored blocks is expanded to cover a wider region and worse when it is shrunk. East Asians are also slower than Americans are at detecting changes in the center of the screen. The data suggest that East Asians allocate their attention more broadly than Americans. The authors consider potential factors that may contribute to the development of such attention allocation differences.

Keywords

culture; East Asian; Western; cognition; attention; visual working memory; context

Cross-cultural investigations of cognitive differences have suggested that East Asians and Westerners have different cognitive styles; East Asians tend to be more holistic and Westerners tend to be more analytic (Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005). These cognitive style differences are manifested in scene processing, with Westerners attending more to focal objects and East Asians attending more to the background context. For instance, when American and Japanese participants describe briefly presented vignettes, the American descriptions focus on the salient focal objects and the Japanese descriptions focus more on background context and relationships between the focal objects and the background context (Masuda & Nisbett, 2001). When asked to compare two consecutively presented images (the second a slight variant of the first) in a change blindness task, Americans detect more changes in focal objects while the Japanese detect more changes occurring in the backgrounds of the scenes (Masuda & Nisbett, 2006). Finally, studies monitoring eye movements during scene encoding have demonstrated that Americans focus on focal objects sooner and longer than East Asians whose attention is oriented away from focal objects and toward backgrounds (Chua, Boland, & Nisbett, 2005).

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These studies demonstrate that cultural background influences how attention is distributed when viewing scenes. But what is the source of these differences? One possibility is that they reflect different cultural biases in what is considered as informative and worthy of report about scenes, especially when these scenes are presented briefly and there are time constraints on the judgments to be made. It is also possible that lower level attentional and working memory processes contribute to East-West differences in scene encoding. Here, we consider two factors that could contribute to cultural differences in scene viewing: (a) attentional breadth differences and (b) differences in how the relationships between elements in a display are processed.

It is known that individuals differ in attentional breadth, the size of the region over which individuals allocate their attention (e.g., Sekuler, Bennett, & Mamelak, 2000). Furthermore, the latency of detecting focal and peripheral changes in pictures in change blindness tasks is moderated by the size of attentional breadth (Pringle, Irwin, Kramer, & Atchley, 2001). Masuda and Nisbett (2006) reported that Japanese participants are more likely to detect more peripheral changes compared to focal changes than Americans and vice versa. Their results suggest the possibility of cultural differences in attentional breadth such that East Asians have broader attentional foci than Westerners do. The present experiments more directly test this hypothesis.

It is also possible that East Asians and Westerners differ in how they encode and maintain relationships in working memory that in turn lead to the scene encoding differences. Indirect evidence for this possibility comes from studies in which East Asians are found to be more field dependent than Westerners are. Specifically, on the Rod-and-Frame task, East Asians were influenced by the frame to a greater extent than Westerners were, resulting in larger deviations from the vertical in their placement of the rod (Ji, Peng, & Nisbett, 2000). Thus, the second hypothesis tested is whether or not East Asians encode and maintain spatial relationships between items better than Westerners do.

To investigate these two possible sources of cultural differences, we tested East Asians and Westerners in a visual change detection paradigm. In visual change detection, people are initially asked to encode a simple set of visual objects (e.g., colored blocks) and then maintain them until a second display is presented. The final stage involves comparing the first display to the second and determining whether any of the visual features have changed. Because such displays lack any inherent meaning, cultural differences in judgments of informativeness or value are unlikely to contribute to performance differences between East Asians and Westerners. Thus, any cultural differences that might then be observed can be more cleanly attributed to basic attentional and working memory processes. In this regard, our decision to use simple visual geometric displays rather than complex pictures or photographs differentiates this study from previously carried-out research on East-West cognitive differences (e.g., Gutchess, Welsh, Boduroglu, & Park, 2006; Masuda & Nisbett, 2001).

Previous research on visual change detection has demonstrated that change detection performance is in part determined by a search process that precedes the comparison stage. In other words, locations of objects in the second display have an impact on whether or not color changes are detected. This is due to the fact that in any given trial, the first display gets encoded and maintained in short-term store, whereas attention has been directed in the second display determines how quickly and accurately the correspondence between the items from the first and second display are established and how accurately and quickly the comparisons are carried out. When objects are presented in identical locations, change detection accuracy is higher than when objects are randomly moved around (Jiang, Olson, & Chun, 2000). Jiang and colleagues have argued that this is because the organization of representations in visual short-term memory is configuration based. When objects are not in expected locations, the visual display needs to be searched to identify corresponding objects. This search process has been shown to interfere with the maintenance of the objects (Fencsik, 2003). Once the corresponding objects are identified, they are sequentially compared, and feature changes are noted. We argue that attentional breadth and relational processing may influence the search process and consequently affect how accurately changes are detected.

In this study, we adopted the change detection paradigm used by Jiang and colleagues (2000). In their paradigm, participants made color change judgments when the items were kept in the identical locations across two displays (same condition) or when they were displaced. In half of the displaced trials, objects moved randomly within the quadrants (random condition); and in the other half of the trials, the relationships among the objects were preserved, for example, by expanding the layout of the objects (expand condition). They demonstrated that when the spatial configuration formed by the items is preserved across the two displays (possibly by expanding or shrinking the configuration), change detection performance is equal to when they are kept in the identical locations and disproportionately higher than when objects are randomly displaced. We examined whether East Asian and Western performance would differ on color change detection when locations of objects are manipulated in the second display.

If East Asians have wider attentional focus than Americans do, they may allocate their attention to a wider region while viewing any given display. Given that performance in visual change detection is particularly influenced by where attention is initially directed to in the second display, any such attentional foci differences between culture groups may affect how accurately color changes are detected when locations of objects in the second display are manipulated. If East Asians attend to a wider region when attending the second display, then they may more easily identify corresponding squares in the periphery leading to higher change detection accuracy in the expand condition. When objects in the second display are more central, East Asians may begin to lose information about the first display during the search phase. On the other hand, if Americans have narrower attentional focus, they may be more accurate at detecting color changes at the central locations (e.g., as in the shrink condition in Experiment 2), compared to their East Asian counterparts.

We also anticipated that any cross-cultural attentional focus differences might influence performance on randomly interspersed focal detection trials (20% of total trials). In these trials, the fixation cross was followed by a centrally located square rather than four colored squares. Participants were asked to make a key press immediately following detection of the square. These focal detection trials encouraged continuous vigilance, but more important, these trials indexed how diffusely attention was allocated to the central region. If attentional focus varies by culture, then it is also likely that individuals with a broader attentional lens would allocate their attention to a wider region and respond slower to these focal detection trials. Therefore, East Asians' slower reaction time (RT) on the focal detection trials in the absence of cultural RT differences on the visual change detection trials would bolster the claim of attentional focus differences between East Asian and Americans.

In addition to examining possible cultural differences in attentional focus, the change detection paradigm tested possible cultural differences in encoding and maintaining relationships. It is possible that differences in performance on scene encoding and memory tasks may be partially due to an East Asian superiority in encoding relationships among elements in a scene (e.g., Goh et al., 2007; Masuda & Nisbett, 2001). Jiang et al. (2000) found that color change detection accuracy is higher when configurations are preserved than when objects are haphazardly displaced (also see Fencsik, 2003). If East Asians are better at encoding and maintaining relationships, then they may be more accurate than Americans at color change detection, specifically on trials where spatial relationships of objects are preserved (e.g., same, expand), compared to trials when they are not.

Experiment 1

In Experiment 1, we compared East Asian and American visual change detection performance across the same location, expand, and random conditions. If East Asians have wider attentional focus, then we would expect them to perform significantly better on the expand trials than Americans do. If East Asians are better at encoding relationships than Americans are, we could expect them to perform relatively better on the same and expand trials versus random trials.

Method

Participants—Twenty-eight East Asian students and 28 American students at the University of Michigan (ages 18 to 25) participated for payment or course credit (no differences were noted between paid and unpaid participants).[1] East Asian participants had lived in the United States for an average time of 1.91 years (±1.29) and had arrived within the past 5 years. East Asians were from China (60%), Taiwan, Hong Kong, South Korea, and Japan. All Americans were of non-Asian descent. All participants had normal or corrected-to-normal vision, and none reported colorblindness.

Materials and procedure—Participants were asked to perform a color change detection task. In one type of trial, participants had to decide whether there was a color change between the first and second displays (referred to as "change detection" trials from here onwards). The second type of trial was the focal detection trials (explained later). These two types of trials were randomly intermixed (see Figure 1). Participants were given 20 trials in the practice phase (16 change detection and 4 focal detection), followed by 144 trials in the data collection phase (120 change detection and 24 focal detection). Participants initiated each trial by pressing the space bar after a "ready" prompt. Each trial started with a black fixation cross (0.5 cm. × 0.5 cm.) that remained on the screen for 507 ms. Participants were asked to maintain fixation throughout the trial.

During the change detection trials, the fixation cross was followed by a display consisting of four 0.8 cm. × 0.8 cm. colored blocks (red, green, blue, purple, cyan, yellow, magenta, white, or black) on a gray background. A dim cross (gray scale 150, 18 cm. × 18 cm.) was present at the center of the display to serve as a reference frame. The initial display was presented for only 150 ms., to prevent participants from making eye movements during encoding. After a blank interval of 907 ms. with the gray background, a second set of four colored squares was presented until the participant responded. In a particular display, color repetitions were not allowed, and when color changes were introduced, one of the colored boxes was changed to one of the remaining colors.

There were three types of change detection trials equally distributed across the experiment: same location, expand, and random. On *same location* trials, colored blocks were located in exactly the same locations across the two displays. On *expand* trials, the locations of the objects in the second image were determined by expanding out the locations from the initial display by a factor of 1.7, preserving the configuration but not the identical locations. On *random* trials, the objects in the second image were randomly moved within each quadrant. The amount of displacement in the random condition was equated to that in the expand condition to ensure that differences between the conditions could not be accounted for by differences in the amount of displacement.[2] On half of the change detection trials, there was an actual color change, and these changes were evenly distributed across the three conditions and four quadrants. Following incorrect responses, feedback was provided.

[1]Two participants were dropped from Experiment 1, because their overall accuracy level was 2 standard deviations below the average, leaving us with 27 in each culture group.

[2]The algorithm for calculating these dot locations can be obtained from the authors.

For the focal detection trials, the fixation cross turned into a (0.8 cm. × 0.8 cm.) square at the center of the screen. Participants were instructed to make a key press as soon as they detected a central square. If the RT was longer than 500 ms., participants were reminded to keep their eyes on the cross. Although this feedback was based on their RT, participants were told that it was independent of performance.

The experiment was programmed using E-prime software (Psychology Software Tools, Pittsburgh), and the stimuli were presented on 17 in. Dell Ultrasharp monitors. Participants were seated 57 cm. from the monitor, where 1 cm. corresponds to 1 degree of visual angle.

Results and Discussion

For all three color change detection conditions, *d* prime (d'), a signal detection measure of how well one can discriminate color-change trials from no-color change trials, was calculated. Cultural differences in attentional allocation were tested through a 2 (Culture: American, East Asian) × 3 (Condition: Same, Expand, Random) mixed ANOVA (see Table 1). There was no main effect for culture, but there were significant differences across the conditions qualified by a significant Culture × Condition interaction.

The significant interaction was due to the cultural difference on the expand trials, $t(52) = 2.54$, $p < .02$, Cohen's $d = .60$, and the lack of any cultural difference on the same and random trials, *t*s < 1. As shown in Figure 2, East Asians ($M = 3.03 \pm .78$) were significantly better at detecting visual changes than Americans were ($M = 2.50 \pm .73$) on the expand trials. This cultural difference was also observed at the individual level: 75% of the East Asians had higher scores on expand compared to shrink and random trials, whereas only 33 % of the Americans showed this pattern.

Because East Asians' performance on same location trials was not as high as on the expand trials, $t(26) = -2.42$, $p = .02$, Cohen's $d = .59$, these findings cannot be attributed to better encoding and maintenance of relationship information—for in both the same location and the expand trials, the spatial relationships between the visual objects were preserved. If East Asians' significantly higher performance on the expand trials were to be attributed to their attention being allocated to more peripheral regions of the visual display compared to Americans, then they should be at a disadvantage on tasks requiring them to focus on more central locations. Focal detection trials provided further evidence for this claim. East Asians were slower (M = 1616 ms., SD = 1231.5) at detecting the central square than Americans were (M = 806 ms., SD = 712.1), $t(52) =2.96$, $p < .005$, Cohen's $d = .81$.[3] These focal detection RT differences were observed in the absence of any RT difference across cultures on the change detection trials, $t < 1$.

Experiment 2

In Experiment 2, we further tested the hypothesis that East Asians have wider attentional focus than Americans, by using the same paradigm but replacing the expand trials with shrink trials. We predicted that the broader attentional focus of East Asians would put them at a disadvantage on shrink trials.

[3]When the same comparison was carried out on median reaction times instead of average reaction times, the same cultural pattern was observed, $t(52) = 2.26$, $p = .03$.

Method

Participants—Seventeen East Asian students (14 Chinese) and 17 American students participated. East Asians had been living in the United States for an average of 1.99 years (*SD* = 1.18). All other participant characteristics were identical to Experiment 1.

Procedure—All parameters were identical to Experiment 1, except expand trials were replaced by shrink trials by switching the order of presentation of change detection displays from Experiment 1. Specifically, in shrink trials, the color squares in the first image were the expanded locations and the ones in the second image were the initial locations from Experiment 1. This ensured that the objects occupied similar regions of space across the two experiments.

Results and Discussion

As in Experiment 1, d' was calculated and entered into a 2 (Culture: American, East Asian) × 3 (Condition: Same, Shrink, Random) mixed ANOVA (see Table 1). The analysis revealed a significant main effect of condition, which was qualified by a significant interaction. As can be seen in Figure 3, performance on the same and random conditions did not vary across culture, *t*s < 1, but on the shrink trials, East Asians were significantly worse than Americans at detecting color changes, $t(32) = 2.13$, $p < .05$, Cohen's $d = .73$. Overall, 76% of the East Asians but only 47% of Americans showed this pattern at the individual level.

Analyses of the RT data demonstrated that, as in Experiment 1, East Asians (M = 1,360 ± 708 ms.) were slower than Americans were (M = 695 ± 244 ms.) in focal detection, $t(32) = 3.84$, $p < .001$, Cohen's $d = .94$. There was also a marginal effect of culture on visual change detection RT, $t(32) = 1.89.01$, $p = .069$, Cohen's d =.65. Americans (M = 945 ± 213 ms.) were slightly faster than Asians were (M = 1089 ± 230 ms.).

General Discussion

The two experiments reported are the first to provide evidence for cultural differences in attentional focus with simple, culture-free stimuli. In this regard, our findings are particularly novel. East Asians benefited more than the Americans from displays covering a broader region, as in the expand trials in Experiment 1. On the other hand, their performance suffered compared to the Americans when trials required attention to be allocated more centrally, as in the shrink and focal detection trials.

To further support our claims that East Asians have wider attentional focus than Americans do, we carried out a post hoc analysis on the random trials. In Experiment 1, we were able to identify five trials from the random condition in which each one of the objects in the second display was displaced outward at least as much as those objects in the expand condition. We predicted that East Asians would be better at detecting color changes in these trials compared to the Americans. A *t* test[4] revealed that there was a trend in this direction, $t(50)$ =1.72, $p < .1$, Cohen's $d = .48$ ($M = 4.58$, $SD = .50$ and $M = 4.31$, $SD = .62$, for East Asians and Americans, respectively).

The cultural differences in RT on the focal detection trials (in the range of 600 to 700 ms.) were particularly striking. In both experiments, East Asian participants were slower than American participants at detecting a centrally presented square. These differences are likely to be based on processes involving switching from color change detection trials to focal detection trials and attentional shift processes as participants zoom into the center and away

[4]Data from two participants were dropped from these analyses, because their accuracy across these five trials was more than 2 standard deviations of the overall group mean.

from the initially attended periphery. Although the current design does not allow us to identify the relative contributions of these two factors, several competing explanations for these cross-cultural RT differences in focal detection trials can likely be ruled out. They are probably not due to a general slowness of East Asians compared to Americans given only the small differences in overall RT (approximately around 100 ms.), reaching marginal significance only in Experiment 2. They are also not likely to be a consequent of nonvigilance of East Asians; change detection accuracy was similar between the two groups. Third, the lack of a cultural difference at switching from focal detection to visual change detection trials suggests that the overall pattern of RT data cannot be solely accounted by East Asians being worse at task switching in general. Specifically, East Asians were equally fast as Americans shifting from focal detection to visual change detection trials, $t(55) < 1$ (Experiment 1) and $t(32) < 1$ (Experiment 2). A general task-switching explanation is also inconsistent with recent studies that find that bilingual East Asians are typically better at task switching than Westerners are (Bialystok, 2001).

It could be argued that the differences that we have attributed to cultural differences in attentional focus may be partly explained by strategic, top-down differences in task goal processing across the two culture groups. The experimental task used in this research consisted of two different types of trials: visual change detection and focal detection. Because there were fewer focal detection trials compared to visual change detection trials, the visual change detection trials may have been given greater importance. If such a bias was more prominent among our East Asian sample compared to our American sample, then our results regarding the East Asian’s slowing down in the focal detection trials could have been attributed to top-down differences in goal processing. However, such an account would fail to explain how East Asians’ performance shifted across the expand condition in Experiment 1 and the shrink condition in Experiment 2.

We argue, therefore that the data from both the change detection and focal detection trials suggest that there are attentional focus differences in East Asians and Westerners. It is important to note that the reported experiments do not allow us to distinguish the underlying cause of these attentional focus differences. It is possible that East Asians have a strategic preference to attend to the periphery, or alternatively, they may be better at attending to the periphery. Even if these attentional focus differences are strategic in nature, the fact that these are systematic across culture groups is noteworthy. Whether the attentional focus differences found in this study are due to strategic preferences or ability, these studies do not provide direct evidence that they lead to cultural differences in scene processing. Further research is necessary to establish whether cultural differences in attentional breadth cause cultural differences in scene processing.

Future research should also directly investigate attentional breadth differences using other direct measures of attentional breadth such as functional field of view. It is unfortunate that the current study does not allow us to conclude anything specific about the spatial extent of these attentional biases. It is possible that at certain eccentricities, both cultures perform similarly. Studies parametrically varying the degree of expansion and shrinkage in visual change detection can possibly establish whether there is a range of eccentricities in which both cultures operate similarly.

It is interesting that in both experiments, neither culture group showed a configuration effect. That is, individuals were not more accurate on trials in which configurations were preserved (same, expand, and shrink) compared to trials in which configurations were disrupted (random). Many factors may have contributed to the divergent findings between the studies reported here and the original work by Jiang et al. (2000) that found configuration effects, including but not limited to differences in psychophysical parameters (e.g., shorter encoding times) and sampling characteristics.[5] Therefore, cultural differences in how spatial relationships are encoded and maintained in visuospatial working memory cannot be ruled out. However, the current experiment provides no direct evidence for cultural differences in relational processing.

Another issue that future research needs to address is the generalizability of these findings. As with most cross-cultural studies investigating East Asian and Western differences in cognitive performance (e.g., Chua et al., 2005; Gutchess et al., 2006; Miyamoto, Nisbett, & Masuda, 2006), the sample used in our study was selected from East Asians who had moved to the United States in the past few years, mostly for education purposes. Even though such a group represents a subsample of the general East Asian population, we believe that finding our effects in an immigrant population is even more impressive, given that these individuals may have been partially acculturated to the mainstream Western culture. Nevertheless, future research should directly address whether our findings replicate among East Asians living in East Asia.

Previous work suggests several possible explanations for cultural differences in attentional breadth. One possibility is that although East Asians are typically part of complex, interdependent social networks with prescribed role relations that require them to play close attention to surroundings, Westerners live in social worlds that emphasize individuality and independence (Markus & Kitayama, 1991; Nisbett, Peng, Choi & Norenzayan, 2001). It is possible that such differences might lead East Asians to develop an attentional bias through which they distribute their attention to a broader region.

A second possibility is that East Asians and Westerners experience different physical environments. In one study of American and Japanese scenes (Miyamoto et al., 2006), for example, both objective and subjective measures suggested that Japanese scenes are more complex and have fewer clear boundaries than American scenes. Even though it is not directly established that these findings—on Japanese cities being more complex than American cities—generalize to other East Asian cities, it can be argued that living in more complex environments may lead East Asians to attend broadly. By contrast, living in contexts where objects are more easily distinguishable from their contexts may lead Westerners to focus more on objects rather than backgrounds. Indeed, Westerners have been reported to have an object bias; while encoding complex scenes, Americans engage the object-processing neural regions more than East Asians do (Gutchess et al., 2006). It is possible that this object bias could also be explained by Americans focusing in on the center if the target objects in scenes appeared consistently in more central than peripheral locations.

The two experiments reported here add to a growing body of research demonstrating that culture influences basic information processing as well as higher cognition and social interactions. Further research is needed to establish why these cognitive differences emerge and under what real-world circumstances they are manifested.

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[5]When results from these experiments are compared with results of Jiang, Olson, and Chun (2000), who reported a configuration effect, one striking difference emerges. Even though participants in both studies achieve similar levels of accuracy, their small yet experienced sample ($N = 7$, with most having participated in other visual change detection studies) seems to have false-alarmed less than our group, resulting in higher d' estimates. Additional attempts to replicate the configuration effect using the same parameters as the two experiments reported here proved to be futile (Boduroglu & Shah, 2005).

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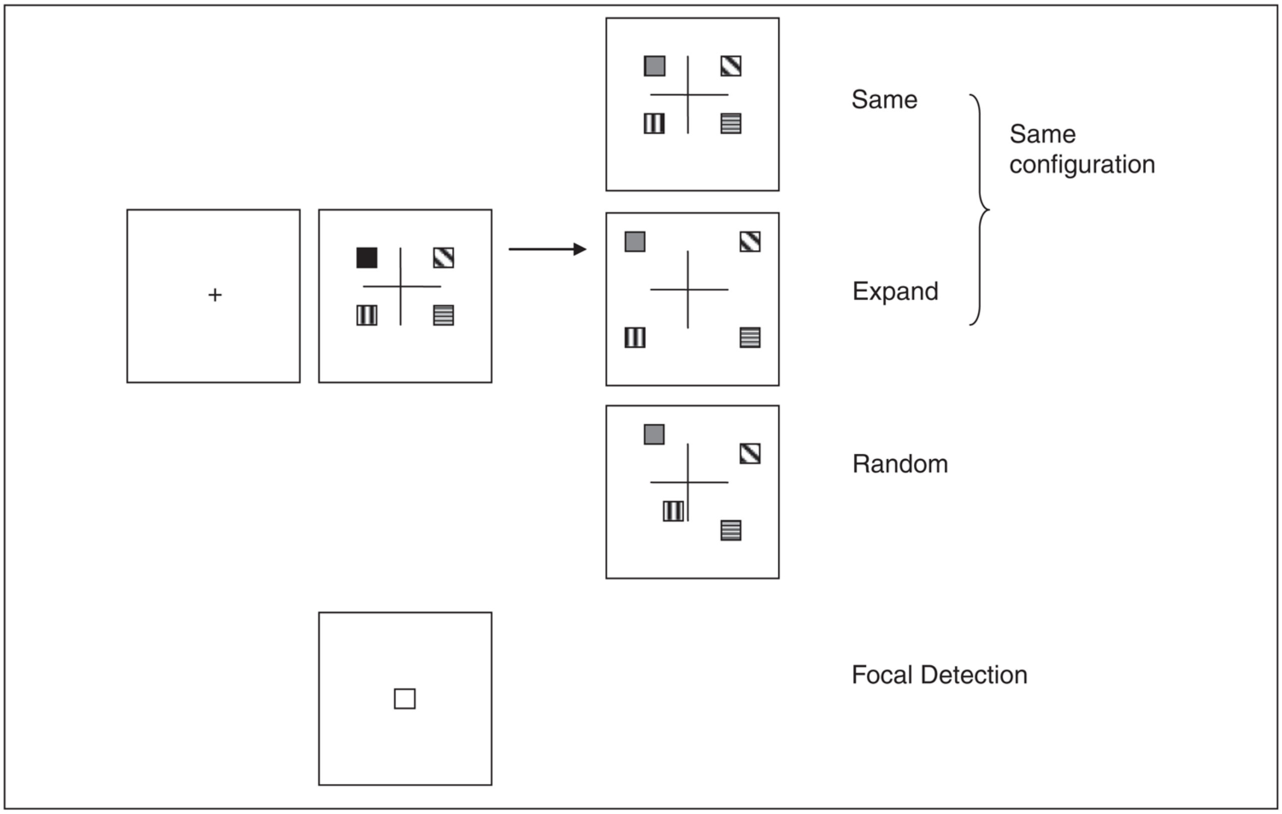

Figure 1. Outline of Experimental Conditions
Note: Different shadings on different squares represent the different colors used in the experiments.

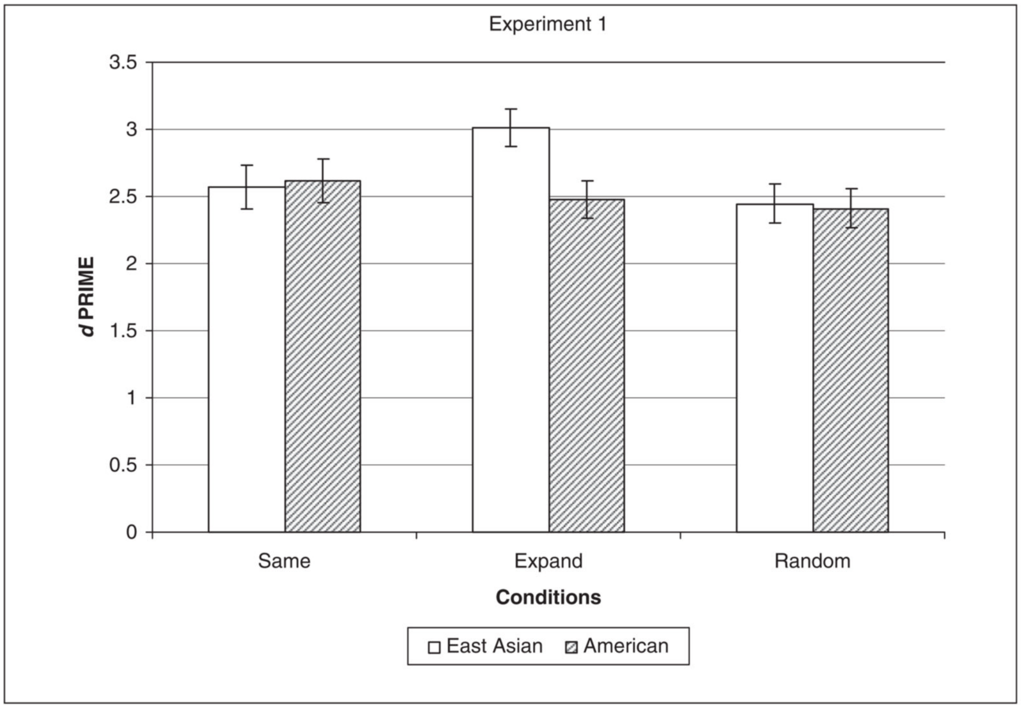

Figure 2. Experiment 1: Sensitivity for the Three Experimental (Same, Expand, Random) Conditions

Note: Error bars represent standard errors of the mean.

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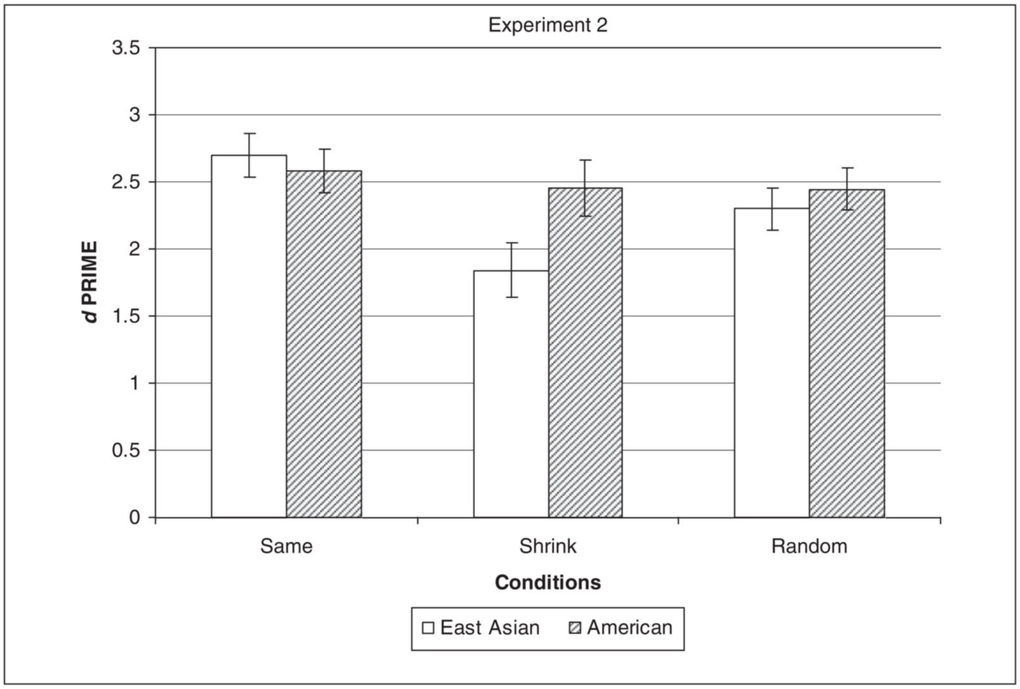

Figure 3. Experiment 2: Sensitivity for the Three Experimental (Same, Shrink, Random) Conditions

Note: Error bars represent standard errors of the mean.

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Table 1

Statistical Analyses Results

	df	*F*	MSE	*p*	p_{rep}	η_p^2
Experiment 1						
Condition	2, 104	3.6	.35	< .05	.91	.065
Culture	1, 52	0.96	1.17	*ns*	.58	.016
Culture × Condition	2, 104	3.97	.35	< .05	.93	.071
Experiment 2						
Condition	2, 64	6.05	.34	< .05	.98	.159
Culture	1, 32	1.34	.89	*ns*	.67	.040
Culture × Condition	2, 64	3.36	.34	< .05	.89	.095