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FlashReport

A processing advantage associated with analytic perceptual tendencies: European Americans outperform Asians on multiple object tracking

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ABSTRACT

Analytic visual processing and holistic visual processing have been conceptualized in terms of attention to focal objects vs. the background. We expand the study of perceptual biases associated with these attentional patterns using the *multiple object tracking* task, which measures people's ability to track multiple moving target objects amidst otherwise identical distractors. We test two competing hypotheses: (1) Asians' more frequent eye saccades will enable them to quickly cycle through the multiple target objects before the objects move too far away, giving them another perceptual advantage; and (2) European Americans' tendency to focus attention on the focal objects while inhibiting attention to less important objects might facilitate tracking of multiple moving objects. We find that European Americans significantly outperform Asians on multiple object tracking. The research expands the conceptualization of analytic processing and holistic processing to include *selective attention* as a key component, a facet that has not been previously identified.

Introduction

Over the past decade, psychologists have documented substantial cultural variation in basic visual attention. An attentional pattern in which perceivers devote more attention to focal objects than to background objects and do not perceptually bind focal objects with the background is called *analytic*, and is common among people in European American contexts. In contrast, an attentional pattern in which perceivers distribute attention evenly to focal and background objects and bind focal objects with the background is called holistic, and is common among people in Asian contexts (Ji, Peng, & Nisbett, 2000; Kitayama, Duffy, Kawamura, & Larsen, 2003; Masuda & Nisbett, 2001, 2006; Miyamoto, Nisbett, & Masuda, 2006). Attentional differences are evident even in basic eye movements—Americans make more eye fixations to focal objects in a visual scene, whereas Asians make more eye saccades to background objects (Chua, Boland, & Nisbett, 2005). The terms *analytic* and *holistic* do not refer to causal latent constructs at the level of the individual – performance on different tasks is often uncorrelated across individuals (Na et al., 2010) – but instead are descriptive labels that summarize the patterns of attention that are common within particular cultural contexts (Borsboom, Mellenbergh, & van Heerden, 2003; Cervone, 2005).

The differences between Asians' and European Americans' attentional styles can help explain cultural differences in some important perceptual biases. For example, Asians have greater expertise at detecting changes in a scene, and thus are less susceptible to *change blindness* (Chua et al., 2005; Masuda & Nisbett, 2006; Miyamoto et al., 2006). In the present research, we use another perceptual task – one that involves dynamic selective attention – and ask whether the holistic attention that is associated with better performance on change detection will facilitate or impair performance on this task requiring selective attention.

Multiple object tracking is a task that measures people's ability to track moving target objects amidst otherwise identical distractors (Pylyshyn, 1989, 1994; Pylyshyn & Storm, 1988). This task has been extensively used to investigate dynamic object-based visual attention (Cavanagh & Alvarez, 2005). In a typical multiple object tracking task, participants are shown a number of identical objects that are moving around in a two-dimensional space, and are asked to track some number of those objects for a certain duration. While the number of objects that people can successfully track varies with many parameters, such as the spatial separation between targets (Franconeri, Jonathan, & Scimeca, 2010), research suggests that people's tracking capacity likely follows a narrow normal distribution with a mean of about four objects (Oksama & Hyönä, 2004).

Although multiple object tracking is conceptualized as a basic visual–attentional process, research suggests that people's tracking skill is influenced by experience. For example, Allen, McGeorge, Pearson, and Milne (2004) found that radar operators, that is, people who use "radar to monitor, control and supervise aircraft," and thus "are required to keep track of multiple objects moving in many different directions" (Allen et al., 2004, 337), performed better on multiple object tracking than undergraduate students. Further, Green and

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Bavelier (2006) found that training individuals to play action video games increased their multiple object tracking skills. That women perform less well on multiple object tracking skills compared to men can be explained, in part, by women's relative lack of action video game experience (Feng, Spence, & Pratt, 2007). Given that the cultural context – the social and physical environment that people inhabit – shapes people's experiences continuously, we tested whether there might be cultural differences in performance on multiple object tracking.

Previous research affords contrasting predictions about whether the analytic or the holistic pattern of attention would be associated with an advantage in multiple object tracking. Proposing a serial processing model, Oksama and Hyönä (2008) provided evidence that people keep track of target objects by sequentially cycling attention from one target object to another, while storing the identity–location associations of the non-attended target objects in an episodic memory buffer. Further, Zelinsky and Neider (2008) found that when tracking more than two objects, people sequentially switch gaze from one target object to another, and the speed of gaze switching is correlated with tracking accuracy. Therefore, the tendency to make more eye saccades to different objects in the visual field (Chua et al., 2005) might enable Asians to quickly cycle through the target objects before the objects move too far away, giving Asians an advantage in tracking moving targets compared to European Americans.

Alternatively, if European Americans selectively focus attention on more important objects, then they might be likely to perform better than Asians on multiple object tracking. Previous research has found that enhanced attention to target objects and inhibited attention to distractors lead to superior performance on multiple object tracking (Bettencourt & Somers, 2009; Pylyshyn, 2006). For example, Doran and Hoffman (2010, Experiments 1 and 3) asked participants to do a standard multiple object tracking task, but at random intervals, a flash was presented either on a target, on a distractor, or in the empty space. They measured brain event-related potential during the task and found that the N1 component (an indicator of allocation of visual attention) was enhanced for flashes that occurred on targets and was suppressed for those that occurred on distractors. These findings indicate that multiple object tracking involves selectively focusing on target objects while suppressing distractors. If European Americans engage in selective attention to a greater extent than Asians, then they might be more effective than Asians at tracking multiple moving objects. We tested these two competing predictions in the present study.

Method

Participants

Participants were 35 European Americans (25 women, 10 men) and 30 international Asians (13 women, 17 men) studying at Stanford University. Asian students had grown up in India, Pakistan, Sri Lanka, or Nepal.

Procedure

Our multiple object tracking task was closely based upon that of Dye and Bavelier (2010, Experiment 3). Participants were positioned on a chin rest 60 cm from a 21-inch Apple Macintosh computer screen. The experiment was administered using MATLAB v7.6 using the Pyschophysics Toolbox. Each trial began with 16 circles (each subtending .4° visual angle) in a circular dark gray background (subtending 10° visual angle from its center). Participants had to press a key to begin a trial. At this point, some of the circles were cued (colored blue) while the rest stayed gray. The circles then began moving randomly in the horizontal–vertical plane at a speed of 5°/s. Participants were instructed to attend to the blue circles. After 2 s, the blue circles changed to gray, leaving all 16 circles indistinguishable. The circles never touched each other or overlapped one another, repelled one another before contact, and were repelled by the outer edges of the background and by the center fixation circle. Participants had to track the target circles for 5 s, at which point all circles stopped moving. At this point, either one of the target circles or one of the distractor circles (with equal probability) turned white, and participants had to indicate whether the probed circle was a target or a distractor (see Fig. 1 for an illustration of the task timeline, taken from Pylyshyn, 2004, p.802).

The progression of trials was determined by an adaptive algorithm designed to converge on participants' attentional capacity (as in Dye & Bavelier, 2010, Experiment 3). Only one circle was cued on the first trial. If participants responded correctly on three consecutive trials, the number of cued circles was increased by one (up to a maximum of 8 targets). The number of cued circles was reduced by one if participants responded incorrectly on any trial (up to a minimum of 1 target). The task ended either after 50 trials or if participants made 8 correct–incorrect reversals, whichever occurred earlier.

Results

We computed participants' multiple object tracking score by averaging the number of cued circles on the last 10 correct trials (as in Dye & Bavelier, 2010, Experiment 3). A *t*-test found that Americans successfully tracked more objects on average than Asians, $t(63) = 2.71$, $p < .01$, Cohen's $d = .68$; for Americans, $M = 4.22$, $SD = 1.21$; for Indians, $M = 3.50$, $SD = .86$. We next conducted an ANCOVA that tested whether this cultural difference is robust after controlling for a number of factors that have been previously shown to influence attentional capacity: gender (Feng et al., 2007), field of study (humanities/social sciences = −1; undecided = 0; science/engineering = 1; Towle et al., 2005), and number of hours of action video games per week played in the past year (Green & Bavelier, 2006). Neither gender, $F(1, 60) =$

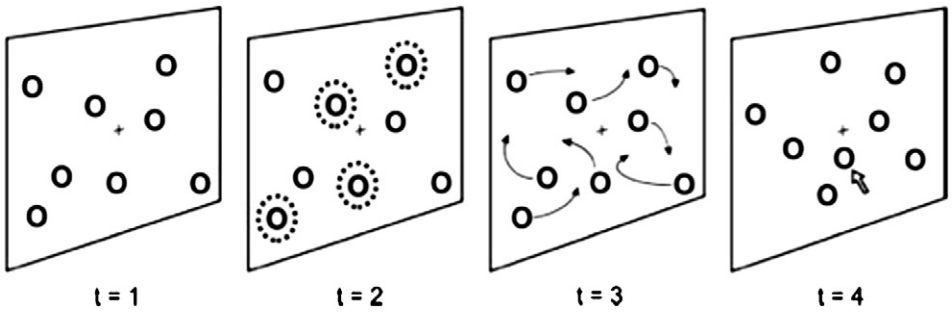

Fig. 1. Sequence of events in the multiple object tracking task. All circles are colored gray and stationary (t = 1; note that number of circles in figure differs from number used in experiment). Some circles are then colored blue (indicated by shaded circles in t = 2). The circles then start moving and after 2 s, the blue circles change to gray (t = 3). After another 5 s, the circles stop moving and one of the circles is colored white (indicated by the arrow at t = 4). Participants indicate whether the probe circle was one of the circles initially colored blue or not. (Adapted from Pylyshyn, 2004, p.802.)

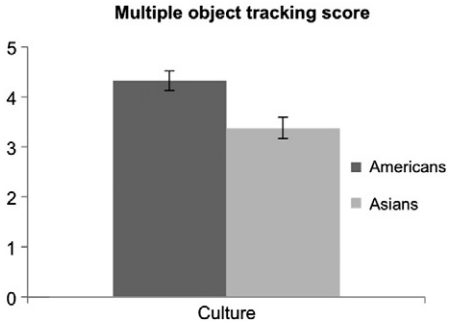

Fig. 2. Multiple object tracking score (adjusted marginal means) by culture. Error bars depict standard error of the mean.

0.23, p > .63, nor major, $F(1, 60) = 1.14$, $p > .29$, nor action videogame history, $F(1, 60) = .01$, $p > .92$, was a significant predictor. Notably, culture was a significant predictor even after controlling for these variables, $F(1, 60) = 9.11$, $p < .005$, adjusted marginal means = 4.32 vs. 3.39 (see Fig. 2). An additional ANCOVA indicated that culture did not interact with gender, action video game history, or field of study, interaction p's > .14.

Discussion

We found that European Americans could track 28% more moving objects, or about one more moving object, than Asians, documenting substantial cultural variation in multiple object tracking. Apparently, Asians' superior performance on change detection does not reflect generally enhanced attentional skills. Instead, superior performance at change detection comes at the expense of an ability to distinguish more goal-relevant objects from less goal-relevant objects, even in the absence of a significant background. This finding of superior performance by European Americans suggests that the concept of analytic processing includes an enhanced capacity for *selective attention*—focusing attention on designated focal objects without being distracted by less relevant focal objects.

Previous theorizing has primarily distinguished analytic attention and holistic attention on the basis of attention to focal objects or the background (Nisbett & Masuda, 2003; Nisbett & Miyamoto, 2005). However, the contrast between Asians' enhanced performance on change detection but impaired performance on multiple object tracking suggests another important dimension that can be used to distinguish analytical and holistic processing: the dispersion of attention between more vs. less goal-relevant objects. Asians focus attention both on more and less relevant objects, leading to reduced change blindness but to worse multiple object tracking, whereas European Americans focus attention on more relevant objects instead of less relevant ones, leading to greater change blindness (as the background is usually less relevant) but better multiple object tracking (as they can better distinguish more vs. less relevant focal objects).

Future research could also examine environmental factors that differentially shape people's multiple object tracking skills in different cultures. For example, Miyamoto et al. (2006) found that compared to American physical environments, Japanese physical environments contain more objects and have objects that are closer together and harder to distinguish from each other. In an experiment, the researchers found that participants (both American and Asian) who viewed a large number of Japanese scenes showed reduced change blindness compared to those who viewed a large number of American scenes. The researchers concluded that densely packed Japanese environments broaden the span of people's visual attention.

Similarly, it is likely that the greater unpredictability of the movement of physical objects in many Asian environments might play a role in a person's relatively poor multiple object tracking skills. For example, in many densely populated Asian cities, road traffic is highly disorganized, with many cars, motorcycles, scooters, bicycles, people, and in some cases, even animals, often moving in relatively unpredictable directions, and even suddenly commencing or ceasing motion (e.g., Yang, Deng, Wang, Li, & Wang, 2006). Successful navigation in such environments might require broadly distributed attention that can quickly assess movements of many different objects in the visual field. However, this same pattern of attention might be a handicap when tracking a few moving objects while ignoring others. In contrast, an environment with more predictability would allow people to focus on the goal-relevant target objects while ignoring distractors. Future research might test whether the length of time immigrants spend in Asia or in the U.S. influences their multiple object tracking ability. Further, using virtual reality techniques, participants might be asked to simulate navigation in Asian or American cities and then administered the test of multiple object tracking. An intriguing question then arises: Might the unpredictability of the social environment, not just the physical environment, also shape multiple object tracking?

Of course, these cultural differences in visual attention are not fixed or essential—they likely reflect expertise gained through habitual experience with one type of processing over another. Making sense of any event or scene is likely to involve both types of processing, depending on what constructs are accessible in memory or what type of attention is demanded by the context (Oyserman, Sorensen, Reber, & Chen, 2009).

Cultural experience seems to make people in Asian cultural contexts and Western cultural contexts better at different tasks related to perceiving the world—Holistic processing is associated with reduced change blindness but also impaired object tracking, whereas analytical processing is associated with increased change blindness but also superior object tracking. Holistic processing may be an outgrowth of a cultural perspective that holds that all objects in the field are interdependent and can have an influence on each other. Holistic processing then operates from a logic of inclusion and fosters an expertise in seeing relations among objects. Analytic processing, in contrast, is a likely correlate of a cultural perspective that holds that objects in the field are independent and can be separated from one another. This type of processing operates on the logic of exclusion and creates an expertise in rejecting some objects as not relevant. For example, Asians' reduced ability to focus on target objects while ignoring targets that are not immediately goal-relevant might make them slower in contributing to a discussion because of relatively greater difficulty in deciding what is a relevant point and what is a distracting issue (Kim & Markus, 2002). Similarly, this tendency might explain cultural differences in the extent to which people's judgments of a target person's emotional expression are influenced by the emotions of other people in their surroundings (Masuda et al., 2008). In the domain of online social networks, Asians might be more distracted by information about friends of one's friends, whereas European Americans might be more focused in tracking information about important others.

The finding that European Americans are better than Asians at tracking goal-relevant objects might reflect broader cultural differences in processing information based on the individuals' own goals, preferences, and beliefs. Perhaps European Americans are better skilled at focusing on information of personal relevance, whereas Asians distribute attention across both personally relevant and non-relevant information. Future research could test whether cultural differences in attention to goal-relevant objects generalize beyond visual attention to the social domain. Overall, these newly identified cultural differences in attention to more vs. less goal-relevant objects may be useful mechanisms for explaining a variety of powerful cultural influences on social behavior.

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References

Allen, R., McGeorge, P., Pearson, D., & Milne, A. B. (2004). Attention and expertise in multiple target tracking. *Applied Cognitive Psychology*, *18*, 337–347.

Bettencourt, K. C., & Somers, D. C. (2009). Effects of target enhancement and distractor suppression on multiple object tracking capacity. *Journal of Vision*, *9*, 1–11.

Borsboom, D., Mellenbergh, G. J., & van Heerden, J. (2003). The theoretical status of latent variables. *Psychological Review*, *110*, 203–219.

Cavanagh, P., & Alvarez, G. A. (2005). Tracking multiple targets with multifocal attention. *Trends in Cognitive Sciences*, *9*, 349–354.

Cervone, D. (2005). Personality architecture: Within-person structures and processes. *Annual Review of Psychology*, *56*, 423–452.

Chua, H. F., Boland, J. E., & Nisbett, R. E. (2005). Cultural variation in eye movements during scene perception. *Proceedings of the National Academy of Sciences*, *102*, 12629–12633.

Doran, M. M., & Hoffman, J. E. (2010). Target enhancement and distractor suppression in multiple object tracking. *Visual Cognition*, *18*, 126–129.

Dye, M. W., & Bavelier, D. (2010). Differential development of visual attention skills in school-age children. *Vision Research*, *50*, 452–459.

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science*, *18*, 850–855.

Franconeri, S. L., Jonathan, S. V., & Scimeca, J. M. (2010). Tracking multiple objects is limited only by object spacing, not by speed, time, or capacity. *Psychological Science*, *21*, 920–925.

Green, C. S., & Bavelier, D. (2006). Enumeration versus object tracking: Insights from video game players. *Cognition*, *101*, 217–245.

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

Kim, H. S., & Markus, H. R. (2002). Freedom of speech and freedom of silence: An analysis of talking as a cultural practice. In R. Shweder, M. Minow, & H. R. Markus (Eds.), *Engaging cultural differences: The multicultural challenge in liberal democracies* (pp. 432–452). New York: Russell Sage Foundation.

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

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

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

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

Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and physical environment: Holistic versus analytic perceptual affordances. *Psychological Science*, *17*, 113–119.

Na, J., Grossman, I., Varnum, M. E. W., Kitayama, S., Gonzalez, & Nisbett, R. E. (2010). Cultural differences are not always reducible to individual differences. *Proceedings of the National Academy of Sciences*, *107*, 6192–6197.

Nisbett, R. E., & Masuda, T. (2003). Culture and point of view. *Proceedings of the National Academy of Sciences*, *100*, 11163–11175.

Nisbett, R. E., & Miyamoto, Y. (2005). The influence of culture: Holistic vs. analytic perception. *Trends in Cognitive Sciences*, *9*, 467–473.

Oksama, L., & Hyönä, J. (2004). Is multiple object tracking carried out automatically by an early vision mechanism independent of higher-order cognition? An individual difference approach. *Visual Cognition*, *11*, 631–671.

Oksama, L., & Hyönä, J. (2008). Dynamic binding of identity and location information: A serial model of multiple identity tracking. *Cognitive Psychology*, *56*, 237–283.

Oyserman, D., Sorensen, N., Reber, R., & Chen, S. X. (2009). Connecting and separating mind-sets: Culture as situated cognition. *Journal of Personality and Social Psychology*, *97*, 217–255.

Pylyshyn, Z. W. (1989). The role of location indexes in spatial perception: A sketch of the FINST spatial-index model. *Cognition*, *32*, 65–97.

Pylyshyn, Z. W. (1994). Some primitive mechanisms of spatial attention. *Cognition*, *50*, 363–384.

Pylyshyn, Z. W. (2004). Some puzzling findings in multiple object tracking (multiple object tracking): I. Tracking without keeping track of object identities. *Visual Cognition*, *11*, 801–822.

Pylyshyn, Z. W. (2006). Some puzzling findings in multiple object tracking (multiple object tracking): II. Inhibition of moving nontargets. *Visual Cognition*, *14*, 175–198.

Pylyshyn, Z. W., & Storm, R. (1988). Tracking multiple independent targets: Evidence for a parallel tracking mechanism. *Spatial Vision*, *3*, 1–19.

Towle, E., Mann, J., Kinsey, B., O'Brien, E. J., Bauer, C. F., & Champoux, R. (2005). Assessing the self efficacy and spatial ability of engineering students from multiple disciplines. *35th ASEE/IEEE Frontiers in Education Conference, S2C* (pp. 15–20).

Yang, J., Deng, W., Wang, J., Li, Q., & Wang, Z. (2006). Modeling pedestrians' road crossing behavior in traffic system micro-simulation in China. *Transportation Research Part A*, *40*, 280–290.

Zelinsky, G. J., & Neider, M. B. (2008). An eye movement analysis of multiple object tracking in a realistic environment. *Visual Cognition*, *16*, 553–566.