Automatic Mechanisms for Social Attention Are Culturally Penetrable

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Abstract

Are mechanisms for social attention influenced by culture? Evidence that social attention is triggered automatically by bottom-up gaze cues and is uninfluenced by top-down verbal instructions may suggest it operates in the same way everywhere. Yet considerations from evolutionary and cultural psychology suggest that specific aspects of one's cultural background may have consequence for the way mechanisms for social attention develop and operate. In more interdependent cultures, the scope of social attention may be broader, focusing on more individuals and relations between those individuals. We administered a multi-gaze cueing task requiring participants to fixate a foreground face flanked by background faces and measured shifts in attention using eye tracking. For European Americans, gaze cueing did not depend on the direction of background gaze cues, suggesting foreground gaze alone drives automatic attention shifting; for East Asians, cueing patterns differed depending on whether the foreground cue matched or mismatched background cues, suggesting foreground and background gaze information were integrated. These results demonstrate that cultural background influences the social attention system by shifting it into a narrow or broad mode of operation and, importantly, provides evidence challenging the assumption that mechanisms underlying automatic social attention are necessarily rigid and impenetrable to culture.

Keywords: Social attention; Gaze cueing; Automaticity; Culture; Evolution; Calibration; Cognitive penetrability; Eye tracking

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1. Introduction

Across cultures, individuals must locate objects that impact survival and reproduction. Critically, individuals are not limited to what they can directly see or know. What *other* people attend to can provide valuable information about where an object is and how important it might be. Attending to where others are attending—an ability known as social attention—is especially influenced by gaze cues. Evidence that systems underlying gaze cueing are automatic (Friesen & Kingstone, 1998; Hood, Willen, & Driver, 1998), early developing (Farroni, Massaccesi, Pividor, & Johnson, 2004), and evolutionarily ancient (Deaner & Platt, 2003) may presuppose their invariance across cultures. But are these systems necessarily resistant to cultural influences? By examining responses to gaze cues, we tested whether the social attention system is *culturally penetrable*.

The central cueing paradigm is commonly used to study social attention (Birmingham & Kingstone, 2009; Frischen, Bayliss, & Tipper, 2007). It is well established that gaze from a single face reflexively shifts attention, producing a *cueing effect*: Participants detect targets faster on congruent trials, when a gaze cue looks to the side where the target eventually appears, than on incongruent trials, when it looks to the opposite side (Friesen & Kingstone, 1998; Hood et al., 1998). Because gaze direction is completely uninformative (50% valid; Friesen & Kingstone, 1998) or counterpredictive to target side (20% valid; Downing, Dodds, & Bray, 2004; Driver et al., 1999), cueing effects suggest cue direction triggers the mechanism underlying the effect in an automatic or stimulus-driven fashion. Importantly, this effect does not persist indefinitely but depends on stimulus onset asynchrony (SOA)—length of time between gaze cue onset and target onset. Effects typically appear as early as 200 ms (Friesen & Kingstone, 1998) and last up to 700 ms (Driver et al., 1999), decaying (Friesen & Kingstone, 1998) or reversing (Frischen, Smilek, Eastwood, & Tipper, 2007) at longer SOAs. We will refer to SOAs under 700 ms as the automatic interval of social attention.

A striking finding from cultural psychology is that cultural differences exist in basic cognitive processes (see Nisbett, Peng, Choi, & Norenzayan, 2001, for review), including those relevant to the social attention system. East Asians tend to fixate on and remember details about background faces or objects more than Westerners (Masuda & Nisbett, 2001; Masuda et al., 2008), likely due to the stronger emphasis on interdependence in East Asia compared to North America (Kuhnen & Oyserman, 2002; Lin & Han, 2008; Markus & Kitayama, 1991). Event-related potential (ERP) research shows that compared to Asian Americans, European Americans show larger frontal N2 responses 310–330 ms after object presentation, indicating more focused attention in early attentional processes (Kitayama & Murata, 2013). Thus, cultural differences have been shown not only in later strategic processes of attention, but also in earlier attentional processes,[1] suggesting that scope of attention may be broader in general for East Asians than North Americans.

Yet when it comes to social attention, there are empirical and theoretical reasons for thinking the underlying processes are cognitively impenetrable or uninfluenced by goals and beliefs (Pylyshyn, 1984).[2] Empirically, automatic gaze cueing persists even when participants believe the cue is unrelated (Friesen & Kingstone, 1998) or counterpredictive

(Driver et al., 1999) to where the target appears. Theoretically, impenetrability ensures that the system is not overwhelmed with information to process. If information from anywhere in the mind influenced social attention, processing would be crippled by combinatorial explosion because mechanisms would have to process more information than time or resources allow. This point is magnified for processes such as gaze cueing that must occur rapidly and online in which time and resources are especially limited.

Although the social attention system may be resistant to explicit information about cue validity and to information implicit in the task (e.g., 50% validity of the cue), under certain conditions "top-down" information can penetrate the social attention system. The cueing effect is stronger for participants who are familiar with target faces than for those who are unfamiliar with the same set of target faces, but only among female participants (Deaner, Shepherd, & Platt, 2007), who generally tend to be more sensitive to social cues (Geary, 1998). The cueing effect may also be sensitive to social status, given that people show a stronger gaze cueing effect for faces they learned were high versus low status (from reading fabricated curriculum vitae), regardless of the specific identity of the faces (Dalmaso, Pavan, Castelli, & Galfano, 2012; Pavan, Dalmaso, Galfano, & Castelili, 2011). By demonstrating that the same stimuli can be processed differently depending on information encoded in the participant's mind about the familiarity or status of the gaze cue, these studies suggest that the system may be cognitively penetrable.

Yet these investigations leave some open questions. First, prior studies can also be explained without appealing to top-down effects, challenging the cognitive penetrability interpretation. In the case of familiarity, stronger gaze cueing to familiar faces could occur because of top-down effects on social attention directly or because perceptual expertise develops for familiar faces, producing better encoding, which has downstream effects on social attention (Deaner et al., 2007). In the case of status, moderation effects could again occur because of top-down effects or because people are less motivated to look at the eyes of low-status faces (Dalmaso et al., 2012). Second, although these results provide evidence that immediate context (social status information) and recent environmental history (familiarity) can influence social attention, an open question is whether more distal environmental factors, those that extend further back in one's environmental history such as culture, can have lasting effects on social attention. Third, even if these studies possibly demonstrate top-down influences on social attention, a theoretical framework that explains why and how these effects occur is missing.

In order to explain prior results and motivate the current experiment, we integrate perspectives from evolutionary and cultural psychology, starting with the idea that the mind is equipped with evolved mechanisms that are calibrated by information in the local environment (Sperber, 1994; Tooby & Cosmides, 1992). When aspects of the environment vary, a fixed mechanism may fail to function adaptively across different conditions. Therefore, mechanisms that can be calibrated by cues from the environment may evolve, optimizing or fitting the mechanism to different environments. There is increasing evidence, especially in social domains, that environments program mechanisms for attachment, stress response, language acquisition, and dimensions of personality. What these domains have in common is environmental variation; for instance, systems for attachment

and stress response are programmed differently depending on level of adversity in the early social environment (Belsky, Steinberg, & Draper, 1991; Boyce & Ellis, 2005), language systems are programmed differently depending on what speech sounds and grammar are present in the language environment (Pinker, 1994), and mechanisms underlying personality are programmed differently depending on one's own phenotypic features (Lukaszewski & Roney, 2011).

In the domain of social attention, the most effective way to process gaze cues may vary depending on aspects of the cultural environment to the extent that they provide information about what would be important to attend to. Among several key factors, cultural norms about the self as being more or less interdependent and connected to others (Markus & Kitayama, 1991) may carry information about the importance—in the culture —of focusing on others and what they are attending to. Computationally, cues associated with interdependence norms, including verbal and non-verbal behaviors of people in the local culture, may be key inputs for regulating how social attention—in the individual— focuses on others and what they attend to. Because these interdependence norms happen to differ across cultures, this may have consequence for how social attention is programmed.

One specific way in which culture may cause social attention to vary involves the processing of multiple gaze cues. Given that the social complexity of group living often requires attending to multiple individuals at once, mechanisms underlying social attention may be engineered to handle gaze information across several individuals. But the scope of social attention, or how many social cues and relations between cues a person can simultaneously attend to and integrate, may be open to environmental input. The stronger interdependence norm of anticipating others' needs (Mojaverian & Kim, 2013) and acting in accordance with others' goals (Miller, Das, & Chakravarthy, 2011) in East Asia (vs. North America) might calibrate the scope of attention (Nisbett et al., 2001), leading East Asians to attend more broadly to social cues than North Americans, even at the automatic level in social attention shifting.

In this study, our goals were two-fold. First, given that cueing research has primarily used a single face, but social encounters often involve assessing gaze across multiple individuals, we used multiple gaze cues in a novel task to examine whether varying the social information *surrounding* a central face can illuminate how the social attention system works (Fig. 1). Manipulating background gaze cues to either match or mismatch a central gaze cue allowed us to test a boundary condition of the cueing effect: Is the cueing effect influenced by competing background information surrounding the central cue? Second, and more important, we examined whether the effect of background social cues depends on culture: Are mechanisms underpinning social attention calibrated to attend to and integrate across social information more broadly in East Asian than in Western cultures? To examine this question, we used a task of covert attention, or attention shifting without accompanying eye movements (Jonides, 1981), rather than overt attention, or attention shifting with accompanying eye movements. This task provided a conservative test of our research question because it would require that cultural differences in attention occur covertly, before the eyes have time to move. Meeting this goal would help address
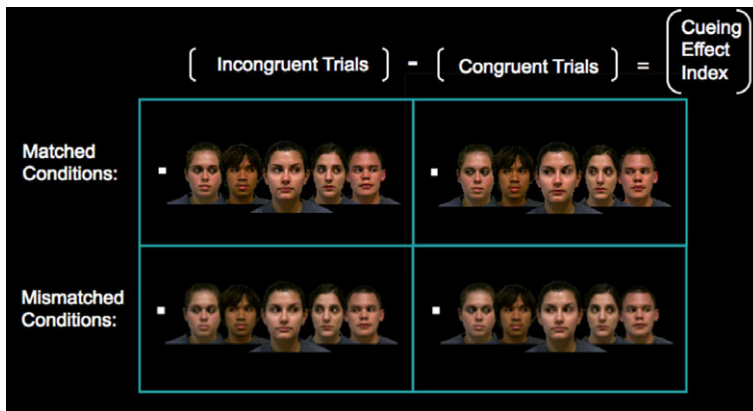
Fig. 1. Foreground gaze cue was either incongruent (left column) or congruent (right column) with target and either matched (top row) or mismatched (bottom row) background gaze cues. The cueing effect index is calculated by taking reaction times on incongruent trials and subtracting reaction time on congruent trials.

the set of open questions raised by previous research and, by taking an integrated cultural-evolutionary perspective, would provide one of the first accounts synthesizing findings on the penetrability of social attention.

On the basis of the theoretical and empirical considerations discussed earlier, we tested competing hypotheses. The cultural impenetrability hypothesis proposes top-down cultural factors are unable to penetrate the social attention system; therefore, it predicts that in both cultures the cueing effect should appear within the automatic cueing interval, but dissipate outside this interval (Friesen & Kingstone, 1998; Frischen, Smilek, et al., 2007). In contrast, the cultural penetrability hypothesis predicts that culture shapes how social attention develops and operates by shifting the system into one of at least two modes of operation: for East Asians, a broader mode that leads background cues to influence the cueing effect during the automatic cueing interval, and for European Americans, a narrower mode that prevents background cues from influencing automatic cueing.

The cultural penetrability account has two subhypotheses. One possibility is that, for East Asians, who are predicted to attend more broadly (both foreground and background) than European Americans (foreground only), some minimal amount of time must elapse in order to extend covert attention over background cues and process them with enough precision. This would be consistent with research demonstrating tradeoffs between how well and how many stimuli can be processed at short intervals (Bays & Husain, 2008; Zhang & Luck, 2011). These tradeoffs may become less severe under longer SOAs when there is more time to shift attention across multiple items and process them with greater precision. Therefore, on the late-acting subhypothesis, the background may influence cueing for East Asians only in the later part of the automatic cueing interval (i.e., at the medium SOA). However, if the tradeoff is minor even under short time intervals, then less time may be necessary to capture background information with precision. Therefore, on the early-acting

subhypothesis, background cues may influence the cueing effect for East Asians from the start of the automatic cueing interval (i.e., at both short and medium SOAs).

2. Method

2.1. Participants

We tested 82 participants: 41 East Asians born and raised for 16+ years in China, Japan, or Korea (M_{age} = 21.2 years, SD_{age} = 1.78; 25 females) and 43 European Americans born in the United States with at least one parent born in the United States (M_{age} = 19.7 years, SD_{age} = 1.28; 18 females). Two additional participants were excluded: One fell three standard deviations above the group average for trial outliers, anticipations, and expirations (Table 1), and one failed to follow instructions. Participants were students enrolled at an American university and received course credit or a gift card for participation.

2.2. Apparatus and stimuli

Eye movements were recorded at 50 Hz using a corneal reflection eye tracker (Tobii x50; Tobii Technology, Stockholm, Sweden). Through E-Prime Extensions for Tobii (version 2.0.8.22), E-Prime software (version 2.0.8.90; Psychology Software Tools Inc., Pittsburgh, PA, USA) interfaced with the eye tracker and controlled stimulus presentation on a 30-inch, 1,920 × 1,200 pixel TFT LCD monitor with the participant positioned 57–60 cm away. The foreground face was centrally presented onscreen with four peripheral background faces. On each trial, five faces were randomly selected from an image bank

Table 1
Eye tracking analysis for trial outliers, anticipations, expirations, and target fixation

	Criteria	Percentage of All Trials (%)
Outlier trials	Reaction time to detect target was 2 *SD* above or below the grand mean across all trials for each participant at each SOA	6.20 (East Asians) 7.41 (European Americans)
Anticipation trials	Reaction time to detect target was <100 ms	0.85 (East Asians) 0.32 (European Americans)
Expiration trials	2,000 ms expired before fixation of target	2.57 (East Asians) 2.60 (European Americans)
Target fixation trials	Fixation within area of interest (AOI: 150 × 150 pixels centered on target) overlaying target (30 × 30 pixels) for 200 ms of continuous looking; 200 ms not included in reaction time from target onset to target fixation	Remaining trials after removing outliers, anticipations, and trial expirations

Table 2
Stimuli measurements

Stimuli	Measurements (Degrees of Visual Angle)
Background faces	
Distance from screen midline to center of image	
Leftmost face	17.3°
Second leftmost face	9.4°
Rightmost face	17.3°
Second rightmost face	9.4°
Image size	
Whole face (left to right edge of face)	7.5°
Eye region (leftmost part of left eye to rightmost part of right eye)	4.3°
Left eye (leftmost to rightmost part of left eye)	1.8°
Foreground face	
Distance from screen midline to center of image	0°
Image size	
Whole face (left to right edge of face)	9.9°
Eye region (leftmost part of left eye to rightmost part of right eye)	5.9°
Left eye (leftmost to rightmost part of left eye)	2.1°
Target	
Distance from screen midline to center of image	25.4° (left or right side)
Image size	1.6°

Notes. Because we used images of real faces, which had minor differences in the size of their facial features, we calculated values by averaging measurements from two randomly selected trials.

of 12 faces varying in gender and ethnicity, and the target was a white square (stimuli measurements in Table 2).

2.3. Design and procedure

We used a novel multi-gaze cueing task in which competing background gaze cues flanked a central face in a 2 (Matching condition: matched vs. mismatched) × 3 (SOA: 200 vs. 600 vs. 1,000 ms) × 2 (Culture: East Asian vs. European American) design with repeated measures on the first two factors. The 200, 600, and 1,000 ms SOAs are referred to as short, medium, and long SOAs, respectively, with the first two falling within the automatic cueing window. There were 520 trials total: 240 test (20 per condition), 240 filler, and 40 catch trials evenly distributed across four blocks, producing 130 trials per block. On test trials, cues did not predict where the target appeared (50% valid) or when it appeared (the SOA was selected randomly without replacement), setting up a test of automatic attention shifting (Friesen & Kingstone, 1998; Posner, 1980). Foreground and background faces gazed equally often to the left and right, and the target appeared equally often on the left and right. Filler trials were similar to test trials except foreground or background faces displayed direct rather than averted (left or right) gaze. These were included

Table 3
Means and standard errors of absolute reaction times by cue direction (foreground–background), stimulus onset asynchrony (SOA), and culture

	Matching Condition				Mismatching Condition			
	Congruent–Congruent		Incongruent–Incongruent		Congruent–Incongruent		Incongruent–Congruent	
	M (ms)	*SE* (ms)	*M* (ms)	*SE* (ms)	*M* (ms)	*SE* (ms)	*M* (ms)	*SE* (ms)
200 ms SOA								
European Americans	344.17	6.57	362.35	6.55	350.20	6.93	367.90	7.46
East Asians	351.51	6.41	373.31	8.77	350.98	6.75	374.12	8.28
600 ms SOA								
European Americans	337.01	5.28	345.29	6.20	332.20	5.02	346.87	5.97
East Asians	331.14	7.13	344.64	8.06	339.25	8.54	341.97	7.37
1,000 ms SOA								
European Americans	350.51	5.17	354.42	5.58	359.23	6.32	347.27	6.05
East Asians	350.16	8.25	353.46	7.87	345.32	7.37	350.30	7.06

to create stimulus diversity so that participants could not easily guess the gaze direction of future test trials. On catch trials, no target appeared. The purpose of the catch trial was to keep participants "honest" by checking that they were waiting for the target to appear before they moved their eyes, reducing the likelihood of anticipatory eye movements.

We measured reaction times (RTs) to detect the target, defined as duration between target onset and start of target fixation. After processing data for outliers, anticipations, and trial expirations (Table 1), we computed a cueing effect index for each condition by subtracting RTs on congruent foreground trials from RTs on incongruent foreground trials (Fig. 1; Table 3). A more positive index indicated a stronger cueing effect, an index not different from zero indicated no cueing effect, and a more negative index indicated a stronger reverse cueing effect.

Following a five-point calibration and practice round of 12 randomly selected trials, the test round included four blocks of trials separated by short rest periods. Participants were instructed before and after practice: "Look straight ahead until the target appears, and when the target appears, look at it as quickly as possible no matter what side it appears on." There were three phases in each test trial (Fig. 2). In the closed phase, participants saw five faces with eyes closed. Using gaze-contingent eye tracking, after the participant looked within an area of interest around the central eyes for 500 ms, the cue phase began. In the cue phase, eyes gazed left or right. Background cues gazed in the same direction but were unrelated to foreground gaze direction. In the target phase, cues remained onscreen while the target appeared on the left or right after 200, 600, or 1,000 ms from cue onset. Participants had to move their eyes to the target as quickly as possible and fixate it for 200 ms to end the trial. Trials expired after 2,000 ms if the participant failed to fixate the target.

Although the task involved an eye movement to the target during the target phase, participants had to rely on covert rather than overt attention (Jonides, 1981) to register
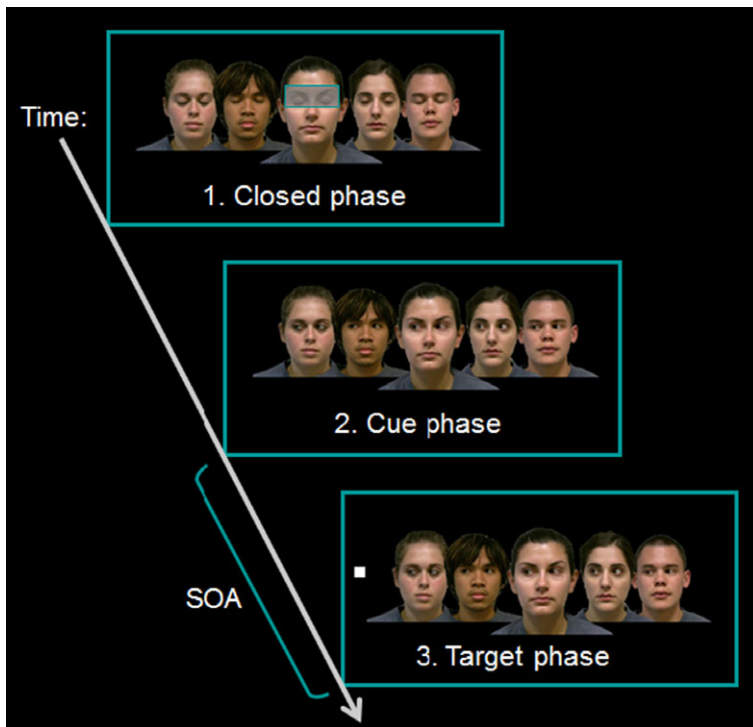
Fig. 2. Structure of test trial. During closed phase, participants must look in area of interest depicted with transparent window (not visible to participants). SOA, stimulus onset asynchrony.

background gaze cues before the target appeared. We predicted that cultural differences in covert social attention during the cue phase, when foreground and background gaze information appeared, would influence the speed to detect the target during the target phase.

3. Results

A mixed ANOVA yielded a main effect of SOA, $F(2, 164) = 16.9$, $p < .001$, $\eta_p^2 = .171$, and consistent with the cultural penetrability hypothesis, an interaction between matching condition, SOA, and culture, $F(2, 164) = 4.36$, $p = .014$, $\eta_p^2 = .051$. To examine the interaction, we analyzed the data at each SOA separately. At the short SOA, a two-way ANOVA (culture × matching condition) produced no main effects or interactions (all ps > .477; Fig. 3), suggesting that the cueing effect magnitude did not differ between groups in the matched or mismatched condition. Additionally, in both cultures cueing effects were significantly above zero as demonstrated by one-sample t-tests against zero under matched conditions (European Americans: $t(42) = 5.55$, $p < .001$, $d = 0.85$; East

(a) Matched conditions
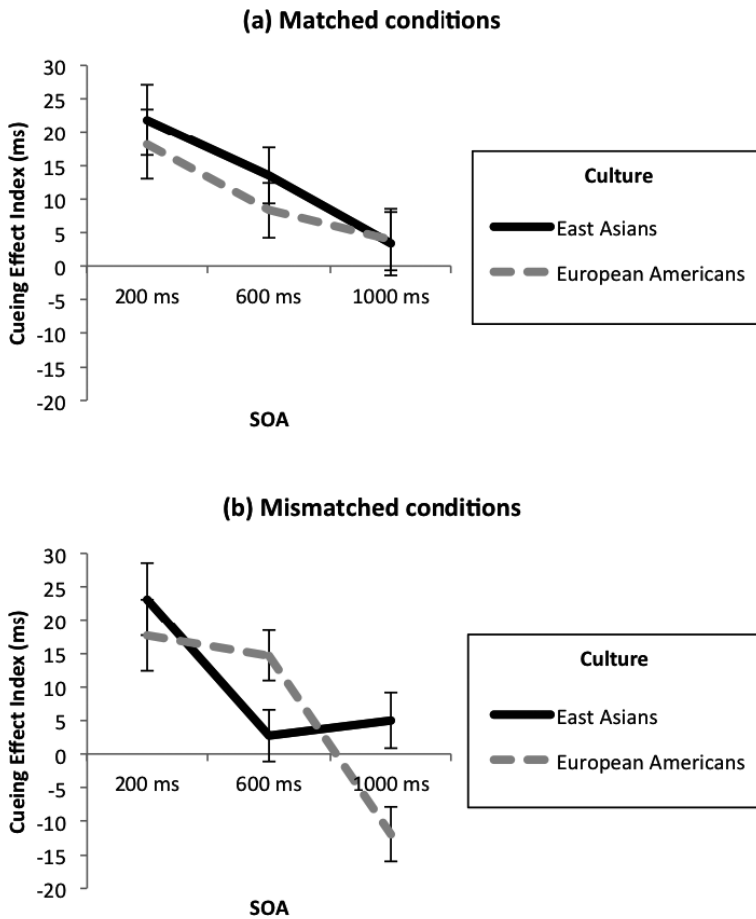

(b) Mismatched conditions

Fig. 3. Cueing effect index as a function of culture and SOA for (A) matched conditions and (B) mismatched conditions. Error bars represent *SEM*.

Asians: $t(40) = 3.19$, $p = .003$, $d = 0.50$) and mismatched conditions (European Americans: $t(42) = 3.63$, $p = .001$, $d = 0.55$; East Asians: $t(40) = 3.93$, $p < .001$, $d = 0.61$).

Critically, at the medium SOA, there was an interaction between culture and matching condition, $F(1, 82) = 5.01$, $p = .028$, $\eta_p^2 = .058$ (Fig. 3). Consistent with the late-acting cultural penetrability hypothesis, there was a significant cultural difference in the cueing effect under mismatched conditions, $t(82) = 2.23$, $p = .028$, $d = 0.49$. When foreground and background mismatched, not only did the magnitude of cueing effects differ, but also the European Americans continued to produce a cueing effect significantly above zero, $t(42) = 4.50$, $p < .001$, $d = 0.69$, whereas the cueing effect disappeared for East Asians, $t(40) = 0.63$, $p = .530$.[3] Subsequent analysis revealed no cultural difference in cueing effect magnitude under matched conditions, $p = .375$, and significant or marginally sig-

nificant cueing effects above zero for both cultures (European Americans: $t(42) = 1.93$, $p = .059$, $d = 0.30$; East Asians: $t(40) = 3.39$, $p = .002$, $d = 0.53$).

At the longest SOA, there was an interaction between culture and matching condition, $F(1, 82) = 4.45$, $p = .038$, $\eta_p^2 = .051$ (Fig. 3). Although all cueing effects either disappeared or reversed, there was a significant cultural difference in cueing effect magnitude under mismatched conditions, $t(82) = -2.93$, $p = .004$, $d = 0.64$. European Americans produced a reverse cueing effect, $t(42) = -3.36$, $p = .002$, $d = 0.51$, whereas for East Asians the cueing effect disappeared, $t(40) = 1.09$, $p = .284$. Under matched conditions, cueing effects disappeared for both cultures ($ps > .348$).[4]

4. Discussion

This study demonstrated that surrounding background gaze cues can interfere with automatic attention shifting to a central gaze cue, and thus, the gaze cueing effect may be modulated by background social information. However, the nature of this effect depended on culture. At the medium SOA, conflicting background gaze cues interfered with attention shifting to a central gaze cue only among East Asians. Within 600 ms, East Asians integrated foreground and background cues, producing reaction time costs when cues mismatched. For European Americans, background gaze did not appear to influence cueing at short and medium SOAs; it was as if those cues were invisible. This evidence supports the (late-acting) cultural penetrability hypothesis that mechanisms for social attention are configured by cultural input to adjust the attentional field of view, shifting into one of two modes of operation: Cultural environments like those in the West cause the social attention system to adopt a narrower setting, whereas Eastern cultural environments cause it to adopt a broader setting. In this case, attending more broadly could indicate that East Asians were either attending to more gaze cues or attending more to the relations between cues (whether they match or mismatch) and then integrating across them (cf. Masuda & Nisbett, 2001; Nisbett et al., 2001). An interesting direction for future research is to explore these possibilities. The absence of a cultural difference at 200 ms suggests that under time constraints, there is a tradeoff between quantity of cues processed and quality of processing. A minimum amount of time, between 200 and 600 ms, must elapse before multiple background cues can be processed with enough precision to influence processing of the foreground cue among East Asians during the automatic window of gaze cueing.

At longer SOAs, when automatic social attention turns off and volitional cueing turns on, European American and East Asian participants' gaze cueing patterns also showed different cueing signatures. For European Americans, it was not until the longest SOA, after automatic cueing had decayed, that conflicting background information interfered with the cueing effect in the mismatched condition. This is consistent with research showing that cueing effects decay (Friesen & Kingstone, 1998) or reverse (Frischen, Smilek, et al., 2007) at longer SOAs. Although we did not expect the cueing effect to decay for one cultural group and reverse for the other, research on the reverse cueing effect (inhibi-

tion of return) suggests that presenting an additional, unrelated cue following the gaze cue (i.e., changing background color surrounding a central face; Frischen, Smilek, et al., 2007) may contribute to inhibition of return at longer SOAs. In the current study, background faces may have served as this additional cue for European Americans at the longest SOA, moving their attention in the opposite direction, where their attention had not been previously. However, for East Asians, their attention would have already been swayed by the background earlier in time. Although the results at the longest SOA are intriguing and were not predicted ahead of time, they ultimately concern volitional attention, whereas our account primarily focuses on automatic mechanisms supporting social attention. The connection between automatic and volitional social attention, and whether this interacts with culture, are important directions for future research.

Is it possible that East Asian participants executed more eye movements to the background faces before the target appeared, influencing the cueing effect at the medium SOA? To address this, we ran follow-up analyses comparing how much the cultural groups looked at the background faces. Analyses revealed no significant differences in how long or often the groups looked at the background during the automatic window of attention.[5] Because the stimuli were not designed to examine how much participants look at the background (e.g., the faces weren't spaced optimally for the resolution limits of the tracker), these results should be interpreted with caution. Yet there are several reasons why a cultural difference in eye movements during the automatic cueing window is unlikely. First, gaze-contingent tracking prevented participants from moving their eyes before the cues appeared, and instructions were provided to look center until the target appeared. Second, during cueing tasks, participants tend not to move their eyes before responding to the target (Posner, 1980). Third, it would have likely interfered with their performance as it does on manual detection tasks (Friesen, Ristic, & Kingstone, 2004), predicting longer absolute RTs for East Asians. Given that the overall raw RTs between groups (East Asians: $M = 350.51$ ms, $SE = 6.81$ ms; European Americans: $M = 351.39$ ms, $SE = 5.31$ ms) did not differ statistically (NHST: $t(82) = 0.085$, $p = .932$; Bayesian analysis: Bayes factor = 13:1 in favor of the hypothesis that the RTs do not differ vs. the hypothesis that the RTs differ—considered "strong" odds), it seems unlikely that East Asian participants were moving their eyes, or at least no more so than European Americans; otherwise their performance would have been slower relative to the European American group. Fourth, with respect to overt attention, there is recent evidence to suggest that eye movements in East Asians and European Americans, although not identical in all respects, may be similar with respect to eye movement patterns and how long they look at background information (Evans, Rotello, Li, & Rayner, 2009; Rayner, Castelhano, & Yang, 2009; Rayner, Li, Williams, Cave, & Well, 2007; but see also Boland, Chua, & Nisbett, 2008 and Chua, Boland, & Nisbett, 2005). Together, these considerations suggest that the cultural effects are driven by differences in covert attention between the two groups, not pre-target eye movements.

Background cues could have influenced the cueing effect for East Asians by either enhancing it when the background matched the foreground, interfering with it when they mismatched, or both. In this study, only interference was found, which is consistent with

previous research showing that multiple congruent cues fail to influence the cueing effect (Capozzi, Bayliss, Elena, & Becchio, 2014). One reason why background cues may not have strengthened the cueing effect when they matched the foreground cue is that the cueing effect may have already been at ceiling at the medium SOA and could not be further strengthened. A second possibility is that when background cues are redundant with the foreground cue, as in the matched condition, social attention mechanisms may turn off subroutines for integrating across the cues.

Consistent with our first goal, these findings demonstrate how the social attention system integrates multiple gaze cues. Although research has shown that multiple (vs. single) gaze cues looking in the same direction do not modulate the cueing effect, they do modulate affective evaluations of a target object (Capozzi et al., 2014). By manipulating multiple background gaze cues to either match or mismatch a central gaze cue, the current study is the first to demonstrate that background social information, which should also command attention, can interfere with the automatic cueing effect. Notably, if only European Americans were tested, we would have drawn the tentative but erroneous conclusion that background gaze cues do not affect central gaze cueing automatically.

Considering our second goal, our findings suggest that the scope of culture's influence on attention includes not only strategic attention, but also automatic mechanisms of social attention. Although prior evidence suggested that social attention is uninfluenced by information in memory, such as instructions about cue predictiveness (Driver et al., 1999; Friesen & Kingstone, 1998), and is therefore cognitively impenetrable, our findings fall consistent with more recent studies supporting cognitive penetrability (Dalmaso et al., 2012; Deaner et al., 2007), demonstrating that the system is also culturally penetrable, or shaped by the cultural environment. Cultural inputs relevant to social attention are likely engrained in certain systems repeatedly, if implicitly, across the life span. It is possible that the social attention system is sensitive to specific classes of information, such as cultural norms about what is important to attend to in the social world (current study) or relative status of one's own group relative to another (Dalmaso et al., 2012). Given that social class, or group status, can be considered a form of culture (Cohen, 2009; Kraus, Piff, & Keltner, 2011), previous findings of top-down influences on the cueing effect may be synthesized within a broader sociocultural framework. The social attention system may process gaze cues automatically, but then process relations between cues only to the extent that they are meaningful to the person perceiving the stimulus (Bruner, 1957, 1973), and thus, "top-down" experiences may calibrate the system to attend more broadly or narrowly to different "bottom-up" stimuli relevant to social attention.

This research on how the social attention system functions within the sociocultural environment may also have implications for understanding cultural transmission more broadly. Cultural factors associated with construal of self may influence cognitive processes (e.g., Kuhnen & Oyserman, 2002), including social attention, and at the same time, social attention may contribute to the development of one's own construal of self via more or less attention to others. The mutual influence of social attention and these key cultural factors may then contribute to the broader cultural environment, which in turn

reinforces patterns of social attention in others. Thus, social attention may be a crucial process involved in the cultural transmission of construal of self.

The psychological adaptation underpinning social attention develops early and reliably, has a phylogenetic basis, and carries a specialized function (Birmingham & Kingstone, 2009; Deaner & Platt, 2003; Farroni et al., 2004). It is often assumed, incorrectly, that mechanisms with this profile are rigid in two respects: They are anti-developmental, or steady across development (Gopnik & Meltzoff, 1997; Shea, 2012), and pan-cultural, or invariant across cultures (Lewontin, Rose, & Kamin, 1984; Shea, 2012). The anti-developmental charge has been challenged by research showing that psychological adaptations have evolved to develop and operate in ways governed by developmental environments (Belsky et al., 1991; Boyce & Ellis, 2005; Lukaszewski & Roney, 2011; Pinker, 1994). The current research challenges the other pillar of the rigidity assumption by demonstrating that evolved mechanisms, such as those supporting social attention, are not resistant to culture, but may be designed to be shaped by it.

Notes

1. Although these processes occur early in processing, whether they are automatic is unclear because the research was not designed to test for automatic processing.
2. We use "cognitive impenetrability" broadly to mean not only that goals and beliefs stored in working memory are blocked from influencing online processes and changing their output, but also that they are blocked from influencing developmental processes and changing developmental outcomes.
3. The absent cueing effect at the medium SOA under mismatched conditions for East Asians could have been due to either interference from incongruent background cues with a congruent central cue or facilitation from congruent background cues with an incongruent central cue. We tested between these possibilities by examining raw scores from congruent and incongruent trials that went into the cueing effect index. East Asians incurred a cost on congruent trials when the background mismatched compared to when it matched the congruent cue, $t(40) = 2.23$, $p = .032$, $d = 0.35$, rather than a gain on incongruent trials when the background mismatched compared to when it matched the incongruent cue, $p = .528$.
4. An anonymous reviewer asked whether the greater proportion of females in the East Asian group could explain the differences between the cultural groups. To explore this possibility, we re-ran the analysis with sex as a between-subjects fac-

tor. There were no main effects or interactions involving sex (all $ps > .14$). In particular, the three-way interaction between SOA, matching condition, and sex failed to reach significance ($p = .28$). We did not find evidence that the greater number of East Asian females drove the observed differences in social attention between the groups.

5. For the analysis, we chose to include eye movements during the cue and target phases, starting with the onset of the cues and ending with the start of the saccade toward the target, because it covered the entire window of time when eye movements could have occurred during a trial and set up a more sensitive test for detecting differences between cultural groups. We ran two analyses: one looking at durations, computed by summing of length of all fixations to the background, and one looking at visits, computed by counting the number of fixations to the background.

References

Bays, P. M., & Husain, M. (2008). Dynamic shifts of limited working memory resources in human vision. *Science*, *321*, 851–854. doi:10.1126/science.1158023

Belsky, J., Steinberg, L., & Draper, P. (1991). Childhood experience, interpersonal development, and reproductive strategy: An evolutionary theory of socialization. *Child Development*, *62*, 647–670.

Birmingham, E., & Kingstone, A. (2009). Human social attention. *Annals of the New York Academy of Sciences*, *1156*, 118–140. doi:10.1111/j.1749-6632.2009.04468.x

Boland, J. E., Chua, H. F., & Nisbett, R. E. (2008). How we see it: Culturally different eye movement patterns over visual scenes. In K. Rayner, D. Shen, X. Bai, & G. Yan (Eds.), *Cognitive and cultural influences on eye movements* (pp. 363–378). Tianjin, China: Tianjin People's Publishing House.

Boyce, W. T., & Ellis, B. J. (2005). Biological sensitivity to context: I. An evolutionary-developmental theory of the origins and functions of stress reactivity. *Development and Psychopathology*, *17*, 271–301.

Bruner, J. S. (1957). On perceptual readiness. *Psychological Review*, *64*, 123–152.

Bruner, J. S. (1973). *Beyond the information given: Studies in the psychology of knowing*. Oxford, UK: W. W. Norton.

Capozzi, F., Bayliss, A. P., Elena, M. R., & Becchio, C. (2014). One is not enough: Group size modulates social gaze-induced object desirability effects. *Psychonomic Bulletin & Review*, *22*, 850–855. doi:10.3758/s13423-014-0717-z

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 of the United States of America*, *102*, 12629–12633. doi:10.1073/pnas.0506162102

Cohen, A. B. (2009). Many forms of culture. *American Psychologist*, *64*, 194–204. doi:10.1037/a0015308

Dalmaso, M., Pavan, G., Castelli, L., & Galfano, G. (2012). Social status gates social attention in humans. *Biology Letters*, *8*, 450–452. doi:10.1098/rsbl.2011.0881

Deaner, R. O., & Platt, M. L. (2003). Reflexive social attention in monkeys and humans. *Current Biology*, *13*, 1609–1613. doi:10.1016/j.cub.2003.08.025

Deaner, R. O., Shepherd, S. V., & Platt, M. L. (2007). Familiarity accentuates gaze cuing in women but not men. *Biology Letters*, *3*, 64–67. doi:10.1098/rsbl.2006.0564

Downing, P. E., Dodds, C. M., & Bray, D. (2004). Why does the gaze of others direct visual attention? *Visual Cognition*, *11*, 71–79. doi:10.1080/13506280344000220

Driver, J., Davis, G., Kidd, P., Maxwell, E., Ricciardelli, P., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. *Visual Cognition*, *6*, 509–540.

Evans, K., Rotello, C. M., Li, X., & Rayner, K. (2009). Scene perception and memory revealed by eye movements and receiver-operating characteristic analyses: Does a cultural difference truly exist? *Quarterly Journal of Experimental Psychology*, *62*, 276–285. doi:10.1080/17470210802373720

Farroni, T., Massaccesi, S., Pividor, D., & Johnson, M. H. (2004). Gaze following in newborns. *Infancy*, *5*, 39–60. doi:10.1207/s15327078in0501_2

Friesen, C. K., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin & Review*, *5*, 490–495.

Friesen, C. K., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. *Journal of Experimental Psychology: Human Perception and Performance*, *30*, 319–329.

Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze-cueing of attention: Visual attention, social cognition and individual differences. *Psychological Bulletin*, *133*, 694–724.

Frischen, A., Smilek, D., Eastwood, J. D., & Tipper, S. P. (2007). Inhibition of return in response to gaze cues: The roles of time-course and fixation cue. *Visual Cognition*, *15*, 881–895. doi:10.1080/13506280601112493

Geary, D. C. (1998). *Male, female: The evolution of human sex differences*. Washington, DC: American Psychological Association.

Gopnik, A., & Meltzoff, A. N. (1997). *Words, thoughts, and theories*. Cambridge, MA: MIT Press.

Hood, B. M., Willen, J. D., & Driver, J. (1998). Adult's eyes trigger shifts of visual attention in human infants. *Psychological Science*, *9*, 131–134.

Jonides, J. (1981). Voluntary vs. automatic control over the mind's eye's movement. In J. B. Long & A. D. Baddeley (Eds.), *Attention and performance IX* (pp. 187–203). Hillsdale, NJ: Erlbaum.

Kitayama, S., & Murata, A. (2013). Culture modulates perceptual attention: An event-related potential study. *Social Cognition*, *31*, 758–769. doi:10.1521/soco.2013.31.6.758

Kraus, M. W., Piff, P. K., & Keltner, D. (2011). Social class as culture: The convergence of resources and rank in the social realm. *Current Directions in Psychological Science*, *20*, 246–250. doi:10.1177/0963721411414654

Kuhnen, U., & Oyserman, D. (2002). Thinking about the self influences thinking in general: Cognitive consequences of salient self-concept. *Journal of Experimental Social Psychology*, *38*, 492–499.

Lewontin, R. C., Rose, S., & Kamin, L. J. (1984). *Not in our genes*. New York: Pantheon Books.

Lin, Z., & Han, S. (2008). Self-construal priming modulates the scope of visual attention. *Quarterly Journal of Experimental Psychology*, *62*, 802–813. doi:10.1080/17470210802271650

Lukaszewski, A. W., & Roney, J. R. (2011). The origins of extraversion: Joint effects of facultative calibration and genetic polymorphism. *Personality and Social Psychology Bulletin*, *37*, 409–421. doi:10.1177/0146167210397209

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review*, *98*, 224–253.

Masuda, T., Ellsworth, P. C., Mesquita, B., Leu, J., Tanida, S., & Van de Veerdonk, E. (2008). Placing the face in context: Cultural differences in the perception of facial emotion. *Journal of Personality and Social Psychology*, *94*, 365–381. doi:10.1037/0022-3514.94.3.365

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.

Miller, J. G., Das, R., & Chakravarthy, S. (2011). Culture and the role of choice in agency. *Journal of Personality and Social Psychology*, *101*, 46–61. doi:10.1037/a0023330

Mojaverian, T., & Kim, H. S. (2013). Interpreting a helping hand: Cultural variation in the effectiveness of solicited and unsolicited social support. *Personality and Social Psychology Bulletin*, *39*, 88–99. doi:10.1177/0146167212465319

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

Pavan, G., Dalmaso, M., Galfano, G., & Castelili, L. (2011). Racial group membership is associated to gaze-mediated orienting in Italy. *PLoS ONE*, *6*, 325608. doi:10.1371/journal.pone.0025608

Pinker, S. (1994). *The language instinct*. New York: Harper.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, *32*, 3–25.

Pylyshyn, Z. W. (1984). *Computation and cognition: Towards a foundation for cognitive science*. Cambridge, MA: MIT Press.

Rayner, K., Castelhano, M. S., & Yang, J. (2009). Eye movements when looking at unusual/weird scenes: Are there cultural differences? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*, 254–259. doi:10.1037/a0013508

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

Shea, N. (2012). New thinking, innateness and inherited representation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*, 2234–2244. doi:10.1098/rstb.2012.0125

Sperber, D. (1994). The modularity of thought and the epidemiology of representations. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 39–67). New York: Cambridge University Press.

Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 19–136). New York: Oxford University Press.

Zhang, W., & Luck, S. J. (2011). The number and quality of representations in working memory. *Psychological Science*, *22*, 1434–1441. doi:10.1177/0956797611417006