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Are you mad at me? Social anxiety and early visual processing of anger and gaze among Asian American biculturals

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Abstract

Eyes are not universally attended to across different populations. Directly looking at the eyes of other people is a socially constrained behavior in many non-Western countries. Furthermore, perceiving emotions and faces are culturally regulated processes (Elfenbein and Ambady, in Psychol Bull 128(2):203–235, 2002; Caldara, in Curr Direct Psychol Sci 26(3):249–255, 2017). This study aims to bridge the gap between the cross-cultural and social cognition literature on gaze and threatening eye perception by understanding the relations between the early visual event-related potentials (ERPs) and social anxiety among Asian American biculturals. EEG was recorded from Asian American undergraduates while they watched isolated eye stimuli under four conditions: Angry Expression with an Averted Gaze, Angry Expression with a Direct Gaze, Neutral Expression with an Averted Gaze, and Neutral Expression with a Direct Gaze. The P1 ERP was sensitive to the combined effect of eye gaze and expression such that the largest amplitudes were recorded during the Angry-Averted eye condition. In contrast, no differences among the four conditions were found for the N170. Furthermore, we found an indirect effect between interdependent self-construal and social anxiety mediated by the P1. Interdependent self-construal was associated with smaller P1 s, which were related to greater social anxiety. The indirect effect supports the Asian American double bind (Lau et al., in Cult Divers Ethnic Minor Psychol 15(1), 77–85, 2009) and identifies a neural mechanism of lessened attention to eyes that may mediate increased social unease. These results emphasize the important role of culture in emotion perception via the eyes.

Keywords Eye gaze · Eye expression · Emotion · Event-related potentials · P1 · Asian Americans · Bicultural · Social cognition

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Introduction

The subtle messages perceived in others' eyes are culturally bound and may be particularly fraught with error and anxiety for bicultural individuals who are navigating two cultural worlds. Cultural and social norms influence the way people perceive the world, including the novel and familiar faces that surround them. Perceiving others' eyes, in particular, serves a distinct social and emotional function. According to the social cognition literature, perceiving eyes facilitates the ability to read facial expressions quickly (Frischen et al. 2007; Itier and Batty 2009), which is key to inferring another person's identity, thoughts, and feelings (Lee and Anderson 2017). Asian Americans and Asians living in the US might struggle to balance two conflicting cultural norms and expectations. In many East Asian contexts, direct eye contact can be perceived as threatening and disrespectful, and averted eye gaze is more appropriate. However, in many Western contexts, the reverse is true. The proficiency in perceiving the eyes of others may have social consequences. The current study sought to understand the role of early visual event-related potentials (ERPs) in the processing of eye gaze, eye expression, and cultural self-construals in predicting social anxiety in a bicultural Asian American sample.

Bicultural orientation: Asian Americans and the double bind

Culture has the power to shape not only worldviews but also broad psychological functions like perception, attention, and cognition (Hofstede 2003; Markus and Kitayama 1991; Varnum et al. 2010). The constructs of individualism and collectivism, as well as independent and interdependent self-construal, have been extensively studied, particularly among Asian American biculturals who navigate between Asian, collectivist values of 'homeland' and American, individualist cultural values. Interdependence and collectivist cultures value connectedness and interpersonal relationships while independence and individualist cultures are marked by self-reliance and self-actualization (Markus and Kitayama 1991; Triandis 1989). Collectivism and individualism often function orthogonally (Oyserman et al. 2002), thus individuals can be low in collectivism and high in individualism, or, as is often the case with Asian biculturals residing in the U.S., relatively high in both collectivism and individualism.

Asian cultures prioritize group harmony and attunement to other's emotions. For Asians and Asian American biculturals, accurate emotion recognition is key to maintaining an interdependent self-construal and group harmony. If an ingroup member is upset or angry, one (especially of lower status) adjusts one's behavior to maintain harmony. Failure to recognize others' emotions threatens the group. Yet, Asian Americans, when compared to European Americans, showed lower recognition for negative emotions (Lau et al. 2009). A subsequent survey reported increased social anxiety. Furthermore, they are socialized through cultural norms and power dynamics to downregulate their emotions (Tsai 2007), perhaps because emotions can be detrimental to the group.

These findings support a theory of the Asian-American double bind—individuals with collectivist cultural backgrounds that have strict social norms regarding eye contact are less (not more) practiced at recognizing and displaying emotions. To compound the difficulty, Asian biculturals living in a diverse American society are required to read emotions in diverse others, many outside of the ingroup. In social contexts outside of the ingroup advantage (Beaupré and Hess 2006), the double bind of valuing attunement with lower ability to perceive emotion may be particularly consequential, thus highlighting the need to better understand the consequences of culture and emotion recognition.

Social anxiety

Indeed, one such consequence may be increased social anxiety. Higher social anxiety in Asian and Asian American populations is well documented (Fang et al. 2016; Hong and Woody 2007; Ho and Lau 2011; Norasakkunkit and Kalick 2002; Hsu and Alden 2007; Okazaki 1997, 2002; Schreier et al. 2010), including the cultural syndrome of tajinkyofusho in Japan (Chang 1997). Social anxiety is caused by distorted perceptions of social situations and emotion dysregulation and characterized by fear of negative evaluation and discomfort in social settings. Anxiety impairs executive functioning by increasing attention to threatening stimuli as well as reducing the processing efficiency of the perceived threat (Eysenck et al. 2007), negatively affecting mentalization (Hezel and McNally 2014). This pattern of automatic perceptual attention and subsequent cognitive avoidance is central to the hypervigilance-avoidance hypothesis. Indeed, people with social anxiety disorder (SAD) have higher activity in areas related to emotion, visual attention, and attentional control and lower activity in areas related to cognitive regulation compared to a control group when looking at socially threatening stimuli such as harsh expressions (Goldin et al. 2009). Individuals diagnosed with generalized social phobia show an attentional bias towards angry faces compared to neutral or happy faces (Mogg et al. 2004). This literature suggests one mechanism connecting culture and increased social anxiety, even at subclinical levels, may lie in faulty emotion recognition, in particular, hypervigilance to negative emotion.

Emotions and facial expressions

Perceptions of negative emotion may be informed by attending to the eyes. Making eye contact with another person activates the social brain network and facilitates cognitive and emotional processing, which allows us to recognize other people's thoughts and feelings, and consequently empathize with them (Senju and Johnson 2009). Eyes are processed configurally with other facial features rather than analytically, and studies propose that eyes—salient as early as 100 ms after viewing a photo of a face—might be the most important component of facial perception (Itier et al. 2007). According to numerous lesion, neuroimaging, and primate studies, eyes and gaze are processed along a largely posterior network involving the occipital lobe, superior temporal sulcus, fusiform gyrus, intraparietal sulcus, orbitofrontal cortex, and amygdala (Calder and Young 2005). Eye contact is

believed to cause stronger heart rate deceleration, shorter looking times, and higher ratings of arousal for both European and East Asian samples (Akechi et al. 2013).

Eye tracking studies highlight cultural differences in facial perception by analyzing specific regions of interest—in particular, the mouth, the eyes, and the nose. While some evidence supports the universal nature of processing faces and expressions (Ekman and Friesen 1971), emerging evidence suggests cultural specificity (see Caldara 2017 for a review). For example, Western Caucasians scan in a scattered, analytical, triangular pattern that traces over eyes, nose, and the mouth while East Asians adopt a more global strategy, focusing on the central nose region of the face while presumably configurally processing the eyes and mouth (Blais et al. 2008). Cultural differences in scanning the face have been proposed to underlie lower levels of facial recognition in East Asians (Jack et al. 2009). The "Reading the Mind in the Eyes" test consists of cropped photos of the eye region so that eyes and brows are the only source of affective information. Results from this task suggests that not only can people gather basic emotions such as fear and anger from the eyes alone, they can discern complex mental states such as revenge and desire as well (Baron-Cohen et al. 1997). Given the extensive research documenting the importance of reading eyes in the perception of emotional expressions (Adams and Kleck 2003, 2005), and the invariance in nose expression, we focused our study on perceiving eye expression and gaze in order to minimize potential cultural variability in focus of attention when processing faces.

Direct and averted gaze

Direct gaze leads to more accurate ratings of emotional intensity in pictures by a way of inducing self-awareness (Baltazar et al. 2014). Behavioral and electrophysiological evidence suggests that exposure to direct eye gaze stimuli has an affective priming effect (Chen et al. 2016). However, the meaning of eye contact is not universal but culturally specific. Making eye contact in the United States and most Western countries is regarded as an appropriate, if not crucial, part of social interactions. However, many African, Native American, and Asian cultures deem eye-contact as an inappropriate behavior due to various religious, historical, and social factors (Argyle and Cook 1976; Kleinke 1986). The history of Confucianism and tradition of respect for elders in East and Southeast Asian cultures prevail to this day as power dynamics. One example is possessing the social insight of knowing when to seek or avoid direct eye contact. Many Asian cultures socialize from an early age to lower their gaze in the presence of elders or authority figures as a sign of respect and humility. Specifically, lowering eyes is a normalized gesture in many Asian countries. While considering an answer to a question, Canadian and Trinidadian participants tended to look up while Japanese participants tended to shift their gaze down, consistent with their cultural norms (McCarthy et al. 2006). Given this, Asian Americans may be more sensitive to averted compared to direct gaze.

Anger and gaze

The expression of anger is prominent in the eye region and symbolizes a physical or social threat. The "anger superiority effect" posits that threatening facial expressions are more attentionally salient than friendly faces. Anger is often conceptualized as an approach-oriented emotion that is paired with direct gaze while fear is an avoidance-oriented emotion paired with averted gaze (Adams and Kleck 2005). One theory suggests incongruent emotion and gaze pairings (e.g., averted angry expression) raise ambiguity and potentially reduce perceptual capabilities. The interaction between anger and eye gaze seems to vary depending on the type of stimulus and task demand, although the pattern of results is not clear (see Hamilton 2016). In a classification task between two distinct emotions with direct and averted gaze, researchers found that participants generally identified angry expressions faster when looking at stimuli featuring a direct gaze compared to angry expressions with an indirect gaze (Bindemann et al. 2008). The delaying effect of averted eye gaze on recognition suggests that perception of gaze and expression are not only independent but sequential. Depending on the attentional demand of a stimulus with an ambiguous gaze, there may be less attention directed to processing expressions afterwards. Identifying emotional expression requires configural processing while detecting gaze direction only requires localized feature processing. For emotional expressions that are not easily discriminable, the direction of the gaze interferes with the subsequent emotion processing and judgement (Graham and LaBar 2012). This suggests a potential interaction between emotion and eye gaze for Asians and Asian Americans. Since averted gaze is culturally congruent, and thus readily detected, anger should be processed as particularly informative.

Event-related potentials

ERP have been shown to be sensitive to the cultural dimensions of processing affective stimuli (see e.g. Fong et al. 2014; Goto et al. 2013; Russell et al. 2015), and they are particularly useful for investigating the temporal dimension of the neural processing of facial expression. Early visual P1 and N170 ERP components have been found to be sensitive to emotional expressions (see Hajcak et al. 2011; Hinojosa et al. 2015 for reviews). In general, enhanced amplitudes are seen in response to emotional facial expressions relative to neutral facial expressions, especially when the facial expressions are negative (e.g. those expressing anger, disgust and fear). The P1 and N170 tend to be maximal at lateral posterior electrode sites. Additionally, there is an asymmetry in the scalp distribution, with larger amplitudes occurring on the right. The P1 is sensitive to negative facial expressions even when viewed passively or when presented in the peripheral field of vision (Carretié et al. 2004; Delplanque et al. 2004), which is consistent with the negativity bias in processing emotional stimuli. In addition, early ERPs in response to threatening expressions have generally been found to be greater in highly anxious participants (Fox et al. 2008; Hagemann et al. 2016; Li et al. 2005; Mueller et al. 2009; Rossignol et al. 2013).

With respect to eye gaze, the literature is less consistent. For the P1, some studies reported that direct gaze is related to larger P1 s (e.g., Conty et al. 2012) whereas others find that averted gaze is related to larger P1 s (e.g., Berchio et al. 2016; Schmitz et al. 2012), and some do not find an effect of gaze (Fichtenholtz et al. 2009; Nomi et al. 2013). The N170 has also been found to be sensitive to eye gaze is some studies (see e.g. Fichtenholtz et al. 2009), but not others (see Li et al. 2017; Nomi et al. 2013).

The current study sought to understand the associations between early visual ERPs and eye gaze, eye expression, cultural values, and social anxiety in Asian and Asian American biculturals. Based on the literature, we hypothesized that bicultural Asians and Asian Americans would be more sensitive to angry compared to neutral eyes, as well as more sensitive to averted gaze compared to direct gaze as indicated by larger early ERPs. Furthermore, we hypothesized an interaction, such that the greatest effect would be found for angry averted gazes.

We also hypothesized that early attention to the information provided by eyes would shed light on the link between culture and social anxiety. Specifically, we hypothesized that interdependent self-construal would positively correlate with social anxiety (Lau et al. 2009), and this relation would be mediated by early attention to the eyes. We propose two alternative hypotheses on how early attention to eyes could vary by cultural self-construal and social anxiety: Greater interdependent self-construal would result in greater sensitivity to angry and averted gaze as Asian Americans pay more attention to the averted, culturally relevant, stimuli. This increased sensitivity would be related to greater self-reported social anxiety. Alternatively, greater interdependent self-construal would be related to less sensitivity to angry and averted eyes, reflecting the Asian American double bind's diminished capability for emotion perception. Lower sensitivity or early attention would in turn predict greater social anxiety.

Methods

Participants

Thirty-two self-identifying Asian American participants, ages 18–22 years, were recruited from an undergraduate consortium in Southern California for course credit or monetary compensation. Four participants were excluded from final analysis due to excessive artifacts during EEG recordings, and the remaining 28 participants (19 females, M_{age} = 20.1; SD = 1.55) were analyzed for this study. Participants had normal or corrected-to-normal vision. The procedures were approved by the Pomona College Institutional Review Board.

The sample of 28 Asian Americans represented diverse ethnic, immigrant, and economic backgrounds. Four participants identified as first generation (14.3%), six identified as 1.5 generation (21.4%), 17 identified as second generation (60.7%), and one identified as fourth generation (3.6%). All but one participant reported that English was their primary language or one of their primary languages. Markers of socioeconomic status were generally high. Most participants rated their subjective

SES on the MacArthur ladder scale as above average (*Median* = 7 out of 9, *SD* = 1.55).

Stimuli

A total of 180 unique eye stimuli were created from 90 color photos of angry or neutral faces directly facing the camera from the JACFEE, JACNeuF (Matsumoto and Ekman 1988) and NimStim (Tottenham et al. 2009) stimuli sets. The eye regions, including eyebrows, were cropped to approximately 200 × 120 px. Ninety cropped photos of angry and neutral eyes facing directly were digitally manipulated in Adobe Photoshop to create an averted condition by shifting the pupils several millimeters to the left or to the right. Forty-five photos were selected for each of the following four conditions: Angry Direct Gaze, Angry Averted Gaze, Neutral Direct Gaze, and Neutral Averted Gaze.

To assure the neutral eyes would not be perceived negatively, a manipulation check was conducted. Ten additional participants were recruited and asked to identify the emotion of the eyes as negative (e.g., angry, surprise, sad, disgust, fear), neutral, or other. Participants accurately identified angry eyes as negative 90.4% of the time and neutral eyes as neutral 87.6% of the time.

Procedure

Participants were seated in a chair 70 cm away from a 22-inch Dell monitor at eye level. They were instructed to keep track of the number of blue eyes in order to promote active processing of the visual stimuli. Stimuli were presented in a randomized order without repetition over the course of four blocks of 45 trials using E-Prime 2.0 software (Psychological Software Tools Inc, Pittsburgh, PA 2012). Each block consisted of a jittered fixation cross ranging from 1000 to 1500 ms duration, followed by a 19 × 7 cm eye stimulus at a visual angle of 15.5° for 1500 ms and an interstimulus interval of 100 ms (see Fig. 1). After the recording, participants completed a self-report survey on Qualtrics (Qualtrics, Provo, UT 2017).

EEG recording and analysis

EEG was continuously recorded using Electrical Geodesics Inc. 128-channel Hydrocel Geodesic Sensor Net. The electrode net was connected to a DC-coupled high impedance (200 MΩ) Net Amps 300 amplifier. Analog voltages were amplified by a gain of 1000 and a bandpass filter of 0.3–100 Hz was used during recording. Voltages were digitized with a 24-bit A/D converter at 250 Hz. The impedance for all of the electrodes were kept below 50 kΩ. Raw EEG data were filtered using a 0.1–30 Hz bandpass filter. EEG epochs were segmented beginning 100 ms prior to the onset of the stimulus and 1000 ms after its onset. Trials with artifacts were eliminated based on the following criteria: contained signals over 200 μV, had more than 10 bad channels, contained an eye blink (signal > 140 μV within first 640 ms), or contained an eye movement (signal > 55 μV within first

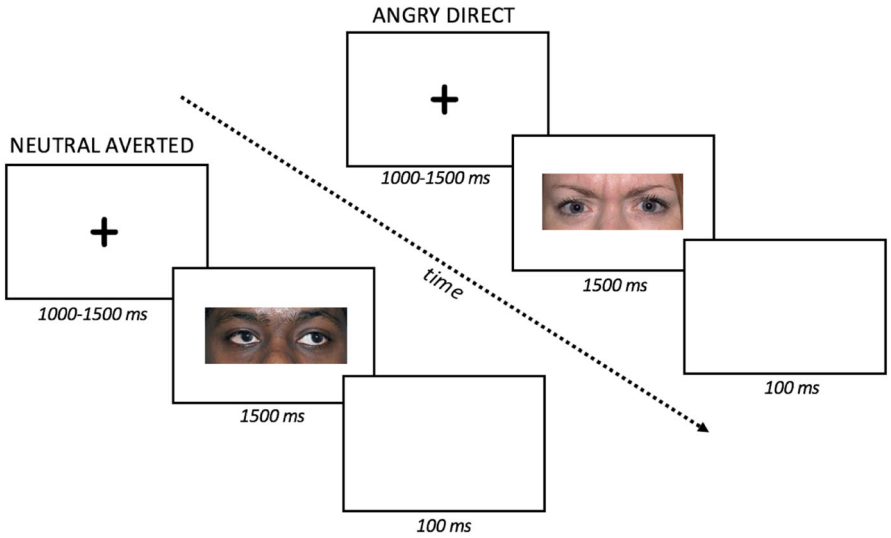

Fig. 1 Trial procedure for Angry Direct condition (top) and Neutral Averted condition (bottom)

640 ms). EEGs were averaged, re-referenced to the average reference, and baseline corrected.

As previously mentioned, four participants were removed from further analyses because the number of artifact-free trials fell below 50% of the trials. Therefore, EEG data from 28 participants were entered into the following analyses. Based on the resulting spatial topography map and converging literature on early ERP sensitivity to emotional facial stimuli, (e.g. Hinojosa et al. 2015), we analyzed the peak amplitudes of the P1(100–180 ms) and N170 (130–210 ms) ERP components for the average of the left P7/PO7 and right P8/PO8 occipito-parietal electrode pairs.

Self-report measures

Self-construal

The Self-Construal Scale (Singelis 1994) is a 30-item scale measuring independent and interdependent self-construal. Independent items include "I act the same way no matter who I am with" and interdependent items include "Even when I strongly disagree with group members, I avoid an argument". Items were answered on a seven-point Likert scale (1 = *strongly disagree* to 7 = *strongly agree*). The independence subscale consisted of 15 items ($\alpha = 0.79$) and the interdependence subscale consisted of 15 items ($\alpha = 0.82$).

Social economic status

Subjective SES was measured by the MacArthur Scales of Subject Social Status USA Ladder (Adler and Stewart 2007), which prompts participants to place their social position in relation to others in the United States on a nine-rung ladder.

Social Anxiety (SAS-A)

The Social Avoidance Scale for Adolescents (La Greca and Lopez 1998) is a 18-item scale consisting of three subscales: fear of negative evaluation (8 items, $\alpha = 0.86$), social avoidance and distress in general situations (4 items, $\alpha = 0.81$), and social avoidance specific to new situations (6 items, $\alpha = 0.86$). A composite Social Anxiety Scale score was calculated by combining the three subscales (18 items, $\alpha = 0.89$). The items range from 1 to 5 (1 = *not at all* and 5 = *all the time*).

Results

Early event-related potentials

In order to investigate Asian Americans' early neural response to facial expression and gaze, we conducted a 2 (Expression: Angry/Neutral) × 2 (Gaze: Direct/Averted) × 2 (Lateralization: Left/Right) repeated measures ANOVA for the average amplitude of the early event-related potentials, P1 and N170, at the left P7/PO7 and right P8/PO8 regions of interest (see Fig. 2). These electrodes were selected based on literature identifying these as regions of maximal activity for face and eye stimuli, and verified with visual inspection to be an area of maximal activity for our study.

For the P1, there was a main effect of Lateralization, $F(1, 27) = 11.19$, $p = 0.002$, such that amplitudes were greater for the right electrodes (P8/PO8) than for the left electrodes (P7/P07). In addition, there was a main effect of Expression, $F(1, 27) = 4.38$, $p = 0.005$, such that as predicted, the P1s to Angry Eyes were greater than to Neutral eyes. Also, as hypothesized, a two-way Gaze × Expression interaction emerged, $F(1, 27) = 14.79$, $p = 0.007$. Tukey post hoc analyses revealed that for the Averted Gaze condition, the P1 to Angry Eyes was larger than to Neutral Eyes, $t(53) = 3.56$, $p = 0.004$, whereas for the for Direct Gaze condition there was no difference in amplitude, $t(53) = 0.85$, $p = 0.40$ (see Fig. 3).

Contrary to our hypothesis, there was no main effect of Gaze, $F(1, 27) = 1.01$, $p = 0.32$, and there was no Lateralization by Expression interaction, $F(1, 27) = 0.27$, $p = 0.61$, Lateralization by Gaze interaction, $F(1, 27) = 0.10$, $p = 0.79$, or Lateralization by Gaze by Expression interaction, $F(1, 27) = 0.08$, $p = 0.11$, $p = 0.74$.

For the N170, no effects were found. Specifically, there were no significant main effects of Lateralization, $F(1, 27) = 1.65$, $p = 0.21$, Expression, $F(1, 27) = 0.16$, p = 0.70, or Gaze, $F(1, 27) = 0.43$, p = 0.52. There were no two-way interactions of Lateralization × Expression, $F(1, 27) = 0.26$, $p = 0.61$, Lateralization × Gaze,

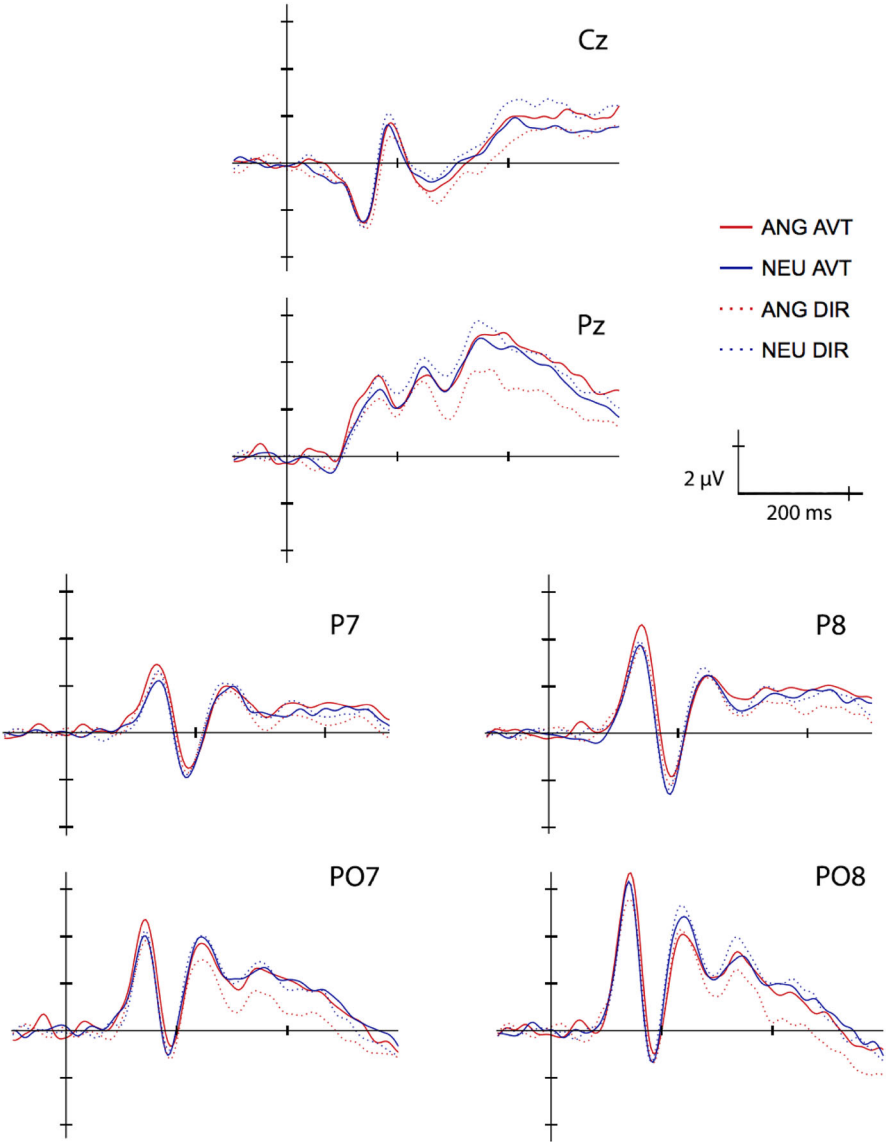

Fig. 2 ERPs for four stimuli conditions: Angry Averted, Neutral Averted, Angry Direct, and Neutral Direct. At lateral posterior sites (P7, PO7, P8, PO8) the angry averted amplitude is significantly greater at P1 ERP

$F(1, 27) = 0.46$, $p = 0.50$, or Gaze × Expression, $F(1, 27) = 0.55$, $p = 0.46$, and there was no three-way interaction of Lateralization × Gaze × Expression, $F(1, 27) = 1.23$, $p = 0.28$.

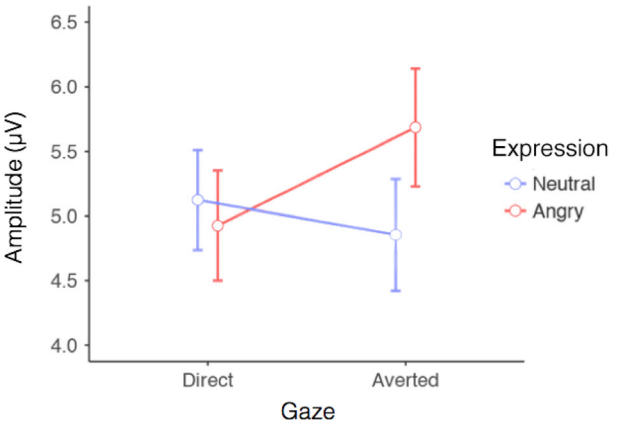

Fig. 3 Amplitude of P1 at P7, PO7, P8, PO8 sites for the Expression × Gaze conditions. Post-hoc multiple comparisons revealed that P1 in Angry-Averted condition was significantly larger than P1 in Neutral-Averted condition ($p < 0.005$). Error bars represent standard errors of the mean

ERP and self-report correlations

In order to investigate the hypothesized relationship between the ERP data and the self-report scales, we created a variable reflecting the primary finding from the ERP analyses. The difference variable in the P1 ERP between the Angry and Neutral expressions during the Averted Gazes was created by subtracting the P1 amplitude in response to the Angry minus the Neutral eyes for the Averted Gaze condition. More positive values reflected greater processing for the Angry compared to the Neutral Averted Gazes. Correlations among the ERP and self-report measures are presented in Table 1.

Table 1 Correlations between ERPs, cultural variables, and social anxiety subscales and composite score

Variable	M	SD	1	2	3	4	5	6
Descriptive Statistics and Bivariate Correlations								
1. P1 Averted Difference	0.83	1.22	–					
2. Interdependence	5.18	0.64	− 0.42*	–				
3. Independence	4.63	0.67	0.12	0.13	–			
4. FNE	3.31	0.62	− 0.51**	0.22	− 0.08	–		
5. SAD New Situations	3.43	0.57	− 0.54**	0.12	− 0.22	0.51**	–	
6. SAD General	2.97	0.77	− 0.23	0.10	0.04	0.38*	0.57**	–
7. SAS Composite	3.27	0.52	− 0.54**	0.19	− 0.11	0.85*	0.83***	0.74***

P1 Averted Difference difference between Angry Averted and Neutral Averted at P1, *FNE* fear of negative evaluation, *SAD New Situations* social avoidance and distress to new situations, *SAD General* generalized social avoidance and distress, *SAS* Social Anxiety Scale

*$p < 0.05$; **p < 0.01; ***p < 0.001

As predicted by the double bind hypothesis, the derived P1 Angry-Neutral Averted variable was negatively related to interdependent self-construal ($r = -0.42$, $p = 0.03$) such that greater interdependent self-construal was associated with smaller P1 amplitudes (see Fig. 4a). In addition, the P1 Angry-Neutral Averted variable was negatively correlated with Fear of Negative Evaluation ($r = -0.51$, $p = 0.006$), Social Avoidance for New Situations ($r = -0.54$, $p = 0.003$), and Social Anxiety Composite scores ($r = -0.54$, $p = 0.003$), such that greater social anxiety was also associated with smaller P1 amplitudes (see Fig. 4b).

We tested an indirect model between Interdependence and Social Anxiety Composite score using the mediation and moderation modeling tool PROCESS (Hayes 2012) with the P1 Angry-Neutral Averted Gaze difference variable as a mediator (see Fig. 5). The indirect effect was significant (Z = 1.93, $p = 0.05$) with higher interdependence scores associated with a smaller difference between P1 Angry and Neutral Averted amplitudes ($b = -0.79$), and smaller ERP differences were associated with higher Social Anxiety scores ($b = -0.24$). A bias-corrected bootstrapped estimation analysis with 5000 samples revealed that a confidence interval for the indirect effect did not include zero, $b = 0.19$, $SE = 0.11$, 95% CI 0.035–0.491. The direct effect was not significant (Z = 1.03, $p = 0.30$).

Discussion

The present study examined Asian Americans' early visual processing to gaze and emotional expression of eyes as related to social anxiety. As hypothesized, increased P1 amplitudes were greater for angry compared to neutral eyes. No simple effects were found for gaze, but Asian Americans showed an interaction: an increased P1 amplitude to averted angry eyes. We then investigated associations among early ERP measures, cultural orientation, and social anxiety in hopes of understanding the relation between interdependence and social anxiety (Lau et al.

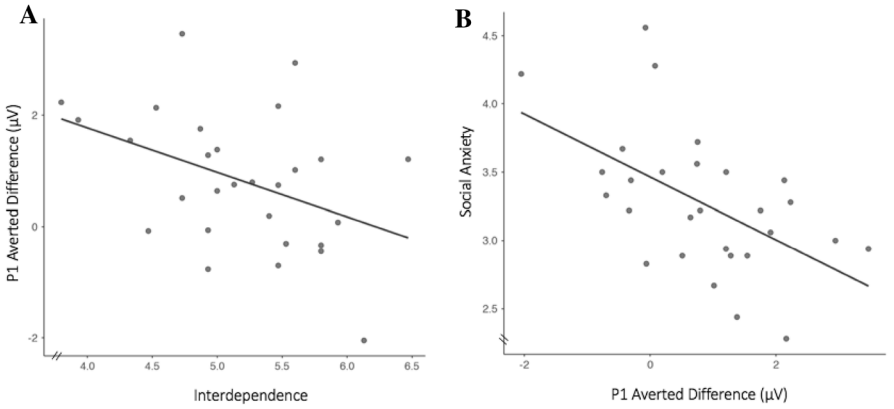

Fig. 4 **a** Correlation between Interdependence and P1 Averted Difference ($p = 0.03$). **b** Correlation between P1 Averted Difference and Social Anxiety Composite Score ($p = 0.003$)

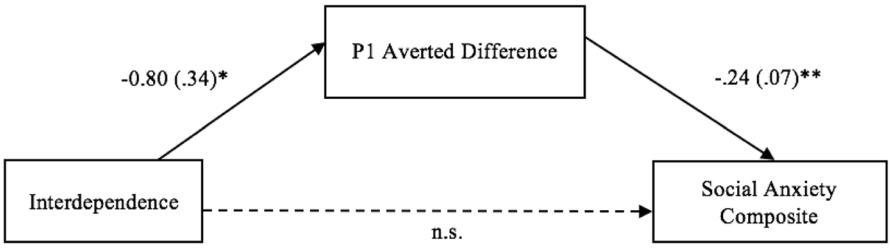

Fig. 5 Unstandardized regression coefficients and standard error in parentheses showing indirect model of Interdependence and Social Anxiety Composite mediated by posterior P1 Difference between Angry Averted and Neutral Averted. Indirect model is significant in an analysis of 5000 sample bootstraps. $^{*}p < 0.05$; $^{**}p < 0.01$

2009). In support of the double bind hypothesis, interdependent self-construal was found to be related to decreased P1 amplitudes for angry eyes with an averted gaze. This indicator of early attention was, in turn, negatively related to social anxiety. Thus, we found support for an indirect effect from interdependent self-construal to social anxiety through ERPs for reading emotion and gaze in the eyes.

In this study, the P1 was sensitive to the interactive effect of gaze and expression of eyes such that the P1 amplitude was greatest for angry eyes with an averted gaze. The P1 represents extrastriate visual processing and is facilitated in response to increased allocation of attentional resources (Heinze et al. 1994; Mangun et al. 1997). This suggests that Asian Americans allocated more early attentional processing to the averted angry eyes compared to neutral gazes and the direct angry gaze. These results are consistent with other studies finding that culture influences early visual ERPs (Lin et al. 2008; Sui et al. 2012).

Our findings support the literature that suggests threat is processed quickly. The difference in the P1 to angry compared to neutral eyes is consistent with other studies that have found that threatening faces, especially when looking directly, serve as an unambiguous, quickly processed, expression of hostility (Staugaard 2010).

Averted gaze can also be emotionally salient, and has been found to signal avoidance (Argyle and Cook 1976), disinterest (Itier and Batty 2009; Strick et al. 2008), and has been rated as more unpleasant than direct gaze (Schmitz et al. 2012). Relative to an angry direct gaze, the meaning of averted angry gaze is more ambiguous and is processed more slowly (Adams and Kleck 2003). Additionally, the amygdala, which has been proposed to be involved in disambiguating emotionally salient stimuli (e.g. Lindquist et al. 2012; Pessoa 2008; Whalen 2007), has been found to show greater activity in response to averted eyes (Straube et al. 2010) and averted angry eyes relative to direct angry expressions (Adams et al. 2003; Ziaei et al. 2017). The interaction suggests that the phenomena resists reduction to individual components of gaze and expression and should be studied complexly and interactively.

The strong interaction of gaze and expression that emerged in our data can be understood within a cultural context. This is consistent with Jack et al. (2012) who found that East Asians regard subtle gaze shifts as critical components of an

emotional expression rather than an independent gesture. First, averted gazes may reflect a culturally appropriate emotional attunement. Rather than signaling disinterest, these gazes may suggest an attempt to foster social harmony. Angry averted gazes may be interpreted as an attempt to mitigate the negative emotional arousal of the target and an attempt to maintain the relationship. Thus, an averted angry gaze may be a socially engaging look for Asian Americans (see Kitayama et al. 2006), commanding greater attention and processing than either an angry look or averted gaze alone.

We did not find an effect of eye expression or eye gaze on the N170 despite the extensive literature on the sensitivity of the N170 to emotional facial expressions (Hinojosa et al. 2015). One reason may be that the stimuli used in the present study intentionally focused attention to the eyes. In contrast with the vast literature using faces, we used cropped photos of eyes. Other studies that also used cropped eyes did not find an effect of eye gaze on the N170 (Schmitz et al. 2012; Tsuji and Shimada 2017), suggesting that the N170 may be less sensitive to eye expression than facial expression.

Our study also investigated the relationship among cultural self-construal, eye gaze and expression, and social anxiety. Contrary to our hypotheses, we did not find a direct correlation between interdependence and social anxiety (Lau et al. 2009). In a study with first and second generation Asian Americans (Ho and Lau 2011), the relationship between interdependent self-construal and social anxiety was reduced in more acculturated individuals. Our null finding may reflect this greater acculturation as all but one of our participants indicated English as a primary language, and they were mostly second generation.

Despite failing to find support for the hypothesized direct effect, a noteworthy indirect effect emerged between culture and social anxiety. Supporting one of our competing hypotheses, higher interdependent self-construal was associated with lower P1 amplitudes to averted angry eyes. This is consistent with the double bind hypothesis (Lau et al. 2009) wherein cultural sensitivity to other's emotions coupled with obstacles in developing experience with reading emotions lead to social unease, and suggests a mechanism through reading eyes. Given that interdependence is associated with greater sensitivity to reading others' thoughts and emotions (Wu and Keysar 2007), two interpretations arise. First, the negative correlation between interdependence and P1 amplitude to averted angry eyes may reflect greater efficiency in processing negative expressions in others. Perhaps those who are interpersonally, interdependently oriented show a stronger negativity bias compared to independents (Schimmack et al. 2002) and thus are more efficient. Alternatively, those higher in interdependent self-construal may allocate less early attention to or downregulate the more ambiguous, emotionally salient condition (angry averted eyes). In light of the negative relation of the P1 with social anxiety, such that those attending less to angry averted gazes show greater social anxiety, the argument suggesting greater efficiency seems less plausible. Rather, some inefficiency or lowered attention seems more likely as those that fail to appropriately notice the angry averted eyes have greater social anxiety. To our knowledge, ours is the first study to investigate gaze and expression using only eyes as stimuli and in relation to social anxiety. Other ERP studies differ in essential

ways, making comparisons between the P1 and social anxiety link within the literature difficult (e.g. Schmitz et al. 2012; Tsuji and Shimada 2017).

The indirect effect reflects these two relations: greater interdependent self construal associated with decreasing P1 amplitudes for averted angry eyes, which are in turn associated with increasing social anxiety. Importantly, our results suggest a specific mechanism through which social anxiety may be culturally related. Bicultural Asians and Asian Americans navigate two cultural systems of individualism and collectivism (Hong et al. 2000; Fong et al. 2014). Our data suggest that it is the interdependent cultural frame that is indirectly related to social anxiety through less attention to averted angry eyes. More interdependent Asian Americans may not attend to or downregulate attention to these *potentially* threatening expressions. This is consistent with Kitayama et al. (2006) who found that East Asians reported negative disengaging situations as less intense than did European Americans. Cheung and Park (2010) found that increased interdependence was associated with anger suppression, which was associated with depression. Our findings parallel their results in that interdependency was related to decreasing reaction to a negative emotion, which was associated with negative mood. Attenuated response to anger for interdependent East Asians may represent a decoding rule that minimizes negative emotions in much the same way that display rules minimize the expression of negative emotions (Matsumoto 1989; Mauss et al. 2010). This research together with our results are consistent with the cultural double bind (Lau et al. 2009) wherein Asian biculturals value interdependence but may not read emotions of others well. Our results suggest that lower early processing of eyes may be culturally constrained and related to the unease Asian Americans face in social situations.

Another seemingly plausible interpretation is that those that are low in interdependence lack a social buffer offered by a strong ingroup. These individuals may need to consistently and carefully attend to others for information. Therefore, less interdependence is related to a greater P1. While this seems compelling, it is ultimately inconsistent with our other results that suggest angry averted eyes in particular are most attended to.

Interestingly, the overall level of social anxiety endorsed in our nonclinical sample appears relatively high. Compared to a study of Asian American students at two large, public universities in Southern California (Lau et al. 2009), the social anxiety levels in the current sample are higher by one standard deviation. Yet, the average response indicated in our sample was slightly higher than 'sometimes' experiencing anxiety, putting our sample in the subclinical range. The higher level of anxiety reported in Asians is likely to reflect, in part, the greater experience of mixed emotions among East Asian cultures, which has been attributed to dialectic beliefs (e.g., Schimmack et al. 2002) and cultural differences in ideal affect (Sims et al. 2015).

Limitations and future directions

Although the novel stimulus set is generalizable across race and gender, they are not without limitation. In an optimal study, the physical parameters of the stimuli (e.g.

luminance, contrast, and spatial frequency) and phenotypic variation would be carefully taken into account. Most angry expressions in the study featured furrowed brows and contracted eyelids, which may have concealed important visual information critical to rapidly recognizing human eyes. Direct neutral gaze cropped close to the eyes may have had an arousing or threatening affect. Furthermore, recent studies have raised the issue of ecological validity by looking at neural and eye movement responses to real-life faces instead of photos of faces (Pönkänen et al. 2010; Peterson et al. 2016). With innovative technological developments, future research can better construct realistic stimuli.

While there's an abundance of evidence advocating for both analytical and holistic processing of faces and eyes, some eye-tracking studies indicate that the eye area is underutilized compared to the mouth regions or eyebrows (Blais et al. 2012; Jack et al. 2012). Future study should explore the relations between culture and underutilization of the eyes to determine whether these findings vary by acculturation level and generalize beyond Asians to other cultural groups. Furthermore, future studies should investigate how the perception of ingroup and outgroup gaze and expression are processed and related to social anxiety.

Conclusion

Making eye contact with another person can either reflect a universally human social behavior or an adherence to cultural norms. Much of the psychological research conducted in North America and Europe presumes eye contact as a normative social function. This study explored how appropriate reading of eyes could facilitate or hinder adjustment into a new culture. Specifically, we focused on the early neural processing of gaze and affect among Asian American biculturals who manage complex social conventions about eye contact and the ability to recognize emotions. Increased interpersonal anxiety in Asian Americans has been well documented; here, we introduce early neural responses to gaze and negative emotion in eyes as one neural mechanism.

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