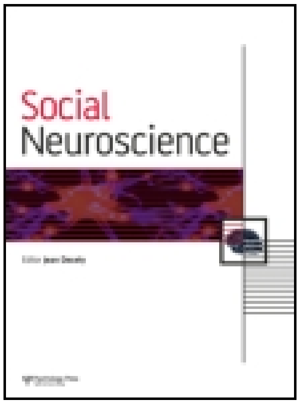

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Cultural differences in sensitivity to social context: Detecting affective incongruity using the N400

Sharon G. Goto [a] , Alicia Yee , Kelly Lowenberg [a] & Richard S. Lewis [a]

[a] Department of Psychology, Pomona College, Claremont, CA, USA

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Cultural differences in sensitivity to social context: Detecting affective incongruity using the N400

Sharon G. Goto, Alicia Yee*, Kelly Lowenberg, and Richard S. Lewis

Department of Psychology, Pomona College, Claremont, CA, USA

East Asians and Asian-Americans tend to allocate relatively greater attention to background context compared to European Americans across a variety of cognitive and neural measures. We sought to extend these findings of cultural differences to affective stimuli using the N400, which has been shown to be sensitive to deep processing of affective information. The degree to which Asian-Americans and European Americans responded to semantic incongruity between emotionally expressive faces (i.e., smiling or frowning) and background affective scenes was measured. As predicted, Asian-Americans showed a greater N400 to incongruent trials than to congruent trials. In contrast, European Americans showed no difference in amplitude across the two conditions. Furthermore, greater affective N400 incongruity was associated with higher interdependent self-construals. These data suggest that Asian-Americans and those with interdependent self-construals process the relationship between perceived facial emotion and affective background context to a greater degree than European Americans and those with independent self-construals. Implications for neural and cognitive differences in everyday social interactions, and cultural differences in analytic and holistic thinking are discussed.

Keywords: Culture; N400; Interdependent self-construal; Context; Emotion.

The recent literature on cultural differences in cognition has generally found that East Asians and Asian-Americans attend to the background context more than European Americans, who attend to the foreground and focal objects. This has been replicated across several paradigms such as memory for underwater scenes (Masuda & Nisbett, 2001), change blindness (Masuda & Nisbett, 2006), visual change detection (Boduroglu, Shah, & Nisbett, 2009), eye movement patterns (Chua, Boland, & Nisbett, 2005), the Framed Line Test (Kitayama, Duffy, Kawamura, & Larsen, 2003), and the Rod and Frame Test (Ji, Peng, & Nisbett, 2000). These empirical findings have been interpreted in terms of the analytic–holistic distinction postulated by Nisbett and colleagues. East Asian cognitive styles are characterized as more holistic and European American cognitive styles are characterized as more analytic (Nisbett & Miyamoto, 2005; Nisbett, Peng, Choi, & Norenzayan, 2001).[1] One characteristic of a holistic cognitive style is a wide focus of attention and the processing of the

[1]Nisbett and colleagues (Nisbett & Miyamoto, 2005; Nisbett et al., 2001) refer to "Western" and "East Asian" cognitive styles, where "Western" refers to Western Europeans and European North Americans and "East Asian" refers to those living in East Asia. In previous work, East Asian Americans have shown more holistic cognitive styles in comparison with European Americans (Goto et al., 2010; Lewis et al., 2008). We use the terms "East Asian American" and "European American" in recognition of people of East Asian descent and European descent, respectively, living in North America.

Correspondence should be addressed to: Sharon G. Goto, Department of Psychology, Pomona College, 647 N. College Way, Claremont, CA 91711, USA. E-mail: sgoto@pomona.edu

*Present address: Department of Psychology, University of Oregon, Eugene, OR, USA

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relationship among objects in the broad attentional field. In contrast, an analytic cognitive style is characterized by a narrower focus of attention, typically processing focal, foreground objects.

Neuroscientific methods have been used to further investigate these cultural differences in visual perception of focal and background objects. These studies have discovered cultural differences in neural activity in object-processing regions of the occipital lobe when viewing focal objects (Goh et al., 2007; Gutchess, Welsh, Boduroglu, & Park, 2006) and in frontal and parietal attentional areas when performing context-dependent judgments of line length (Hedden, Ketay, Aron, Markus, & Gabrieli, 2008). Furthermore, the novelty P3 event-related potential (ERP) has been shown to be sensitive to cultural differences in attention to visually presented targets and contextually novel items (Lewis, Goto, & Kong, 2008).

Although the cultural differences in foreground versus background information seem robust, given the growing literature, the linkages between the cultural neural differences in analytic versus holistic processing and everyday life remain unclear. Some associations with social behavior have emerged, but they have relied solely on behavioral evidence. For example, with respect to social influence, Miyamoto and Wilken (2010) found that Americans assigned as "leader" tend to rely more on an analytic style compared to their Japanese counterparts. Using cartoon figures, Masuda et al. (2008) found that the interpretation of the emotions of the foreground faces was more strongly influenced by the emotions of the background faces in Japanese participants when compared to Westerners. Japanese participants judged the foreground faces as more "happy" or more "sad" (there was a marginal effect for "anger") when the background faces expressed the congruent emotion. Furthermore, by tracking eye movements, they found Japanese participants initially glanced at the foreground faces, but more quickly began viewing the background faces.

We utilized the N400 to extend the findings of cultural differences in processing context using neural measures suggestive of deep, semantic processing. The N400 is an ERP that has been shown to be sensitive to processing semantic relationships (Holcomb & Neville, 1991; Kutas & Federmeier, 2011; Kutas & Hillyard, 1980). The increased magnitude of the N400 associated with unexpected or incongruent semantic events may reflect the increased cognitive processing necessary to integrate anomalous semantic information or meaning (e.g., Holcomb, 1993). For example, Goto, Ando, Huang, Yee, and Lewis (2010) presented participants with a background scene such as a parking lot. Then, they "popped" a central object onto the background image that was either congruent (e.g., a car) or incongruent (e.g., a crab). For Asian-Americans, the magnitude of the N400 was greater when an incongruent object was superimposed upon the background image than when the object was congruent. This was not found for European Americans, suggesting their relative inattention to background information. Evidence for cultural differences was particularly compelling, since all participants viewed the background before the foreground object was placed, and yet cultural differences emerged in how the two groups processed the semantic relationship between the background and foreground.

Na and Kitayama (2011) also relied on the N400 to look at cultural differences in context sensitivity to visual processing. If individuals with interdependent self-construals are more sensitive to situational influences of behavior, then they should be less likely to spontaneously infer traits from an initial behavior. As evidence of greater spontaneous trait activation, they found that European Americans showed greater magnitude of the N400 to antonyms of implied traits compared to Asian-Americans. This study importantly provided evidence for cultural differences in semantic processing of social contextual information.

We sought to extend previously explored cultural differences in neurocognitive processes to include sensitivity to affective relationships across a broad visual field. More specifically, we investigated whether Asian-Americans would be more likely to process incongruities in affect between facial expressions and visual scenes. The literature on cultural differences in social behavior contains examples of East Asians being more sensitive to social information, such as knowledge (Haberstroh, Oyserman, Schwarz, Kuhnen, & Ji, 2002) and emotional perspectives of others (Cohen & Gunz, 2002) compared to European North Americans. Like Masuda et al. (2008), we based our study on the premise that situational appraisals of emotion (Mesquita & Leu, 2007) are at least partially culturally determined. That is, individuals read their landscape for cues of social constraint (Gilbert & Malone, 1995; Na & Kitayama, 2011), suggesting that the emotional landscape can be to some extent culturally determined. Since European Americans tend to be more independent, with thoughts and actions emerging from the self and relatively independent of others, they may process less social information from the background compared to East Asian Americans. On the other hand, East Asians who tend to have more interdependent self-construals would likely utilize contexts to process social information (Choi & Nisbett, 1998; Markus & Kitayama, 1991; Morris & Peng, 1994). This builds upon the budding literature on cultural neural differences in emotion which has focused on the localization of affective facial recognition and processing (e.g., Chiao et al., 2008; Derntl et al., 2009).

Since other research has found the N400 to be sensitive to semantic incongruity of emotion (Deveney & Pizzagalli, 2008; Ishii, Kobayashi, & Kitayama, 2010; Leuthold, Filik, Murphy, & Mackenzie, 2012), we adapted the protocol by Goto et al. (2010) to investigate whether East Asian Americans show greater semantic processing of facial emotion in the context of incongruent background affective scenes compared to European Americans. We chose human faces displaying emotion as foreground stimuli and juxtaposed emotion of faces on a variety of positive or negative affective background scenes. Based on previous research (Goto et al., 2010; Masuda et al., 2008), we expected East Asian Americans would display greater N400s than European Americans when processing emotionally incongruent faces and backgrounds and no difference with respect to congruent faces and backgrounds.

In addition, based on previous studies of self-construal and cognition using neural measures (Goto et al., 2010; Hedden et al., 2008; Lewis et al., 2008; Na & Kitayama, 2011) the relationship between the N400 and self-construal was investigated. Since self-construal, or how one sees oneself in relation to others (Markus & Kitayama, 1991), is inherently social in its focus, its relationship to the processing of social background and foreground information should be salient. However, the reported relationships with interdependence versus independence have been somewhat inconsistent to date (see Kitayama & Uskul, 2011). Therefore, we anticipated a relationship between self-construal and semantic processing of context in this study, then empirically determined the specific direction.

METHOD

Participants

Participants were 46 undergraduate students, ages 18–25 years, from the Claremont colleges, a consortium of West Coast liberal arts colleges. All participants were right-handed, monoracial, and had normal or corrected-to-normal vision. Of 55 originally sampled participants, nine were eliminated (three Asian-Americans and six European Americans) due to excessive ocular and muscle artifacts during the ERP session or incomplete survey data. Remaining in the study were 23 Asian-Americans and 23 European Americans. Half of the participants were self-identified European Americans (12 women and 11 men) and half were self-identified East Asian Americans (13 women and 10 men). European American students were born and raised in the United States. All Asian-Americans were of East Asian descent and were either born in the United States or immigrated to the United States before the age of 8. Eligibility and group categorization were determined using a preliminary online survey that included questions about ethnicity and handedness, as well as two distracter questions. Participants also filled out a demographics survey at the end of the experiment that was used to further characterize our subject pool. Participants were recruited from introductory psychology courses, Asian-American psychology courses, and advertisements. Informed consent was obtained in compliance with the Pomona College Institutional Review Board. After completion of the experiment, participants were compensated $15 or given subject pool credit for the session.

Materials and apparatus

Self-construal survey

Participants were administered a 30-item version of the Self-Construal Scale (SCS) developed by Singelis (1994). This 7-point Likert scale consists of 15 independent items, such as “I enjoy being unique and different from others in many respects,” and 15 interdependent items, such as “I feel my fate is intertwined with the fate of those around me.” Treating independent and interdependent self-construals as orthogonal constructs, independent and interdependent self-construal scores were derived by calculating the average response to items from each subscale separately. Although often used in cross-national comparisons, the SCS and other measures like it have been successfully used to discriminate populations within a country (see Oyserman, Coon, & Kemmelmeier, 2002).

Visual stimuli

Stimuli consisted of 100 unique affective scenes from the International Affective Pictures System (Lang, Bradley, & Cuthbert, 2008). Scenes were selected for their human social nature. Half of the affective scenes were negative (valence: $M = 3.1$, SD = 0.62; arousal: $M = 5.0$, SD = 0.75) and half were positive (valence: $M = 7.4$; SD = 0.31, arousal: $M = 7.4$, SD = 0.91). Superimposed upon the center of the affective scenes were faces selected from Matsumoto and Ekman (1989). Eight faces were used in this study (consisting of all combinations of smiling or frowning expressions, male or female faces, and Japanese and European American faces). Two emotions, sadness and happiness, were selected given the robust results for these two emotions in Masuda et al. (2008). Focal faces were superimposed upon the affective scenes such that 50 trials consisted of affectively congruent combinations (i.e., happy face superimposed upon a positive scene or a sad face superimposed upon a negative scene) and 50 trials consisted of incongruent combinations (i.e., happy face superimposed upon a negative scene or a sad face superimposed upon a positive scene).

The stimuli were presented on a Dell 22-inch computer monitor centrally positioned at eye level, 75 cm from the observer's eyes (Dell Corp., Round Rock, TX, USA). The affective scenes subtended 95 square degrees of visual angle. The superimposed focal faces were presented in the center of the affective scenes and subtended an average of 4.2×4.2 degrees of visual angle. E-Prime (Psychology Software Tools Inc., Pittsburgh, PA, USA) was used to program the presentation of the stimuli.

Procedure

Five practice trials were followed by four sets of 25 stimuli. Between each set, subjects were allowed to take a break for as long as they felt necessary. Participants were presented with a fixation cross ("+") in the center of the computer screen for an interval between 500 and 1500 ms. Then, an affective scene was presented for 600 ms. This was followed by the presentation of a face superimposed upon the affective scene for 600 ms. The emotional face was either congruent or incongruent with the affective scenes. The sequence of trials was randomized within each block for each subject.

The incidental orienting task for participants was to determine whether the emotion expressed on the focal face was happy or sad. Participants were given two response boxes, one for each hand. If the focal face was "happy," they were instructed to press "1" simultaneously with both hands. If the focal face was "sad," they were instructed to press "2." If undecided, then they were instructed to press "3." Reaction time and accuracy were recorded. After the experimental procedure, all participants completed the SCS, followed by demographic questions.

Electroencephalography (EEG) acquisition

EEG was recorded using the Electrical Geodesics Inc. 256-channel Hydrocel Geodesic Sensor Net soaked in a potassium chloride saline surfactant solution (Electrical Geodesics Inc., Eugene, OR, USA). Each electrode of the net used an AgCl-plated carbon-fiber pellet connected to a gold pin by a lead-shielded wire. The net was connected to a DC-coupled high impedance (200 MΩ) Net Amps 300 amplifier. Electrodes were adjusted to impedances below 50 kΩ, which preserves the signal integrity ($<$0.1% error) for a system of this design (Ferree, Luu, Russell, & Tucker, 2001). The analog voltages were amplified by a factor of 1000 and a bandpass filter of 0.3–100 Hz was used during recording. Voltages were digitized with a 16-bit A/D converter at 250 Hz. Recording electrodes were referenced to the participant's vertex electrode.

ERP analysis

NetStation 4.3 software was used to process the raw EEG data (Geodesics Inc., Eugene, OR, USA). Raw data were filtered using a 0.3–30 Hz bandpass filter. ERPs were epoched from 200 ms before the onset of the background scene to 1600 ms after its onset. Trials were rejected if they contained ocular artifacts (greater than 70 μV difference between eye channels) or more than five bad channels (100 μV difference between successive samples or reaching amplitudes of 200 μV). Subjects with fewer than 20 artifact-free trials in either the congruent or incongruent conditions were eliminated from analyses in the study. For the Asian-Americans, there remained, on average, 36 trials (out of 50) for ERP analyses in the congruent condition and 37 trials (out of 50) for the incongruent condition per subject. For the European Americans, there remained, on average, 37 trials (out of 50) for ERP analyses in the congruent condition and 37 trials (out of 50) for the incongruent condition per subject. For the ERPs in response to the affective scene, all trials were averaged together, re-referenced to the average reference, and baseline corrected to the 200 ms period preceding the background stimulus. For the ERPs in response to the face superimposed upon the affective scene, trials for each condition (congruent and incongruent) were averaged separately, re-referenced to the average reference, and baseline corrected to the 200 ms period preceding the onset of the affective scene.

RESULTS

Behavioral performance

As expected, the behavioral results suggested no obvious differences in the degree to which the Asian-Americans and European Americans behaviorally responded to the facial emotion identification task (see Tables 1 and 2). In order to orient participants during the N400 task, subjects performed an incidental perceived emotion judgment of the faces that were superimposed on the background affective scenes. For the happy faces, there was no difference in accuracy between the Asian-Americans ($M = 0.95$; SD $= 0.06$) and European Americans ($M = 0.95$; SD $= 0.08$), $t(44) = 0.04$, ns; $d = 0$. There was also no difference in accuracy for the sad faces between Asian-Americans ($M = 0.95$, SD $= 0.06$) and European Americans ($M = 0.95$; SD $= 0.08$), $t(44) = 0.04$; ns; $d = 0$. For happy judgments, there was no difference in reaction times between Asian-Americans ($M = 633$ ms; SD $= 152$ ms) and European Americans ($M = 618$ ms; SD $= 110$ ms), $t(44) = 0.37$, ns; $d = 0.11$. Similarly, for the sad judgments, there was no difference in reaction times between the Asian-Americans ($M = 647$ ms; SD $= 149$ ms) and European Americans ($M = 633$ ms; SD $= 118$ ms), $t(44) = 0.34$, ns; $d = 0.10$.

In addition, there were no differences in reaction times between the two groups for the congruent face–affective scene pairings (Asian-Americans: $M = 636$ ms; SD $= 160$ ms; European Americans: $M = 631$ ms; SD $= 111$ ms), $t(44) = 0.14$, ns; $d = 0.04$ or the incongruent face–affective scene pairings (Asian-Americans: $M = 627$ ms; SD $= 113$ ms; European Americans: $M = 630$ ms; SD $= 114$ ms), $t(44) = 0.11$, ns; $d = 0.03$.

Furthermore, the Asian-Americans did not show a significant difference in reaction times between the congruent ($M = 636$ ms; SD $= 160$ ms) and incongruent face–affective scene pairings ($M = 627$ ms; SD $= 113$ ms), $t(22) = 0.67$, ns; $d = 0.06$. Similarly, the European Americans did not show a significant difference in reaction times between the congruent ($M = 631$ ms; SD $= 111$ ms) and incongruent ($M = 630$ ms; SD $= 114$ ms) face–affective scene pairings, $t(22) = 0.08$, ns; $d = 0.01$. Finally, there were no significant correlations between the behavioral responses and the self-construal scores ($r < 0.15$).

TABLE 1
Accuracy of facial emotion judgment

Facial emotion	*Asian-Americans (n = 23) M (SD)*	*European Americans (n = 23) M (SD)*
Happy	0.95 (0.06)	0.95 (0.08)
Sad	0.95 (0.06)	0.95 (0.08)

TABLE 2
Mean reaction times for facial emotion judgment (in milliseconds)

Trial type	*Asian-Americans (n = 23) M (SD)*	*European Americans (n = 23) M (SD)*
Facial emotion		
Happy	633 (152)	618 (110)
Sad	647 (149)	633 (118)
Background stimuli		
Congruent	636 (160)	631 (111)
Incongruent	627 (113)	630 (114)

Electrophysiological analyses

In order to investigate the electrophysiological processing of the social affective task, ERPs were created for the period from 200 ms before the onset of the affective, background scene through 1600 ms following its onset. The background affective scene was presented alone for 600 ms, followed by the face being superimposed upon the background scene for another 600 ms (see Figure 1). In order to investigate group differences in processing the background scene, repeated measures ANOVAs were conducted on the mean amplitude for 70 electrodes spanning the extent of the electrode net coverage for six temporal windows (0–100 ms, 100–200 ms, 200–300 ms, 300–400 ms, 400–500 ms, and 500–600 ms) spanning the duration of the presentation of the background affective scene alone. Ethnicity was entered as a between-subject variable and a Greenhouse–Geisser correction was used for violation of sphericity. For each of the temporal windows, there was no main effect of ethnicity [0–100 ms: $F(1) = 2.5$, ns; 100–200 ms: $F(1) = 2.7$, ns; 200–300 ms: $F(1) = 2.2$, ns; 300–400 ms: $F(1) = 1.6$; 400–500 ms: $F(1) = 1.8$; 500–600 ms: $F(1) = 2.0$].

The shape of the ERPs resulting from the face superimposed upon the background was very similar to those reported by Goto et al. (2010) (see Figure 1). There was a peak negativity occurring around the time the face was superimposed upon the affective background. The ERP became increasingly positive, except for a brief negative deflection occurring around 400 ms post-onset of the face upon the affective background. This negativity characterized the

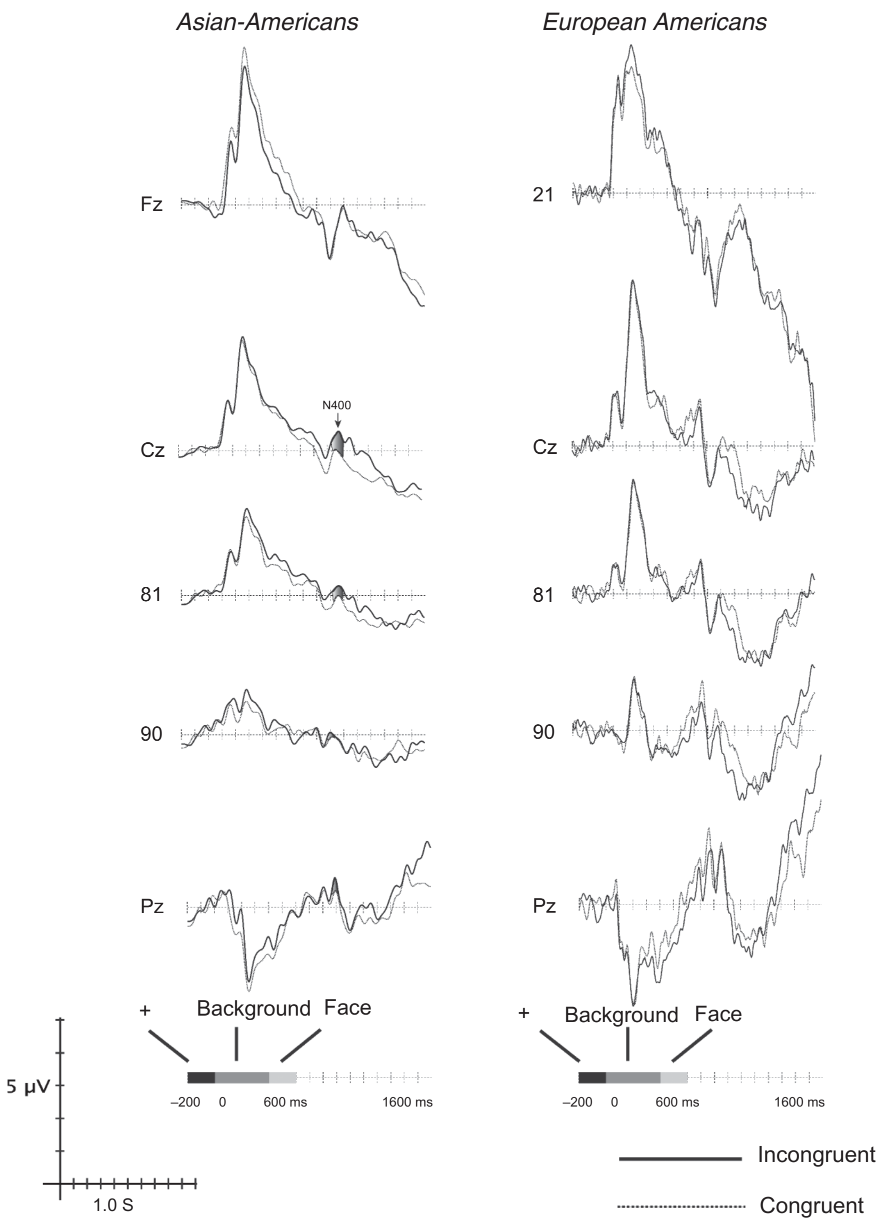

Figure 1. ERPs for centroposterior midline electrodes for Asian-Americans and European Americans. Voltage is plotted as a function of time, 200 ms before the onset of the affective scene to 1600 ms post-onset. N400 is shaded. Notice the greater negative response of Asian-Americans to the incongruent condition centered on 400 ms after the onset of the face superimposed upon the affective background scene (1000 ms after the onset of the background scene). Figures are smoothed for presentation purposes.

N400. The scalp topography of the N400 was also similar to that reported by Goto et al. (2010) (see Figure 2). The N400 was maximal at midline centroposterior electrodes and was largely symmetrical. Furthermore, no significant correlations were found between N400 amplitude and behavioral performance (i.e., accuracy and reaction time) in the facial affect judgment task ($r < 0.1$).

Hypothesis testing

In order to quantify the N400, we measured the mean amplitude of the vertex (Cz) and two immediately posterior electrodes (# 81 and #90) across a 350—450 ms latency window following the onset of the face, which was superimposed upon the affective scene. The amplitudes of the three electrodes were averaged

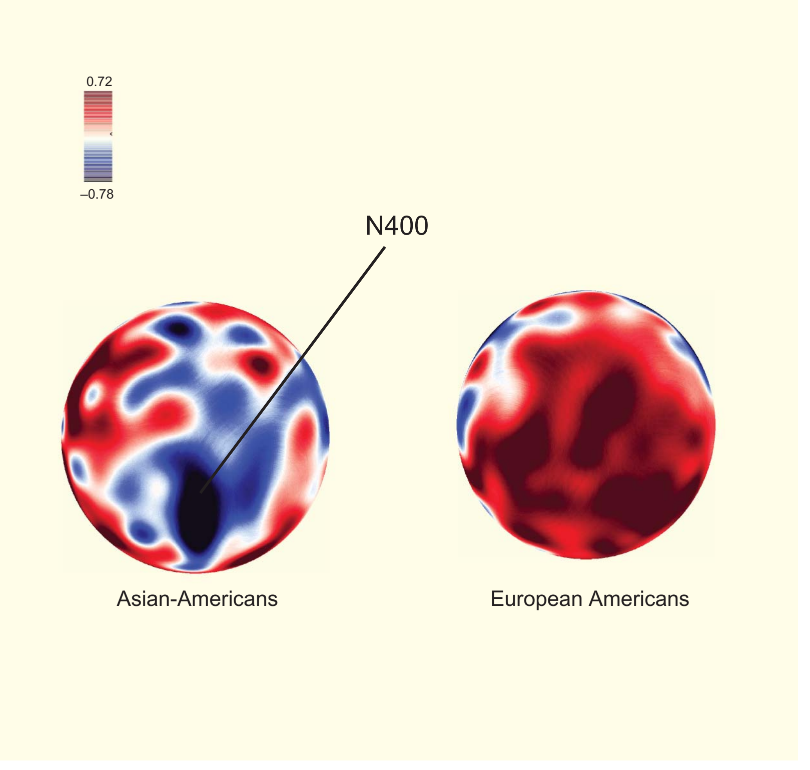

Figure 2. Scalp topography of voltage difference between the incongruent and congruent conditions for the Asian-Americans (left scalp topography) and the European Americans (right scalp topography). Greater negativity for the incongruent condition is indicated by blue coloring. Notice the greater N400 during the incongruent condition for Asian-Americans along the centroposterior midline electrode sites. Color-coded scale is in μV.

and entered into a 2 (ethnicity) × 2 (congruent–incongruent condition) repeated measures ANOVA. There was an ethnicity by condition interaction, $F(1,44) = 5.8$, $p = .02$; $\eta_p^2 = 0.12$ (see Figure 3). The Asian-Americans showed greater negativity to incongruent trials than congruent trials, $t(22) = 2.2$, $p = .035$; $d = 0.94$. In contrast, the European Americans did not show a difference in amplitude across the two conditions, $t(22) = 1.0$, ns; $d = -0.43$. Furthermore, subtracting the amplitude during the congruent trials from the amplitude during the incongruent trials resulted in significantly larger N400 difference wave amplitude for the Asian-Americans than for the European Americans, $t(44) = 2.2$, $p = .035$; $d = 0.31$. There was neither a main effect of ethnicity, $F(1,44) = 0.46$, ns; $\eta_p^2 = 0.01$, nor a congruency condition, $F(1,44) = 1.9$, ns; $\eta_p^2 = 0.04$.

Relationship between self-construal and ERPs

We tested whether European American participants would display greater independent self-construal, whereas Asian-American participants would display greater interdependent self-construal. Retaining all items of the SCS resulted in a Cronbach's alpha of 0.81 for the independent subscale and deleting one item resulted in an alpha of 0.70 for the interdependent subscale, suggesting moderately high reliability for both scales. On the independent subscale, European Americans ($M = 4.5$, SD = 0.79, range = 2.8) were not significantly more independent than Asian-Americans ($M = 4.3$, SD = 0.75, range = 2.7), $t(44) = 0.87$, ns; $d = 0.26$), and on the interdependent subscale, Asian-Americans ($M = 4.7$, SD = 0.72, range = 1.9) were not significantly more interdependent than European Americans ($M = 4.6$, SD = 0.57, range = 2.3), $t(44) = 0.52$, ns; $d = 0.15$.

Correlational analyses were conducted between the SCS independent and interdependent subscales[2] and the N400 amplitude of the difference wave. The

[2] Composite scores representing unidimensionality (collectivism–individualism) were also calculated and analyzed (see Chiao et al., 2009), resulting in a consistent, but weaker correlation with the N400; $r = 0.22$; $p = .14$.

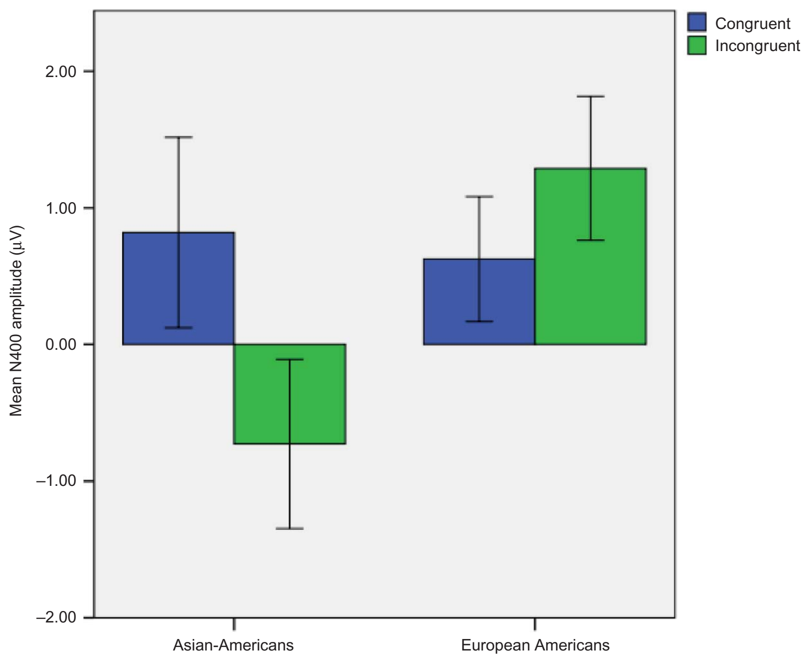

Figure 3. Mean amplitude for 350–450 ms latency window following the onset of the face for electrodes Cz, 81, and 90 for Asian-Americans and European Americans. Greater negativity for the incongruent condition is evident for only the Asian-Americans. There is no group difference in amplitude for the congruent condition.

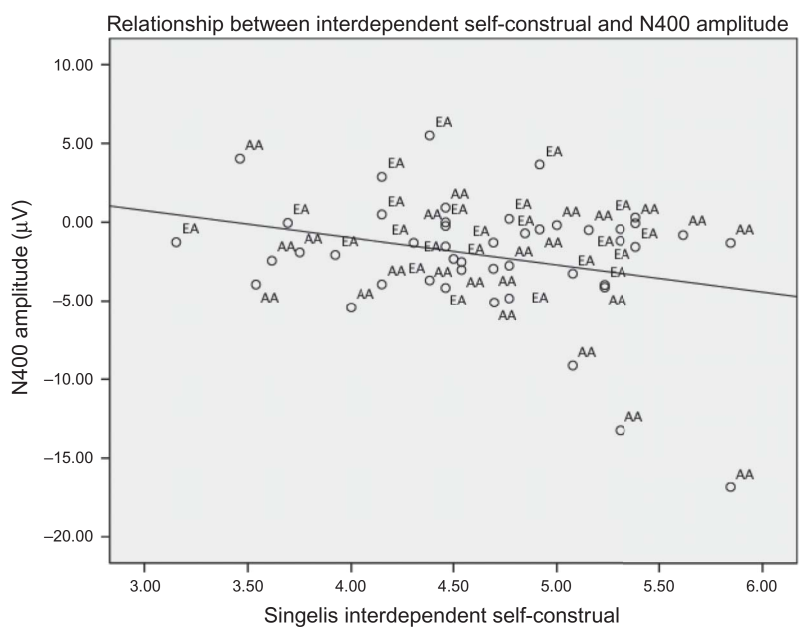

Figure 4. Scatter plot of the relationship between interdependent self-construal and N400 amplitude. The figure shows that greater interdependent self-construal is associated with increasing magnitude or negativity of the N400 (AA = Asian-American; EA = European American).

greater the magnitude of the N400 incongruity effect, the higher the interdependent self-construal score ($r = 0.29$, $p = .05$; see Figure 4). No relationship was found between the N400 and the independent self-construal score ($r = 0.09$, ns). When European Americans and Asian-Americans were analyzed separately, the results were similar, but lacked statistical power.

DISCUSSION

We investigated cultural differences in the semantic processing of emotionally expressive faces superimposed upon background affective scenes using the N400. Resulting N400s were measured to infer the amount of semantic processing of the relationship between the foreground facial expression and the affective background scene. As expected, for East Asian Americans larger N400s resulted when the affective background scenes were followed by affectively incongruent foreground facial expressions. In contrast, no such N400 incongruity effect was found for European American participants. To the best of our knowledge, this is the first study to show cultural differences in brain activity associated with semantic processing of visually presented affective relationships. Additionally, interdependent self-construal was positively related to the magnitude of the N400.

The cultural differences that emerged in the magnitude of the N400 are consistent with previous cognitive, neural, and theoretical literature emphasizing the different degree to which context influences processing of information across cultures. Our findings can be explained by East Asian Americans invoking a holistic cognitive style (Nisbett & Miyamoto, 2005; Nisbett et al., 2001). Within this framework, Asian-American's perceptual processing is considered to be context dependent, with relatively greater attention allocated to the relationship between the focal facial expression and the background affective context. In contrast, European American's analytical perceptual processing is considered to be more context independent, with the foreground facial expression being processed independently of the background affective context. These findings are consistent with previous empirical work using behavioral measures (e.g., Chua et al., 2005; Ji et al., 2000; Kitayama et al., 2003; Masuda & Nisbett, 2001; Mauss & Butler, 2010), as well as growing evidence using neural measures (Hedden et al., 2008; Ishii et al., 2010; Jenkins, Yang, Goh, Hong, & Park, 2010; Lewis et al., 2008; Na & Kitayama, 2011). Interestingly, these neural studies suggest that culture may not only reside in one's environment, but also within the brain.

Utilizing socially rich stimuli that require complex processing of contextual situations broadens the applicability of the N400 to include investigations of cultural differences in deeper affective processing. Originally, the N400 design was used to measure the semantic processing of linguistic stimuli, but more recently, the N400 has been shown to be sensitive to semantic processing across a variety of domains, including visually presented nonlinguistic stimuli (e.g., Ganis & Kutas, 2003; Goto et al., 2010; West & Holcomb, 2002), as well as auditory (Ishii et al., 2010) and visually (Zhang, Guo, Lawson, & Jiang, 2006) presented affective stimuli. This study supports the extant literature and extends our understanding of the sensitivity of the N400 to include cultural differences in the semantic processing of visually presented affective stimuli.

Our findings are also consistent with Masuda et al's. (2008) study of foreground and background facial emotions and yet extend our understanding in important ways. Masuda found that Japanese participants, but not European North American participants, were affected by contextual faces when perceiving emotions of the foreground faces. We found that complex affective background scenes also differentially affect the perception of foreground facial emotion by culture. Furthermore, if the N400 is a reflection of processing of semantic relationships, affective or otherwise, then our data suggest that Asian-Americans must be processing the meaning of the relationship between the affective valence of the background scene and the facial expression to a greater extent than European Americans (see Kutas & Federmeier, 2011 for a review of the N400 literature). In contrast to Masuda's paradigm, which may simply elicit judgments of similarity or difference between background and foreground facial expressions, this study relies on more complex emotional scenes and specifically investigates cultural differences in semantic affective processing.

As anticipated, we found that interdependent self-construal was positively correlated with the N400. Those with higher interdependence displayed greater N400s. This suggests that individuals with high interdependent scores processed the affective incongruity between the affective background and the emotional faces more than did individuals with low interdependent scores. No relationship emerged with independence. Finding a relationship between independent/interdependent self-construal and neural activity is consistent with a growing body of literature in cultural neuroscience (see Kitayama & Uskul, 2011 for a review). Given a unidimensional conceptualization of self-construal, more interdependence and less independence are typically found to be correlated with neural activity associated with greater use of contextual information. Treating the constructs of interdependence and independence as orthogonal, more interdependence (Lewis et al., 2008) or less independence (Goto et al., 2010) is correlated with neural activity associated with greater use of contextual information. Separating the constructs yields results where sometimes interdependence seems to be the driving force and sometimes independence. By operationalizing the constructs orthogonally, we seek to refine our understanding of culture in addition to the neural mechanisms that vary by culture. At this point, these distinctions might be related to measurement concerns stemming from the self-report of interdependency/independency (Heine, Lehman, Peng, & Greenholtz, 2002) or to differences in the nature of the tasks. Perhaps the current relationship with interdependent self-construal stems from the task being social in nature (i.e., reading faces) as opposed to nonsocial (i.e., reading objects) as in Goto et al. (2010).

The focus on East Asian Americans rather than East Asians living in Asia carries many benefits and challenges. First, this study importantly broadens the generalizability of the analytic and holistic framework, suggesting that cultural differences in cognition are robustly found in diasporic samples (Goto et al., 2010; Hedden et al., 2008; Lewis et al., 2008; Na & Kitayama, 2011). Second, the relationship between interdependent self-construals (and not race) points to the usefulness of understanding cultural difference as greater than skin-deep.

Furthermore, in this study Asian-Americans were not different from European Americans in important ways. Given that the Asian sample was drawn from an educational, residential setting that demands high, persistent fluency in the dominant American culture, perhaps the unexpected similarities in interdependent and independent construals should have been expected. However, this conclusion precludes a potentially interesting test of self-construal mediating the relationship between cultural/racial group and neural processes (e.g., Lewis et al., 2008; Na & Kitayama, 2011). Future studies should continue to investigate the phenomenon in other diasporic samples to understand the role of acculturation (see Hedden et al., 2008).

In addition, no between-group differences were found on behavioral measures of accuracy and reaction time. This is consistent with the cultural neuroscience literature and attests to the sensitivity of neural measures in investigations of culture. Behavioral measures reflect the sum total of a series of computational processes, whereas neural measures can isolate these processes in time and space. Therefore, behavioral data and electrophysiological data may appear to be contradictory without actually invalidating one another. In sufficiently simple visual tasks, especially incidental orienting tasks, such as ascribing happiness or sadness to a face, as used in this study, different cultural groups may be able to perform equally well while at the same time process the stimuli differently (Goto et al., 2010; Hedden et al., 2008; Ishii et al., 2010). We see the emergent neural differences but lack of behavioral differences as illustrating the importance of neural measures in cultural research due to their greater sensitivity. Furthermore, cultural differences in neural activity that are independent of behavioral differences are a unique contribution of the field of cultural neuroscience, which differs from cultural psychology where behavioral differences are expected.

Finally, our use of the semantic processing of standardized affective stimuli provides unique opportunities for understanding the intersections of culture, the brain, and emotion. This study complements other research that has focused on the amygdala's role in viewing facial affect (Adams et al., 2009; Chiao et al., 2008) and facial recognition of emotion (Derntl et al., 2009) across cultures. Given that the N400 has been associated with temporal lobe activity (Lau, Phillips, & Poeppel, 2008; Van Petten & Luka, 2006), our data are suggestive of neural activity in the temporal lobe that manifests cultural differences in the semantic processing of affect. However, it is important to recognize that cultural differences in processing information are likely to occur before semantic processing of focal–background relationships. Given the work on cultural differences in visual attention in cognitive (e.g., Boduroglu et al., 2009; Chua et al., 2005) and neural (e.g., Hedden et al., 2008) studies, it is probably the case that the relatively late semantic incongruity indexed by the N400 is the result of attentional processes that direct one's attention to processing objects across the visual field. Indeed, Hedden et al. (2008) have identified using functional magnetic resonance imaging (fMRI) cultural differences in frontal and parietal attentional networks that may influence the semantic processing of objects in our visual field. Presumably, these attentional networks influence the subsequent semantic processing of stimuli in the visual field. Unfortunately, fMRI lacks the temporal resolution necessary to determine when this activity occurs relative to the N400. ERP methodology is ideal for identifying how early cultural differences can be detected in processing visual information. This study was not designed to investigate this issue, and the overlapping ERPs for the background and foreground objects complicate the identification of how early culture influences visual processing. Future research should focus on understanding the stages of processing where culture has an impact. Combined EEG/fMRI or source estimation EEG studies should be able to provide greater insight into these issues. Furthermore, although this study did not investigate the valence of affect, future studies should systematically investigate cultural differences in the semantic processing of positive versus negative backgrounds and facial expressions beyond "happy" and "sad" (Eid & Diener, 2001; Na & Kitayama, 2011) toward a more comprehensive understanding of emotion, culture, and the brain.

In conclusion, the current finding of neural cultural differences in semantic processing of social information is significant. It contributes to a growing body of evidence suggesting that culture should be conceptualized as residing within the brain, as well as outside of the brain. For example, reading others in terms of whether their emotion is appropriate given the situation might closely resemble the complicated judgments that bicultural individuals encounter in daily life (e.g., Yip, 2009). Our study importantly extends the complexity of context to include socioemotional contexts wherein cultural differences are frequently found.

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REFERENCES

Adams, R. B., Rule, N. O., Franklin, R. G., Wang, E., Stevenson, M. T., Yoshikawa, S., . . . Kveraga, K. (2009). Cross-cultural reading the mind in the eyes: An fMRI investigation. *Journal of Cognitive Neuroscience*, *22*, 97–108.

Boduroglu, A., Shah, P., & Nisbett, R. E. (2009). Cultural differences in allocation of attention in visual information processing. *Journal of Cross Cultural Psychology*, *40*, 349–360.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., . . . Iidaka, T. (2009). Neural basis of individualistic and collectivistic views of self. *Human Brain Mapping*, *30*(*9*), 2813–2820.

Chiao, J. Y., Iidaka, T., Gordon, H. L., Nogawa, J., Bar, M., Aminoff, E., . . . Ambady, N. (2008). Cultural specificity in amygdala response to fear faces. *Journal of Cognitive Neuroscience*, *20*(12), 2167–2174.

Choi, I., & Nisbett, R. E. (1998). The cultural psychology of surprise: Holistic theories and recognition of contradiction. *Journal of Personality and Social Psychology*, *79*, 890–905.

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.

Cohen, D., & Gunz, A. (2002). As seen by the other . . . : Perspectives on the self in the memories and emotional perceptions of Easterners and Westerners. *Psychological Science*, *13*, 55–59.

Derntl, B., Habel, U., Robinson, S., Windischberger, C., Kryspin-Exner, I., Gur, R. C., & Moser, E. (2009). Amygdala activation during recognition of emotions in a foreign ethnic group is associated with duration of stay. *Social Neuroscience*, *4*(4), 294–307.

Deveney, C. M., & Pizzagalli, D. A. (2008). The cognitive consequences of emotion regulation: An ERP investigation. *Psychophysiology*, *45*, 435–444.

Eid, M., & Diener, E. (2001). Norms for experiencing emotions in different cultures: Inter- and intranational differences. *Journal of Personality and Social Psychology*, *81*, 869–885.

Ferree, T. C., Luu, P., Russell, G. S., & Tucker, D. M. (2001). Scalp electrode impedance, infection risk, and EEG data quality. *Clinical Neurophysiology*, *112*, 536–544.

Ganis, G., & Kutas, M. (2003). An electrophysiological study of scene effects on object identification. *Cognitive Brain Research*, *16*, 123–144.

Gilbert, D. T., & Malone, P. S. (1995). The correspondence bias. *Psychological Bulletin*, *117*, 21.

Goh, J. O., Chee, M. W., Tan, J. C., Venkatraman, V., Hebrank, A., Leshikar, E. D., . . . Park, D. C. (2007). Age and culture modulate object processing and object-scene binding in the ventral visual area. *Cognitive, Affective & Behavioral Neueroscience*, *7*, 44–52.

Goto, S. G., Ando, Y., Huang, C., Yee, A., & Lewis, R. S. (2010). Cultural differences in the visual processing of meaning: Detecting incongruities between background and foreground objects using the N400. *Social Cognitive and Affective Neuroscience*, *5*, 242–253.

Gutchess, A. H., Welsh, R. C., Boduroglu, A., & Park, D. C. (2006). Cultural differences in neural function associated with object processing. *Cognitive, Affective & Behavioral Neuroscience*, *6*, 102–109.

Haberstroh, S., Oyserman, D., Schwarz, N., Kuhnen, U., & Ji, L. J. (2002). Is the interdependent self more sensitive to question context than the independent self?: Self-construal and the observation of conversational norms. *Journal of Experimental Social Psychology*, *38*, 323–329.

Hedden, T., Ketay, S., Aron, A., Markus, H. R., & Gabrieli, J. D. E. (2008). Cultural influences on neural substrates of attentional control. *Psychological Science*, *19*, 12–17.

Heine, S. J., Lehman, D. R., Peng, K., & Greenholtz, J. (2002). What's wrong with cross-cultural comparisons of subjective Likert scales? The reference-group effect. *Journal of Personality and Social Psychology*, *82*, 903–918.

Holcomb, P. J. (1993). Semantic priming and stimulus degradation: Implications for the role of the N400 in language processing. *Psychophysiology*, *30*, 47–61.

Holcomb, P. J., & Neville, H. J. (1991). The electrophysiology of spoken sentence processing. *Psychobiology*, *19*, 286–300.

Ishii, K., Kobayashi, Y., & Kitayama, S. (2010). Interdependence modulates the brain response to word-voice incongruity. *Social Cognitive and Affective Neuroscience*, *5*, 307–317.

Jenkins, L. J., Yang, Y.-J., Goh, J., Hong, Y.-Y., & Park, D. C. (2010). Cultural differences in the lateral occipital complex while viewing incongruent scenes. *Social Cognitive and Affective Neuroscience*, *5*, 236–241.

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

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.

Kitayama, S., & Uskul, A. K. (2011). Culture, mind, and the brain : Current evidence and future directions. *Annual Review of Psychology*, *62*, 419–449.

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event-related brain potentional (ERP). *Annual Review of Psychology*, *62*, 621–647.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, *201*, 203–205.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual* (Technical Report A-8). Gainesville: University of Florida.

Lau, E. F., Phillips, C., & Poeppel, D. (2008). A cortical network for semantics: (de) constructing the N400. *Nature Reviews Neuroscience*, *9*, 920–933.

Leuthold, H., Filik, R., Murphy, K., & Mackenzie, I. G. (2012). The on-line processing of socio-emotional information in prototypical scenarios: Inferences from brain potentials. *Social Cognitive and Affective Neuroscience*, *7*, 457–466.

Lewis, R. S., Goto, S. G., & Kong, L. (2008). Culture and context: East Asian American and European American differences in P3 event-related potentials. *Personality and Social Psychology Bulletin*, *34*, 623–634.

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.

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.

Matsumoto, D., & Ekman, P. (1989). American-Japanese cultural differences in intensity ratings of facial expressions of emotion. *Motivation and Emotion*, *13*, 143–157.

Mauss, I. B., & Butler, E. A. (2010). Cultural context moderates the relationship between emotional control values and cardiovascular challenge versus threat responses. *Biological Psychology*, *84*, 521–530.

Mesquita, B., & Leu, J. (2007). The cultural psychology of emotion. In S. Kitayama & D. Cohen (Eds.), *Handbook of cultural psychology* (pp. 734–759). New York, NY: Guilford Press.

Miyamoto, Y., & Wilken, B. (2010). Culturally contingent situated cognition: Influencing other people fosters analytic perception in the United States but not in Japan. *Psychological Science*, *21*, 1616–1622.

Morris, M. W., & Peng, K. (1994). Culture and cause – American and Chinese attributions for social and physical events. *Journal of Personality and Social Psychology*, *67*, 949–971.

Na, J., & Kitayama, S. (2011). Spontaneous trait inference is culture-specific: Behavioral and neural evidence. *Psychological Science*, *22*, 1025–1032.

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

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

Oyserman, D., Coon, H. M., & Kemmelmeier, M. (2002). Rethinking individualism and collectivism: Evaluation of theoretical assumptions and meta-analyses. *Psychological Bulletin*, *128*, 3–72.

Singelis, T. M. (1994). The measurement of independent and interdependent self-construals. *Personality and Social Psychology Bulletin*, *20*, 580–591.

Van Petten, C., & Luka, B. J. (2006). Neural localization of semantic context effects in electromagnetic and hemodynamic studies. *Brain and Language*, *97*, 279–293.

West, W. C., & Holcomb, P. J. (2002). Event-related potentials during discourse-level semantic integration of complex pictures. *Cognitive Brain Research*, *13*, 363–375.

Yip, T. (2009). Simultaneously salient Chinese and American identities: An experience sampling study of self-complexity, context, and positive mood among Chinese young adults. *Cultural Diversity and Ethnic Minority Psychology*, *15*, 285–294.

Zhang, Q., Guo, C., Lawson, A., & Jiang, Y. (2006). Electrophysiological correlates of visual affective priming. *Brain Research Bulletin*, *11*, 316–323.