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Cultural Shaping of Neural Responses:

Feedback-Related Potentials Vary with Self-Construal and Face-priming

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Abstract

Previous work shows that when an image of face is presented immediately prior to each trial of a speeded cognitive task (face-priming), the error-related negativity (ERN) is up-regulated for Asians, but it is down-regulated for Caucasians. These findings are consistent with the hypothesis that images of “generalized other” vary cross-culturally such that they evoke anxiety for Asians, whereas they serve as safety cues for Caucasians. Here, we tested whether the cross-cultural variation in the face-priming effect would be observed in a gambling paradigm. Caucasian Americans, Asian Americans, and Asian sojourners were exposed to a brief flash of a schematic face during a gamble. For Asian Americans, face-priming resulted in significant increases of both negative-going deflection of ERP upon negative feedback (feedback-related negativity or FRN) and positive-going deflection of ERP upon positive feedback (feedback-related positivity or FRP). For Caucasian Americans, face-priming showed a significant reversal, decreasing both FRN and FRP. The cultural difference in the face-priming effect in FRN and FRP was partially mediated by interdependent self-construal. Curiously, Asian sojourners showed a pattern similar to the one for Caucasian Americans. Our findings suggest that culture shape neural pathways in both systematic and highly dynamic fashion.

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As Aristotle famously proclaimed, “Man is by nature a social animal.” Modern research in psychology has provided ample evidence for this time-honored observation by examining how humans process and respond to the faces of their conspecifics. For example, human newborns have an exquisite sensitivity to face stimuli (Meltzoff & Moore, 1983). Among human adults, a specific region of the brain (the fusiform face area) is devoted to processing faces (Kanwisher & Yovel, 2006; Meltzoff & Moore, 1983). And more recent research suggests that a mere exposure to face-like images is sometimes sufficient to modulate one’s motivational state (Haley & Fessler, 2005; Rigdon, Ishii, Watabe, & Kitayama, 2009).

In the current work, we built on this growing body of research on face processing and investigated the hypothesis that the motivational effect of an exposure to a face stimulus (face-priming) depends on one’s cultural background. In particular, our previous work suggests that face-priming up-regulates error processing for Asians, but it may down-regulate it for Caucasian Americans (Kitayama, Snibbe, Markus, & Suzuki, 2004; Na & Kitayama, 2012; Park & Kitayama, 2014). To sharpen our analysis, we drew on existing work on electro-cortical responses to reward prediction errors (Holroyd & Coles, 2002), and hypothesized that face-priming would modulate the sensitivity to reward prediction errors depending on the cultural backgrounds of the subjects (Kitayama & Tompson, 2015). Specifically, we anticipated that face-priming would up-regulate the electro-cortical responses to reward prediction errors for individuals with Asian, interdependent cultural backgrounds. In contrast, face-priming was expected to down-regulate the latter for those with Caucasian, independent cultural backgrounds.

Culture: Two Senses in the Concept

We use the term culture in two different ways, following prior effort by social and behavioral scientists to define this term (Kroeber & Kluckhohn, 1952). First, culture in singular refers to a historically accumulated set of meanings and practices. In this sense, culture varies systematically across regions of the globe in terms of the model of the self that is shared and authenticated therein (Kitayama & Uskul, 2011; Markus & Kitayama, 1991). Second, cultures in plural refer to historically demarcated ethnic or racial groups. Thus, people of Caucasian and Asian descent will be referred to as Caucasians and Asians, respectively.

Reflecting long-term ecological conditions and the subsistence systems that they afforded over the last 10,000 years, cultural traditions that emerged in Eastern regions of the Eurasian continent (Asian cultures) are thought to be more interdependent or less independent compared with the traditions that developed in relatively more Western regions (Caucasian cultures) (Kitayama & Uskul, 2011; Oishi, 2014; Talhelm et al., 2014; Uskul, Kitayama, & Nisbett, 2008). Although not clearly demarcated, the two broad regions of East and West have accumulated relatively unique sets of both meanings (lay theories, religious beliefs, and common sense) and practices (behavioral scripts, rituals, and conventions). Over time, various physical features of residents such as skin tone, eye color, and height among many others (ethnicity or race markers) have changed, mediated through a series of polymorphic genetic changes. Thus, ethnicity or race (e.g., Asian vs. Caucasian, or culture under the second definition) serves as a reasonable proxy of cultural traditions each individual carries (culture in the first sense).

Notably, while Asian vs. Caucasian cultures originally developed in Eastern vs. Western regions of the Eurasian continent, the cultural traditions from the respective regions have since been implanted in other regions of the globe, most notably in North America, as people from the Eurasian continent immigrated to the North American continent over the last several hundred years. Whereas Asian Americans carry Asian cultural meanings and practices, Caucasian Americans carry Caucasian cultural meanings and practices.

In our conceptualization, culture in the first sense is an amalgam of both collective (i.e., socially shared) and individual (i.e., cognitively represented) components that are interconnected to form a loosely organized system of meanings and practices (Kitayama, 2002; Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997). Self-report measures of the construal of the self as independent or interdependent (Singelis, 1994) is an index of that aspect of culture that is cognitively represented in each person's self-concept.

Culture and Generalized Other

In Western cultures, especially Caucasian American cultures, the self is assumed to be independent. According to this independent model of the self, one's behavior is guided and organized by his or her internal attributes such as desires, attitudes and preferences. In contrast, in Eastern cultures, especially East Asian cultures, the self is assumed to be interdependent. According to this model of the self, one's behavior is guided and organized by others' expectations and obligations to them. Depending on which model of the self is more dominant in their own cultures, individuals may show contrasting psychological responses in the presence of other people.

Close interdependence with others in social relations requires attunement to each other's social expectations. Interdependent individuals (e.g., Asians and Asian Americans) are therefore motivated to adjust their behaviors to social expectations. Accordingly, when interacting with known others, worries may arise regarding what obligations they might have, where they might fall short by way of satisfying expectations, and what evaluations may be put on the self. Consistent with this analysis, Asians typically attend closely to their potential shortcomings and negative features (Kitayama et al., 1997). They are thus relatively pessimistic (Chang & Asakawa, 2003), and high in social anxiety (Okazaki, Liu, Longworth, & Minn, 2002). This pessimism is likely adaptive in Asian culture because it enables the individuals to avoid any potential social mishaps or transgressions and to conform to the expectations of others. Once socialized in this interdependent cultural system, individuals may eventually associate certain negative emotions such as worry, apprehension, and anxiety to images of a “generalized other” (Mead, 1934). Accordingly, face cues may be sufficient to activate neural pathways linked to the negative emotions of fear and anxiety.

In contrast, independence of the self entails relative autonomy from others’ expectations. In interacting with others, independent individuals (e.g., Caucasian Americans) will not experience as much worry or anxiety as Asians would. Evidence shows that they attend to positive aspects of themselves (Kitayama et al., 1997) and are relatively optimistic (Taylor & Brown, 1988). Moreover, Caucasians often praise and complement one another because helping close others to maintain their self-esteem is considered an important way to display one’s friendship to them (Heine, Lehman, Markus, & Kitayama, 1999). Consistent with this evidence, Caucasian Americans tend to be relatively low in social anxiety (Okazaki, 2000) while showing higher levels of general trust as compared to Asians (Yamagishi, Cook, & Watabe, 1998). Once socialized in this cultural context, individuals are unlikely to associate negative emotions to face cues. Instead, since close others often willingly provide emotional support to one’s self-esteem and confidence, the faces of these others may serve as a safety signal. Accordingly, the face cues may be expected to inhibit the neural pathways linked to negative emotions such as fear and anxiety.

Face-priming and Error-Related Negativity (ERN)

When anxiety is elicited, individuals become more vigilant of potential threats (Cisler & Koster, 2010). They carefully monitor both their behaviors and the surrounding environment for errors and conflicts (Hajcak, McDonald, & Simons, 2003). In a recent experiment, Park and Kitayama (2014) tested whether error processing would be modulated by exposure to face images. Both Caucasian Americans and East Asians performed a speeded flanker task, where participants were instructed to respond to the direction of a center arrow flanked by either congruent (same direction) or incongruent (opposite direction) arrows. Right before the flanker was presented, a racially and emotionally neutral looking realistic face image was presented very briefly for an average duration of 90ms. When individuals make an error in a speeded cognitive task, a marked negative deflection around the fronto-central scalp region arises immediately after the initiation of the response itself. This event-related potential (ERP) component is called the error-related negativity (ERN) (Holroyd & Coles, 2002). The ERN is thought to originate in or near the anterior cingulate cortex (ACC), and indicate a negative reward prediction error that is based on a computation of the current outcome (an incorrect response) as being worse than expected (a correct response) (Gehring, 2002; Miltner, Braun, & Coles, 1997; Nieuwenhuis, Holroyd, Mol, & Coles, 2004). This prediction error signal may be augmented by response conflict between competing responses (Botvinick, Cohen, & Carter, 2004; Yeung, 2004). Previous work shows that ERN is associated with trait anxiety (Hajcak et al., 2003; Moser, Moran, Schroder, Donnellan, & Yeung, 2013).

Park and Kitayama (2014) found that Asians showed a significantly greater ERN in the face-priming condition than in control conditions (where either an image of a house or scrambled face was presented as a prime). This finding is consistent with the hypothesis that face images induce transient anxiety. In contrast, Caucasian Americans showed a marginally reduced ERN in the face-priming condition as compared in the control conditions. In order to examine the hypothesis that Asians are relatively interdependent and thus they worry about potentially negative evaluations the others might hold about them, the researchers used a self-report self-construal measure. In line with the hypothesis, the cultural difference in the face-priming effect was predicted by interdependent self-construal such that Asians were both higher in interdependent self-construal and showed a greater magnitude of the face-priming effect. The Park and Kitayama (2014) study provides initial evidence for the hypothesis that face images transiently increase anxiety for Asians. When anxiety is induced, the ACC may be sensitized. As a consequence, the same error response may produce a larger error signal (ERN). Conversely, when anxiety is relieved, the ACC may be de-sensitized. Consequently, the same error response may produce a smaller error signal (ERN). The Caucasian result is consistent with this analysis, although caution is required because the result was statistically marginal.

Extension to a Gambling Paradigm

Although the Park and Kitayama (2014) findings are promising, it leaves two important issues unaddressed. First, the speeded cognitive task may particularly likely to produce anxiety for Asians because this task is akin to an intelligence test, which is valued rather strongly in Asian cultures (Sue & Okazaki, 1990). It is also unclear whether the effect of face-priming on error-processing may generalize to non-cognitive tasks. Second, the error signal that was tested in the Park and Kitayama (2014) study was contingent on the detection of an error in one's own response. It is not clear whether the same face-priming effect would be observed in response to feedback of one's response as correct or incorrect.

To address these questions, we adapted a gambling task, which involves no cognitive, IQ test-like component. Moreover, in a gamble, subjects make a choice between two options. One option is linked to a gain of a certain monetary amount and the other, a loss of the same amount. When outcome feedback is delivered, it produces two different error signals, both of which are contingent on the feedback. Hence, the gambling task is quite suitable to assess the generality of the hypothesis that mere exposure to face images is sufficient to increase or decrease the ACC sensitivity depending on cultural background of subjects.

In the typical gambling task, the frequency of win versus loss trials is set to be equal. Under such conditions, loss feedback produces a negative-going ERP component centered around the fronto-central scalp region. This component is called the feedback-related negativity (FRN) (Gehring, 2002; Gehring & Willoughby, 2004; Miltner et al., 1997). In addition to the FRN (which is contingent on loss feedback), the win feedback produces an analogous error signal because the win is just as unexpected as the loss. Specifically, the win feedback produces a positive-going ERP component around the same region. This component is referred to as the feedback correct-related positivity or, simply, the feedback-related positivity (FRP) (Holroyd, Pakzad-Vaezi, & Krigolson, 2008).

Holroyd and Coles (2002) have proposed that both FRN and FRP are reward prediction signals reflecting phasic shifts in dopamine activity in the ACC. Because anxiety is likely to sensitize the ACC, it may be expected to increase the magnitude of both FRN and FRP. Consistent with this expectation, numerous studies have shown that motivational states influence FRN (Gehring, 2002; Holroyd & Coles, 2002). For example, the FRN magnitude increases when motivation is increased by monetary incentives (Boksem, Tops, Wester, Meijman, & Lorist, 2006; Hajcak, Moser, Holroyd, & Simons, 2006). To date, much previous work focused only on FRN. However, Walsh and Anderson (2012) show that increased motivation (and, thus, increased ACC sensitivity) is associated with increases of the magnitude of both FRN and FRP. That is, FRN becomes more *negative* and FRP, more *positive* (Walsh & Anderson, 2012).

In short, a gambling paradigm provides us with an opportunity to assess the robustness and generality of the Park and Kitayama (2014) ERN findings. We hypothesized that for Asians, face-priming would increase the ACC sensitivity, thereby increasing both FRN and FRP. For Caucasians, we hypothesized that face-priming would reduce the ACC sensitivity, thereby decreasing both FRN and FRP. Furthermore, we anticipated that the cultural difference in the face-priming effect on FRN and FRP would be explained at least in part by individual differences in interdependent self-construal.

Asian Americans and Asian Sojourners

In sharpening our cross-cultural predictions, we compared three ethnic groups, Caucasian Americans (US-born Americans of Caucasian ancestry), Asian Americans (US-born Americans of Asian ancestry), and Asian sojourners (Asian-born Asians who have stayed in the US for up to 10 years). Previous cross-cultural work on Caucasian vs. Asian differences typically examined Caucasians in the United States and Asians in Asian countries such as China, Japan, and Korea. Some sizable number of studies tested Asian Americans instead of Asians in Asia, and confirmed the cross-cultural predictions. A meta-analysis of studies using scale measures of independent vs. interdependent self-construal (or equivalently, individualism vs. collectivism) show that Asian Americans tend to be just as interdependent as Asians in Asia are (Oyserman, Coon, & Kemmelmeier, 2002). Asian Americans carry Asian cultural traditions, as much as Caucasian Americans carry Caucasian cultural traditions. Hence, we expected that our Asian prediction (face-priming producing increases of both FRN and FRP) would hold for Asian Americans.

It has so far been relatively rare to use Asian-born Asians in the U.S. as an Asian sample. When this sample is tested, the results appear to be more variable. It is conceivable that Asian-born Asians retain their Asian identity and cultural tradition (Kitayama et al., 2014). However, it is also conceivable that they chose to come to North America because they did not fit in to the Asian interdependent culture. They may constitute a relatively less interdependent or more independent subgroup in Asian societies and thus exhibit different neural responses. The latter possibility would suggest that Asian sojourners might be relatively more independent in comparison with Asian Americans (Kitayama, Duffy, Kawamura, & Larsen, 2003). It was therefore uncertain whether our prediction for Asian Americans would hold for Asian sojourners.

Method

Participants

Forty-four East Asian and 42 Caucasian American undergraduates at the University of Michigan participated in the study for course credit and a chance to win a monetary reward of up to $10. The ethnicity of each participant was determined by self-reported ancestry (East Asian vs. European). Seven participants were removed for medication use (2), history of head injury (3), and deliberately not following instructions (2). 10 more participants were dropped because inspection with standard artifact rejection criteria (Luck, 2014) revealed that their ERP data were excessively noisy. In total, 69 participants (29 males, M_{age} = 19.1, SD = 1.37) of either Caucasian (34 total, 16 males, M_{age} = 18.7, SD = 0.87) or East Asian (35 total, 13 males, M_{age} = 19.5, SD = 1.63) descent were included. Among East Asians, 14 of them had spent less than 10 years in the U.S. when tested (5 males, M_{age} = 20.36, SD = 1.74), and most of them came to the U.S. for college. All of the remaining 21 East Asian participants had been both born and raised in the U.S. These two groups are referred to as Asian sojourners and Asian Americans, respectively. All participants had normal or corrected-to-normal vision.

Procedure

Upon arrival, participants were told that the study would record brain responses during a simple gambling task. All participants were seated approximately 60cm from a 15-inch CRT color monitor while EEG electrode equipment was attached. Next, participants were given a practice block including 10 trials to get familiar with the procedure, followed by the actual experiment consisting of 6 blocks with 32 trials each. The gambling task procedure was modified from a design used by Gehring and Willoughby (2004).

-Insert Figure 1 about here-

Participants were given 5000 points to start the gamble. They were told that depending on the amount of points they had at the end of the study they would be awarded up to 10 dollars. On each trial, a fixation point was presented for 500ms, followed by two blank squares placed side by side (see Figure 1). Participants were told to choose one of them to earn points. They were to make their selection by pressing one of the two corresponding keys on the keyboard with their index fingers. They were told that there would be some distracting stimuli between the two windows and were asked to ignore them. The cards remained on the screen for up to 10s or until the choice was registered. Feedback was given 1000ms after the choice was made, by having the cards turn green or red (indicating win and loss, respectively). Point information was displayed on the card in black text indicating how many points (either 50 or 150 points) were won or lost. The points won or lost were either added or subtracted from the participant's running total points. 800ms after feedback, the next trial started with the presentation of a fixation cross. Following the completion of each block, participants were asked how much they thought they had won or lost points in the preceding block on a scale from 1 to 10 (1: *lose a lot*, 10: *win a lot*). After responding, the total points earned were displayed at the end of each block.

Within the gambling task adopted, participants were presented with a priming stimulus on each trial. When the two cards were presented, either a schematic face or a scrambled face was also presented between the cards simultaneously. Schematic faces varied in emotional expression, (i.e., neutral, happy, or angry). Sample priming stimuli are shown in Figure 1. The priming stimulus was displayed for 90ms, whereas the cards remained on the screen until participants made a choice. Participants were asked to ignore "distracter figures" that would be flashed while performing the gambling task. There was the total of four priming conditions (the three face conditions and a control [i.e., scrambled face] condition). Within each block of 32 trials, half of the trials corresponded to each of the two point conditions (50 vs. 150 points). In addition, the four priming conditions were allocated three trials each. The outcome of the gamble was randomly determined on each trial. Over the six blocks, there were 24 trials in each of the 8 conditions defined by priming (4) and point (2).

Each of the four priming conditions had the total of 48 trials across the 6 blocks (outcome [2] x point [2] x 6 blocks). To minimize any habituation effects, we prepared 48 unique schematic faces by jittering head shape (circle, vertical oval, horizontal oval, square, vertical rectangle, horizontal rectangle) and relative positions of nose and mouth each of which varied in 8 directions and 3 distances. Emotions were manipulated by changing the shapes of eyebrows and the mouth. Scrambled images were created by taking each modified face-stimulus and entering them into an image-scrambling program such that every scrambled image contained the same ratio of black to white space. The scrambled-image generator breaks up each picture into very small squares and subsequently rearranges them in a completely random fashion. The size of the squares was set to be small enough so that the resulting scrambled image had no resemblance to any face parts.

Following the computer task, participants filled out a packet of questionnaires. This packet included 10 scales. First, we had a modified self-construal scale (Park & Kitayama, 2014) to measure scores for independence (10 items) and interdependence (10 items) separately. Participants rated themselves on a 7-point rating scale (1="strongly disagree", 7="strongly agree"). Second, we also had a brief version of the scales designed by Gosling and colleagues to assess Big-5 personality traits (Gosling, Rentfrow, & Swann, 2003). Participants used a 7-point rating scale and rated whether two brief descriptions each would apply to themselves for extraversion (e.g., "extraverted and enthusiastic"), neuroticism (referred to by Gosling et al. as emotional stability [reversed], e.g., "anxious and easily upset"), conscientiousness (e.g., "Dependable and self-disciplined"), openness to experience (e.g., "open to new experiences and complex"), and agreeableness (e.g., "sympathetic and warm").

The inter-item correlations (equivalent to the reliabilities) were extremely low (less than .3) for conscientiousness, openness, and agreeableness. Thus, these traits were dropped. In addition, we also used Penn State Worry Questionnaire (PSWQ: 1="*not at all typical of me*", 5="*very typical of me*") (Meyer, Miller, & Metzger, 1990) to measure worry and the anxious arousal subscale of the Mood and Anxiety Symptom Questionnaire (MASQ: 1="*not at all*", 5="*extremely*") (Clark & Watson, 1991) to measure anxiety. The relevant ratings were averaged to yield mean scores. These means as well as the reliabilities for each of the three cultural groups are summarized in Table 1. As can be seen, the reliabilities were not always sufficiently high (> .60) although most were close to the .60 cutting point.

-Insert Table 1 about here-

After receiving a money reward (determined in accordance with their performance on the gamble task), participants were debriefed and dismissed.

Physiological Recording and Processing

The EEG was recorded with 32 channel electrodes using the BioSemiActiveTwo System as well as 6 external electrodes used for ocular correction and re-referencing. The data were digitized at a rate of 512 Hz and resampled at 256 Hz, and then re-referenced to the average of the two mastoids. The data were analyzed using MATLAB with EEGLAB plugin and ERPLAB extension. We applied an offline bandpass filter with a lowpass of 30Hz and a high pass of 0.1Hz. Trials were rejected if they exceeded +/-200mv, if they fluctuated more than 50mv between two sampling points, or if they had little to no activity (under .5mv) over the course of the trial. Trials with blinks occurring +/-100ms around the face-stimulus were removed to ensure visual processing of the priming stimuli. All other trials containing blink ocular artifacts were corrected based on a commonly used algorithm (Gratton, Coles, & Donchin, 1983). We segmented based on a 200ms pre-stimulus baseline and 800ms post-feedback (1000ms in total).

During a lengthy procedure like the one adopted in the current study, subjects may lose concentration and disengage from the task on some trials. When this happened, priming stimuli might not be processed effectively and therefore the effects of the primes may be compromised. To address this issue, we used pretrial alpha increase to identify the trials wherein subjects likely became disengaged. Waves in the frequency range of 8-12Hz (called alpha) are very common during awaking hours. Importantly, they are typically suppressed (resulting in low alpha power) when people actively process information (Klimesch, Sauseng, & Hanslmayr, 2007). One may therefore anticipate that the decreased pre-trial alpha power is a good index of the subject's concentration and/or motivational engagement during the trial. Consistent with this expectation, a recent study found that pre-trial alpha suppression during a cognitive vigilance task involving detection of sub-threshold stimuli significantly correlates with subjective attention, which in turn is known to be related to task performance (Macdonald, 2011). This finding is in line with previous evidence that pretrial alpha suppression is correlated with the ability of subjects to detect stimuli that are presented at a sub-threshold level (Ergenoglu et al., 2004).

We computed the average alpha power between 8-12Hz at the O1 and O2 electrodes during the 2000ms time window immediately preceding the presentation of priming stimuli. This was done separately for each subject. We then eliminated the trials that showed an alpha increase that was greater than the average by 2 standard deviations or more. On average we eliminated 3% of trials. In no case did we exclude more than 7% of trials. An FRN-FRP face-priming index (see below) obtained after excluding high-alpha trials correlated highly with the original index (obtained before exclusion), $r = .94$.

To determine whether face primes were in fact registered and processed, we time-locked the waveforms to the presentation of a prime and examined an N170 component at the occipito-temporal electrode sites. This component is thought to originate in the fusiform face area and respond to the processing of face stimuli (Rossion & Jacques, 2008). An inspection of the waveforms confirmed the presence of N170 peaking at 160ms post-prime at the right posterior temporal electrodes, most prominently at P8. In carrying out this analysis, due to the close proximity of the P8 electrode and the mastoids, an average reference of all 32 electrodes was used to measure the N170. The negativity at 160ms post-prime was preceded by a positivity peaking at 100ms post-prime. We first computed the average amplitudes +/-15ms around the two peaks and computed the difference between them so that positive values show a greater negative-going deflection at 160ms post-prime.

-Insert Figure 2 about here-

To control for other overlapping components (e.g., P3 and P2), both FRN and FRP were measured using a base-to-peak method recommended by previous researchers (Hajcak, Moser, Holroyd, & Simons, 2007; Holroyd & Coles, 2002; Holroyd, Nieuwenhuis, Yeung, & Cohen, 2003). As in previous work, the FRN peaked around 270ms post-feedback. The preceding positive peak was found around 220ms. Inspection of individual waveforms revealed, however, that these peaks show some between-individuals variation. To minimize the noise caused by this individual difference in the timing and relative amplitude of these peaks, we first computed the mean amplitudes +/-20ms around the two peaks (Luck, 2014). We then obtained the difference between the two amplitudes. As illustrated in Figure 2, negative values show a negative-going deflection of the wave from the 220+/-20ms post-feedback to the 270+/-20ms post-feedback, whereas positive values show a positive-going deflection of the wave from the 220+/-20ms post-feedback to the 270+/-20ms post-feedback. In each condition defined by outcome and prime, we computed both the mean bottom-to-peak amplitude for the loss trials (FRN) and the comparable mean amplitude for the win trials (FRP). The magnitude of FRN is indicated by negative values, whereas the magnitude of FRP is indicated by positive values.

Results

Individual Difference Measures

We first tested whether the three cultural groups would vary in independent and interdependent self-construals. A culture x gender x self-construal dimension ANOVA performed on the scale scores showed a significant interaction between culture and self-construal dimension, $F_{(2, 63)} = 5.69$, $p < .005$. As expected, Caucasian Americans were both more independent and less interdependent (*M*s = 5.38 and 4.77, respectively), as compared to Asian Americans (*M*s = 4.99 and 5.18, respectively), $t\text{s}_{(53)} = 2.15$ and -2.64, *p*s < .05. Interestingly, our Asian sojourner group fell in-between, no different from either Caucasian Americans or Asian Americans on either independence or interdependence (*M*s = 5.18 and 5.06 for independence and interdependence, respectively), all *p*s > .094. When independence and interdependence were compared within each group, Caucasian Americans showed a significantly higher mean score for independence than for interdependence, $t_{(33)} = 4.00$, $p < .001$. A difference in the same direction was evident, but no longer significant for Asian sojourners, $t < 1$. The pattern was reversed for Asian Americans although the reversal was not statistically significant, $t_{(20)} = -1.10$. Extraversion was significantly higher for both Caucasian Americans and Asian sojourners as compared to Asian Americans, *t*s > 2, *p*s < .05. None of the other scales showed any effect of culture. Correlations among the individual difference measures are summarized in Table 2.

-Insert Table 2 about here-

Behavioral Data

Performance in the gamble was determined in fully random fashion, with a result that some participants won more (and lost less) points than others. Although the average likelihood of win was close to 50% (*M* = 52%, *SD* = 6%), the final score varied somewhat across participants (*M* = 5857 points, *SD* = 2525 points). There was no cultural difference in the total amount earned over the initial 5000 points given (*M* = 857 points, *SD* = 2525 points), *F* < 1. Nor was there any significant cultural difference in the total win ratio that remained similar at 52%, 52%, and 53% for Asian Americans, Asian sojourners, and Caucasian Americans, respectively, *F* < 1. There was no significant cultural difference in the time required for choices, with the mean decision time of 780, 1004, and 803ms for Caucasian Americans, Asian sojourners, and Asian Americans, respectively, $F_{(2, 66)} = 2.18$, $p > .1$.

N170: An Index of Face Processing

The N170 ERP component was examined to ensure that face stimuli were in fact registered equally for Asian Americans, Asian sojourners, and Caucasian Americans. Unfortunately, for N170 analysis one Asian American, one Caucasian American, and eight Asian sojourners had to be removed due to equipment malfunction at electrode site P8. For this reason, the Asian sojourner N170 data were dropped. Figures 3-A and B show prime-locked waveforms for Asian Americans and Caucasian Americans at the P8 electrode. A 2x2 ANOVA performed on the N170 magnitude (prime [face vs. scramble] x culture [Caucasian vs. Asian American]) showed a main effect of face, $F_{(2, 51)} = 56.45$, p < .001. The N170 was greater for the face primes than for the scramble primes, showing that faces were registered in the brain. This effect was equally observed for the two cultural groups analyzed. The interaction between prime and culture was negligible, $F_{(2, 51)} < 2$, $p > .2$. Other effects achieved statistical significance.

-Insert Figures 3-A and B about here-

Feedback-Related Negativity (FRN) and Positivity (FRP)

Topographic maps of difference waves (FRN-FRP) are shown in Figures 4-A, B, and C. The ERP effect is centered around FCz and Cz, consistent with previous work on the gambling task. We thus averaged these and three adjacent electrodes (Fz, FC1, and FC2) to yield our measures of FRN and FRP. Mean amplitudes of the five electrodes were highly correlated (rs > .9). A preliminary analysis focusing only on the three face type conditions showed no significant effects of face type, ps > .10. We therefore combined the three face type conditions to form a face condition and compared the collapsed face condition with the scrambled face control condition. The waveforms time-locked to feedback are also shown in Figures 4-A, B, and C. The time window that is relevant to FRN and FRP (200-290ms) is highlighted in gray. FRN and FRP were analyzed as a function of outcome (win vs. loss [or equivalently, FRN vs. FRP]), prime (happy, neutral, angry face, vs. scrambled face), point (50 vs. 150), and culture (Caucasian American vs. Asian sojourners vs. Asian Americans).

-Insert Table 1 about here-

The mean FRNs and FRPs for the three cultural groups are summarized in Table 3. Remember that we calculated FRN and FRP such that FRN are negative and FRP, positive. A 3x2x2x2x2 ANOVA (culture x gender x outcome x prime x point) was performed on these means. As expected, FRN was significantly negative than FRP, $F_{(2, 66)} = 58.54$, $p < .001$. Importantly, a three-way interaction involving outcome, prime, and culture was significant, $F_{(2, 66)} = 5.96$, $p < .005$.[1] This interaction was not qualified by any other variables including gender and points gained or lost on each gamble (50 vs. 150 points). To probe the nature of the outcome x prime x culture interaction, we ran a 2x2x2 ANOVA (outcome x points x prime) on each of the cultural groups separately. As shown in Figure 5, in all three groups, FRN was significantly more negative than FRP. However, this effect was significantly smaller in the face condition than in the scramble condition for Caucasian Americans, $F_{(1, 33)} = 5.63$, $p = .024$. The pattern was similar for Asian sojourners although the outcome x prime interaction was negligible for them, $F < 1$. In contrast, for Asian Americans, the pattern was reversed, with the FRN-FRN difference significantly larger in the face condition than in the scramble condition, $F_{(1, 20)} = 5.90$, $p = .025$.

The effect of face-priming on FRN and FRP was symmetrical, such that where one increased, the other increased (as in the Asian American group) whereas where one decreased, the other decreased (as in the Caucasian American group and more subtly in the Asian sojourner group). The effect of face, however, was somewhat stronger for FRP than for FRN. In fact, when separate culture x prime ANOVAs were performed on FRN and FRP, the culture x prime interaction was significant for FRP, $F_{(2, 66)} = 4.68$, $p = .013$, but not for FRN, $F_{(2, 66)} = 1.17$, $p > .3$. However, there was no evidence that the face x culture interaction was significantly larger for FRP than for FRN.[2] Thus, the most conservative conclusion at this point is that the culture x prime interaction occurs on FRN and FRP approximately equally.

To compare the magnitude of the face priming effect across the three cultural groups, we obtained a single index of face-priming effect. We subtracted the FRN-FRP difference in the scramble condition from the corresponding difference in the face condition. If the FRN-FRP difference is larger in the face condition than in the scramble condition (as in Asian Americans), the index will yield a positive score, whereas if the FRN-FRP difference is smaller in the face condition than in the scramble condition (as in Caucasians and Asian sojourners), the index will yield a negative score. With Fisher's least significant differences (LSD) test, the face priming index was significantly more positive for Asian Americans than for both Caucasian Americans and Asian sojourners, *p*s < .001 and .05, respectively. The difference between the latter two groups was negligible. Hence, the pattern for Asian sojourners was closer to the pattern for Caucasian Americans than for Asian Americans.

Lastly, the 3x2x2x2x2 ANOVA (culture x gender x outcome x prime x point) showed a significant main effect of culture, $F_{(2, 66)} = 3.25$, $p < .05$. As evident in Figure 5, both FRN and FRP tend to be more negative in Caucasians as compared to the two Asian groups. For Caucasians, FRN was clearly visible, but FRP was not. In contrast, for the two Asian groups, FRP was visible, but FRN was not. It appears that Caucasians are rather optimistic in the sense that their default expectation is to win gambles (thus, resulting in an error signal when they lose). In contrast, Asians (both Asian Americans and Asian sojourners) appear to be pessimistic in the sense that their default expectation is to lose gambles (thus, resulting in an error signal when they win). This phenomenon is consistent with previous behavioral evidence (Chang & Asakawa, 2003; Kitayama et al., 1997), and must be further investigated in the future.

-Insert Figures 4 and 5 about here-

Relationship between Self-Construal and Face-priming Effect

Table 2 summarizes the correlations between the individual difference measures and the FRN-FRP face-priming effect. Two correlations were significant. Interdependent self-construal was associated positively with the FRN-FRP face-priming effect, $r = .26$, $p = .03$, whereas extraversion was associated negatively with it, $r = -.24$, $p = .05$. Pertinent scatter plots can be found in Figures 6-A and B.

-Insert Figures 6-A and B about here-

The finding that the face-priming effect was predicted by interdependent self-construal is consistent with the hypothesis that individuals who are embedded in tightly knit, interdependent social relations associate emotions of worry and anxiety to images of generalized others. Thus, it is of interest to determine whether the cultural difference in the face-priming effect we observed would be mediated by interdependent self-construal. In this analysis, we focused on Caucasian Americans and Asian Americans because these two groups are arguably more comparable than Asian sojourners because both groups spent much of their lives in the US. The main difference between the two groups is their cultural background. In contrast, Asian sojourners might be a widely heterogeneous group of Asians who moved to the U.S. under different circumstances after spending earlier lives in different Asian societies.

A mediation analysis was thus conducted to analyze the extent that interdependent self-construal accounts for the relationship between culture and the FRN-FRP face priming effect (see Figure 7). When culture (Asian American = 1, Caucasian American = 0) was a sole predictor, it significantly predicted the face-priming effect. When interdependent self-construal was entered, the mediated link (Culture → Interdependent self-construal → Face-priming effect) was significant, while the direct effect of culture was reduced (95% bias-corrected bootstrapping Confidence Interval (CI) = [.0472, .8126]). The mediation was partial because the direct effect of culture remained significant after the mediator (interdependent self-construal) was entered. We also ran a comparable analysis with extraversion as a potential mediator, which did not yield any evidence of mediation.

-Insert Figure 7 about here-

Discussion

FRN-FRP, Face, and Culture

The goal of the current investigation was to test the hypothesis that a mere exposure to face cues (i.e., face-priming) is sufficient to modulate the sensitivity of the ACC-based error-monitoring system (Kitayama & Tompson, 2015). On the basis of previous cultural psychological work, we expected that this effect would depend on participants' cultural background. Specifically, for Asians, we predicted face-priming to increase the sensitivity of the ACC. Thus, both FRP and FRN were expected to be larger in the face (as compared to scrambled face) condition. In support of this expectation, we found the FRN-FRP face-priming effect to be significantly positive for Asian Americans. In contrast, for Caucasian Americans we anticipated that face-priming would de-sensitize the ACC, which in turn should decrease the magnitude of both FRP and FRN. As predicted, the FRN-FRP face-priming effect was significantly negative. The face-priming effect was significantly larger for Asian Americans than for Caucasian Americans. The contrast between Caucasian Americans and

Asian Americans extended findings from an earlier study by Park and Kitayama (2014) by showing that an analogous face-priming effect is evident even when the task is neither linked to competence nor involving any motor responses.

Our analysis received additional evidence from the correlations we observed between the FRN-FRP face-priming effect and individual difference measures. The FRN-FRP face-priming effect increased as a function of interdependent self-construal, whereas it decreased as a function of extraversion. Notably, when Asian Americans were compared against Caucasian Americans, the cultural difference in the FRN-FRP face-priming effect was significantly mediated by interdependent self-construal (Figure 7). This finding supports the hypothesis that how one views the self as connected with others may be instrumental in establishing implicit meanings associated with the face images and consequently one's neural responses to the presentation of a face.

In the current work, we found little evidence that emotional expressions of the priming faces had any effect on the face-priming effect. However, we remain cautious in interpreting this finding, since it could be an artifact due to our study being underpowered because of a relatively small number of trials allocated to each emotion condition. Moreover, it could also be possible that schematic faces may not be sufficiently realistic to elicit differential reactions, and thus yield no differences between emotion conditions. Future studies might discover effects should they use a larger number of trials and more realistic faces.

Sojourner Paradox?

Interestingly, a pattern for Asians who spent fewer than 10 years in the U.S. (called Asian sojourners) was similar to the pattern we observed for Caucasian Americans rather than Asian Americans. This finding is mirrored by a similar cultural differences observed when analyzing self-construal measures. As compared to Caucasian Americans, Asian Americans were clearly less independent and more interdependent. However, Asian sojourner means fell between the two extremes, not significantly different from either group.

Previous cultural studies that tested East-West differences often compare Caucasian Americans with either Asians living in East Asian countries such as China, Japan, and Korea or with Asian Americans. To the best of our knowledge, the current study is the first that systematically compared Asian sojourners with Asian Americans. However, a few previous studies compared Caucasians with Asian sojourners. One study to note examined the cultural variation in causal attribution, expecting Asians (but not Caucasian Americans) to seek more situational reasons as an explanation for another person's behavior. This study tested Chinese graduate students at the University of Michigan and found them to be virtually no different from Caucasian American students (Morris & Peng, 1994). Another study tested whether Asians might be more holistic in attention than Caucasian Americans. When Japanese sojourners at the University of Chicago were tested, they were relatively more similar to Caucasian Americans (who were less holistic) than Asians in Asia (who were highly holistic) (Kitayama et al., 2003). In neither of these studies, comparable groups of Asian Americans were tested.

It is possible that Asian sojourners quickly acculturate to become virtually no different from Caucasian Americans within a fairly short time span. This could be because many of them are highly motivated to be similar to those in the mainstream U.S. culture (i.e., Caucasian Americans rather than other minority group members including Asian Americans). This hypothesis, however, may be hard-pressed to account for the fact that Asian Americans remain to be both less independent and more interdependent as compared to Caucasian Americans. Indeed, some existing studies suggest that acculturation of Asian immigrants to North American mainstream cultures can take at least a few generations (Heine et al., 1999). It would seem more plausible then that Asian sojourners in top U.S. universities are self-selected to be more independent even before they come to the U.S. These Asians may choose to come to the U.S. in part because they are already independent and find it hard to fit into Asian, interdependent societies. This issue must be more systematically addressed in future work. Future work should look into these alternative possibilities by closely examining each individual's immigration profile and personal history.

Limitations and Future Directions

We wish to acknowledge shortcomings of the current work. First, we deliberately chose to use schematic faces to test the hypothesis that the ACC is sensitive to the image of "generalized other." However, future work should use real face images as well to see if the results might converge. In all likelihood, emotions that are associated with face images may vary widely as a function of the faces being attractive or unattractive, an ally or enemy, and of the same or opposite sex. Although future work could attempt to manipulate these variables, the current paradigm may serve as a powerful means to identify reward/punishment contingencies that are tacitly established in different cultural contexts.

Second, within the current gamble paradigm it was difficult to examine behavioral consequences of reward prediction errors. One might suppose that after an unexpected loss, people work harder to win on the next gamble. However, it is not clear exactly what behaviors this effort might foster. In fact, in the current work, the ERP signals of reward prediction errors (FRP and FRN) predicted none of the behavioral measures we tested (i.e., choice of the same square or the other one, increase or decrease of response time). Future work would benefit from an identification of reliable behavioral indicators of the motivation to win in a gamble.

Despite these open issues, the current work clearly shows the importance of culture in analyzing brain responses that occur both spontaneously and automatically. Our findings suggest that psychological processes can depend on culture and, therefore, accurate descriptions of these processes would require careful specification of dimensions of culture.

Moreover, these findings suggest that the field of psychology as a whole would benefit from more careful analysis of the cultural backgrounds and other features participants bring to the study.

Lastly, our work contributes to the effort put forth by the field of cultural neuroscience, which has emerged at the interface of cultural psychology and neuroscience over the last several years (Han et al., 2013; Kim & Sasaki, 2014; Kitayama & Uskul, 2011; Kitayama, Park, & Cho, 2015). The cultural neuroscience approach is premised on the hypothesis that the human mind is biologically prepared and, yet, it requires substantial socio-cultural input to be complete and fully functional. Our work underscores that the role of society and culture in shaping neural mechanisms may be much larger than typically assumed by many scholars in both psychology and neuroscience. It thus provides further evidence on the importance of assessing the extent of socio-cultural influences on the brain across various domains of human functioning.

Footnotes

[1]This interaction was no different when the percentage of win vs. loss was used as a covariate, $F_{(2, 65)} = 5.50$, $p = .01$. We thus dropped this covariate. It is of note, however, that this variable interacted with outcome, $F_{(1, 65)} = 8.06$, $p < .01$. FRN became significantly larger when the percent winning increased (and thus, the perceived likelihood of winning increased), $r = .25$, $p < .05$. Curiously, there was no such correlation for FRP. No interpretation was attempted.

[2]That is, when FRP was reversely coded so that both FRP and FRN vary in the same direction, the outcome x prime x culture interaction was negligible, $F < 1$. Nevertheless, more research is required before firm conclusions can be made. In particular, recent studies (see Proudfit, 2015, for a review) have shown that both FRP and FRN can be decomposed into separable components that are linked to dissociable functions such as reward processing and error processing. It might seem plausible that whereas FRP is influenced primarily by reward processing (as argued by Proudfit) FRN may be modulated by error processing. One promising direction of future work, then, will be to test finer-grained hypotheses about how these separable components (and the brain activities reflected in them) might respond to face cues. This work may show whether and how the conditioning of the brain regions to the face cues might vary across cultural groups.

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Table 1. Individual difference measures included in the present study. Reliabilities (αs), means, and standard deviations for each group are given.

	α			Asian Americans		Asian sojourners		Caucasian Americans	
	AA	AS	CA	Mean	SD	Mean	SD	Mean	SD
Self-construal									
Independence	.48	.38	.80	4.99	0.59	5.18	0.48	5.37	0.68
Interdependence	.60	.54	.52	5.18	0.60	5.06	0.52	4.77	0.54
Big 5 Personality Traits									
Extraversion	.77	.65	.87	3.57	1.49	4.57	1.33	4.57	1.77
Neuroticism	.86	.79	.78	3.12	1.52	3.25	1.25	3.35	1.37
Other individual difference measures									
PSWQ	.58	.63	.58	52.14	14.20	48.07	11.96	51.91	11.47
Anxious Arousal	.87	.65	.78	24.95	8.49	22.64	4.55	22.94	6.56

Table 2. Correlations among the individual difference measures and those between these measures and the FRN face priming effect (the first raw).

	Variables	1	2	3	4	5	6	7
1.	Independence							
2.	Interdependence	-.10						
3.	Extraversion	.47***	.00					
4.	Neuroticism	-.23	-.08	-.07				
5.	PSWQ	-.30*	.06	-.29*	.59***			
6.	Anxious Arousal	-.04	-.18	-.07	.32**	.32**		
7.	FRN face priming effect	.04	.26*	-.24*	-.10	-.03	.02	

Note. $^{***}p<.001$, $^{**}p<.01$, $^{*}p<.05$, $^{\dagger}p<.1$.

Table 3. Mean FRN (negative ERP deflection around 270ms post-feedback in the loss condition) and FRP (positive ERP deflection) as a function of face priming and culture.

		Asian Americans		Asian sojourners		Caucasian Americans	
		Face	Scrambled face	Face	Scrambled face	Face	Scrambled face
Loss (FRN)	*M*	-0.73	-0.24	0.29	0.08	-2.4	-2.86
	SD	3.47	3.86	2.74	3.32	3.13	3.97
Win (FRP)	*M*	1.91	0.91	1.93	2.27	0.02	0.68
	SD	3.14	4.01	2.26	2.24	3.84	3.9
Difference		-2.64	-1.15	-1.64	-2.19	-2.42	-3.54

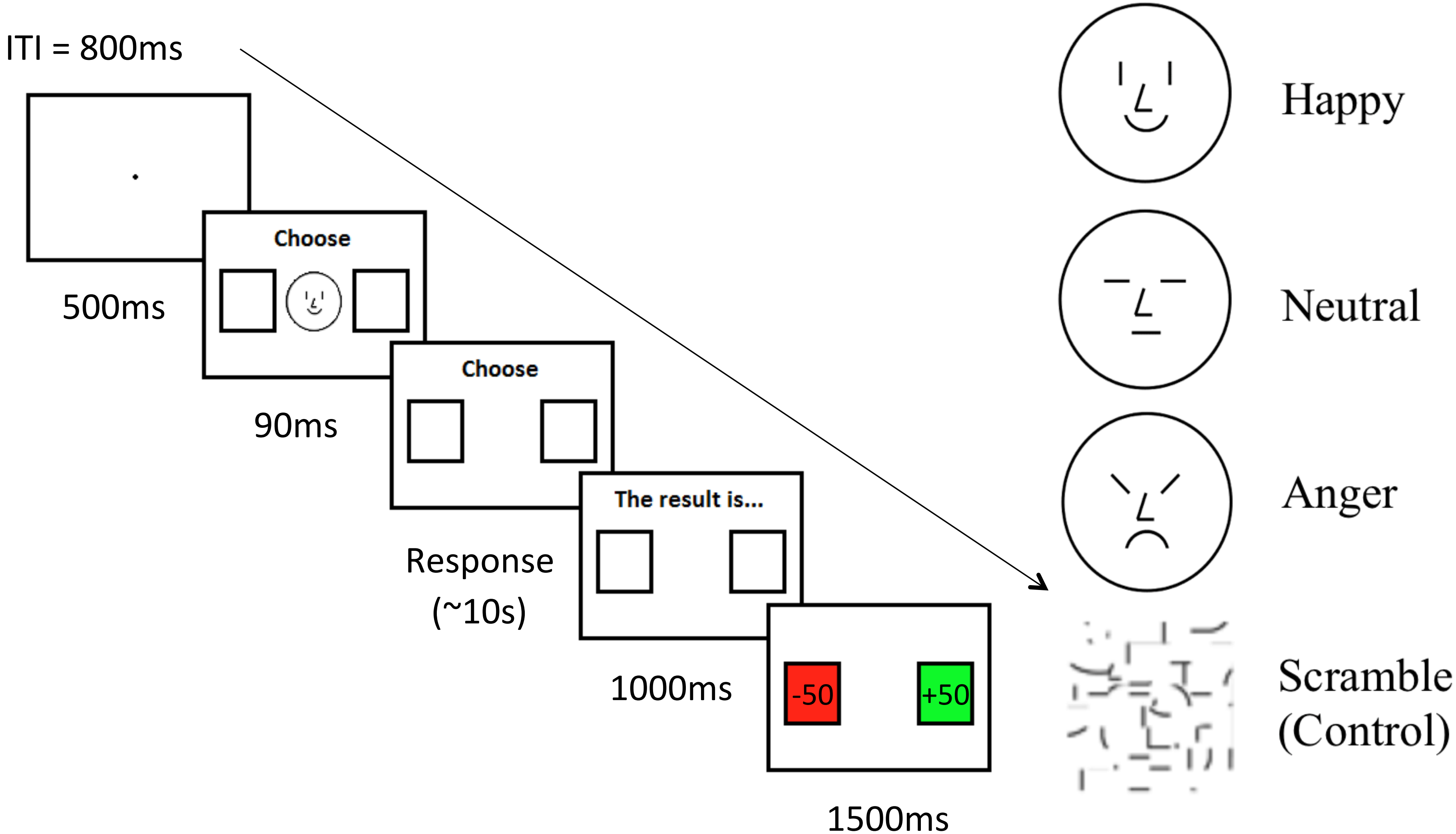


Figure 1. Experimental procedure and example face and scramble priming stimuli used.

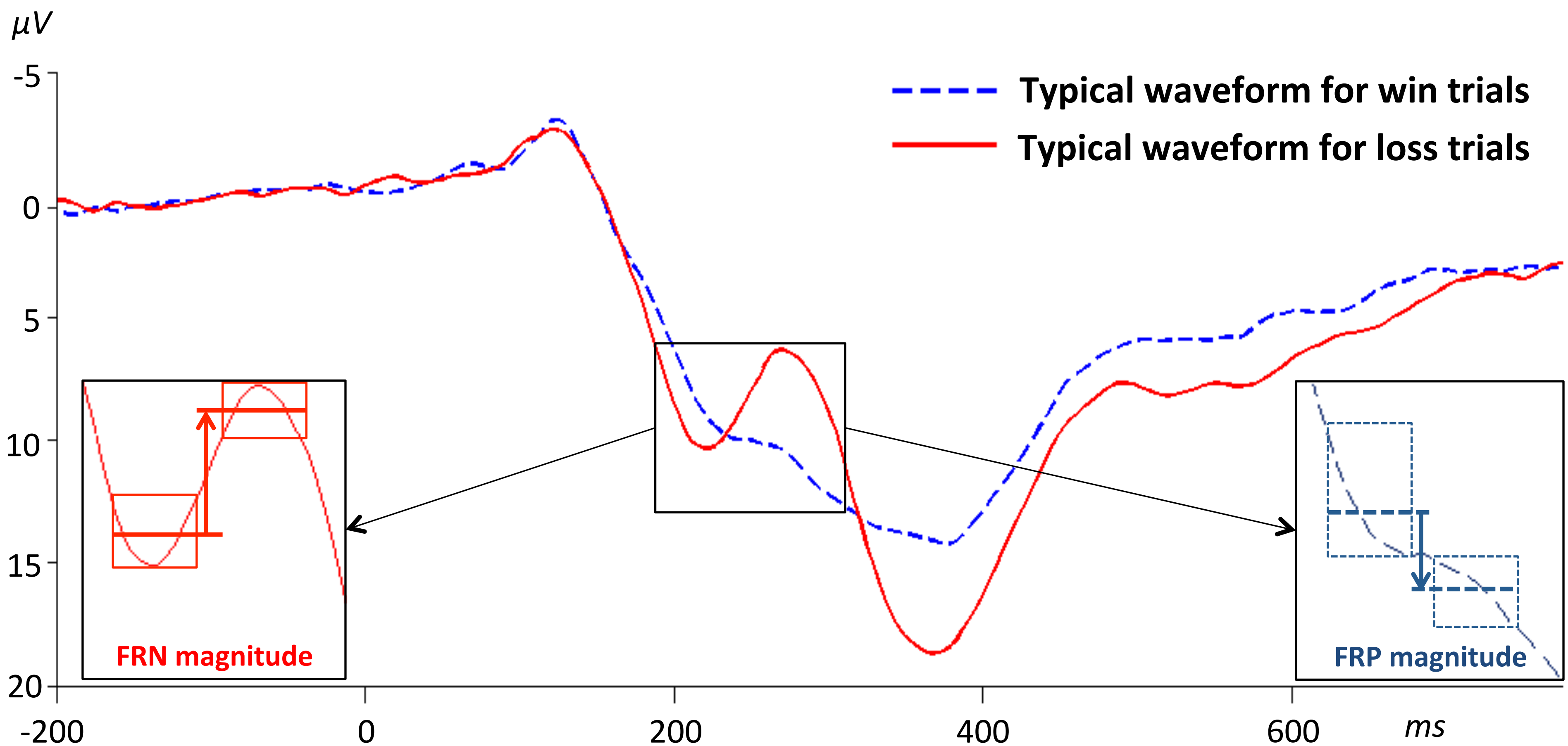


Figure 2. Measurement of the bottom-to-peak amplitude of feedback-related potentials for loss (feedback-related negativity, FRP) and win (feedback-related [positivity, FRP). FRN is a negative-going deflection of ERP upon negative (i.e., loss) feedback, whereas FRP is a positive-going deflection of ERP upon positive (i.e., win) feedback.

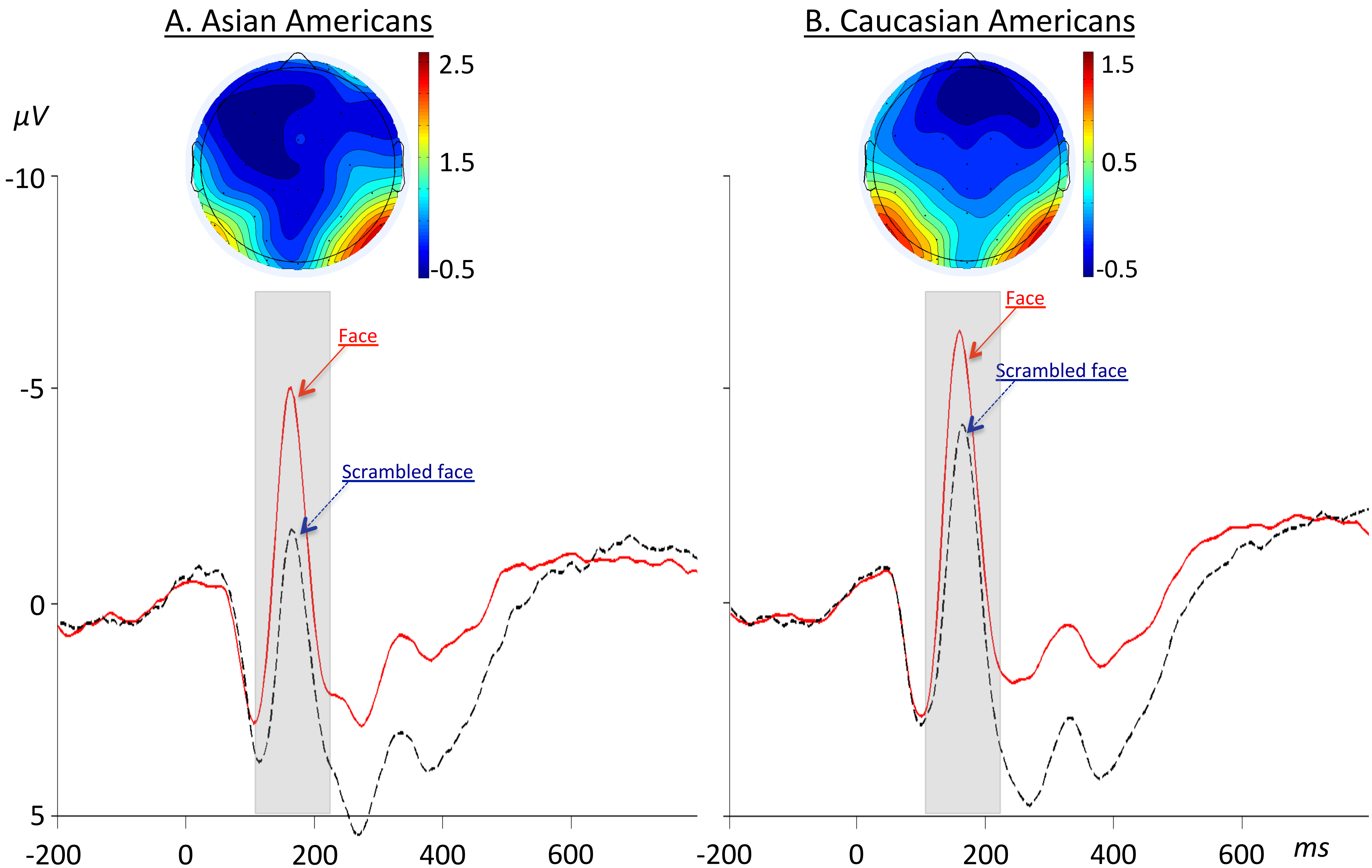


Figure 3. N170 in the face and scrambled face conditions for Asian Americans (A) and Caucasian Americans (B). The topographic maps show that the difference wave over the 110-210ms window was maximal at the right posterior temporal area (P8) in both cultural groups. The Asian sojourner group was dropped from this analysis because of attribution of subjects due to deficient electrodes.

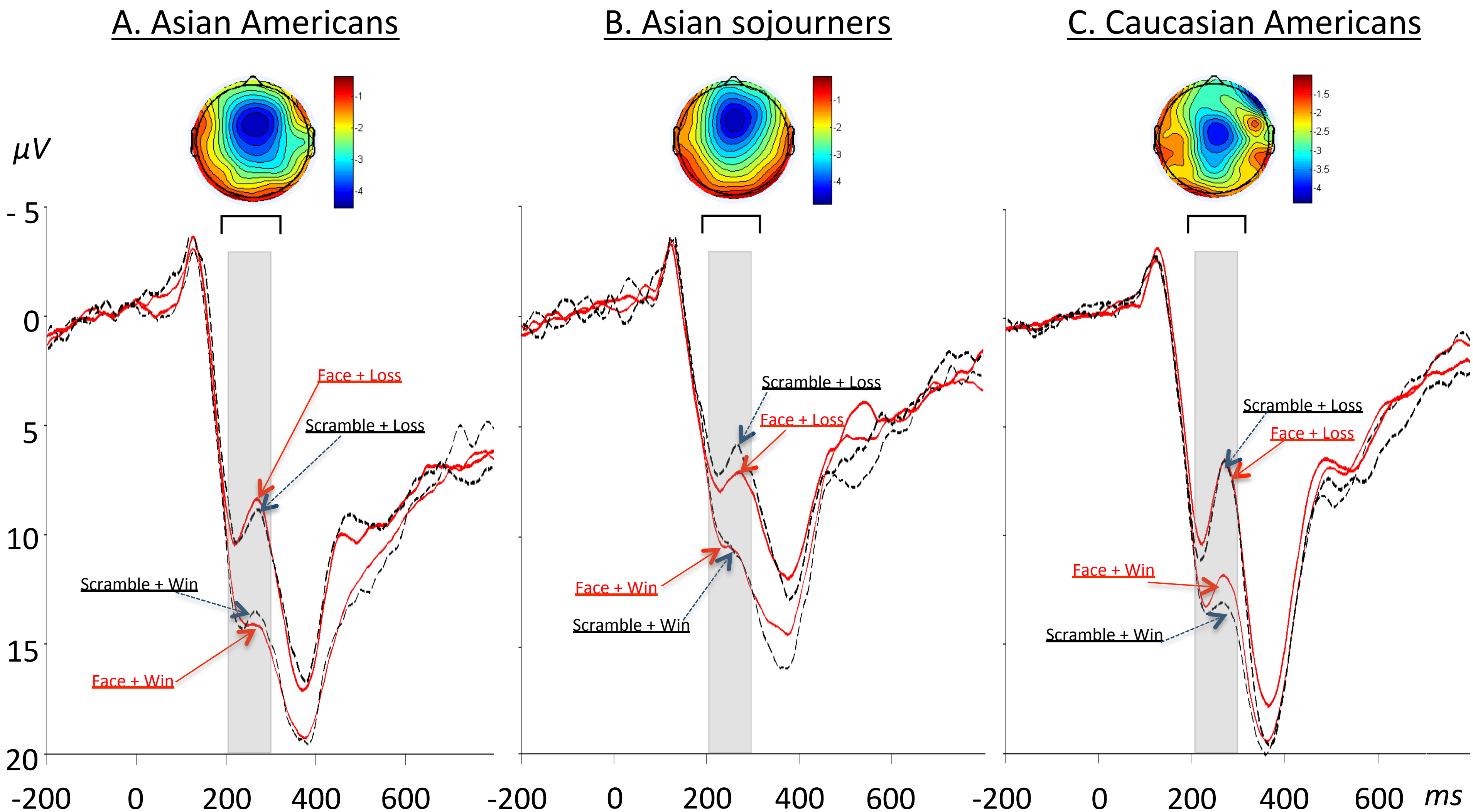


Figure 4. Face priming effect on FRN/FRP in the three cultural groups. The critical time window (200-290ms post feedback) is indicated by the gray rectangle. For Asian Americans (A), both the bottom-to-peak (B-P) increase of negativity for the loss trials (FRN) and the B-P increase of positivity for win trials (FRP) were greater in the face condition (the red solid wave) than in the scrambled face condition (the black dotted wave). In contrast, for Caucasian Americans (C), the pattern tended to be reversed. The pattern for Asian sojourners (B) was more similar to the one for Caucasian Americans (C).

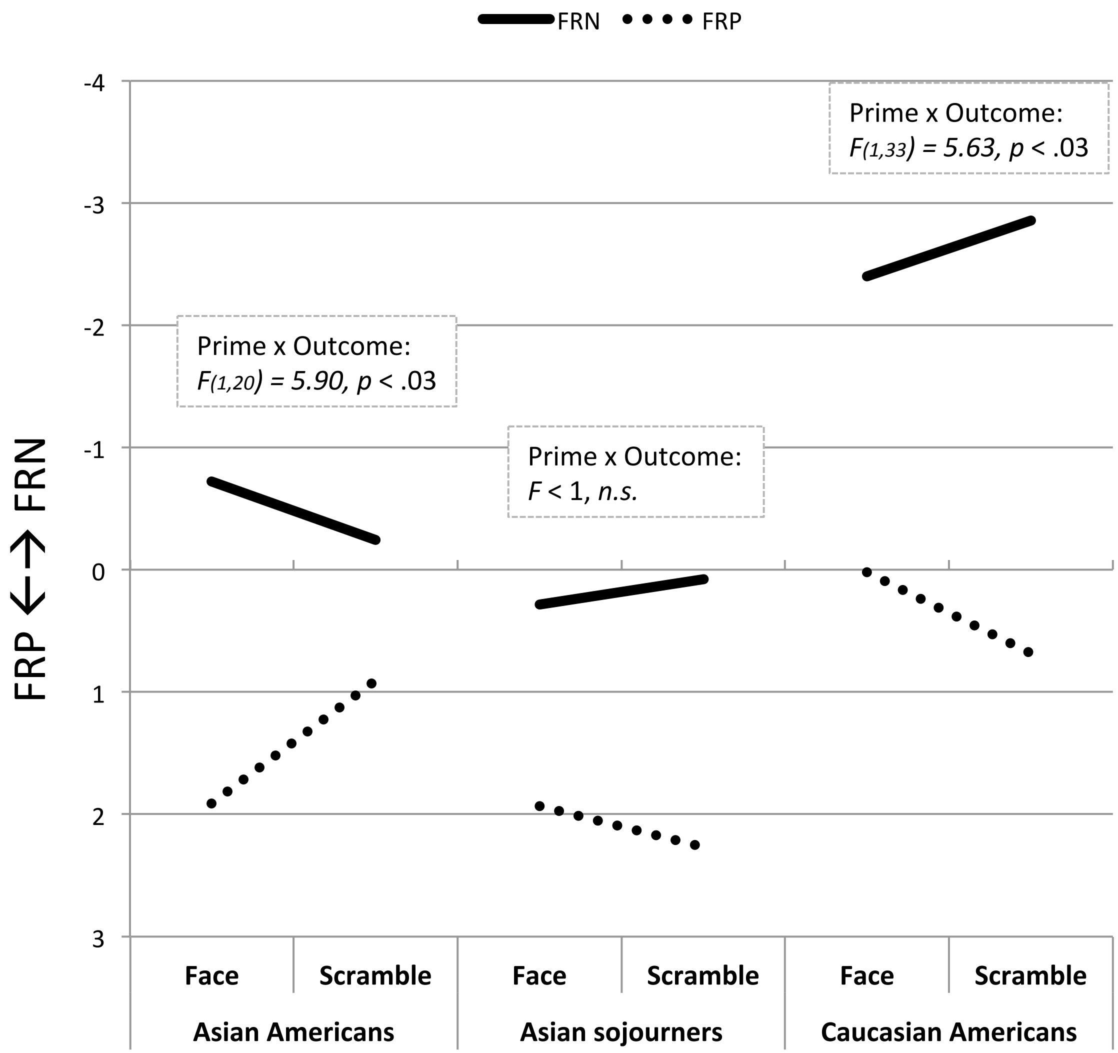


Figure 5. FRN and FRP as a function of face priming and culture. The Y-axis indicates the magnitude of FRN (negative values) and FRP (positive values). Whereas face-priming increases both FRN and FRP combined for Asian Americans, it decreases FRN and FRP combined for Caucasian Americans. The pattern for Asian sojourners was similar to the one for Caucasian Americans.

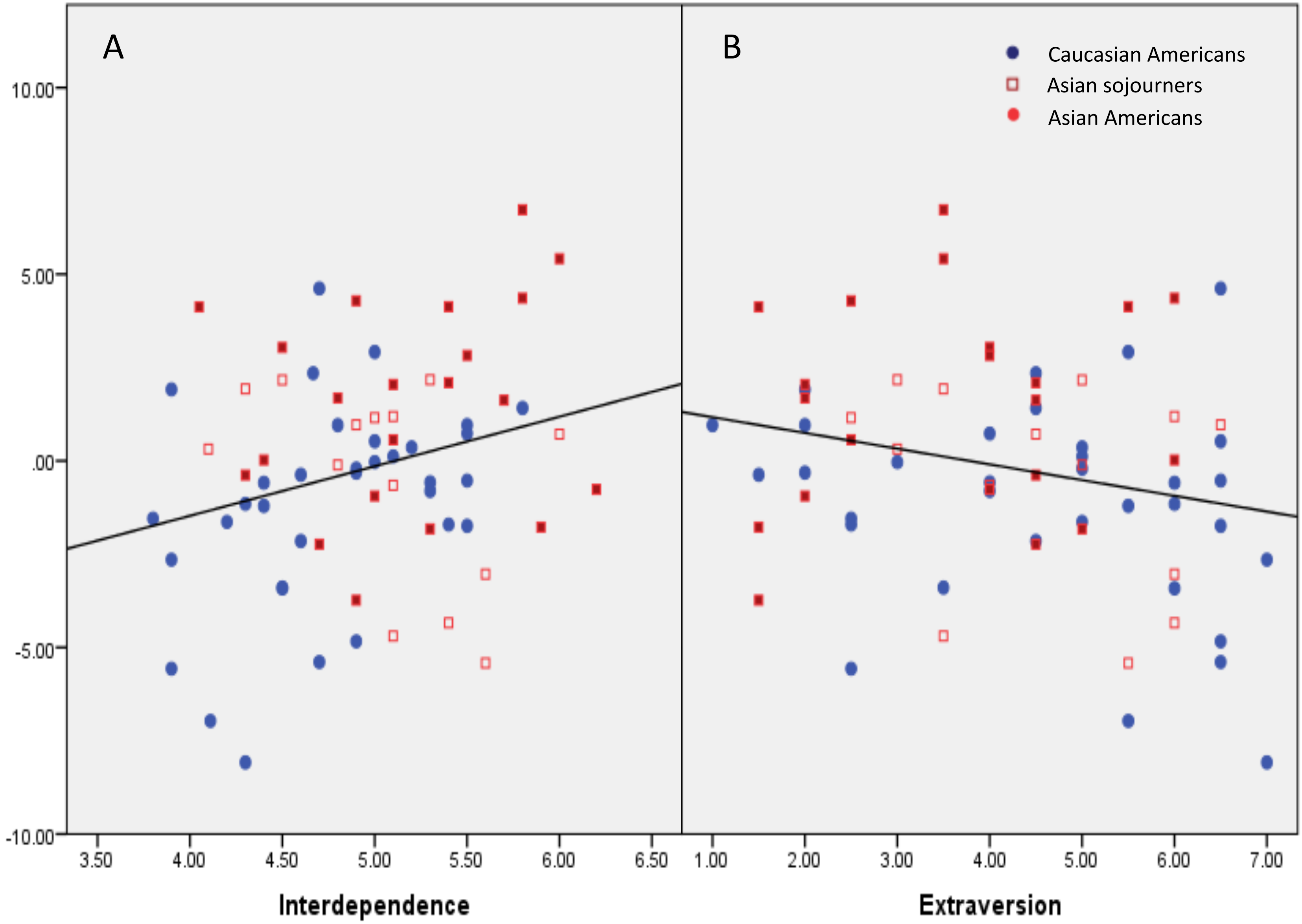
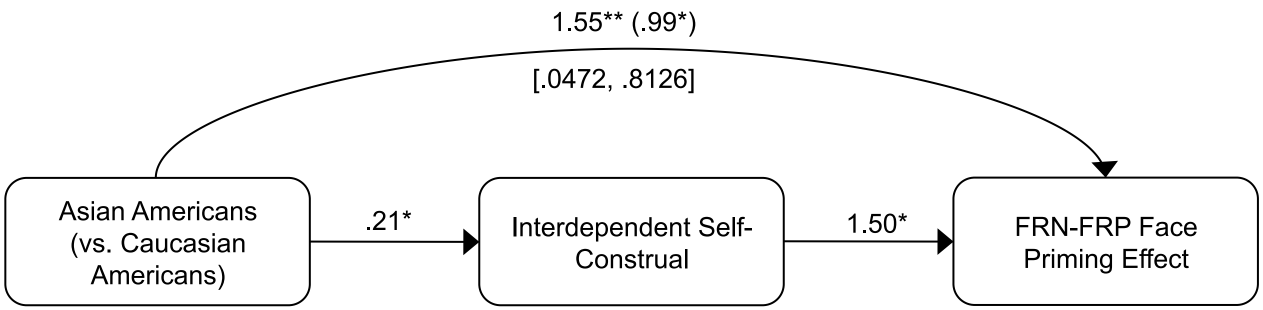


Figure 6. Predicting FRN-FRP face priming effect as a function of interdependent self-construal (A) and extraversion (B). Interdependence predicted an increase of FRN-FRP face priming effect, whereas extraversion predicted a decrease of the effect.



* $p < .05$, ** $p < .001$

Figure 7. Mediation analysis predicting the FRN-FRP face priming effect by culture (Asian American vs. Caucasian American), mediated by interdependent self-construal. The mediation effect (culture → interdependence → face priming) was significant as indicated by the fact that the 95% confidence [.0472, .8126) didnot include zero. When the mediated path was taken into account, the direct effect was reduced (1.55→ .99) although it was still significant, indicating that the mediation was partial.