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Culture shapes electrocortical responses during emotion suppression

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Previous work has shown that emotional control is highly valued in Asian culture. However, little is known about how this cultural value might influence emotional processing. Here, we hypothesized that Asians are 'culturally trained' to down-regulate emotional processing when required to suppress emotional expressions. Such down-regulation, however, is unlikely for European Americans because their culture values emotional expression (*vs* control) more. To test these predictions, we adopted the parietal late positive potential (LPP) of the event-related potential as an objective indicator of emotional processing. Both Asian and European Americans were exposed to either unpleasant or neutral pictures while instructed to either attend or suppress expression of emotions. Both groups showed an equally pronounced parietal positivity ~600 ms post-stimulus. As predicted, however, Asians subsequently showed a significant decrease of the parietal LPP in the suppression (*vs* attend) condition. The initial positivity completely disappeared 2000 ms post-stimulus. In contrast, for European Americans the parietal LPP suppression effect was completely absent although there was an early occurring, sustained increase in frontal positivity in the suppression (*vs* attend) condition. Implications for culture and emotion research are discussed.

Keywords: emotion regulation; culture; suppression; event-related potentials; late positive potential

INTRODUCTION

On 11 March 2011, an earthquake of enormous magnitude hit Eastern Japan, followed by tsunamis of unprecedented height and might, which washed away virtually everything, including both people and houses, from the coastal area that spanned over nearly 300 km. Subsequent international media coverage highlighted, among other things, the discipline and self-control that was evident in the survivors of the natural calamity. No one was angry or sad. No one was even weeping. Many of the victims maintained calm, if subdued, emotional demeanors to the degree that was unfathomable to many Western observers (e.g. King, 2011). An anecdote such as this invites a number of intriguing questions. For example, did the victims suppress their emotional expressions? If so, did they also modulate the extent of emotional processing? In other words, did they feel something contrastingly strong inside? Or did the act of suppression tame such feelings as well?

In the present work, we draw on existing research on culture and emotion and advance the hypothesis that Asians are 'culturally trained' to attenuate the processing of emotion-evocative content when trying to suppress emotional expression. We also expect that this type of cultural training is quite unlikely in European American cultures. We then use an event-related potential (ERP) measure to test this hypothesis. By so doing, we seek to contribute to the existing body of scientific knowledge on both emotional development and the neuroscience of emotion regulation competences (see Campos *et al.*, 1989; Gross, 2007, for reviews).

Culture and emotion

Emotion has obvious biological underpinnings and, not too surprisingly, many aspects of it are arguably universal across different societies and cultures (Darwin, 1972; Ekman, 1972; Levenson, 1999). Nevertheless, culture can also significantly influence various facets of emotion, including cognitive appraisal, expression and perhaps subjective experience (Mesquita and Frijda, 1992; Kitayama and Markus, 1994). Culture may influence emotion in part because norms surrounding emotional responses are very different across cultures and, accordingly, people are socially encouraged and 'culturally trained' to act very differently vis-à-vis their own emotions. For example, children are socialized to show the 'right' emotions, with their caregivers and peers praising them when they do and frowning upon them when they express emotions that are socially inappropriate. Although overt behaviors in general and expressive behaviors of emotion in particular are often assumed to follow subjective experience, recent work on neuro-plasticity (see e.g. Schwartz, 2002; Kitayama and Park, 2010, for reviews) has made it quite plausible that the norm-guided regulation of overt-behaviors can sometimes cause dramatic changes in the psychobiological structures and processes involved in the very subjective experience that is thought to cause the behaviors.

A series of studies by Tsai and colleagues have demonstrated that unlike in the West where high-arousal emotions are very much valued, in Asia low-arousal emotions are considered more desirable (e.g. Tsai *et al.*, 2006). This cultural value for low-arousal emotions such as calmness and serenity is related historically to Confucian traditions, which have regarded emotions—particularly strong ego-focused ones such as anger and frustration—as a hindrance against ever-important social harmony and social order (Kitayama *et al.*, 2006). Moreover, evidence is mounting that emotion control (Mauss and Butler, 2010), especially control of emotional expression by suppression (Matsumoto *et al.*, 2008), is strongly valued in Asia. These emotion-related values and attitudes are in stark contrast to those in European American culture wherein emotional expression is more valued and, correspondingly, expressive suppression is often considered as undesirable and unhealthy (Kim and Markus, 1999; Mauss and Gross, 2004), with various negative psychological consequences (Butler *et al.*, 2007). At present, however, little is known about whether these cultural values and attitudes toward emotion and emotion control might influence emotional processing.

Expressive suppression in east and west

Our analysis starts with the assumption that cross-culturally divergent values on emotion control influence what people—both children and adults alike—are expected to do vis-à-vis their own emotions. Whereas

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European Americans are likely to be encouraged to feel emotions fully and express them, Asians are likely to attenuate their emotions as well as inhibiting their overt manifestations (see Rothbaum *et al.*, 2000, for a review). If the practice of regulating emotional responses is repeatedly engaged over a number of different occasions, individuals might eventually become able to change, with great ease, their emotions in culture-congruous fashion. As amply demonstrated by work on the facial feedback hypothesis (Strack *et al.*, 1988; Zajonc *et al.*, 1989), expressive behaviors can modulate emotional experience although no clear consensus exists today regarding exactly how this modulation might occur.

More specifically, in Asian cultural contexts individuals are often encouraged to control and suppress their emotional expressions by staying disengaged from the scene and thus remaining calm (Kitayama *et al.*, 2000; Rothbaum *et al.*, 2000; Mesquita, 2001). These cultural practices may reflect the fact that in these cultural contexts expression of the inner self, including one's inner feelings of emotion, is not highly valued (Kim and Markus, 1999) and, correspondingly low- (rather than high-) arousal emotions are given much premium (Tsai *et al.*, 2006). Self-expression—especially expression of the self's unique inner qualities—is seen as disturbing of social harmony and interdependence with others (Markus and Kitayama, 1991). Years of cultural training to not express emotions may dampen emotional reactivity reflected across multiple biological systems, including the brain, especially in contexts that encourage suppression.

In contrast, in Western cultural contexts, children may sometimes be encouraged to control and suppress their emotions; but for the most part they are encouraged more to express their inner feelings, desires, as well as preferences and opinions. Hence, efforts to control and down-regulate emotions are likely to be met with an even more important cultural imperative of expression of unique inner features of the self, including emotional experience (Kim and Markus, 1999). It is culturally undesirable not to express what one feels. It may be expected, then, that when asked to suppress their emotional expressions, Westerners would not down-regulate emotional processing.

Research in European American populations generally supports this claim (e.g. Gross, 1998). In particular, Goldin *et al.* (2008) showed that when asked to cognitively reappraise the content of an emotionally evocative film clip so that the meaning of the film content could become emotionally benign, European Americans successfully modulated their emotional reactivity as reflected in reduced amygdala activity. Importantly, however, when asked to suppress emotional expressions while exposed to the film, amygdala activity was not decreased. If anything, under the condition of expressive suppression, there was a significant 'increase' of amygdala activity. Although it has yet to be replicated, the paradoxical potentiation of the amygdala under the condition of expressive suppression might show that European Americans attended their emotions more, thereby increasing emotional processing, in an effort to control them (see Wegner, 1992).

Additional evidence for our theoretical analysis comes from a recent study by Mauss and Butler (2010). The researchers examined autonomic responses during anger provocation and found a pattern typically associated with difficulty and challenge (Tomaka and Blascovich, 1994; Mendes, 2009) for Asians who strongly endorsed the emotion control values. This indicates that an attempt to control anger is norm-congruous for Asians. In contrast, European Americans showed a very different pattern that is typically linked to threat (Tomaka and Blascovich, 1994; Mendes, 2009). This supports the contention that controlling emotions goes against the prevalent European American norm of self-expression. It is because of this that emotion control was self-threatening for European Americans.

Altogether, our analysis implies that the instruction to suppress emotional expressions would differentially influence emotional processing across cultures. Evidence indicates that emotion suppression is norm-congruous in Asia. We therefore hypothesize that Asians are culturally trained to down-regulate emotional processing when asked to suppress emotional expression. In contrast, emotion expression is much more valued in European American culture. As a consequence, European Americans are unlikely to down-regulate emotional processing under the comparable condition of emotion suppression.

The parietal late positive potential as an Indicator of emotional processing

In the present work, we used a specific component of the event related brain potential (ERP) to assess the degree of emotional processing. Substantial evidence exists that the late positive potential (LPP) is a temporally sensitive index of emotional processing stages (for a review see Olofsson *et al.*, 2008). The LPP is a long-lasting positivity that peaks ~300–400 ms after the onset of a stimulus and extends for the duration of the stimulus. It is typically maximal at the Pz (midline-parietal) electrode. Cuthbert and colleagues have shown that self reported arousal ratings of stimuli are tightly related to the magnitude of the parietal LPP, further linking the parietal LPP to emotional experience (Cuthbert *et al.*, 2000; Schupp *et al.*, 2000). Moreover, combined ERP and functional magnetic resonance imaging (fMRI) studies suggest that the parietal LPP reflects enhanced perceptual processing of emotional stimuli in visual cortices resulting from re-entrant processes from the amygdala (Sabatinelli *et al.*, 2005, 2007).

Most important to the primary aims of the current study, a series of experiments show that the parietal LPP is reliably modulated by emotion regulation strategies (Moser *et al.*, 2006, 2009, 2010; Hajcak and Nieuwenhuis, 2006; Krompinger *et al.*, 2008; Thiruchselvam *et al.*, 2011). For example, Moser *et al.* (2009) tested European Americans and showed that the amplitude of the parietal LPP was significantly decreased during instructions to cognitively reappraise the impinging stimuli so as to reinterpret the stimuli as emotionally more benign. This indicates that once the impinging stimuli are reconstrued as less emotional, they receive much less emotional processing. As may be expected, this decrease in LPP is correlated with decreases in self-reported intensity of emotions (Hajcak and Nieuwenhuis, 2006). At present, however, there is no study that has tested possible effects of expressive suppression on parietal LPP amplitude across cultures.

Present study

The goal of the present work was to examine potential cultural differences in the effect of emotional suppression instructions on the magnitude of the parietal LPP that is elicited by emotionally evocative negative visual stimuli. Because Asians are hypothesized to have learned to down-regulate emotional processing to suppress emotional expression, we predicted that Asians would show smaller parietal LPPs in the emotion suppression instruction condition than in a passive viewing, control condition. In contrast, European Americans are hypothesized not to seek to modulate emotional processing when trying to suppress emotional expressions. Hence, we predicted that European Americans would not show any reduced parietal LPP in the emotion suppression condition, relative to the passive viewing control.

METHODS

Participants

Seventeen European Americans (7 male, 10 female, Age $M = 19.65$, $s.d. = 1.22$) and 17 East Asian (3 male, 14 female, Age $M = 20.70$, $s.d. = 2.34$) undergraduates from the University of Michigan participated in the current study in exchange for $20. All Asian participants were born in an East Asian country (China, Japan, Singapore or South Korea) and had lived there at least 7 years before moving

to the USA. In majority of the cases, Asians came to the USA to attend the University. All were right-handed and had normal or corrected-to-normal vision. Informed consent was obtained at the beginning of the experiment. The gender distribution did not differ significantly between the two cultural groups ($\chi^2 = 2.27$, $df = 1$, $P > 0.10$). When included in the analyses, gender was not significant either alone or in interaction with other variables unless otherwise noted.

Stimuli and procedures

Sixty unpleasant, high arousing pictures (valence: $M = 2.28$, arousal: $M = 6.29$) and 60 neutral, low arousing pictures (valence: $M = 5.08$, arousal: $M = 3.25$) were extracted from the International Affective Picture System (IAPS; Lang *et al.*, 1999) based on the IPAS normative ratings. The unpleasant picture set included pictures of mutilation and threat (human and animal), and the neutral picture set included pictures of household items and neutral faces.[1]

Participants were seated ~50 cm from a CRT color monitor in a dimly lit room. The picture-viewing task was administered using E-prime 1.1 software (Psychology Software Tools, Inc). The experimenter in the adjacent control room monitored the participant's physical and eye movements through a Logitech web-camera. Participants followed the instructions and directed their gazes to the pictures. One Asian female diverted her eyes away from pictures on three trials. The data from these trials were excluded.

As in Ohira *et al.* (2006), we ran both 'attend' and 'suppress' instruction conditions. In the attend condition, participants were instructed to pay attention to the emotional responses that were naturally elicited by the picture. Specifically, they were told, 'Please react normally to each picture. Attend to and be aware of any feelings that each picture elicits'. For the suppress condition, participants were instructed to minimize and hide the emotional responses that were naturally elicited by the picture. In particular, they were told, 'Please suppress any emotional responses you may have while viewing each picture. Try to remain calm and to diminish any response reflecting your subjective feelings regardless of the affective valence of the picture. We will monitor your facial expressions while you are looking at the pictures. Try to hide any emotional reactions to the picture so that we will not be able to detect what kind of picture you are viewing'. Participants performed the attend condition followed by the suppress condition.

In order to avoid any task switching effect/carry-over influence of suppression on the subsequent attend condition, we did not counterbalance the order of conditions. This decision should not be cause for concern that habituation might explain differences between the two condition, as several investigations show that even numerous repetitions of IAPS images fail to engender significant decline in emotion-modulated LPP effects (e.g. Olofsson and Polich, 2007). There should therefore be no reason to expect smaller LPPs in the suppression condition because it was second, rather, any effects can be attributed to the experimental manipulation—i.e. suppression instructions.

On each trial, a white fixation point (+) was presented at the center of the screen for 2000 ms followed by 500 ms of blank screen. Then unpleasant or neutral pictures were displayed in random order on the entire screen for 4000 ms. The interval between the offset of the IAPS picture and the onset of the next fixation point was 2500 ms. Three blocks of 20 trials (10 unpleasant, 10 neutral) were presented in each condition. At the beginning of the experiment, participants performed five practice trials for each condition.

Because the functional significance of any neural indicators can be difficult to unequivocally identify without having self-report measures, it may seem desirable to include a rating task of emotional experience at the end of each trial. However, previous work has shown that reporting subjective emotional experiences on a trial-by-trial basis in and of itself can change overall task-related emotional intensity ratings and emotion-related neural processes (e.g. Taylor *et al.*, 2003), thus potentially muddying the effects of instructed emotion regulation. Fortunately in the present case, evidence is quite solid that LPP corresponds closely to emotional processing that is linked to perceived arousal as well as amygdala activity. Hence, in the present work we decided not to include any measure of subjective emotional experience.

After the computer task, participants completed a post-experimental questionnaire, reporting the degree to which they found the experimental task to be interesting (1 = Not interesting at all, 7 = Very interesting), difficult (1 = Not difficult at all, 7 = Very difficult), and boring (1 = Not boring at all, 7 = Very boring). They were also asked how much they felt engaged in the task (1 = Not engaged at all, 7 = Very engaged).

Electrophysiological recording and analysis

The electroencephalogram (EEG) was recorded using active Ag/AgCl electrodes (BioSemi ActiveTwo) placed at the left and right mastoids and 64 scalp sites according to the modified 10–20 System. The electrooculogram (EOG) was recorded from electrodes placed at the outer canthi of each eye, and above and below the left eye. The EEG and EOG signals were digitized at 512 Hz with a band-pass of DC to 104 Hz.

Off-line, the EEG signals were re-referenced to the average of the left and right mastoids. Ocular artifacts were corrected using the algorithm developed by Gratton *et al.* (1983). All signals were low-pass filtered at 20 Hz and then down-sampled to 256 Hz. EEG epochs of 3700 ms (200 ms baseline) were extracted from the continuous data file for analysis. Trials were automatically excluded if the EEG exceeded ±100 μV.

The LPP was quantified at the parietal midline electrode (Pz), where it was maximal, in successive time windows chosen based on previous research (e.g. Cuthbert *et al.*, 2000) and visual inspection of grand-average waveforms (see below). To test cultural differences in emotional suppression the parietal LPP was subjected to a repeated-measures ANOVA with one between subjects factor and two within subjects factors: 2 Culture (European American, East Asian) X 2 Instruction (Attend, Suppress) X 2 Picture Valence (Unpleasant, Neutral).

RESULTS

Engagement in the experimental task

European Americans and Asians reported that they were interested in the experimental tasks ($M = 5.35$ *vs* 5.06 on a 7-point rating scale with 7 = 'Very interested', s.d. = 1.17 *vs* 1.64) and engaged ($M = 5.29$ *vs* 5.24 on a 7-point rating scale with 7 = 'very engaged', s.d. = 1.10 *vs* 1.30). Further, the participants were not bored ($M = 2.94$ *vs* 2.76 on a 7-point rating scale with 1 = 'not bored at all', s.d. = 1.34 *vs* 1.44). The difficulty ratings were slightly lower than the midpoint of the scale ($M = 3.47$ *vs* 3.35, s.d. = 1.77 *vs* 1.62). In none of the measures did we find any cross-cultural differences (Fs (1, 32) <1, *ns*). Thus, any cross-cultural differences we might observe in ERPs cannot be attributed to differential task engagement or task difficulty between European Americans and Asians.

[1]The following IAPS pictures were used: unpleasant (1050, 1090, 1110, 1113, 1120, 1201, 1220, 1300, 1301, 1930, 2205, 2800, 2900, 3000, 3010, 3030, 3051, 3053, 3060, 3061, 3062, 3063, 3064, 3071, 3080, 3100, 3102, 3110, 3130, 3140, 3150, 3170, 3180, 3230, 3261, 3350, 3400, 3500, 3530, 6212, 6230, 6243, 6260, 6313, 6350, 6360, 6370, 6510, 6540, 6560, 6570, 6821, 9006, 9040, 9050, 9140, 9220, 9405, 9410, 9420); neutral (2190, 2200, 2210, 2211, 2214, 2230, 2273, 2280, 2309, 2342, 2359, 2383, 2400, 2480, 2510, 2520, 2521, 2570, 2840, 2880, 5390, 5500, 5531, 5740, 5800, 5900, 7000, 7002, 7004, 7009, 7010, 7012, 7020, 7021, 7025, 7026, 7035, 7050, 7077, 7080, 7092, 7100, 7140, 7150, 7160, 7170, 7175, 7190, 7211, 7217, 7224, 7233, 7235, 7503, 7512, 7550, 7560, 7700, 7950, 9070).

ERPs

Previous work finds the LPP in response to arousing visual stimuli across all scalp locations, but the effect tends to be most pronounced at the midline-parietal location (Pz; Cuthbert *et al.*, 2000). Consistent with previous findings, the present study identified parietally distributed LPPs for the unpleasant pictures. We therefore examined the LPP at Pz. As can be seen in Figure 1, both Asians and European Americans showed a strong positivity, regardless of condition, from 400 to 700 ms after the onset of the unpleasant pictures. There was no such enhanced positivity for neutral pictures. When the mean amplitude of the LPP in the 400–700 ms time window at Pz was submitted to the Culture x Instruction x Picture Valence ANOVA, the main effect of Picture Valence was highly significant ($F(1, 32) = 106.41$, $P < 0.01$, $\eta_p^2 = 0.77$), indicating that the LPP was greater for the unpleasant pictures than for the neutral pictures. There were no effects of other variables or any interactions in this time window ($Fs < 1.60$).

Importantly, however, the two cultural groups began to diverge, starting around 800 ms post-stimulus. Whereas European Americans showed no obvious condition differences throughout the period of the stimulus presentation (up to 3500 ms), Asians showed a substantial decrease of LPP over the same period of time in the suppression condition relative to the attend condition. The initial positivity evoked by unpleasant pictures was completely eliminated by 2000 ms post-stimulus. A similar suppression effect was evident for neutral pictures as well (an effect we will return to later).

Statistical analysis of the average amplitude computed over 1500–3500 ms post-stimulus at Pz showed significant main effects of both Instruction ($F(1, 32) = 10.42$, $P < 0.01$, $\eta_p^2 = .25$) and Valence ($F(1, 32) = 28.71$, $p < .01$, $\eta_p^2 = .47$). Most importantly, however, the interaction between Culture and Instruction also proved significant ($F(1, 32) = 5.00$, $p < .05$, $\eta_p^2 = 0.14$). As shown in Figure 2, post-hoc tests showed a significant Instruction effect for East Asians ($F(1, 16) = 29.63$, $P < 0.01$, $\eta_p^2 = 0.65$), but the Instruction effect was negligible for European Americans ($F(1, 16) = 0.33$, $P = 0.57$).

To further explore the temporo-spatial dynamics of these effects, topographic maps were created for difference waveforms (suppression—attend) at 0–400, 400–800, 800–1200, 1200–1600, 1600–2000, 2000–2400, 2400–2800, 2800–3200 and 3200–3500 ms. As can be seen in Figure 3, Asians showed negative values around1600 ms—indicating the predicted smaller LPP on suppression trials—which grew larger for the remainder of the stimulus presentation and were centered around Pz. For European Americans, the suppression effect at Pz was completely absent. In contrast, European Americans showed positive values—indicating larger LPPs on suppression trials—occurring relatively early, around 800 ms, that continued for the remainder of the stimulus presentation (Figure 3). This effect was centered around the fronto-central midline site (FCz) and, moreover, it was completely absent for Asians.

Statistical evaluation of this enhanced LPP at FCz for European Americans on suppression trials (Figure 4) was conducted using the mean LPP amplitude over 500–3000 ms post-stimulus. In addition to a significant main effect of Valence ($F(1, 32) = 35.66$, $P < 0.01$, $\eta_p^2 = 0.53$), the interaction between Instruction and Culture was significant ($F(1, 32) = 9.61$, $P < 0.01$, $\eta_p^2 = 0.23$). As can be seen in Figure 5, European Americans demonstrated greater positivity in the suppression condition than in the attend condition ($F(1, 16) = 5.19$, $P < 0.05$, $\eta_p^2 = 0.25$), but this effect was significantly reversed for East Asians ($F(1, 16) = 4.68$, $P < 0.05$, $\eta_p^2 = 0.23$)—that is, East Asians showed significant reduction of the LPP at FCz during this time window.[2]

[2]In this analysis, the instruction × picture valence × gender interaction was significant, $F(1, 30) = 7.19$, $P < 0.05$. The frontal positivity was especially weak for male (but not female) participants in the attend (but not suppress) condition with respect to the neutral (but not unpleasant) pictures. No interpretation was attempted.

DISCUSSION

Expressive suppression and emotional processing across cultures

Previous work suggests that Asians habitually suppress their emotions more than European Americans do (e.g. Matsumoto *et al.*, 2008). We reasoned that because Asians do not value expression of the inner self in general and that of emotional experience in particular, they are likely to learn, through 'cultural training', to attenuate emotional processing when they are required to suppress their emotional expression (Mauss and Butler, 2010). We also hypothesized that European Americans value the inner experience of emotion so much that they will rarely down-regulate emotional processing even though it could be quite advantageous for them to do so for the purpose of suppressing emotional expression.

One important innovation of the present study was to draw on prior ERP work and use the parietal LPP component as an objective measure of emotional processing (Hajcak and Nieuwenhuis, 2006; Oloffson *et al.*, 2008) in order to examine the effect of instructions to suppress emotional expression within a cross-cultural research design. The results provide clear support for our predictions. First, under the condition of expressive suppression, Asians showed a significant decrease of the parietal LPP. This evidence is consistent with the hypothesis that Asians are culturally trained to down-regulate emotional processing when trying to suppress their emotional responses. The Asian pattern was noteworthy in its magnitude: The down-regulation of emotional processing was so complete that the parietal LPP returned to the baseline after 2000 ms post-stimulus even though the initial emotional reaction of our Asian participants was just as pronounced as, and in fact, somewhat larger than that of European Americans.

As also predicted by our analysis, we found no attenuation of emotional processing (as indicated by the parietal LPP) when European Americans tried to suppress their emotional expressions. This is consistent with the hypothesis that for European Americans the inner experience of emotion is to be expressed and, thus, down-regulating emotional processing is highly counter-normative. As a consequence, they did not dampen emotional processing (as indicated by the parietal LPP) even though doing so might prove to be effective in enabling them to suppress emotional expression.

The finding that Asians suppress emotion processing, as indexed by the parietal LPP, is consistent with a recent fMRI study conducted by Ohira and colleagues (2006) who exposed Japanese participants to a emotional and neutral pictures while asking them to suppress their emotions, as we did here. Although these Japanese participants showed a pronounced amygdala response in an attend condition, this activity was completely absent in the suppression condition. Together with the Ohira *et al.* data, our current data demonstrate a robust dampening of emotion processing by suppression in Asians. Future work should examine origins of this cultural competence. While we believe that socialization is crucial, this competence might stem, in part, from certain genetic potentials (Way and Lieberman, 2010).

Functional significance of the frontal positivity

The lack of parietal LPP modulation during suppression in European Americans is unlikely to be an artifact caused by lack of motivation. These participants reported that they were at least as engaged and working just as hard as Asians did. Further evidence for this conclusion comes from the quite conspicuous positivity European Americans showed in the suppression (*vs* attend) condition at frontal recording sites (centered around FCz). Because positivity at FCz and other adjacent sites likely reflects self-regulatory functions that are distributed in the prefrontal cortex (dorsolateral prefrontal cortex and the inferior

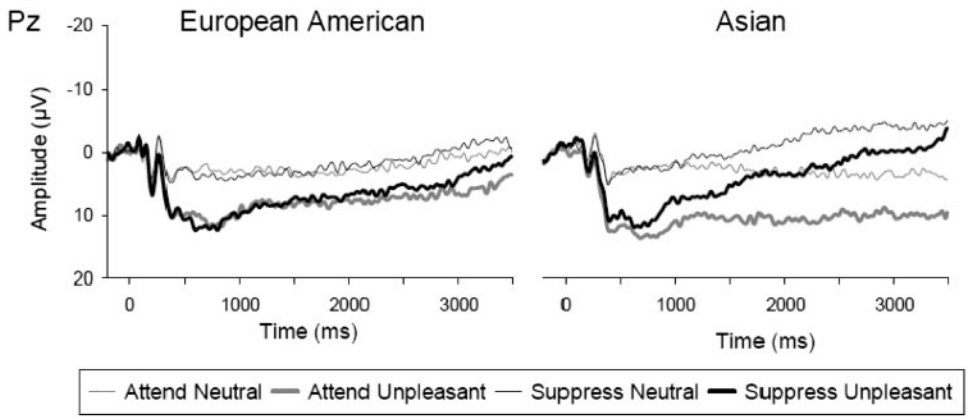

Fig. 1 Stimulus-locked grand averaged waveforms for European Americans (left) and Asians (right) at Pz.

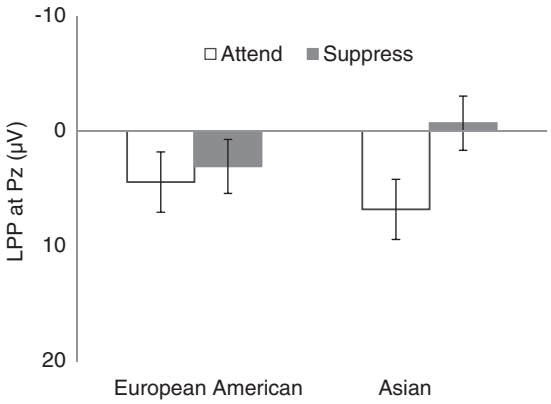

Fig. 2 Mean amplitude of the LPP at Pz between 1500 and 3500 ms time window for the Suppress *vs* Attend conditions and the cultural groups. Picture valences are collapsed. Error bars show the standard errors of the mean.

frontal gyrus) and dorsal anterior cingulate cortex (Paus, 2001; Aron *et al.*, 2003; Taylor *et al.*, 2003; Ochsner and Gross, 2008; Venkatraman *et al.*, 2009; Wagner and Heatherton, 2010), we suggest that this reflects the participants' genuine effort to decrease emotional expression (see Schienle *et al.*, 2011 for a similar interpretation of the frontal positivity). Our result is further consistent with Goldin *et al.* (2008) who showed that expressive suppression was likewise associated with increased prefrontal cortex activation despite a paradoxical increase in amygdala activity.

Together, the data are consistent with the view that European Americans made effort to inhibit their emotional expressions (as revealed in the frontal positivity), but this effort had no influences on their emotion processing, as indexed by parietal LPP amplitude. Consistent with the process model of Gross and colleagues (Gross and Thompson, 2007), expressive suppression appears to follow emotional processing, without affecting the latter. We suggest that this pattern is encouraged by cultural values given to inner experience of emotions, as well as their expressions. Hence, Americans may rarely down-regulate their emotional processing when trying to suppress expressions of their emotions. However, according to this interpretation, Asians did not show any increase in the frontal positivity in the suppression condition because they are culturally trained to down-regulate emotional processing when trying to suppress their emotional responses. Thus, doing so is more automatic and effortless for Asians.

Limitations and future directions

Some limitations of the present work must be acknowledged. First, the pattern which Asian participants showed with respect to neutral pictures was somewhat puzzling. They showed greater LPP decreases during suppression of responses to both unpleasant and neutral stimuli. It is possible that although unpleasant pictures were clearly more arousing than neutral stimuli—as indexed by both normative ratings and LPP amplitude—neutral pictures were not completely devoid of emotion. It may be for this reason that emotional arousal associated with neutral pictures was effectively decreased by Asians in the suppression condition. This finding is consistent with our view that Asians down-regulate emotional processing in general, both strong and relatively weak. Yet, this analysis must be tested more carefully in future work.

Second, in the present work we did not ask participants to rate their emotional experience when exposed to stimulus pictures. Our decision was based on two considerations. First, prior work has established that the parietal LPP is tightly linked, not only to emotional ratings, but also to amygdala activity. Hence, it is safe to hypothesize that parietal LPP amplitude is a highly reliable, valid marker of emotional processing. Second, and more importantly, we worried that when induced to pay attention to emotional experience, Asians might be primed to feel emotions, which might in turn diminish their ability or proclivity to attenuate emotional processing. Nevertheless, now that we have established the surprising degree to which Asians down-regulate emotional processing when required to suppress emotional expression, it will be quite important to examine whether this down-regulation might be modulated by induced attention to subjective experience.

Third, the present work has provided the first cross-cultural evidence that the very assumption held widely in the current literature on emotion regulation—namely, the assumption that expressive suppression never influences emotional experience (Gross and Thompson, 2007)—may be less valid when applied to Asian populations. Nevertheless, our work falls short of determining exactly how Asians managed to down-regulate emotional processing in the expressive suppression condition. Because culturally sanctioned behaviors are likely to be eventually internalized to cause changes in the underlying processing structure of the brain (Schwartz, 2002; Kitayama and Park, 2010), it may be hypothesized that as the act of suppressing overt emotional responses is repeatedly engaged over time in daily experience of Asian culture, Asians eventually achieve a 'cultural expertise' of inhibiting emotional processing so that even covert emotional responses disappear from conscious awareness. This is reminiscent of the state of 'nothingness' that is emphasized in some Asian

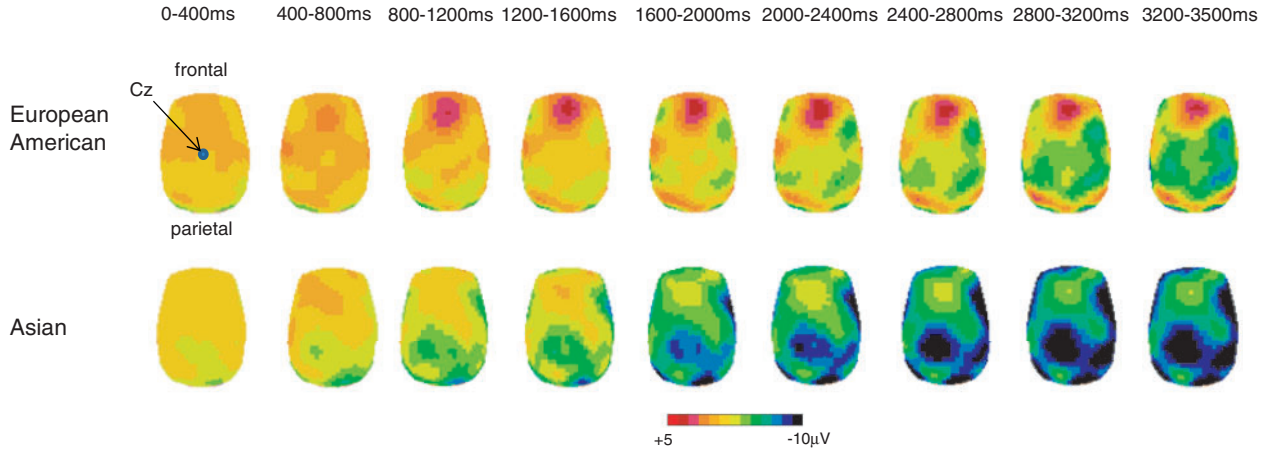

Fig. 3 Topographical maps for difference waves (Suppress condition–Attend condition) for unpleasant pictures in each 400-ms time window for European Americans (top) and Asians (bottom).

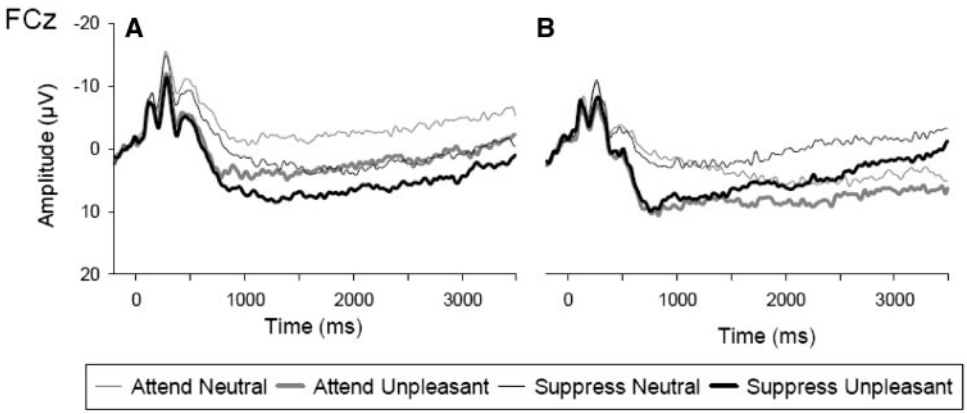

Fig. 4 Stimulus-locked grand averaged waveforms for European Americans (left) and Asians (right) at FCz.

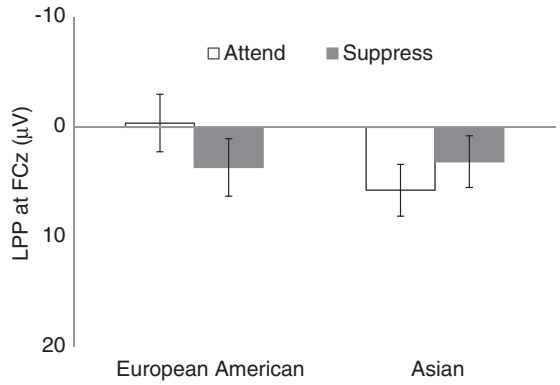

Fig. 5 Mean amplitude of the LPP at FCz between 500 and 3000 ms time window for each condition and cultural group. Picture valences were collapsed. Error bars show the standard errors of the mean.

philosophical traditions such as Taoism and Zen (Uchida and Kitayama, 2009). Further research along this line may reveal fundamental cultural dimensions in the seemingly natural process of emotion and emotional processing.

Fourth, we have hypothesized that the cultural difference in the brain that is demonstrated in the present work is mediated by 'cultural training'. While plausible, this analysis must be tested explicitly in future work. Another important question is whether European Americans still retain the ability to down-regulate emotional processing by suppression. The fact that they often show a paradoxical potentiation of activity when trying to suppress that very activity (Wegner, 1992; Goldin *et al.*, 2008) might imply that the 'cultural training' they receive might have made it very difficult to achieve cognitive or emotional 'calmness'; but clearly, systematic empirical investigation is necessary.

CONCLUSIONS

Despite these shortcomings, our work has made it clear that culture plays a significant role in emotional suppression and emotional processing that is linked to it. It has done so with a neuroscience method (ERP). We believe that this and other such methods are quite useful and even indispensable in the investigation of cultural influences. Fully equipped with these cutting-edge tools, the field of cultural neuroscience is well positioned to explore how the brain might be shaped through each person's active engagement in the social environment of culture (Han and Northoff, 2008; Chiao, 2011; Kitayama and Uskul, 2011). Located squarely in this emerging approach to culture, the present work will help improve intercultural communication and understanding. Ultimately, however, we hope that the present data

help us uncover the fundamental role of culture in wiring and rewiring the brain pathways in the domain of emotion and emotion regulation.

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