Neural responses to affective stimuli across culturally similar and dissimilar situations

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Abstract

Previous research suggests that individuals from individualistic and collectivistic cultures, due to different construal of the self and social groups, might have different emotional experiences and attenuate their emotional experiences differently across situations. The current research investigates the influence of these cultural orientations specifically on the neural response to different valences of emotions and across different social situations. Event-related brain potentials were recorded when individualism-representative Dutch in the Netherlands and collectivism-representative Chinese participants in China (N = 40) viewed affective pictures (the IAPS) while being alone, being accompanied by a culturally similar person, and being accompanied by a culturally dissimilar person. The late positive potential (LPP) in Dutch participants showed a differentiation between valences (negative vs. positive) of emotions while this was not the case for Chinese participants. This suggests a wider range of emotional experience in the Dutch group and possibly stronger emotional attenuation in the Chinese group. Furthermore, the Chinese group showed a hemispheric differentiation in LPP amplitude between culturally similar and dissimilar situations whereas the Dutch did not. However, this effect was small and laterality index analysis indicated that there was no corresponding statistically significant difference in hemispheric dominance. These findings indicate that culture has an effect on neural emotional responding indexed by LPP. Evidence for a role of culture in the impact of social situation on emotional responding indexed by LPP was weak.

Keywords: ERP, LPP, culture, emotion, situation

Introduction

Many theories of emotion recognize the role of social context in how individuals modify their emotional responses (Barrett, Mesquita, & Gendron, 2011). There is also accumulating empirical research indicating that emotional responding is sensitive to the specific situation at hand (Matsumoto & Kupperbusch, 2001). Culture is an important determinant of how one perceives the relationship between the self and the group (i.e. social affiliation). This perception in turn influences the norms regarding which particular emotional responses are desirable in any given situation. Consequently, individuals modify their emotional response so that it is congruent with the prevailing cultural models in their society. The present research investigates to what extent individuals from different cultures, who have different perceptions of the self and the group, might regulate their emotional responding differently when they are accompanied by people of different degrees of affiliation.

Emotion and situation

Social context matters for emotion experience and regulation (Matsumoto & Kupperbusch, 2001). For example, the presence of a friend, compared to the presence of a stranger, increases the expression and experience of positive emotions (Bruder, Dosmukhambetova, Nerb, & Manstead, 2012). Similarly, there is a general reduction of emotional expression in the presence of a stranger (Jakobs, Manstead, & Fischer, 2001). Social context signals how much energy one needs to spend on emotion regulation. Individuals also have a universal need to make economical use of their somatic and neural resources and therefore adjust their emotions accordingly (Coan & Beckes, 2011). For example, when accompanied by a person with whom the degree of affiliation is optimal, people show lower

vigilance for threats and energy expenditure on emotion regulation can thus be lower. Social situation, therefore, influences emotional experience and expression through changes in the degree of social affiliation that such situations impart: high (e.g., friends, family) and low (e.g., strangers).

Emotion and culture

One of the most important determinants of how one perceives affiliation (which – as explained above – affects emotion regulation) is culture. Two of the most well-researched cultural models, individualism and collectivism, differ in terms of how one construes the self and the relations between the self, ingroup (high-affiliation), and outgroup (low-affiliation) members (Markus & Kitayama, 1991; Matsumoto & Hwang, 2010; Mesquita, De Leersnyder, & Albert, 2013). Classical social identity studies and cultural display rule studies show that individuals universally make a distinction between ingroup and outgroup members (Tajfel, 2010) and endorse emotional expressions towards ingroup members more than towards outgroup members (Matsumoto, Yoo, & Fontaine, 2008). However, people from collectivistic cultures (such as East Asian) tend to construe themselves as embedded in their relationships with others compared to those from individualistic cultures. In collectivistic cultures, the distinction between ingroup and outgroup is also stronger than in individualistic cultures (Matsumoto & Hwang, 2010; Matsumoto, Yoo, & Fontaine, 2008; Triandis, Bontempo, Villareal, Asai, & Lucca, 1988). Collectivism is then associated with a smaller distance between the self and the ingroup compared to individualism.

People from individualistic cultures (e.g., Western European or Northern American), on the contrary, tend to construe themselves as separate from other people and have a highly independent sense of self. They usually have more than one ingroup and feel less connected to a

specific ingroup (Markus & Kitayama, 1991; Matsumoto & Hwang, 2010; Matsumoto, Yoo, & Fontaine, 2008; Triandis et al., 1988). Brain imaging studies also suggest that those from individualistic cultures make a clear distinction between the self and close others in terms of mental representation compared with those from collectivistic countries (Chiao et al., 2010; Ng, Han, Mao, & Lai, 2010; Zhu, Zhang, Fan, & Han, 2007). In sum, those who live in individualistic countries are likely to make a clear distinction between the self and any other; whereas, those who live in collectivistic countries are likely to only make a clear distinction between the self and outgroup (see Supplemental Materials Figure 1 for a schematic illustration of this point).

Another aspect of emotional responding on which those from individualistic and collectivistic cultures might have an influence is the range of emotions that individuals allow themselves to experience. People seek to achieve the emotional experience that is congruent with the pertinent cultural models (Mesquita et al., 2013). Collectivism, focusing on harmony in social relationships and interdependence, encourages emotional control in general (Matsumoto, Yoo, & Fontaine, 2008), especially of negative and high-arousal emotions (J. L. Tsai, Knutson, & Fung, 2006; W. Tsai & Lau, 2013) and sometimes also of positive emotions (Chiang, 2012; Matsumoto & Kupperbusch, 2001). Emotion control is valued when positive social outcome is desired (such as suppressing anger to maintain friendship or suppressing pride in front of friends to avoid inciting jealousy) (Butler, Lee, & Gross, 2007). Individualism, however, emphasizes personal feelings and their free expression, which helps in reaffirming the position of the individual in the group (Butler et al., 2007; Markus & Kitayama, 1991; Safdar et al., 2009). Emotional control, in the form of suppressing emotional expression, is considered unhealthy in individualistic cultures (Gross & John, 2003) yet is highly valued in East Asia (Matsumoto, Yoo,

& Nakagawa, 2008; Mauss, Butler, Roberts, & Chu, 2010; W. Tsai & Lau, 2013; Wei, Su, Carrera, Lin, & Yi, 2013).

These intriguing behavioral differences in emotional responding across contexts between individualistic and collectivistic cultures necessitate the investigation of the mechanisms by which individualism and collectivism may influence emotional responding across social situations, and the associated neural underpinnings. Moreover, since culture is tacit, implicit, and non-declarative (Ishii & Eisen, 2017; Kitayama, Ishii, Imada, Takemura, & Ramaswamy, 2006; Kitayama & Markus, 1994), explicit measures may not capture cognitive tendencies under the influence of culture (Kitayama, 2002). The electrophysiological method in the present research made it possible to observe neural correlates of emotional experience – beyond outward facial emotional expressions and self-reports – that members of different cultures have after exercising emotion regulation under the guidance of their cultural knowledge.

The use of EEG and LPP in the present research

Electroencephalographic (EEG) techniques which measure electrical potentials of brain activation through the skull and scalp are excellent tools to study emotional responding at the neural level (Ibanez et al., 2012; Olofsson, Nordin, Sequeira, & Polich, 2008). Sequences of positive- and negative-going electrical potentials elicited by the stimulus (called event-related potentials or ERPs) reflect underlying latent components. Previous research has established that analyzing amplitudes (size) and latencies (timing) of these components can reveal how affective information is processed (Sabatinelli, Keil, Frank, & Lang, 2013; Sabatinelli, Lang, Keil, & Bradley, 2007).

The ERP component that we focused on is the long-lasting late positivity potential (LPP, hereafter) because it is a highly reliable neuro-marker of emotional responding to picture stimuli

(Cunningham & Zelazo, 2007; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Hajcak & Nieuwenhuis, 2006; Ibanez et al., 2012; Olofsson et al., 2008; Sabatinelli et al., 2007; Schupp et al., 2000). LPP usually starts 500-600 ms after stimulus onset, but varies greatly in its duration depending on the duration of stimulus presentation (Olofsson et al., 2008). For example, Hajcak and Olvet (2008) presented stimuli for 2000 ms and found that LPP can continue until 1000 ms after stimulus offset (especially for unpleasant stimuli); whereas, other researchers who used rapid image presentation (120-333 ms) found that LPP only lasts up to 300 ms after picture offset (Schupp et al., 2007; Schupp, Junghöfer, Weike, & Hamm, 2004). LPP is often distributed at the centro-parietal area of the scalp (Olofsson et al., 2008) and LPP peaks, observed when participants view picture stimuli, discriminate two crucial affective stimulus dimensions: valence and arousal (Cuthbert et al., 2000; Dolcos & Cabeza, 2002; Schupp et al., 2000). Specifically, LPP is enlarged to emotional (positive or negative valenced) stimuli relative to neutral stimuli (Hajcak & Nieuwenhuis, 2006) and to stimuli of high arousal relative to stimuli of low arousal. Valence refers to the differences between neutrality, positivity, and negativity in emotions; whereas arousal ranges from high arousal (e.g., aroused) to low arousal (e.g., calm). Different emotions can share the same valence while having different degrees of arousal. For example, elation and contentment both have a positive *valence*, but elation has high *arousa*l while contentment has low *arousal*. In general, negative emotions have higher arousal than positive emotions and negative stimuli usually elicit a larger LPP than positive stimuli as the former induce higher arousal than the latter (Olofsson et al., 2008).

LPP modulation at very late stages is involved in complex emotional integration of affective and contextual processing as well as in emotional regulation strategies (Cacioppo, Crites, & Gardner, 1996; Cornejo et al., 2009; Ibanez, Haye, Gonzalez, Hurtado, & Henriquez,

2009; Ibanez et al., 2012; Olofsson et al., 2008; Williams & Themanson, 2011). Instruction to down modulate one's emotional responding has been linked to reductions in LPP amplitude, and such reductions appear to vary as a function of success of the implemented strategy and across different strategies (Hajcak, Moser, & Simons, 2006; Hajcak & Nieuwenhuis, 2006). Furthermore, hemispheric laterality effects in LPP amplitude in emotional paradigms have also been reported (Cornejo et al., 2009; Cunningham, Espinet, Deyoung, & Zelazo, 2005; Dolcos & Cabeza, 2002; Junghöfer, Bradley, Elbert, & Lang, 2001; Schupp, Junghöfer, Weike, & Hamm, 2003). The right hemisphere might be more involved than the left one in processing complex emotional information and higher hemispheric asymmetry might indicate more intense emotional experience (Cacioppo et al., 1996).

In line with this literature, LPP is also the most informative component in the handful of existing ERP studies investigating cultural influences on emotional responding to picture stimuli. These studies suggest that emotion regulation under cultural influences can be considered complex regulatory processes that take place relatively late, and that follow an initial perceptual evaluation of the stimuli. Hot, Saito, Mandai, Kobayashi, and Sequiera (2006) found a generally smaller LPP amplitude in a collectivism-representative Japanese group compared to an individualism-representative French one, suggesting cultural differences in emotional responding. Varnum and Hampton (2016) observed lower LPP in East Asians than in European Americans when the two groups were instructed to up-regulate their positive emotions, which the East Asians appeared to be less successful at. Murata, Moser, and Kitayama (2013) found that the LPP amplitude of Japanese (but not of European American participants), when instructed to hide negative emotions, significantly decreased compared to when instructed to attend to stimuli, suggesting that the Japanese were more successful in reducing their negative emotional response.

Notably however, none of these prior studies have examined the impact of living in individualistic and collectivistic cultures on neural mechanisms of emotional responding – as indexed by the LPP component – across different culturally relevant social situations.

The present research

We measured LPP when participants from two different cultural backgrounds representing individualism and collectivism (Dutch and Chinese) were presented with picture stimuli of different valences. Apart from viewing the stimuli alone, participants also viewed them while being accompanied by a culturally similar (ingroup) and by a culturally dissimilar (outgroup) person. The Chinese data in the present research was obtained in a larger project with the aim to investigate the mechanism of emotional responding in various ERP components and the data have been reported in an independent publication (Woodcock, Yu, Liu, & Han, 2013). For the purpose of the present research, we collected comparative data in the Netherlands and focused on the cross-cultural comparison of emotional responding via LPP.

Operationalization of culture. In using country of origin and residence as the proxy of culture, we aimed to tap into the existing and possibly largely implicit cultural knowledge that these individuals have acquired. Emotion regulation, especially in the absence of prompt, is expected to be a result of highly exercised and automatized patterns of psychological responses due to the exposure to and passive or active continuous engagement in cultural practices.

Hypotheses. Our two primary hypotheses were based on the increased sensitivity to context in emotional responding that is specifically linked to collectivistic cultures and the decreased range of emotional responding that is consistent with collectivistic cultural models. First, individualism emphasizes free expression of personal feelings while collectivistic cultures

values emotional control. We thus hypothesized that Dutch participants, compared to Chinese participants, would distinguish more between emotional valences (negative vs. positive), which would be evidenced by the LPP amplitude differences in response to negative vs. positive stimuli. Second, collectivism encourages strong connections with ingroup members, but individualism promotes a clear distinction between the self and any other including ingroup members. This means that Chinese participants, compared to Dutch participants, would make little distinction between being alone and being with a culturally similar person, yet they would distinguish between culturally similar and culturally dissimilar situations. On the contrary, the Dutch would make a distinction between all situations (see Supplementary Materials Figures 1 for a schematic illustration of this hypothesis). All of these differences should be evidenced by LPP amplitude differences. Since the effects of emotion on LPP amplitude have been shown to be subject to hemispheric asymmetry, we included hemisphere as a factor in our analyses. We expected that the group differences should be more prominent over the right hemisphere than over the left hemisphere and that any modulation would reduce the laterality and lean towards hemispheric symmetry. As implicit effects of culture may be best evidenced implicitly in neural underpinnings of emotional responding, we also administered questionnaires to obtain participants' explicit, behavioral ratings of arousal to enable the comparison between the measures. We expected the group differences to be manifested in the electro-physiological measures of arousal and to a certain extent, less so in the self-reports of arousal. Finally, we measured participants' use of emotion regulation and expected that the Chinese group would report using more emotion regulation than the Dutch.

Methods

Participants and experimenters

The sample was 20 [large research university students in Beijing] (*M*age = 22.4, *SD* = 3.05) and 20 [large research university students in Amsterdam] (*M*age = 21.00, *SD* = 2.20). All participants were right-handed and female (to exclude potential confounds from gender effects, Shiota & Levenson, 2009). Participants were native speakers of Chinese or Dutch who had resided only in their home country and have either two Chinese or two Dutch parents. Participants had no long-term contact (for example, through a friendship) with people from the outgroup culture and had not met any of the two (also female) researchers before. Whenever the experimenter who accompanied the participants was an outgroup this person also belonged to the same minority group in the respective country. This feature in the experiment was to prevent introducing another factor (the minority/majority factor) in the design. The lab settings between the two universities were almost identical in many technical aspects. In each university, a well-established EEG lab was located within a large campus, flyers about the experiment were distributed at places where students gather such as dining and lecture halls, and students came to the lab voluntarily to participate in the experiments in exchange for a monetary reward. Upon arriving, the participants were greeted by two experimenters whom they have not met before, were helped to put on an EEG cap by these experimenters, and were led to an adjacent room (a Faraday cage) to proceed with the experiment. All of the instructions outside of the Faraday cage were given in written form to participants to minimize the need for verbal instructions. Participants read that the experimenters would sit next to them in order to take notes for further analyses about how they responded to the stimuli. The experimenters would sit on a chair about 1m away from the participant in a way that the experimenter's presence was always clear but that the experimenters could not see the participants' behavioral responses. The second experimenter

(the out-group / culturally dissimilar person) was assisting in conducting the experiments. This remained clear throughout the experiment where the two researchers worked together and further engaged in all other aspects of the experiment. Participation was voluntary and compensation was EUR 20 (or the equivalent in China).

Behavioral measures

Following previous research (Kim et al., 2011; Zhou, Shang, & Wang, 2016), all measures were translated into Dutch and Chinese by a native speaker, back translated by a second native speaker, and any discrepancies were discussed by both translators and the native speakers and resolved accordingly.

Background questionnaire. Participants answered several demographic questions about the participants' age, sex, and nationality (see Appendix).

Self-reported Arousal Questionnaire. Participants indicated their subjective arousal to each picture stimulus on a 7-point Likert scale, ranging from 1 (*not at all aroused, calm, relaxed, dull, sluggish*) to 5 (*extremely aroused, excited, frenzied, jittery, stimulated*) (Lang, Bradley, & Cuthbert, 1997).

Emotion Regulation Questionnaire (ERQ). The ERQ was adapted from the original, a widely used and validated self-report questionnaire of emotion regulation (Gross & John, 2003). Participants responded to items (e.g., "When I was feeling negative emotions, I made sure not to express them") on a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

Manipulation check. Participants indicated on a 9-point Likert scale to what extent they perceived themselves to be similar or dissimilar to the two experimenters in the lab. Similarity concerned cultural group, tradition, customs, beliefs and experiences.

Finally, there were also two questionnaires of cultural orientations (See Supplemental Materials).

Stimulus materials

The stimuli – pictures of positive, negative, and neutral valence (80 each) (normative mean ratings of valence were 7.1, 2.4 and 5.0 and of arousal were 5.3, 6.0, and 3.1, respectively) – were taken from the International Affective Picture System (IAPS) (Lang et al., 1997) (see Appendix B of Woodcock et al., 2013). Those that might elicit Asian or White racial content were avoided. Two researchers examined and chose the IAPS items. We excluded items in which it was easy to tell that the individuals depicted in the pictures were from a particular country or culture. For example, in one stimulus (which we chose not to use) a young person is in a graduation ceremony and is throwing a hat in the air. This was a situation clearly more common in Western countries like the US. Translations of instructions were handled in the same way as those of behavioral measures.

Procedure

Participants gave written informed consent before being seated in front of a 21-inch computer and fitted with the EEG cap (see section EEG recording). A practice session was first administered, followed by experimental trials where participants viewed the picture stimuli in six superblocks (counterbalanced across participants). In the two alone super blocks, participants sat in the room on their own. In the two culturally similar super blocks, Chinese participants sat with a Chinese researcher and Dutch participants with a Dutch researcher. In the two culturally dissimilar super blocks, Chinese participants sat with a Western European researcher and Dutch participants sat with an East Asian researcher. In each super block, there were positive and negative blocks. After every stimulus, participants gave their self-reported ratings of arousal.

Dummy cues (i.e., images displaying irrelevant, non-emotional content) were presented once at the beginning of each block. At the end of every block, participants answered the ERQ. Since we were interested in the differences in valence, ERQ items were administered following every block (which was valence-specific) and were reworded accordingly following the respective valence of that block. In between the super blocks, participants answered the demographic background questionnaire, the cultural orientation questionnaires and the manipulation check questionnaire. See Figure 1 for an overview and more details of the experimental design. The materials and procedure in the Netherlands strictly followed those in China (Woodcock et al., 2013) and were approved by the ethics committees of the European Research Council's and of the Dutch and Chinese universities.

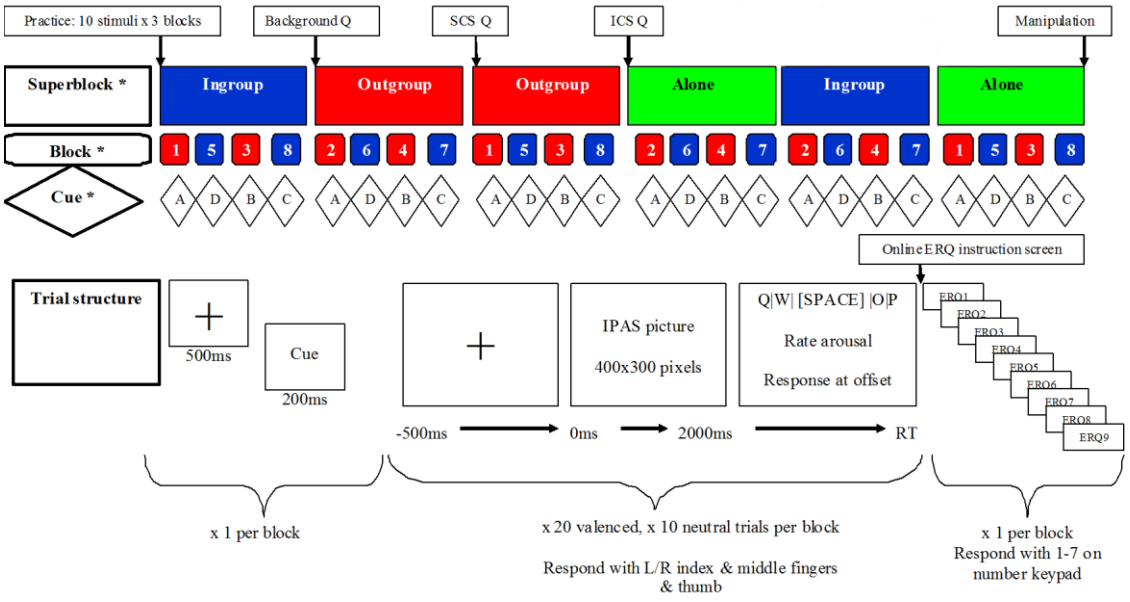


Figure 1. Overview of the experimental design. This is an example of how the experiment was for one participant. The orders of the block and superblocks inside the experiments were counterbalanced across participants. The experiment started with a practice session. In the subsequent experimental trials, participants viewed six superblocks of the IAPS stimuli. In each condition (alone, ingroup / culturally similar, and outgroup / culturally

dissimilar), there were two superblocks, resulting in a total of six superblocks. In each super block, there were two positive (blue) and two negative (red) blocks, which were presented alternately, with the valence of the first block being counterbalanced across participants. There were in total eight distinctive blocks (four negative and four positive, denoted by the numbers 1, 2, 3, 4, 5, 6, 7 and 8) which were recycled across conditions ensuring that within each condition participants only saw a specific stimulus once. Within each block, the IAPS pictures were presented in random order. Each positive block had 20 positive and 10 neutral pictures. Each negative block had 20 negative and 10 neutral pictures. Each trial consisted of a central fixation cross (500 ms), a central IAPS picture (2,000 ms duration), and a blank screen until response, which was when participants gave their self-reported ratings of arousal. Four images displaying irrelevant, non-emotional content were selected from the World Wide Web as dummy cues. One of these dummy cues (denoted by the letters A, B, C, and D) was presented once at the beginning of each block, and which cue was presented for each block was counterbalanced across participants (to avoid systematic association between a particular valence and a cue). At the end of every block, participants answered the ERQ. After the first superblock, participants answered a background questionnaire. Following the final superblock, the manipulation check questionnaire was presented. Following superblocks 2-4, the cultural orientation questionnaires were administered.

EEG recording

The IAPS pictures were presented on a monitor connected to a computer in an adjacent room where Matlab (version 7.11.584 R2010b in China and version 7.7.0 R2008b in the Netherlands) was used to run the experiment and collect behavioral responses. EEG recording was performed using NeuroScan hardware and software (Acquire version 4.5). 62 scalp

electrodes were mounted on a cap based on the 10-20 system, with two additional electrodes placed on the left and right mastoid (M1 and M2). Electro-oculogram (EOG, eye movements) was recorded bipolarly from four electrodes placed around the eyes: two approximately 1 cm above and below the center of the left eye and two about 1.5 cm in the lateral direction of each eye. EEG was online bandpass filtered between 0.05 and 100 Hz and digitized at 250 Hz. Offline bandpass filter was applied between 0.1 and 40 Hz. To avoid eye blinks, trials were rejected if their voltage exceeded +50 or -50 μV at any frontal or frontopolar channel. ERPs were computed for each condition separately from the period between 200 ms before and 2000 ms after stimulus onset and were further analyzed offline. The same model of equipment was used across sites. The same personnel conducted artifact rejection and analyses on the data across sites using the same criteria and automated scripts to ensure comparability of the Dutch and Chinese EEG data.

The LPP over the left hemisphere was defined by averaging across a 3x3 grid of electrodes: C5, C3, C1, CP5, CP3, CP1, P5, P3, and P1. Over the right hemisphere, the corresponding region of interest (ROI) consisted of electrodes: C6, C4, C2, CP6, CP4, CP2, P6, P4, and P2 (Cuthbert et al., 2000; Hajcak & Nieuwenhuis, 2006; Hot et al., 2006; Olofsson et al., 2008; Schupp et al., 2000; Schupp et al., 2003). LPP was defined as the centro-parietal averaged amplitude above each hemisphere. Following previous research that assessed psychometric properties of the LPP and other research also using IAPS and similar duration of stimulus presentation (Moran, Jendrusina, & Moser, 2013; Moser et al., 2017), we extracted the epochs between 600ms and stimulus offset (i.e., 2000ms), divided it into three smaller successive time windows of similar lengths and for analysis focused on the middle window (1000-1500ms) where we expected the LPP to be maximal.

Analyses

Primary EEG analyses were ANOVAs applied to LPP amplitudes in ROIs to examine the effects of Situation (alone, culturally similar, culturally dissimilar), Valence (neutral, positive, negative) and Hemisphere (left, right) as within-subjects factors, as well as Cultural Group (Chinese, Dutch) as a between-subjects factor. Interactions of key importance were the three-way interactions between Cultural Group, Situation and Hemisphere (to examine the impact of culture on sensitivity to different social contexts in terms of emotional responding), and between Cultural Group, Valence and Hemisphere (to examine the impact of culture on sensitivity to stimuli with different valences on emotional responding). Primary behavioral analysis was a corollary ANOVA to examine the effects of Situation, Valence, and Cultural Group on self-reported arousal.

Results

Manipulation check

In both groups, the Wilcoxon Signed Rank tests revealed that, the culturally similar researcher was rated as significantly more culturally similar than the culturally dissimilar researcher (Chinese group: $z = 3.92$, $p < .001$; Dutch group: $z = 3.92$, $p < .001$), suggesting that the manipulation worked well and similarly in both the Chinese and the Dutch group. In addition, the Chinese group felt significantly closer to their culturally similar researcher (M = 7.100, SD = 1.177) than the Dutch group felt to the respective culturally similar researcher (M = 5.775, SD = .910, $t(38) = 3.984$, $p <. 001$). The two groups did not differ in the degree to which they felt dissimilar to the respective culturally dissimilar person (Chinese: M = 3.675, SD = 1.333; Dutch: M = 3.762, SD = 1.078; $t(38) = -.228$, p = .821).

EEG results

The 2 Cultural Group x 3 Situation x 3 Valence x 2 Hemisphere ANOVA was conducted first on the average LPPs for each ROI. See Table 1 for an overview of all effects.

Table 1.

Effect	F	Hypothesis df	Error df	p-value	η^2
Situation	0.440	2	37	0.647	0.023
Situation * Group	1.762	2	37	0.186	0.087
Valence	83.886	2	37	0.000	0.819
Valence * Group	10.878	2	37	0.000	0.370
Hemisphere	1.607	1	38	0.213	0.041
Hemisphere * Group	0.059	1	38	0.810	0.002
Situation * Valence	0.084	4	35	0.987	0.009
Situation * Valence * Group	1.527	4	35	0.216	0.149
Situation * Hemisphere	0.266	2	37	0.768	0.014
Situation * Hemisphere * Group	4.706	2	37	0.015	0.203
Valence * Hemisphere	3.740	2	37	0.033	0.168
Valence * Hemisphere * Group	13.439	2	37	0.000	0.421
Situation * Valence * Hemisphere	1.203	4	35	0.327	0.121

Note. Overview of the results of the Cultural Group x Situation x Valence x Hemisphere ANOVA. Group is the Cultural Group factor.

Main effects

The results indicated no main effect of Situation, ($F(2, 37) = .440$, $p = .647$, $\eta^2 = .023$) and a main effect of Valence, $F(2, 37) = 83.886$, $p < .001$, $\eta^2 = .819$. LPP was largest for negative stimuli ($M = 4.858$, $SE = 0.339$, *95% CI* [4.171; 5.545]), followed by positive stimuli ($M = 4.046$, $SE = 0.316$, *95% CI* [3.504; 4.686]) and was smallest for neutral stimuli ($M = 2.434$, $SE = 0.268$, *95% CI* [1.892; 2.976]). There were neither main effects of Cultural Group ($F(1, 38) =$

1.711, $p = .199$, $\eta^2 = .043$) nor of Hemisphere ($F(1, 38) = 1.607$, $p = .213$, $\eta^2 = .041$) on the mean LPP magnitude. For an overview of the ERPs, see Figure 2.

Interactions

Situation, Cultural Group, and Hemisphere. There was an interaction between Situation, Cultural Group and Hemisphere, $F(2, 37) = 4.706$, $p = .015$, $\eta^2 = .203$ (see Figure 3). When broken down by pairs of situations, the three-way interaction was driven by the contrast between culturally similar and culturally dissimilar situations ($F(1, 38) = 6.055$, $p = .019$, $\eta^2 = .137$) and between culturally similar and alone situations ($F(1, 38) = 5.458$, $p = .025$; $\eta^2 = .126$). Further contrasts specifically for each cultural group (i.e., looking into the Situation x Hemisphere interaction in Chinese and Dutch group separately) revealed that in the Dutch group, in both situations, the LPPs were similarly more prominent over the right hemisphere ($M_{\text{similar left}} = 4.009$, $SD = .439$; $M_{\text{similar right}} = 4.348$, $SD = .440$, $M_{\text{dissimilar left}} = 3.946$, $SD = .429$, $M_{\text{dissimilar right}} = 4.197$, $SD = .437$, $F(1,19) = 1.498$, $p = .236$, $\eta^2 = .073$). On the other hand, in the Chinese group, the LPPs were only more prominent over the right hemisphere in the culturally dissimilar situation. In the similar situation, the LPPs for the Chinese group indicated balanced LPP amplitudes between the two hemispheres ($M_{\text{similar left}} = 3.028$, $SD = .451$ and $M_{\text{similar right}} = 3.070$, $SD = .451$; $M_{\text{dissimilar left}} = 3.257$, $SD = .440$, $M_{\text{dissimilar right}} = 3.427$), $F(1,19) = 5.218$, $p = .034$, $\eta^2 = .215$. Furthermore, the Dutch group tended to show a more balanced pattern of LPPs when alone relative to when in the culturally similar situation (which would suggest that the Dutch group made a distinction between the self and any other) but this effect was not statistically significant, $F(1,19) = 4.057$, $p = .058$, $\eta^2 = .176$. As expected, the Chinese group did not distinguish between being alone and being with a culturally similar person $F(1,19) = 1.938$, $p = .180$, $\eta^2 = .093$.

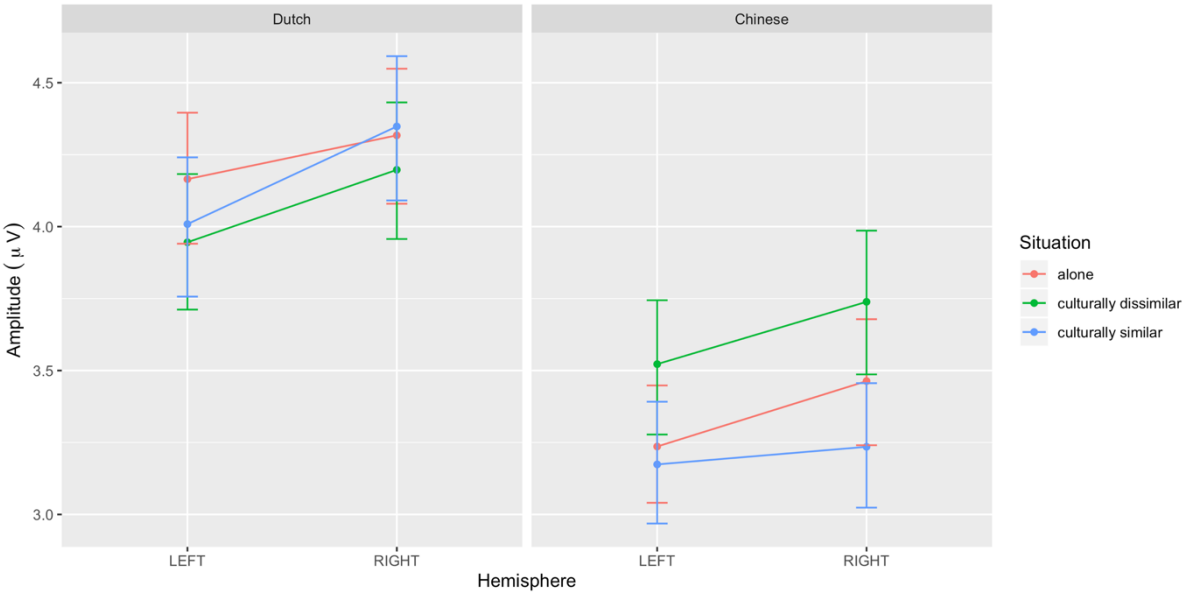


Figure 3. The interaction between Situation, Cultural Group, and Hemisphere in the multivariate analysis where hemisphere was a factor.

To further explore the role of hemisphere in the Situation by Group interaction, we calculated a laterality index (LI) based on the equation LI = (L-R)/(L+R) where L represents the LPP amplitude in the left-hemisphere and R is the LPP amplitude in the right-hemisphere. This yields a value for LI such that -1 < LI < +1, where a positive value indicates left-hemisphere dominance and a negative value indicates right-hemisphere dominance. A 2 Cultural Group x 3 Situation ANOVA was conducted on the LI. The result indicated a non-significant Situation by Group interaction on the laterality index ($F(2,37) = .457$, $p = .637$, Wilks' Lambda), suggesting that the degree to which the groups differed in their emotional responses to different situations did not decisively have a left- or right-hemisphere dominance.

Valence, Cultural Group, and Hemisphere. There was a significant interaction between Valence, Cultural Group and Hemisphere, $F(2, 37) = 13.439$, $p < .001$, $\eta^2 = .421$. When broken down by pairs of valences, the interaction with Hemisphere only arose due to the comparison

between the emotional (i.e. positive and negative) stimuli on the one hand and the neutral stimuli on the other, which showed a larger right than left hemisphere LPP amplitude in the Dutch but not in the Chinese group (see Figure 4). Yet, in both cultural groups, the differences in LPP response to positive vs. negative stimuli (the relevant valence comparison given our hypotheses) were not dependent on Hemisphere (Dutch: $F(1,19) = .078$, $p = .784$, $\eta^2 = .004$; Chinese: $F(1,19) = .106$, $p = .749$, $\eta^2 = .006$). The overall Valence and Cultural Group interaction was significant ($F(2, 37) = 10.878$, $p < .001$, $\eta^2 = .370$) (also suggesting that the three-way interaction was mostly driven by this two-way interaction). Breaking down the Valence by Cultural Group interaction further, when considering positive vs. negative valences, the difference between groups remained significant ($F(1, 38) = 7.966$, $p = .008$, $\eta^2 = .173$). The Chinese group showed similar LPP amplitude in response to positive ($M = 3.651$, $SE = .499$) and negative stimuli ($M = 4.023$, $SE = .500$) ($M_{diff} = -.372$, $SE = .258$, $p = .494$) while the Dutch's LPP amplitude was significantly increased in response to negative stimuli ($M = 5.692$, $SE = .460$) relative to positive stimuli ($M = 4.441$, $SE = .389$) ($M_{diff} = -1.252$, $SE = .175$, $p < .001$) (see Figure 5 and Figure 6). The two groups had very similar responses to neutral stimuli (Dutch: $M = 2.358$, $SE = .329$; Chinese: $M = 2.510$, $SE = .423$)

Following previous research, we also subjected the other two time windows (600-1000ms and 1500-2000ms) to the same statistical models and found a result pattern similar to that of the 1000-1500ms window (the middle window).

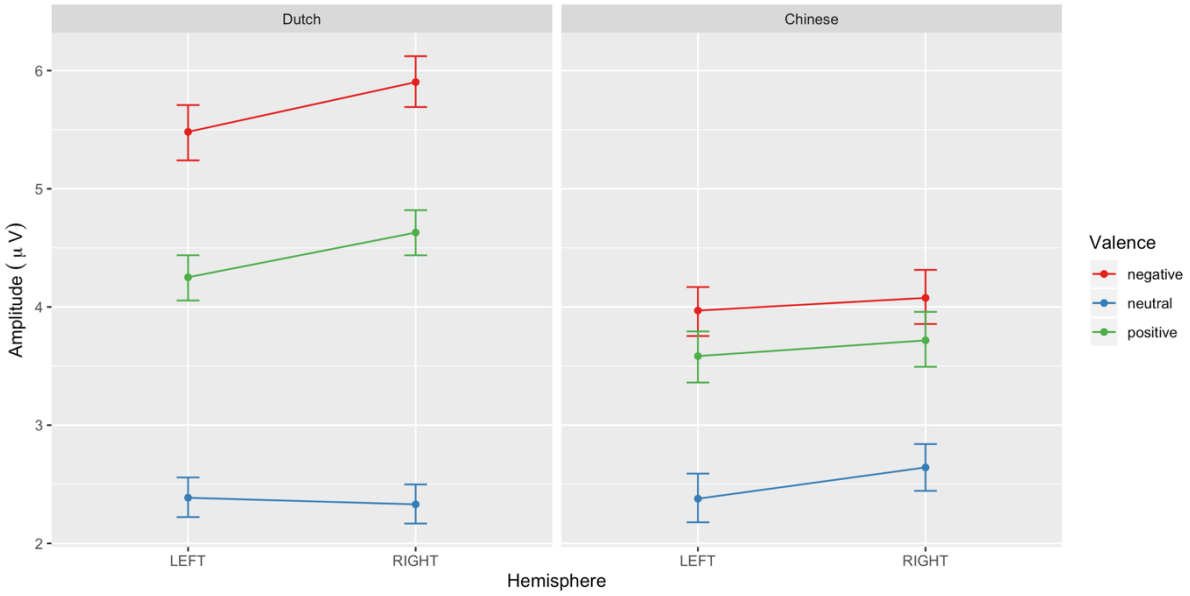


Figure 4. The interaction between Valence, Cultural Group, and Hemisphere. LPP magnitudes (in μV) indicated that the Dutch group showed significantly stronger responses to negative stimuli (relative to positive stimuli). This clear distinction between negative and positive valences suggests a wider range of emotional experience. On the contrary, the Chinese group had very similar LPP amplitude to negative and positive stimuli, suggesting dampened emotional responding.

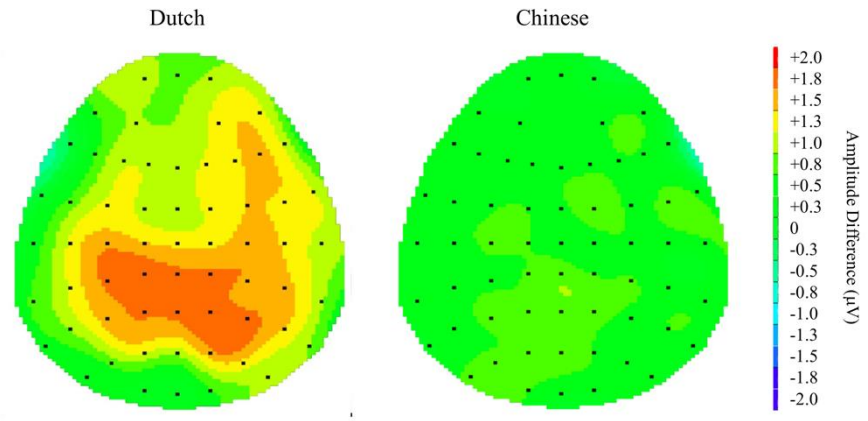
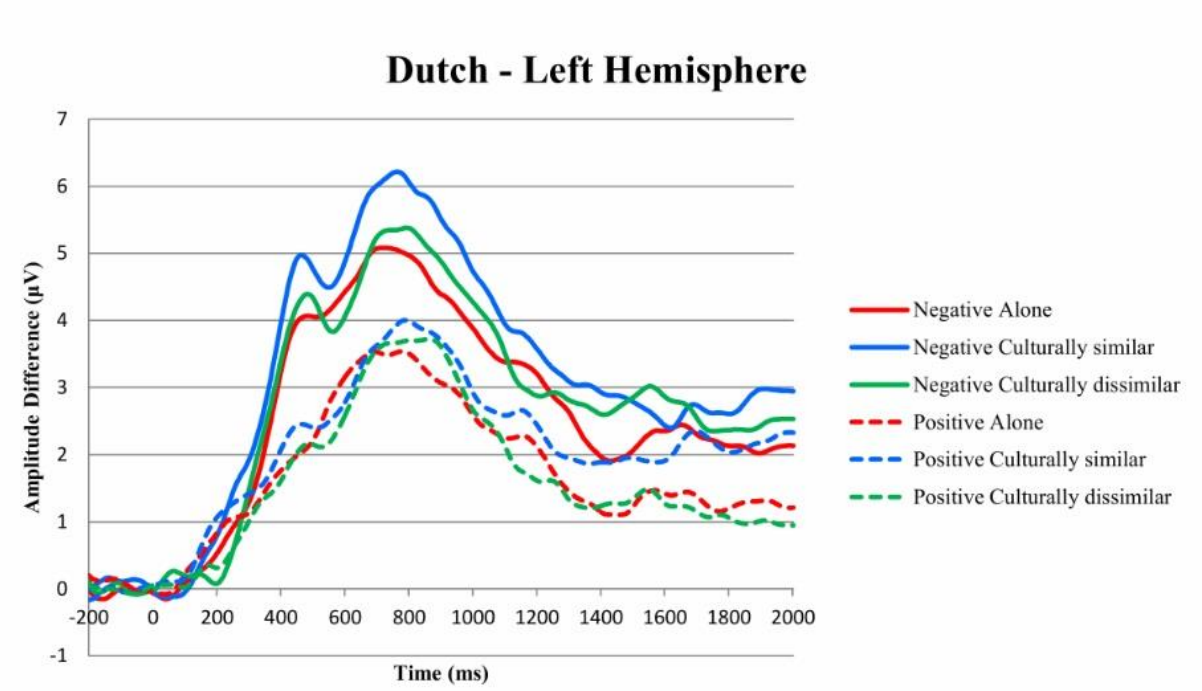
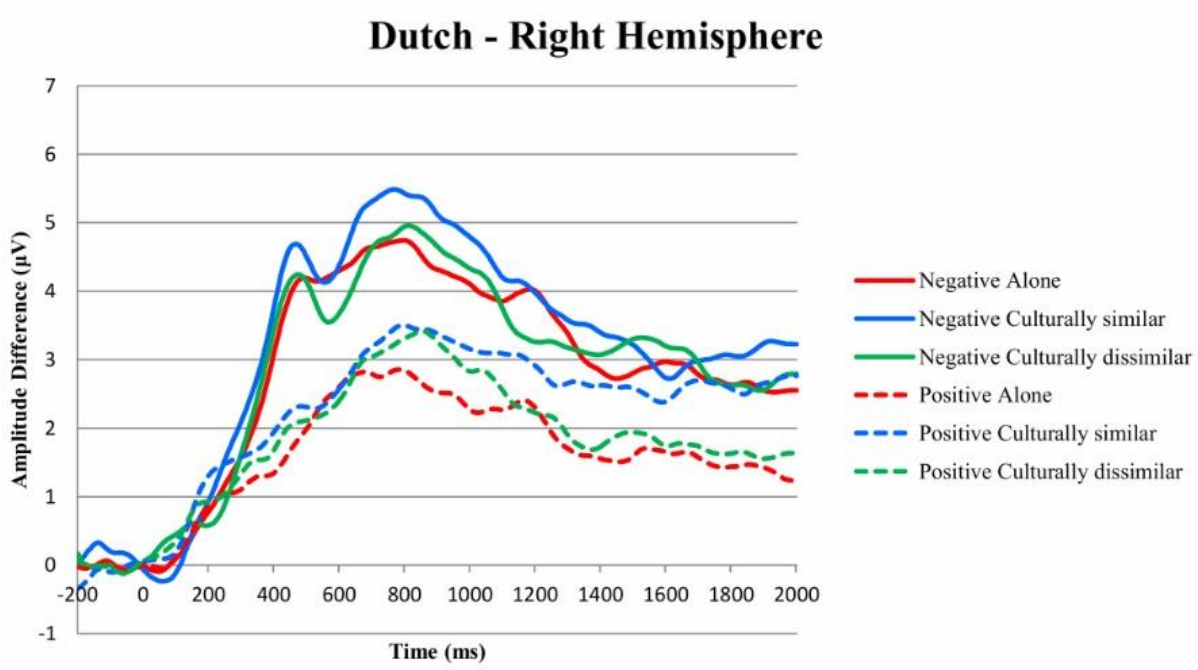
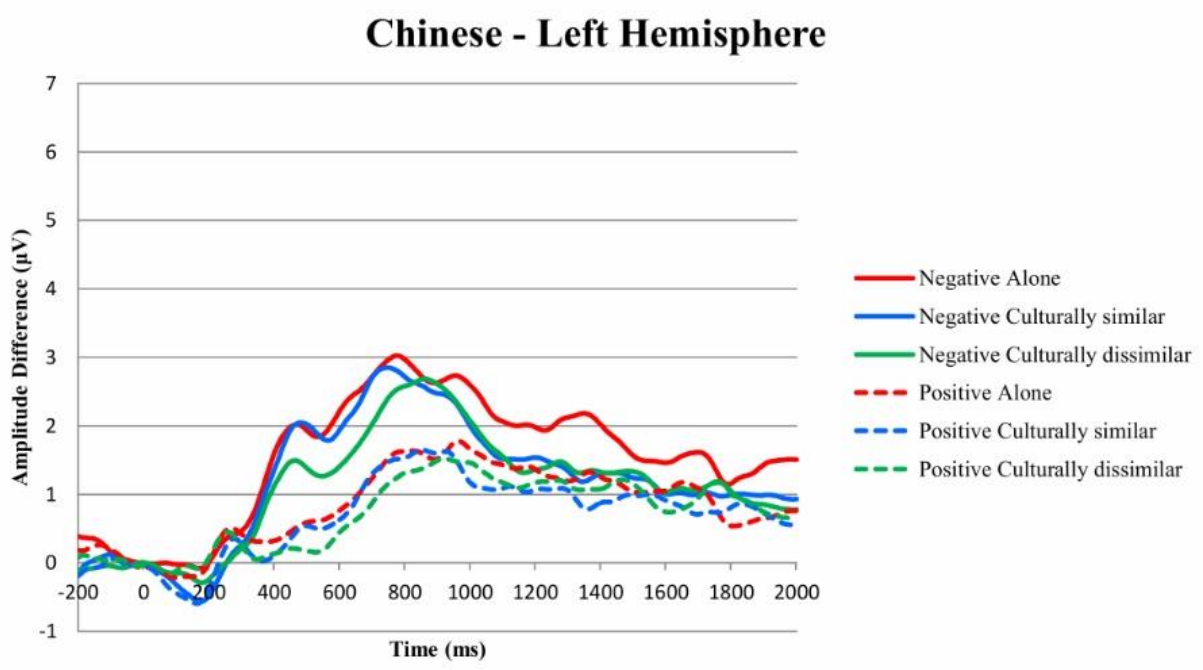


Figure 5. Scalp topographies showing the difference in responses to negative vs. positive pictures between cultural groups at 1250ms after picture onset (i.e., at the center of LPP). Left panel: Dutch group. Right panel: Chinese group. Warmer colors indicate positive differences in amplitude. Consistent with what was expected, the Dutch group showed significantly stronger reaction to negative stimuli compared to positive stimuli, whereas the Chinese group reacted similarly to the two types of stimuli.




Dutch - Right Hemisphere
Amplitude Difference (μV)
7
6
5
4
3
2
1
0
-1
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (ms)
Negative Alone
Negative Culturally similar
Negative Culturally dissimilar
Positive Alone
Positive Culturally similar
Positive Culturally dissimilar


Chinese - Left Hemisphere
Amplitude Difference (μV)
7
6
5
4
3
2
1
0
-1
-200
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Time (ms)
Negative Alone
Negative Culturally similar
Negative Culturally dissimilar
Positive Alone
Positive Culturally similar
Positive Culturally dissimilar

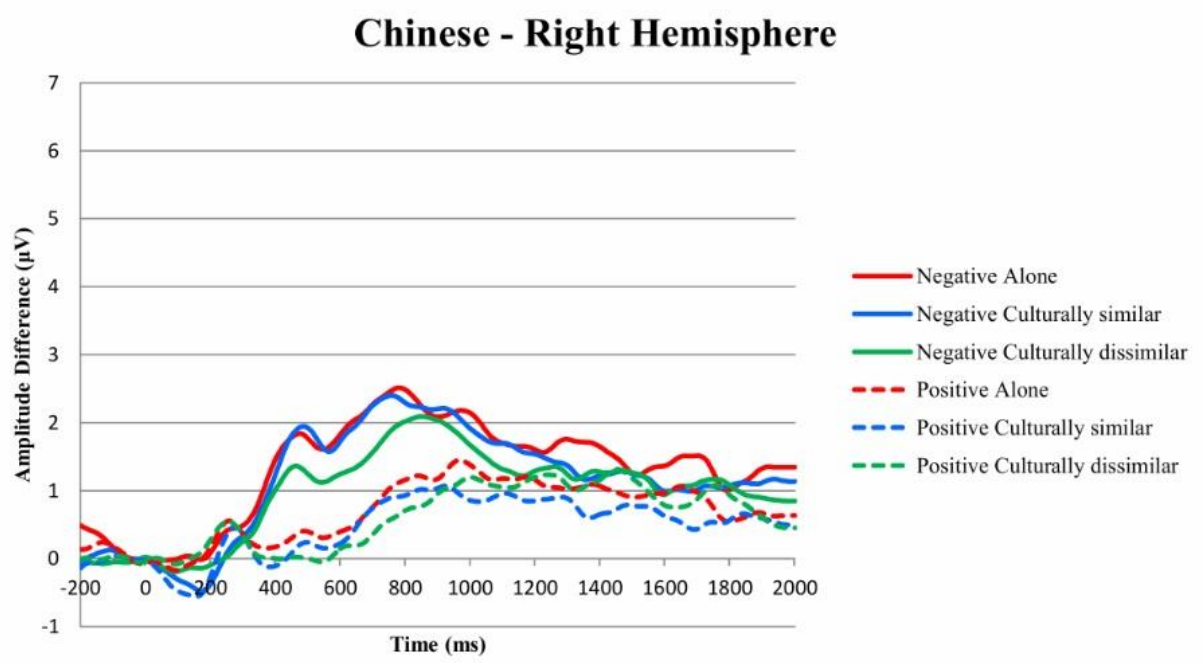


Figure 6. Difference (not raw) waveforms for Dutch and Chinese participants above the left hemisphere (averaged across C5, C3, C1, CP5, CP3, CP1, P5, P3, and P1) and the right hemisphere (averaged across C6, C4, C2, CP6, CP4, CP2, P6, P4, and P2), separated by valence difference (i.e., negative *minus* neutral, positive *minus* neutral) and situation (alone, culturally similar, and culturally dissimilar). Panel 1 shows the left hemisphere and panel 2 the right hemisphere of the Dutch group. Panel 3 shows the left hemisphere and panel 4 the right hemisphere of the Chinese group.

Behavioral results

Self-reported arousal

A 2 Cultural Group x 3 Situation x 3 Valence ANOVA was conducted on self-reported arousal. There was a main effect of Valence, $F(2, 37) = 240.627$, $p < .001$, $\eta^2 = .929$. Consistent with previous studies and the normative ratings of the IAPS, self-reported arousal intensity was highest for negative stimuli ($M = 3.519$, $SE = .106$, 95% CI [3.304; 3.734]), followed by positive

stimuli (M = 2.715, SE = .135, 95% CI [2.441, 2.988]) and lowest for neutral stimuli (M = 1.596, SE = .077, 95% CI [1.439, 1.752]). The Chinese group reported slightly higher arousal than the Dutch group but this main effect of Cultural Group was statistically non-significant, $F(1, 38) = 3.052$, $p = .089$, $\eta^2 = .074$. There was no main effect of Situation, $F(2, 37) = 0.207$, $p = .814$, $\eta^2 = .011$. No matter which situation they were in (alone, culturally similar, culturally dissimilar) our participants reported feeling the same. No interactions were found between Situation and Cultural Group, $F(2, 37) = 0.843$, $p = .439$, $\eta^2 = .044$ and between Situation and Valence, $F(4, 35) = 1.538$, $p = .213$, $\eta^2 = .150$. There was no interaction between Cultural Group and Valence ($F(2, 37) = 1.694$, $p = .198$, $\eta^2 = .084$), the Chinese and the Dutch uniformly indicated that the pictures we used as positive, negative, and neutral stimuli were also positive, negative, and neutral to them, respectively (see Table 2).

Table 2.

				95% Confidence Interval	
Cultural Group	Valence	Mean	SD	Lower Bound	Upper Bound
Chinese	Positive	2.913	0.191	2.527	3.300
	Negative	3.599	0.150	3.295	3.902
	Neutral	1.811	0.109	1.590	2.033
Dutch	Positive	2.516	0.191	2.130	2.903
	Negative	3.440	0.150	3.136	3.744
	Neutral	1.380	0.109	1.159	1.601

Note. Arousal ratings by cultural groups and valence. The interaction between Cultural Group and Valence was non-significant.

Emotion regulation

A 2 Cultural Group x 3 Situation x 2 Valence x 2 Regulation Strategy ANOVA was conducted on the reported use of emotion regulation. There was a main effect of Valence, $F(1,38) = 10.24$, $p = .003$, indicating more self-reported emotion regulation (regardless of strategy) with negative ($M = 4.04$, $SD = 0.13$) than with positive stimuli ($M = 3.72$, $SD = 0.11$). A main effect of Cultural Group, $F(1,38) = 14.87$, $p < .001$ indicated more use of emotion regulation in the Chinese ($M = 4.30$, $SD = 0.16$) than in the Dutch group ($M = 3.45$, $SD = 0.16$). There was no main effect of Situation, $F(1.55, 59.04) = 2.72$, $p = .087$ (Greenhouse-Geisser correction for sphericity). The interactions and other results regarding the questionnaires of cultural orientations can be found in Supplemental Materials.

Discussion

The present research investigated whether cultural differences, via their consequences for the construal of the self in relation to the group, would influence the neural correlates of emotional experience in response to different situations where one is accompanied by people of different degrees of affiliation. Individualism-representative Dutch and collectivism-representative Chinese students participated in an EEG experiment where their centro-parietal LPP were measured while they viewed positive, negative, and neutral stimuli from the IAPS. The participants viewed these stimuli while being alone, while being accompanied by a culturally similar and while being accompanied by a culturally dissimilar person.

EEG findings

Situation and cultural groups. Results demonstrated a subtle difference between Chinese and Dutch groups in the gradient of asymmetry in LPP between the two brain hemispheres. However, this effect was small and only significant when hemisphere was considered as a factor

in multivariate analyses, not in the corresponding laterality index analysis. The subtle effect observed was partially consistent with our hypothesis that the Chinese group, *while* differentiating little between the self and ingroup, would make a distinction between high and low degrees of affiliation, a phenomenon that would be less pronounced in the Dutch group. The Chinese as compared to the Dutch group, indeed evidenced more modulation of LPP in the culturally similar relative to the culturally dissimilar conditions (in terms of amplitude and laterality gradient). However, since these effects were not significant in the laterality index analysis, they must be treated with caution.

Valence and cultural groups. The hypothesized cultural group differences across different valences received strong support. The Chinese group showed similar LPP amplitude (suggesting comparable emotional experience) when viewing negative and positive pictures. On the contrary, the LPP amplitude of Dutch participants significantly enlarged to negative stimuli relative to positive stimuli. Previous research has indicated that negative stimuli elicit larger LPP amplitude than positive stimuli because the former is generally of higher arousal than the latter (Olofsson et al., 2008). Diminished LPP amplitude has been associated with different strategies to attenuate or dampen emotional experience (Hajcak et al., 2006; Hajcak & Nieuwenhuis, 2006; Moser, Hajcak, Bukay, & Simons, 2006). The present Chinese participants might have had more emotional attenuation than the Dutch participants who did not feel the need for it, possibly because their culture endorses emotional experience to a higher degree. This result is congruent with theoretical work suggesting that individualism supports emotional experience and expression which reinforces individual autonomy in the group while collectivism encourages emotional restraint to maintain group harmony (Butler et al., 2007; Markus & Kitayama, 1991; Safdar et al., 2009).

It is notable that previous research has largely focused on the impact of cultural norms on the expression of emotions. In the present study however, our focus was on LPP amplitude as an index of emotional experience. Nevertheless, Murata, Moser & Kitayama (2013) found that Japanese participants had smaller LPP magnitudes than American participants when explicitly instructed to hide their emotions while viewing negative IAPS stimuli, suggesting that Japanese (but not American) participants evidenced lowered emotional arousal when attempting only to reduce their emotional expression. Thus, it is possible that cultural norms around the expression of emotions impact on neural responses to emotional stimuli and the associated emotional experience. Our results provide some support for this position because collectivism-representative Chinese participants – where cultural norms encourage emotional restraint – showed smaller LPP magnitude difference in response to negative vs. positive stimuli than the individualism-representative Dutch participants. Furthermore, given our blocked design, participants were able to build up an expectation of which valence of stimulus to expect so Chinese participants would have been in a position to employ a preparatory emotion regulation strategy throughout a block of trials. Thus, there may be an effect of culture on emotional arousal that arises from well-learned cultural cognitive schemas employed without deliberate effort.

Despite the non-instructed nature of our experimental paradigm, participants were instructed to rate their emotional arousal on each trial. It is therefore interesting to consider the possibility that rating one's emotional arousal acts as a regulation mechanism, which has been suggested – though not consistently – in some previous research (Hutcherson, Goldin, Ochsner, Gabrieli, Barrett, & Gross, 2005; Taylor et al., 2003). If this were the case, the apparently increased down-regulation of arousal in response to negative stimuli by Chinese participants may be linked to group differences in the impact that rating one's emotions has on emotional arousal.

Behavioral findings

In participants' self-reports of arousal there was neither an interaction between situation and cultural group nor between emotion and cultural group, which differed from the EEG results. No matter who the participants were with, Dutch and Chinese participants reported experiencing comparable levels of emotional experience. They also uniformly reported the highest level of arousal for negative stimuli, followed by positive stimuli, and then neutral stimuli. However, the collectivism-representative Chinese participants did report more use of emotion regulation than individualism-representative Dutch participants, a result in line with previous research (Gross & John, 2003).

The incongruence between neurophysiological and behavioral results highlights the benefits of using neurophysiological techniques to investigate affective processing that is either non-declarative or subject to self-report bias. The difference between measures dovetails with the body of previous research suggesting that cultural concepts even when not explicitly endorsed can still be embodied consciously (Kitayama et al., 2006; Markus & Kitayama, 2010). Furthermore, most theoretical accounts of emotions can be represented on a spectrum in which the boundaries between emotion generation and emotion regulation range from sharp to blurry (Gross & Barrett, 2011). From the vantage point of appraisal theories of emotion, for instance, culture could affect how emotions are construed in the first place. Thus, participants might not have been consciously aware of regulating their emotions but their cultural orientations nevertheless could have affected how emotion was experienced.

Limitations and future directions

It is possible that the technical differences in data acquisition across the two sites contributed to the group differences observed in the ERPs. However, there are two indicators that

such a scenario was unlikely. First, we did not observe overall differences between groups, but rather in the specific time windows where participants were expected to differ in their emotion responding. Second, the LPP amplitudes of the Dutch and Chinese participants in response to neutral stimuli did not differ substantially or significantly. They only diverged from each other specifically in response to affective stimuli which was recorded by the very emotional responding-sensitive LPP.

To ensure exact matching across situations, we administered all emotional stimuli three times (once in each situation). If enough normative stimuli had been available then it would have been possible to exactly match normative arousal and valence ratings across multiple groups of different stimuli, and so prevent the need for repeated stimulus presentation. Although systematic effects of repeated presentation of stimuli were avoided through the counterbalancing employed, the general effect of repeated stimulus presentation may have been to dampen the capacity of the stimuli to induce an emotion. Thus, ultimately, this feature of the experimental design is likely to have weakened the effects demonstrated. Future research that either uses a between-subject design or employs a larger pool of stimuli, if available, would be highly valuable.

The strength of our experimental design lies in the use of a situation manipulation and the examination of people's emotional reactions in an ecologically valid scenario, rather than with a computer-generated manipulation. Moreover, participants were tested in their own mother tongue and in their home culture rather than being sojourners in a foreign country. However, as we were one of the few who have used such novel manipulation, existing research on ERP modulation that underlies emotional regulation across situations for comparison is scant

(Olofsson et al., 2008). Future ERP research with comparable manipulations would improve our understanding of emotional responding across culturally social situations.

Although our sample size is rather small given the most recent changes in standard practice in the field, our results still indicate some effect of culture on emotional responding. Future hypothesis testing could therefore greatly benefit from these results. Importantly, our findings highlight one way in which considering culture as a complex fabric of interlinked experiences that shape the way individuals respond, may begin to elucidate broader differences observed across cultures.

Future research could also choose IAPS items that elicit specific emotions instead of general valences because certain emotions might be more relevant to comparisons of culturally similar and dissimilar situations than others (e.g. Matsumoto, Yoo, & Fontaine, 2008). For example, a predominantly collectivistic person might experience more sadness (which invites empathy and can strengthen interpersonal relations) than anger (which can threaten interpersonal harmony) when ingroup members are present. A predominantly individualistic person, however, might maintain the same degree of sadness and anger in the presence of ingroup members. In situations where outgroups members are present, the experience of sadness and anger might, again, differ between predominantly collectivistic and individualistic people (de Greck et al., 2012; Ishii, Kim, Sasaki, Shinada, & Kusumi, 2014; Koizumi et al., 2013). This means that future research developed from the present findings can generate highly specific expectations for the interaction between valence and situation.

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Appendix

Background questionnaire

In China, the Chinese translation was used. In the Netherlands, a Dutch translation was used.

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1. Participant ID:
2. What is your gender (male/female)?
3. What is the date today? (yyyymmdd)
4. What is your date of birth? (yyyymmdd)
5. What is your nationality?

6. What is your native (first) language?

7. Are you right handed or left handed?

8. How long have you spent in China (including Hong Kong, Macao and Taiwan) [the Netherlands]? (years, months)

9. How long have you spent in other countries in East Asia (including Japan, Korea and Mongolia) [Western Europe]? (years, months)

10. How long have you spent in Europe, the United States or Canada? (years, months)

11. Have you lived anywhere else in the world? if "yes" please go to question 12, if "no" please go to question 13

12. Which other countries (not in East Asia, Europe, the United States or Canada) have you lived in and for how long (years, months)?

13. Where do you consider to be your "home town" (the place where you are from)? (Town, City, Country)

14. Are you a fluent English speaker [of East Asian languages]? (yes, no) if "yes" go to question 15, if "no" go to question 16

15. How many years have you been a fluent speaker of English [of East Asian languages]?

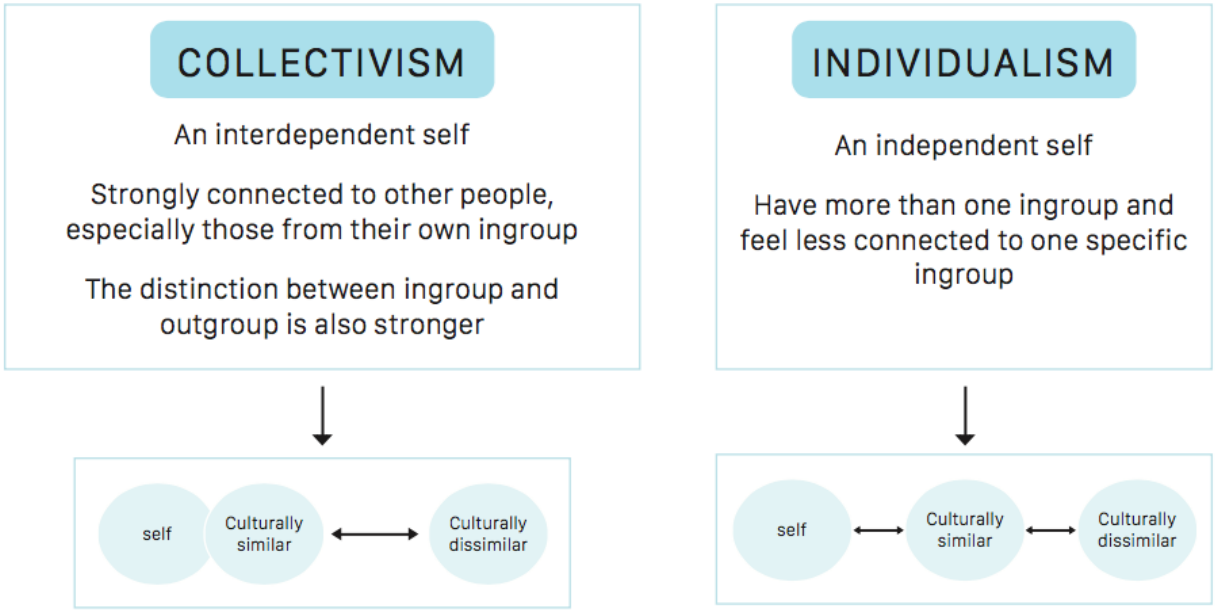
16. Are you a fluent Chinese speaker (including any regional Chinese language/dialect) [Dutch]? if "yes" go to question 17, if "no" go to END

17. Which Chinese language(s) do you speak fluently?

18. How long have you been a fluent speaker of Chinese [Dutch]?

In the Dutch version, the 17 question was skipped.

Supplemental materials



SM Figure 1. Schematic illustration of the hypothesis regarding the interaction between cultural group and situation. Culture is expected to influence how people respond emotionally in situations where they are accompanied by people with different degrees of affiliation. Individualism and collectivism, differ in terms of how one construes the self and the relations between the self, high-affiliation, and low-affiliation members. We expected both groups to make a distinction between ingroup and outgroup as classical social identity theory predicts. In the collectivism-representative group, no significant distance between being by oneself (alone) and being with the ingroup exists but there is a clear distinction between being by oneself (alone) and being with the outgroup. The individualism-representative group, on the other hand, make a clear distinction between the self and any other.

Additional behavioral results

Emotion regulation strategy. The ERQ makes a distinction between two emotion regulation strategies and measures to what extent participants used cognitive appraisal or expressive suppression. Apart from what is reported in the main text, the analyses also yield a significant interaction between Valence and Cultural Group interaction, $F(1,38) = 4.82$, $p = .034$. The Dutch group reported using more emotion regulation ($F(1,19) = 23.2$, $p < .001$) with negative ($M = 3.79$, $SD = 0.15$) than with positive stimuli ($M = 3.11$, $SD = 0.15$). The Chinese group, however, reported no difference in emotion regulation ($F(1,19) = 0.37$, $p = .55$) between positive ($M = 4.25$, $SD = 0.15$ and negative stimuli ($M = 4.35$, $SD = 0.19$). This is in line with our EEG results where the Chinese showed very little LPP differentiation between negative and positive stimuli. Perhaps, the attenuated levels of arousal were a result of comparable levels of emotion regulation used by the Chinese participants during viewing these affective stimuli.

The Regulation Strategy and Cultural Group interaction was also significant, $F(1,38) = 14.38$, $p = .001$. Contrasting the strategies within each group, we found that the Chinese used reappraisal more than suppression, $F(1,19) = 7.18$, $p = .015$ while it was the other way around for the Dutch group, $F(1,19) = 7.22$, $p = .015$. Contrasting the groups within each strategy, we found that the Chinese ($M = 4.67$, $SE = 0.15$) reported using significantly more reappraisal than the Dutch did ($M = 3.11$, $SE = 0.152$), $F(1,38) = 42.845$, $p < .001$. Surprisingly, the Chinese ($M = 3.93$, $SE = 0.25$) and the Dutch ($M = 3.79$, $SE = 0.25$) reported non-significant group differences in suppression, $F(1,38) = 0.16$, $p = .69$.

These results regarding emotion regulation strategy are unexpected and interesting. Collectivism-representative Chinese participants reported higher use of overall emotion regulation than individualism-representative Dutch participants, a finding in line with previous

empirical and theoretical research (Gross & John, 2003). However, although previous studies found that collectivism-representative participants reported more use of *expressive suppression* than individualism-representative participants and concluded that collectivism-representative participants used more suppression (Butler, Lee, & Gross, 2007) (Gross & John, 2003; Matsumoto, Yoo, Fontaine, et al., 2008) our results challenge this conclusion. Previous research did not always directly contrast the strategies within a group. Butler and colleagues (2007), for example, only compared expressive suppression between individualism-representative and collectivism-representative participants. In our data, collectivistic participants just made in total more use of emotion regulation but did not employ the strategy of expressive suppression more than individualistic participants did. Another possibility is that previous research mostly involved Japanese populations (Hot et al., 2006; Murata et al., 2013; Rothbaum, Pott, Azuma, Miyake, & Weisz, 2000) while our participants were exclusively Chinese. Despite strictly following the same experimental procedure, Varnum and Hampton (Varnum & Hampton, 2016) using mostly Chinese participants did not replicate the results of Murata et al. (Murata et al., 2013) who used Japanese participants. Emotional suppression might then be a specific aspect of Japanese culture and not generalizable to other East Asian cultures, which is a question that warrants future research.

Cultural orientation questionnaires.

Self Construal Scale (SCS). The SCS measured individualistic and collectivistic self-construal (Singelis, 1994). It consisted of 15 individualistic items (e.g., “I am the same person at home that I am at school”) and 15 collectivistic items (e.g., “It is important for me to maintain

harmony within my group") on Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

Individualism Collectivism questionnaire (ICS). The ICS measured to what extent the participants endorsed individualistic and collectivistic values (Singelis, Triandis, Bhawuk, & Gelfand, 1995). It consisted of 16 individualistic items (e.g., "I'd rather depend on myself than others") and 16 collectivistic items (e.g., "I usually sacrifice my self-interest for the benefit of the group") on Likert scale ranging from 1 (*strongly disagree*) to 9 (*strongly agree*).

ANOVAs with 2 Cultural Group (Dutch, Chinese) and Collectivism (interdependence) and Individualism (independence) SCS and ICS scores as dependent variables were conducted. There was only an effect of cultural group on collectivism measured by the SCS, $F(1,38) = 5.73$, $p = .022$ while other effects were non-significant.

The two cultural groups did differ in terms of collectivism measured by the SCS, $B = 0.483$, $t(1,38) = 2.393$, $p = .022$, 95% *CI* [.074; .892], $\eta^2 = .131$. The Chinese participants ($M = 4.853$, $SD = 0.143$) were more collectivistic than the Dutch ($M = 4.370$, $SD = 0.143$). But, the two groups did not differ in terms of individualism measured by the SCS, $B = 0.040$, $t(1,38) = 0.190$, $p = .850$, $\eta^2 = 001$. The two groups differ neither in individualism measured by the ICS, $B = -0.050$, $t(1,38) = -0.196$, $p = .845$, $\eta^2 = .001$ nor in collectivism measured by the ICS, $B = 0.184$, $t(1,38) = 0.663$, $p = .511$, $\eta^2 = .011$.

Although both questionnaires measures cultural orientations, the SCS is said to specifically measure individualistic and collectivistic value endorsement (Singelis, Triandis, Bhawuk, & Gelfand, 1995) while the ICS self-construal style (Singelis, 1994). The SCS collectivism score indicates that the Chinese group endorsed collectivistic values more strongly than the Dutch. This is coupled with that the Chinese had a narrower range of LPP amplitude

(which suggests narrower range of emotion expressivity) than the Dutch (the interaction between Valence and Cultural Group in the EEG results). This is in line with our hypothesis which proposed that the Chinese group, under the influence of collectivism which encourages emotional control, would attenuate their emotional response to affective stimuli.

However, the Dutch and Chinese groups did not differ in terms of ICS scores, which means that according to the ICS scores there is no relationship between electro-cortical responses and explicit, self-reported cultural orientation. This is not too surprising given that we have argued that the effect of culture is mainly implicit and non-declarative. Another explanation for the incongruence between the results of different cultural orientations questionnaires is the inconsistencies between the questionnaires themselves which is a complicated issue that attracts a great deal of discussion in the cross-cultural psychology literature (Levine et al., 2003; Taras et al., 2013).

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