

Dynamic cultural modulation of neural responses to one's own and friend's faces

Jie Sui,^{1,2,3} Ying-yi Hong,⁴ Chang Hong Liu,² Glyn W. Humphreys,³ and Shihui Han⁵

¹Department of Psychology, Tsinghua University, Beijing, China, ²Department of Psychology, University of Hull, Hull, UK, ³Behavioural Brain Sciences, School of Psychology, University of Birmingham, Birmingham, UK, ⁴Division of Strategy, Management and Organization, Nanyang Business School, Nanyang Technological University, Singapore, and ⁵Department of Psychology, Peking University, Beijing, China

Long-term cultural experiences influence neural response to one's own and friend's faces. The present study investigated whether an individual's culturally specific pattern of neural activity to faces can be modulated by temporary access to other cultural frameworks using a self-construal priming paradigm. Event-related potentials were recorded from British and Chinese adults during judgments of orientations of one's own and friend's faces after they were primed with independent and interdependent self-construals. We found that an early frontal negative activity at 220–340 ms (the anterior N2) differentiated between one's own and friend's faces in both cultural groups. Most remarkably, for British participants, priming an interdependent self-construal reduced the default anterior N2 to their own faces. For Chinese participants, however, priming an independent self-construal suppressed the default anterior N2 to their friend's faces. These findings indicate fast modulations of culturally specific neural responses induced by temporary access to other cultural frameworks.

Keywords: culture; self-face; brain; self-construal priming; event-related potential

INTRODUCTION

There has been much recent interest in cultural influences on neural correlates of multiple cognitive processes, resulting in increasing number of studies on a newly emergent field called cultural neuroscience (e.g. Han and Northoff, 2008; Hedden *et al.*, 2008; Ambady and Bharucha, 2009; Chiao *et al.*, 2010a; Kitayama and Tompson, 2010). Typically, the cultural neuroscience approach contrasts the neural responses of individuals from East Asia and those of individuals from Western cultures on cognitive tasks. For example, when making decisions whether personality trait words are descriptive of oneself or a familiar other—a typical self-referential task—Westerners (e.g. North Americans) showed greater activation in the medial prefrontal cortex (MPFC) when judging the self than judging a familiar other (Craig *et al.*, 1999; Kelley *et al.*, 2002; Lieberman *et al.*, 2004; Heatherton, *et al.*, 2006). In contrast, East Asians (e.g. Chinese) showed similar MPFC activity when judging the self and a close other (i.e. mother) (Zhu *et al.*, 2007; Wang *et al.*, 2011). These findings have been attributed to the differences in value orientations between the East Asian and Western cultures. That is, Westerners value an independent self-construal, whereby the self is disjoint from others; East Asians, however, value an interdependent self-construal, whereby the self includes significant others (Markus and Kitayama, 1991; Triandis, 1995).

Another approach in cultural neuroscience focuses on the effect of temporary activation of cultural frameworks in contexts on human brain activity. Typically, researchers first increase the temporary accessibility of participants' independent or interdependent self-construals using priming procedures, and then observe their subsequent behavioral and neural responses on some cognitive tasks (Sui and Han, 2007; Lin *et al.*, 2008; Chiao *et al.*, 2010b). There has been supportive evidence that cultural priming was effective in rendering the culturally

typical MPFC responses on a self-referential task (Chiao *et al.*, 2010b; Ng *et al.*, 2010). Chinese-Western bicultural participants showed overlap of neural representations of the self and a close other in the MPFC after Chinese cultural priming but significant differentiation between the self and a close other in the MPFC after Western cultural priming (Ng *et al.*, 2010). In addition, Asian-American bicultural participants showed increased MPFC activity when making general self-judgments (e.g. 'In general, I am truthful') relative to contextual self-judgments (e.g. 'When talking to my mother, I am truthful') after independent self-construal priming, but showed increased MPFC activity during contextual relative to general self-judgments after interdependent self-construal priming (Chiao *et al.*, 2010b).

Taken together, the cultural neuroscience findings indicate that people in the Western and East Asian cultures differ in the neural correlates of self referential processing, which can be further temporarily modulated by cultural priming. However, what is missing in the picture is how the priming of cultural orientation in the contexts may interact with the participants' own 'chronic' cultural orientation. That is, since Westerners (East Asians) in general value independent (interdependent) self-construal (Markus and Kitayama, 1991; Triandis, 1995), how would they respond when primed with an interdependent self-construal or an independent self-construal? Would the match *vs* mismatch between the primed orientation and the 'chronic' cultural orientation give rise to different response patterns? This question is important to examine because it addresses the dynamic brain responses to chronic experiences versus temporary contextual influences. The present article aims to answer this question.

While the previous cultural neuroscience findings suggest that cultural experiences affect brain functioning, cultural psychological research has also shown that cultural influences on human cognition are dynamic rather than static (Hong, 2009; Oyserman and Sorensen, 2009). The premise is that both independent and interdependent self-construals exist in all cultures (Singelis, 1994; Oyserman *et al.*, 2002). To the extent that Westerners habitually construe their self as disjoint rather than conjoint with others, the independent self-construal is on average more chronically accessible in the Western participants' mind than is the interdependent self-construal. However, when contextual cues prime interdependent self-construals,

Received 4 April 2011; Accepted 9 January 2012

Advance Access publication 17 January 2012

This work was supported by the National Natural Science Foundation of China (Project 31170973; 30910103901; 91024032), Marie Curie Incoming International Fellowship, a Royal Society Newton Fellowship, the Wellcome Trust, the Economic and Social Research Council (UK), and the Academic Research Fund (Tier 1: RG2/08, M52010042) from the Ministry of Education, Singapore.

Correspondence should be addressed to Jie Sui, Department of Psychology, Tsinghua University, Beijing, 100084, China. E-mail: jie.sui@gmail.com

hence increasing their temporary accessibility, even Westerners could display responses that are typical of the interdependent self-construals.

The idea of priming cultural frameworks was first introduced by Hong and her associates (Hong *et al.*, 1997, 2000; Hong and Chiu, 2001), and was later modified to prime independent versus interdependent self-construals by other researchers (Gardner *et al.*, 1999, Stapel and Koomen, 2001; see review by Oyserman and Lee, 2008). Gardner *et al.* (1999) were among the few who have systematically examined the interaction of participants' chronic cultural experiences and temporary cultural priming. In their Experiment 2, they administered independent self-construals priming, interdependent self-construals priming or no priming (the control) on participants from Hong Kong and the USA. Results in the control condition revealed a typical cross-cultural difference, i.e. the American participants endorsed more individualist values than collectivist values, whereas the Hong Kong participants endorsed more collectivist values than individualist values. Interestingly, however, the two groups showed different patterns of responses when the priming condition match *vs* mismatch their chronic cultural orientations. Specifically, when the priming matched the participants' chronic cultural orientation (American being primed with independent self-construals, and Hong Kong Chinese being primed with interdependent self-construals), the participants did not show much difference from their respective control conditions. However, participants showed significantly different values from their chronic cultural orientations only when the priming condition did not match their chronic cultural orientation. These results support a culture-as-situated-cognition model that suggests that immediately primed individual or collective 'mind-set' shape one's ongoing perception and cognition (Oyserman *et al.*, 2009).

The present study investigated the neural correlates of the interaction between temporal self-construal priming and participants' chronic cultural orientations. Provided that one would demonstrate chronic/default cultural values in the no priming condition, we examined whether priming independent *vs* interdependent self-construal in British and Chinese participants would give rise to the noted interaction between chronic cultural experiences and temporary cultural priming on self-face recognition. We examined how independent/interdependent self-construal priming affects event-related potentials (ERPs) to images of faces of the self or a close friend relative to the no priming condition in two cultural groups (i.e. British and Chinese). If British on average are independent (Markus and Kitayama, 1991; Triandis, 1995), priming the interdependent rather than independent self-construal would produce larger changes of neural responses to self- and friend's faces relative to a baseline condition without self-construal priming. Conversely, if Chinese on average are interdependent (Markus and Kitayama, 1991; Triandis, 1995), priming the independent rather than interdependent self-construal may change their neural activity to own and friend's faces to a larger degree relative to the baseline condition. Here, we investigated how the brain responds to faces when self-construals are temporarily shifted by self-construal priming that engages one's congruent or incongruent cultural values relative to their chronic/default cultural orientation.

Related to this, in a prior study, we used functional magnetic resonance imaging (fMRI) to assess the effect of self-construal priming on the neural correlates of self-recognition (Sui and Han, 2007). We had Chinese participants carry out a face-orientation judgment task in which they had to decide whether individual faces (of self *vs* friend) were oriented to the left or right after priming independent or interdependent self-construals. Participants showed faster responses to their own faces than familiar faces after the independent self-construal priming but a reverse pattern after the interdependent self-construal priming. In addition, we found that priming Chinese participants with independent self-construal increased right frontal activity association

with self-face recognition, which was, however, weakened by priming their interdependent self-construal. The results indicated that dynamic access to different self-construals within a cultural group can modulate the neural activity of self recognition. Although this study provides the neural evidence of dynamic accessibility of cultural value in Chinese, it is unclear whether the effect also exists in Westerners and how early the priming effect may occur in the brain.

Our recent ERP study showed that self-construal differences arising from long-term cultural practice also influenced neural responses to self-face in British and Chinese participants (Sui *et al.*, 2009). We assessed whether long-term cultural experiences can modulate early components of the ERPs (e.g. the anterior N2 component) (see Breton *et al.*, 1988; Folstein and Petten, 2008, for a review of the N2 component). A strikingly different response occurred early-on (200 ms) and modulated the anterior N2 component when the two groups viewed the two facial categories (own *vs* friend's face). Specifically, the British participants showed larger anterior N2 amplitude to their own *vs* other faces, indicating enhanced perceptual processing for the self over others. In contrast, the Chinese participants showed an opposite effect (a reduced anterior N2 for own *vs* friend's faces), consistent with rapid suppression of self-information and enhanced responses to the faces of close others. The data indicated differential perceptual processing of self-faces in Western and Chinese cultures.

While our previous research focused on the effect of chronic cultural experience on ERP response, the current work aimed to investigate whether an individual's culturally specific pattern of neural activity to faces can be modulated by temporary access to other cultural contexts using the self-construal priming paradigm. We hypothesized that the priming effects would be more prominent in the conditions that mismatch the 'chronic' cultural tendency (i.e. British in the interdependent priming condition, and Chinese in the independent priming condition) than in those that match (i.e. British in the independent priming condition, and Chinese in the interdependent priming condition). Members of a culture that chronically encourages an independent self-construal (like the British participants) would remain unaffected by the independent prime, but show an alternative pattern (a reduced anterior N2 ERP amplitude to self-faces) in the interdependent priming condition. Conversely, members of a culture that chronically encourages an interdependent self-construal (like the Chinese participants) would remain unaffected by the interdependent prime; but show an alternative pattern (reduced N2 ERP amplitudes to friend's faces) in the independent priming condition.

A part of the ERP data in the no-priming condition was published in our previous work (Sui *et al.*, 2009). The current study recruited additional participants to increase the sample size and included all the data in the independent and interdependent conditions and in the no-priming condition. This allowed us to investigate the interaction between the chronic (no-priming) and temporary primed cultural orientations (independent of interdependent priming).

METHODS

Participants

Twenty Chinese (20.6 ± 2.2 years of age, ranged 17–27, 8 males) and 20 British (22.0 ± 5.5 years of age, ranged 19–44, 8 males) college students participated in this study. All participants spoke their own native language. Informed consent was obtained prior to the experiment according to procedures approved by a local ethic committee.

Materials

Self-construal priming

There were a no priming condition and two self-construal priming conditions. In the no priming condition, participants read two stories

about the countryside that did not contain the independent or interdependent pronouns. Participants were asked to circle two nouns (e.g. park and area) in each story. In the independent or interdependent self-construal priming condition, participants were asked to read two stories that were adopted from Sui and Han (2007) (written in Chinese for the Chinese participants and English for the British participants). Each story was about 300–350 words long and described a trip to the countryside. Independent-priming stories used first-person singular pronouns (e.g. ‘I’, ‘mine’). Interdependent-priming stories used first-person plural pronouns (e.g. ‘we’, ‘ours’). The participants were asked to circle all the pronouns in the story. The types of priming stories were counterbalanced across participants.

Face images

We took 10 digital photos of the face of each participant and 10 digital photos of the face of a same gender friend of each participant, whom the participant had known for 2–6 years. The face images with normalized to 100×100 pixels showed 5 left and 5 right profiles of each face and subtended $3.1 \times 3.1^\circ$ of visual angle at a viewing distance of 90 cm, with the face angle ranging from 15° to 90° profile in each direction with equal steps in between. All faces were shown in gray scale with a neutral facial expression. The means of the luminance and contrast of self and friend’s face were first calculated for each participant. Then the luminance and contrast of each image were adjusted to the mean so that they were the same in the self and friend face conditions. The face stimuli were presented on a black background of a 21-inch monitor.

Procedures

The priming procedure asked participants to read a story three times (i.e. first, read a story without circling pronouns or nouns; second, read and circle, finally read and check). Participants’ performances on circling the pronouns or nouns were 100% correct. After reading each story, participants performed two blocks of a face-orientation decision task. Each block consisted of 60 images of self face and 60 images of friend’s face that were displayed in a random order. A block began with the presentation of a white cross at the central of a screen for 1000 ms. A face image was then presented at the center of the screen with a duration of 200 ms, which was followed by a fixation point with a duration varied between 800 and 1200 ms. The task was to identify the orientation of faces by pressing the left or the right buttons on a response pad using the left or right index finger. Participants were instructed to respond as quickly and as accurately as possible. In half of the blocks, participants were asked to respond to their own face (target) while ignoring the friend’s face (non-target). In these blocks, we were able to measure participants’ ERPs to the friend’s face without being contaminated by response preparation and execution. Likewise, in the remaining half of the blocks, participants responded to the friend’s face (target) while ignoring their own face (non-target). In these blocks, we were able to measure uncontaminated ERPs to one’s own face.

The experiment totally consisted of twelve blocks, four in each priming condition. Participants responded to their own face in two blocks and to a friend’s face in another two blocks after each type of priming. The order of priming (independent, interdependent, and no priming) was counterbalanced across participants. The order of tasks (responses to self or friend’s faces) was counterbalanced within participants.

Electrophysiological data recording and analysis

The electroencephalogram (EEG) was recorded from 62 Ag/AgCl scalp electrodes on an elastic cap according to the extended 10–20 systems using a right mastoid as a reference (see Sui *et al.*, 2009). The Chinese data were collected using a Neuroscan system in Beijing, China, and

the British data were collected using a BP system in Hull, UK. Grand averages were calculated after re-referencing individual ERPs to the common average reference. The EEG was amplified by a band pass of 0.1–100 Hz and digitized at a sampling rate of 250 Hz. The eye blink artifacts were monitored with electrodes located up and below the left eye. The horizontal electro-oculogram (EOG) was recorded from electrodes placed about 1.5 cm lateral to the left and right external canthi. The ERPs in each condition were averaged separately off-line with averaging epochs beginning 200 ms before stimulus onset and continuing for 800 ms. After filtering of the EEG with a 1–30 Hz bandpass filter, trials contaminated by eye blinks, eye movements, or muscle potentials exceeding $\pm 60 \mu\text{V}$ at any electrode were excluded from the average. The baseline for ERP measurements was the mean voltage of a 200 ms pre-stimulus interval and the latency was measured relative to the stimulus onset.

Separate averaging was performed for self and friend’s faces as function of priming (independent, interdependent or no priming) and response (target *vs* non-target) conditions. Only correct response trials were averaged. The amplitudes of the N170, vertex positive potential (VPP) and the posterior P3 for self and friend’s faces did not differ across the priming conditions and thus were not reported. The mean ERP amplitudes of the anterior N2 component around 220–340 ms were analyzed at the frontal (Fz, F1–F4), front-central (FCz, FC1–FC4) and central (Cz, C1–C4) electrodes. This time window was chosen in order to cover the priming effect on the N2 observed in both cultural groups. We predicted a culture and prime interaction on the anterior N2 component. Since no significant differences were found between these electrode sites and between the two hemispheres for the anterior N2 component, we only report the most significant anterior N2 effect at Fz.

We conducted $3 \times 2 \times 2 \times 2$ repeated-measures analyses of variance (ANOVA) of the mean amplitudes of the N2 component with Priming (independent, interdependent or no priming) \times Face (self *vs* friend) \times Response (target *vs* non-target) as within-subjects variables and Cultural group (British *vs* Chinese) as a between-subjects variable. In particular, the analysis including a no priming condition as a baseline can maximally reduce cross-site variance in two cultural groups. This also allowed to examine how priming modulate the neural responses to self-faces (and friend’s faces) relative to the no priming condition. A Greenhouse-Geisser correction to the degrees of freedom was used where applicable. Behavioral data were subjected to ANOVAs with Priming (independent, interdependent or no priming) \times Face (self *vs* friend) as within-subject variables and Cultural Group (British *vs* Chinese) as a between-subjects variable.

RESULTS

Behavioral performance

The mean reaction times (RTs) and accuracy is showed in Table 1. The ANOVA of RTs showed a significant main effect of Face, $F(1, 38) = 85.26$, $P < 0.001$, participants responded faster to their own-face than to a friend’s face, suggesting a self-face advantage. There was also a significant main effect of Priming, $F(2, 76) = 29.11$, $P < 0.001$, suggesting faster responses in the no priming condition than in the independent and interdependent priming conditions (P ’s < 0.001). However, there was no significance difference in RTs between the independent and interdependent priming conditions ($P = 0.95$). These main effects were qualified by a significant interaction of Cultural Group \times Face \times Priming, $F(2, 76) = 119.76$, $P < 0.001$. We further conducted AVOVAs of Cultural Group \times Face in the three priming conditions, respectively. There was a significant interaction of Cultural Group \times Face in the no priming condition, $F(1, 38) = 149.94$, $P < 0.001$, reflecting larger self-face advantage effect

Table 1 Mean RTs and accuracy (s.d. in brackets) as a function of Cultural group, Priming and Face

| | Face | RTs (ms) | | Accuracy (%) | |
|------------------------|--------|----------|----------|--------------|------------|
| | | British | Chinese | British | Chinese |
| Self-construal priming | Self | 516 (58) | 479 (92) | 95.5 (4.3) | 97.7 (2.6) |
| | Friend | 530 (67) | 491 (94) | 96.1 (2.9) | 97.3 (3.4) |
| Interdependent | Self | 524 (55) | 475 (79) | 96.7 (2.8) | 97.8 (1.9) |
| | Friend | 527 (61) | 489 (91) | 95.7 (3.1) | 97.0 (4.1) |
| No-priming | Self | 401 (44) | 477 (89) | 96.2 (3.3) | 98.1 (1.8) |
| | Friend | 523 (59) | 493 (96) | 95.3 (3.6) | 97.4 (2.3) |

in British participants [$t(19) = -16.77$, $P < 0.0001$] than in Chinese participants [$t(19) = -3.45$, $P < 0.005$]. There was a significant main effect of Face after the independent priming, $F(1, 38) = 16.23$, $P < 0.001$, but not after the interdependent priming, $F(1, 38) = 3.62$, $P = 0.07$. RTs to participants' own face were shorter than to a friend's face after the independent priming, whereas RTs did not differ between self-face and a friend's face after the interdependent priming (Table 1).

To assess the priming effects relative to the no priming condition in each cultural group, ANOVAs with Face \times Priming in each cultural group were then conducted. British participants showed a significant interaction of Face \times Priming, $F(2, 38) = 205.47$, $P < 0.001$, due to faster responses to own faces than to friends' faces in the no priming and independent priming conditions, $t(19) = -16.77$ and -2.81 , $P < 0.0001$ and 0.02 , but no such effect in the interdependent priming condition, $t(19) = -0.44$, $P = 0.67$. Chinese participants only showed a significant main effect of Face, $F(1, 19) = 12.94$, $P < 0.005$, indicating faster responses to own than friend's faces across the no, independent and interdependent priming conditions, $t(19) = -3.45$, -2.94 and -2.28 , $P < 0.005$, 0.01 and 0.05 , respectively. The RT results of British participants are consistent with the idea that priming their interdependent self-construals reduced the self-face advantage.

Analysis of the accuracy data did not show any significant effects, P 's > 0.10 .

Priming effect on the anterior N2 component

The ANOVAs of the mean N2 amplitudes at 220–340 ms revealed a reliable significant Cultural group \times Priming \times Face interaction, $F(2, 76) = 7.65$, $P = 0.001$. Since there were no significant effects involving Response, we collapsed the ERPs across the target and non-target respond conditions. ANOVAs with two within-subjects variables (i.e. Priming and Face) were then conducted for each cultural group to avoid the cross-site ERP variance. The ANOVA of the N2 amplitudes in Chinese participants showed a significant interaction of Priming \times Face, $F(2, 38) = 4.15$, $p < .03$ (Figure 1). Separate analyses revealed that relative to the no priming condition ($M = -2.74$ μ V), the independent priming decreased the neural responses to friend's faces [$M = -2.32$ μ V, $t(19) = 3.22$, $P = 0.005$], but the interdependent priming did not influence the default N2 amplitudes to friend's face [$M = -2.53$ μ V, $t(19) = 1.46$, $P = 0.16$]. Contrast to the friend condition, neither independent ($M = -2.16$ μ V) nor interdependent ($M = -2.29$ μ V) priming affected the neural activity to self-faces relative to the no priming condition ($M = -2.23$ μ V), $t(19) = 0.61$ and -0.54 , P 's > 0.55 . In order to assess the N2 difference between the self and friend faces, paired t -tests in each priming condition were conducted. Friend's face elicited larger N2 amplitudes than self-faces in both the no priming and interdependent priming conditions, $t(19) = -4.06$ and -2.17 , $P < 0.001$ and 0.05 , respectively, but no

such difference observed in the independent priming condition, $P = 0.16$.

For British participants, ANOVAs of the N2 amplitudes also showed a significant interaction of Priming \times Face, $F(2, 38) = 3.55$, $P < 0.05$ (Figure 2). Separate analyses revealed that the interdependent priming ($M = -2.24$ μ V) decreased the N2 amplitude of self faces compared to the no priming condition [$M = -2.80$ μ V, $t(19) = 2.35$, $P < 0.03$], but the independent priming ($M = -2.89$ μ V) did not affect the neural response to one own faces relative to the no priming condition [$M = -2.80$ μ V, $t(19) = -0.28$, $P = 0.79$]. On the other hand, priming (independent and interdependent: $M = -2.89$ and -2.19 μ V) did not modulate the N2 amplitudes to friend's faces relative to the no priming condition ($M = -2.41$ μ V), $t(19) = -1.58$ and 1.39 , P 's > 0.13 . Paired t -tests between the self and friend's faces further showed that, in the no priming condition, the N2 amplitudes were larger to one's own faces than to friends faces, $t(19) = 2.25$, $P < 0.05$, but no such difference was observed in the independent and interdependent priming conditions, P 's > 0.60 .

To summarize, consistent with our prediction, for British participants, priming the interdependent self-construal reduced the default anterior N2 to their own faces in the no priming condition. For Chinese participants, priming the independent self-construal suppressed the default anterior N2 to their friend's faces in the no priming condition. Thus, when the priming condition mismatched with the chronic cultural orientation of the two groups, the culturally typical anterior N2 effect was eliminated. However, the priming that matches the chronic orientation of a cultural group did not influence the typical culture-specific pattern on the anterior N2 responses relative to the no priming condition.

DISCUSSION

The present results confirm that there are cultural difference in ERPs elicited by one's own and a friend's faces (the anterior N2; see also Sui *et al.*, 2009). However, the findings of the current work go beyond this by showing that the early culturally sensitive neural activity to self-face and a friend's faces was affected by contextual independent vs interdependent self-construal priming. Moreover, the effects of self-construal priming were most prominent when the priming condition did not match the chronic cultural orientation for both the British and Chinese participants, despite that the two cultural groups demonstrated opposite default neural responses to self- and other-faces.

To elaborate, the participants' default neural responses to self-face were significantly modulated by the priming that is incongruent with their chronic orientation, presumably due to temporarily increased accessibility of a contrasting cultural framework. For Chinese participants, whose default self-construal is interdependent (Markus and Kitayama, 1991; Triandis, 1995), priming an independent self-construal (the 'I' context) eliminated the default anterior N2 component to a friend face. For British individuals, whose default self-construal is independent (Markus and Kitayama, 1991; Triandis, 1995), priming an interdependent self-construal (the 'We' context) abolished the default anterior N2 response to their own face. These findings suggest that the culturally-specific neural response to self-face and a friend's face can be modulated by the ongoing contexts that may shift one's self-construal away from his/her default orientation, which are consistent with the findings in cultural psychology (Gardner *et al.*, 1999). Although prior research has shown that self priority in the neural processing of traits or faces can be altered dynamically by self-construal priming (Sui & Han, 2007; Ng *et al.*, 2010; Chiao *et al.*, 2010b), the current study provide the first evidence that the modulation of neural responses to self-face and familiar faces by dynamic contexts can emerge as early as 220 ms after sensory

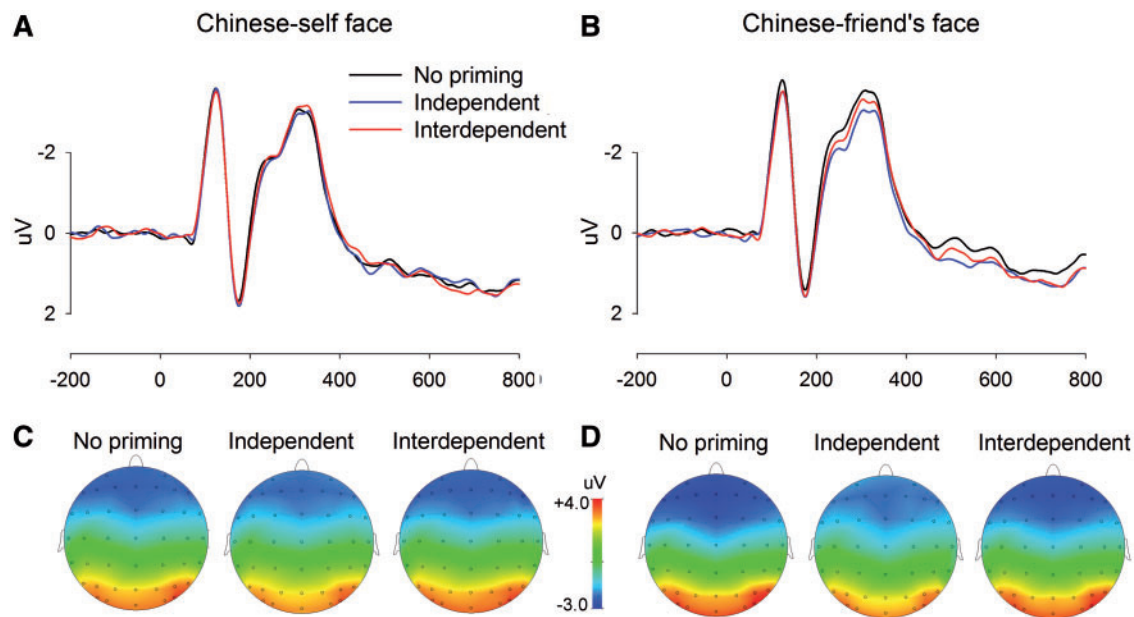


Fig. 1 Priming effects of the anterior N2 elicited by self- and friend's faces at Fz in Chinese participants (collapsed across the target and non-target respond conditions). Priming the independent/interdependent self-construal did not modulate the anterior N2 amplitudes to own-faces relative to the no priming condition (A). Priming the independent self-construal reduced the default N2 amplitudes to a friend's faces in the no priming conditions, but no such effect observed after priming the interdependent self-construal (B). Top views of voltage topographies of the anterior N2 to self-face at all electrode positions are shown in (C) and those of friend's faces in (D).

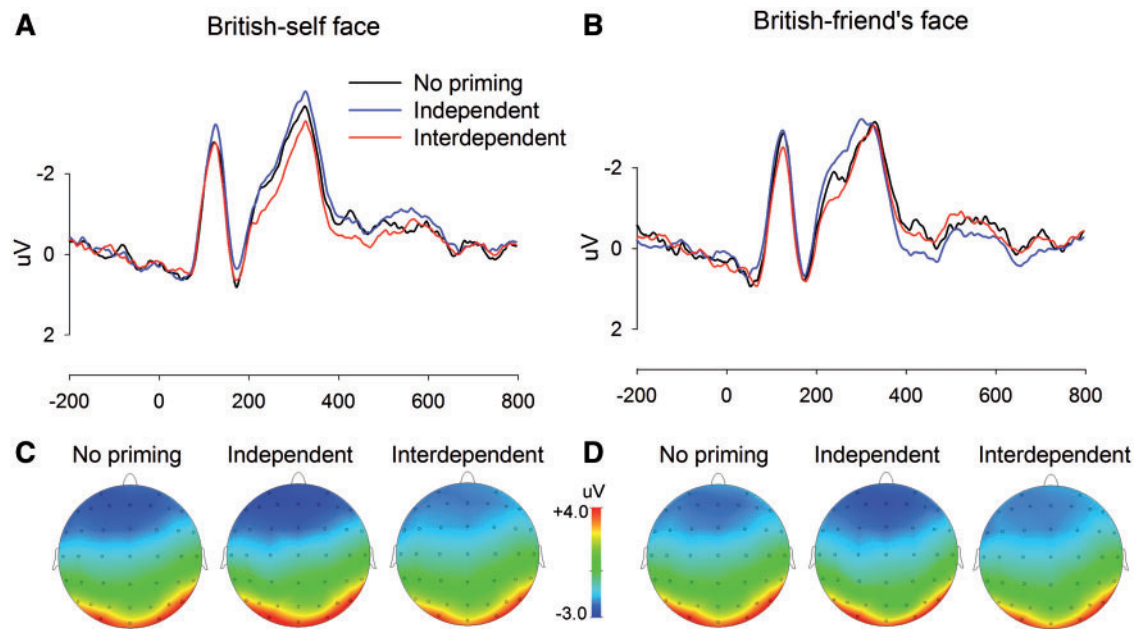


Fig. 2 Priming effects of the anterior N2 elicited by self- and friend's faces at Fz in British participants (collapsed across the target and non-target respond conditions). After priming interdependent self-construal, the anterior N2 amplitudes to own-faces were decreased relative to the no priming condition but no such effect observed after priming the independent self-construal (A). Priming did not modulate the N2 amplitudes to a friend's face compared to the no priming condition (B). Top views of voltage topographies of the anterior N2 to self-face at all electrode positions are shown in (C) and those of friend's faces in (D).

stimulation and the effect of self-construal priming was observed regardless of one's default self-construals.

Our ERP results showed that the priming that activates the self-construal that is congruent with one's own cultural orientation did not change neural responses to self and friend's faces in comparison to the no priming condition. Chinese participants generated comparable N2 responses to a friend's faces in the interdependent and no

priming conditions, and for British participants priming the independent self-construal did not alter their default neural responses to self faces in the no priming condition. The results provide the neural evidence for the findings in cultural psychology that when the priming congruent with participants' chronic cultural orientation, the participants did not show difference from the no priming condition (Gardner et al., 1999).

It is well known that the anterior N2 component is highly sensitive to detecting changes of physical features of stimuli from perceptual templates, which are based on both long-term and short-term experience with visual objects (Breton *et al.*, 1988; Folstein and Petten, 2008). The present results revealed that the anterior N2 component is also sensitive to detecting changes of social salience of stimuli (one's own face *vs* the faces of familiar others). Our prior work has showed that the anterior N2 component responded to the changes of social salience of stimuli established by long-term exposure to a specific culture (Sui *et al.*, 2009). For British participants the anterior N2 component is sensitive to detecting images of one's own face, whereas for Chinese it is sensitive to those of both one's own face and a friend's face. Beyond this, the present study demonstrates that the neural processing of social salience of a stimulus is modulated by temporary accessibility of the independent or interdependent self-construal. These findings provide the ERP evidence for a culture-as-situated-cognition mode proposed in cultural psychology, which stresses the role of online cultural context in perception and cognition (Oyserman *et al.*, 2009).

A plausible interpretation of the priming effects observed in the study is that the priming effect may reflect short experiences primed by an immediate context rather than long-term established experiences. If it is true, we would observe consistent patterns of brain activity after priming the independent (or interdependent) self-construal across British and Chinese participants. However, the results showed that priming the interdependent rather than independent self-construal altered British participants' neural responses to self-faces, whereas priming the independent rather than interdependent self-construal changed Chinese participants' N2 responses to a friend's face. The data clearly demonstrated different priming effects between British and Chinese participants, and priming effect in the direction can be predicted by the default cultural orientations of Western and East Asian societies. These results indicated the joint role of chronic cultural orientations and online cultural contexts on face processing.

In sum, our ERP results indicate that, besides long-term cultural influence on the neuro-cognitive processes of self-face and a friend's face, temporarily priming independent or interdependent self-construal also modulates the neural responses to self-face and a friend's face. People can be shifted away from their default state of culturally specific neural process of self-face and a friend's face, suggesting the dynamic interactive influences of temporal accessibility of cultural value and chronic accessibility of cultural orientations on neural substrates. These fast-acting influences (from 220 ms stimulus onset) can give rise to flexible responding across different contexts and to establishing common ground in communication between individuals from different cultural backgrounds.

The previous neuroscience studies have shown evidence that the functional organization of the brain regions involved in both sensory (e.g. the occipital cortex, Gougoux *et al.*, 2009) and social (e.g. the medial prefrontal cortex, Ma and Han, 2011) processing changes as a function of sensory experiences. Together with the contemporary cultural neuroscience studies, the current work showed evidence that the brain activity involved in cognitions also change as a function of cultural experiences. The cultural neuroscience findings extend the previous neuroscience studies by showing that both sensory and cultural experiences shape the brain activity. However, neural plasticity related to sensory and cultural experiences may play important roles in sensory processing and social cognition, respectively. The cultural neuroscience findings also raise important questions regarding neural plasticity. If people can show drastically different neural responses in response to priming of a contrastive cultural orientation, would it be possible to overwrite participants' 'chronic' cultural tendency given repeated priming of the contrastive cultural orientation? This is in fact the case encountered by migrants or sojourners to a new culture.

Would substantial acculturation in a foreign culture be enough to alter the default neural responses from one's native culture? Even more intriguing, how would the brain change in response to the acculturation process? These questions deserve future investigation.

Conflict of Interest

None declared.

REFERENCES

- Ambady, N., Bharucha, J. (2009). Culture and the brain. *Current Directions in Psychological Science*, 18, 342–5.
- Breton, F., Ritter, W., Simson, R., Vaughan, H.G.Jr (1988). The N2 component elicited by stimulus matches and multiple targets. *Biological Psychology*, 27, 23–44.
- Chiao, J.Y., Hariri, A.R., Harada, T., et al. (2010a). Theory and methods in cultural neuroscience. *Social Cognitive and Affective Neuroscience*, 5, 356–61.
- Chiao, J.Y., Harada, T., Komeda, H., et al. (2010b). Dynamic cultural influences on neural representation of the self. *Journal of Cognitive Neuroscience*, 22, 1–11.
- Craik, F.I.M., Moroz, T.M., Moscovitch, M., et al. (1999). In search of the self: a positron emission tomography study. *Psychological Science*, 10, 26–34.
- Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., May, A. (2004). Neuroplasticity: changes in grey matter induced by training. *Nature*, 427, 311–2.
- Folstein, J.R., Petten, C.V. (2008). Influence of cognitive control and mismatch on the N2 component of the ERP: a review. *Psychophysiology*, 45, 152–70.
- Gardner, W.L., Gabriel, S., Lee, A. (1999). "I" value freedom, but "we" value relationships: self-construal priming mirrors cultural differences in judgment. *Psychological Science*, 10, 321–6.
- Gougoux, F., Belin, P., Vossa, P., Leporea, F., Lassondea, M., Zatorre, R.J. (2009). Voice perception in blind persons: a functional magnetic resonance imaging study. *Neuropsychologia*, 47, 2967–74.
- Han, S., Northoff, G. (2008). Culture-sensitive neural substrates of human cognition: a transcultural neuroimaging approach. *Nature Reviews Neuroscience*, 9, 1–9.
- Heather, T.F., Wyland, C.L., Macrae, C.N., Demos, K.E., Denny, B.T., Kelley, W.M. (2006). Medial prefrontal activity differentiates self from close others. *Social Cognitive and Affective Neuroscience*, 1, 18–25.
- Hedden, T., Ketay, S., Aron, A., Markus, H.R., Gabrieli, J.D.E. (2008). Cultural influences on neural substrates of attentional control. *Psychological Science*, 19, 12–7.
- Hong, Y. (2009). A dynamic constructivist approach to culture: moving from describing culture to explaining culture. In: Wyer, R.S.Jr, Chiu, C., Hong, Y., editors. *Understanding Culture: Theory, Research and Application*. New York: Psychology Press, pp. 3–23.
- Hong, Y., Chiu, C. (2001). Toward a paradigm shift: from cross-cultural differences in social cognition to social-cognitive mediation of cultural differences. *Social Cognition*, 19, 181–96.
- Hong, Y., Chiu, C., Kung, M. (1997). Bringing culture out in front: effects of cultural meaning system activation on social cognition. In: Leung, K., Kim, U., Yamaguchi, S., Kashima, Y., editors. *Progress in Asian social psychology*, Vol. 1, Singapore: Wiley, pp. 139–50.
- Hong, Y., Morris, M.W., Chiu, C., Benet-Martinez, V. (2000). Multicultural minds: a dynamic constructivist approach to culture and cognition. *American Psychologist*, 55, 709–20.
- Kelley, W.M., Macrae, C.N., Wyland, C.L., Caglar, S., Inati, S., Heatherton, T.F. (2002). Finding the self? An event-related fMRI Study. *Journal of Cognitive Neuroscience*, 14, 785–94.
- Kitayama, S., Tompson, S. (2010). Envisioning the future of cultural neuroscience. *Asian Journal of Social Psychology*, 13, 92–101.
- Lieberman, M.D., Jarcho, J.M., Satpute, A.B. (2004). Evidence-based and intuition-based self-knowledge: an fMRI study. *Journal of Personality and Social Psychology*, 87, 421–35.
- Lin, Z., Lin, Y., Han, S. (2008). Self-construal priming modulates visual activity underlying global/local perception. *Biological Psychology*, 77, 93–97.
- Ma, Y., Han, S. (2011). Neural representation of self-concept in sighted and congenitally blind adults. *Brain*, 134, 235–46.
- Maguire, E.A., Gadian, D.G., Johnsrude, I.S., et al. (1999). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Arts and Sciences in America*, 97, 4398–403.
- Markus, H.R., Kitayama, S. (1991). Culture and the self: implication for cognition, emotion and motivation. *Psychological Review*, 98, 224–53.
- Ng, S.H., Han, S., Mao, L., Lai, J.C.L. (2010). Dynamic bicultural brains: a fMRI study of their flexible neural representation of self and significant others in response to culture priming. *Asian Journal of Social Psychology*, 13, 83–91.
- Oyserman, D., Coon, H.M., Kimmelmeier, M. (2002). Rethinking individualism and collectivism: evaluation of theoretical assumptions and meta-analyses. *Psychological Bulletin*, 128, 3–72.
- Oyserman, D., Lee, S. (2008). Does culture influence what and how we think? Effects of priming individualism and collectivism. *Psychological Bulletin*, 134, 311–32.

- Oyserman, D., Sorensen, N. (2009). Understanding cultural syndrome effects on what and how we think: a situated cognition model. In: Wyer, R.S.Jr, Chiu, C., Hong, Y., editors. *Understanding Culture: Theory, Research and Application*. New York: Psychology Press, pp. 25–52.
- Oyserman, D., Sorensen, N., Reber, R., Chen, S. (2009). Connecting and separating mind-sets: culture as situated cognition. *Journal of Personality and Social Psychology*, 97, 217–35.
- Singelis, T.M. (1994). The measurement of independent and interdependent self-construals. *Personality and Social Psychological Bulletin*, 20, 580–91.
- Stapel, D.A., Koomen, W. (2001). I, we, and the effects of others on me: self-construal level moderates social comparison effect. *Journal of Personality and Social Psychology*, 80, 766–81.
- Sui, J., Liu, C.H., Han, S. (2009). Cultural difference in neural mechanisms of self-recognition. *Social Neuroscience*, 4, 402–11.
- Sui, J., Han, S. (2007). Self-construal priming modulates neural substrates of self-awareness. *Psychological Science*, 18, 861–66.
- Triandis, H.C. (1995). *Individualism and Collectivism*. Boulder, CO: Westview Press.
- Wang, G., Mao, L., Ma, Y., et al. (2011). Neural representations of close others in collectivistic brains. *Social Cognitive and Affective Neuroscience*, doi:10.1093/scan/nsr002.
- Zhu, Y., Zhang, L., Fan, J., Han, S. (2007). Neural basis of cultural influence on self-representation. *Neuroimage*, 34, 1310–6.