Cultural Diversity and Ethnic Minority Psychology
2017, Vol. 23, No. 1, 36–44

1099-9809/17/$12.00 http://dx.doi.org/10.1037/cdp0000112

Cultural Differences and Similarities in Beliefs, Practices, and Neural Mechanisms of Emotion Regulation

Yang Qu and Eva H. Telzer
University of Illinois at Urbana–Champaign

Objective: The current research examined whether culture shapes the beliefs, practices, and neural basis of emotion regulation. ***Method:*** Twenty-nine American and Chinese participants reported their implicit theory of emotion and frequency of reappraisal use. They also underwent an fMRI scan while completing an emotion regulation task. ***Results:*** Chinese (vs. American) participants reported more frequent use of reappraisal, which was mediated by their higher incremental theory of emotion (i.e., believing that emotion is changeable through effort). Although there were some cultural similarities in neural activation during emotion regulation, Chinese participants showed less ventrolateral prefrontal cortex (VLPFC) activation than American participants when regulating negative emotions. Lower VLPFC activation was associated with higher incremental theory of emotion and more frequent use of cognitive reappraisal. ***Conclusions:*** Findings suggest that culture may shape how individuals perceive and engage in emotion regulation, and ultimately, the neural mechanisms underlying emotion regulation.

Keywords: culture, emotion regulation, implicit beliefs, cognitive reappraisal, fMRI

Culture plays a key role in shaping how individuals perceive and engage in emotion regulation. Different cultural orientations may lead East Asian and Western individuals to hold different beliefs about emotion. Although the individualism-collectivism distinction between East Asian and Western cultures is nuanced (Oyserman, Coon, & Kemmelmeier, 2002), collectivistic orientation in East Asian culture tends to place heightened emphasis on changing individuals' behaviors and feelings to maintain group harmony (Markus & Kitayama, 1991). In contrast, in individualistic Western culture, personal feelings are perceived as unique to the individual, and expression of one's emotion is encouraged (Markus & Kitayama, 1991). Therefore, instead of overtly expressing their true feelings, as is common in Western culture, East Asian individuals are more likely to both up- and down-regulate their emotional experiences and expressions in daily life to match the emotions of those around them (e.g., Matsumoto, Yoo, & Nakagawa, 2008; Tsai, Chentsova-Dutton, Freire-Bebeau, & Przymus, 2002). In addition, dialectical thinking in East Asian culture is characterized by a belief that reality is constantly changing, such that misery can turn into happiness and happiness can turn into misery (Ji, Nisbett, & Su, 2001; Peng & Nisbett, 1999). Compared to Western individuals, East Asian individuals tend to expect the present state of affairs to change and prefer to see both positive and negative aspects of situations (Ji et al., 2001). Cross-cultural research suggests that compared with European Americans, East Asians need to change their behavior more frequently to adjust to their social environment. Therefore, they tend to hold an incremental theory of self, seeing the self and personality as more flexible than European Americans, who tend to see the self as stable and consistent across situations (Norenzayan, Choi, & Nisbett, 2002). Given that East Asians see the self as more flexible and changeable, it is possible that such flexibility is also true in the emotion domain, such that East Asians may be more likely to believe that emotion is changeable and controllable. In contrast, the lack of necessity to modify their emotion as frequently as East Asians may lead Western individuals to view emotion as a more fixed and stable attribute.

Beliefs of Emotion

Dweck and colleagues have suggested that individuals hold different implicit theories of intelligence (Dweck & Leggett, 1988; Dweck, 1999). They documented and distinguished two types of implicit theories: entity theory and incremental theory. Individuals who favor incremental theory believe that intelligence is malleable, increasable, and controllable. In contrast, individuals who endorse entity theory believe that intelligence is a fixed or uncontrollable attribute. Although most research on implicit theories has focused on intelligence, recent research has extended the concept of implicit theories to the study of emotion (Tamir, John, Srivastava, & Gross, 2007). Individuals who hold higher incremental beliefs view emotion as malleable and controllable (Tamir et al., 2007). In contrast, individuals who hold entity beliefs view emotion as fixed and impossible to control. According to this distinction, East Asians may therefore hold more incremental beliefs of emotion compared to their Western counterparts, seeing emotion as more flexible and changeable through effort.

Yang Qu, Department of Psychology, University of Illinois at Urbana–Champaign; Eva H. Telzer, Department of Psychology and Beckman Institute for Advanced Science and Technology, University of Illinois at Urbana–Champaign.

Correspondence concerning this article should be addressed to Yang Qu, Department of Psychology, University of Illinois at Urbana–Champaign, 603 East Daniel Street, Champaign, IL 61820. E-mail: yangqu3@illinois.edu

Practices of Emotion Regulation

One of the most widely studied strategies to regulate one's emotion is cognitive reappraisal. Cognitive reappraisal refers to the reframing or recontextualization of an emotional stimulus as a way to change the subjective feelings evoked by the stimulus (Gross, 1998; Gross & John, 2003). For example, in a situation where an individual feels sad because of getting a bad grade in school, cognitive reappraisal may take the form of thinking about the useful lessons one can learn in order to feel better. Experimental work has shown that negative emotion can be effectively minimized by cognitive reappraisal in the lab or in everyday life (Dandoy & Goldstein, 1990; Egloff, Schmukle, Burns, & Schwerdtfeger, 2006; Gross, 1998; Gross & John, 2003; Mauss, Cook, Cheng, & Gross, 2007). Surprisingly, research suggests that American individuals rarely use this effective emotion regulation strategy to change their feelings, even if they are told about the usefulness of cognitive reappraisal (Suri, Whittaker, & Gross, 2015).

Little is known about whether culture influences the extent to which people use cognitive reappraisal. Recent research suggests that individuals who hold more incremental (vs. entity) theories of emotion are more likely to use cognitive reappraisal in their daily life (Tamir et al., 2007). Individuals who view emotion as malleable try to actively modify their emotions by changing their appraisal of emotion-eliciting events. In contrast, individuals who view emotion as a fixed entity have little incentive to modify their emotions by using cognitive reappraisal. Therefore, the low frequency of reappraisal use among American individuals may be driven by their beliefs that their emotion is not easy to change. In contrast, if East Asian individuals hold more incremental beliefs of emotion, such beliefs may lead them to use cognitive reappraisal more often in their daily lives.

Cultural Neuroscience Perspective on Emotion Regulation

Significant neuroimaging research has unpacked the neural regions involved in emotion regulation. The right ventrolateral prefrontal cortex (VLPFC) in particular plays a key role in emotion regulation and cognitive reappraisal (for a review, see Cohen & Lieberman, 2010). For example, the right VLPFC is recruited when individuals engage in cognitive reappraisal (e.g., Ochsner et al., 2004; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008). Although prior work has not examined cultural differences in the neural correlates of cognitive reappraisal, recent work has identified important gender differences in the recruitment of the VLPFC during cognitive reappraisal (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008). Specifically, males and females showed similar behavioral tendency to regulate negative emotion. However, compared with females, males showed less VLPFC activation when down-regulating negative emotion, which is thought to be due to the less effort that males need during emotion regulation (McRae et al., 2008). The less VLPFC activation among males suggests that they may use cognitive reappraisal in a more automatic way (McRae et al., 2008).

The field of cultural neuroscience has made tremendous progress in recent years. The use of neuroimaging techniques, such as fMRI and event-related potentials, can help researchers test hypotheses regarding cultural differences in neural functioning and its relations to beliefs and behaviors (e.g., Chiao & Ambady, 2007; Chiao & Immordino-Yang, 2013). For example, previous cultural neuroscience studies have examined how culture modulates the neural mechanisms underlying self-representation and in-group empathy, as well as how such differences in brain activity are associated with different cultural values (e.g., Cheon et al., 2011; Chiao et al., 2009; Zhu, Zhang, Fan, & Han, 2007). With growing empirical evidence, a recent quantitative meta-analysis of 35 fMRI studies has been conducted to document cultural differences in neural processes (Han & Ma, 2014). However, little is known about whether culture, like gender, plays a role in shaping the neural correlates underlying cognitive reappraisal. Therefore, it is particularly important to take a cultural neuroscience approach in the study of emotion regulation, because such an approach will not only unpack the links between beliefs, practices, and neural mechanisms of emotion, but also can provide us a better understanding on the role of the VLPFC in emotion regulation. Because East Asian people may believe that emotion is more changeable and controllable, they may use reappraisal to change their emotion more often in their daily lives. Drawing from prior neuroimaging research on gender differences in emotion regulation (McRae et al., 2008), East Asian individuals may therefore engage in cognitive reappraisal in a more automatic way and recruit less VLPFC activation compared with their Western counterparts. Moreover, extant literature has documented the effects of practice and expertise acquisition on brain activation. Practice in high-level cognitive tasks has been found to result in lower activation in prefrontal regions (e.g., Gevins, Smith, McEvoy, & Yu, 1997; Kelly & Garavan, 2004). Therefore, because of the daily practice of cognitive reappraisal, East Asian individuals are expected to show less activation in the VLPFC compared with their Western counterparts.

Overview of the Current Study

The goal of the current study was to investigate cultural differences and similarities in beliefs, practices, and neural correlates of emotion regulation. To this end, we measured self-reported implicit beliefs of emotion and use of cognitive reappraisal among both American and Chinese participants. During an fMRI scan, participants completed an emotion regulation task during which they viewed negative emotional scenes and were instructed to use cognitive reappraisal to change their emotional experiences. Our key goals were to examine whether American and Chinese participants differed in their beliefs (i.e., implicit theories of emotion) and practices (i.e., use of cognitive reappraisal) of emotion regulation. We further tested whether differences in beliefs underlie cultural differences in the practice of emotion regulation. At the neural level, we examined whether culture modulates neural activation while regulating negative emotion, and whether beliefs and practices are associated with neural activation.

Method

Participants

Twenty-nine first-year undergraduate students participated in the current study, including 14 American (seven women, M =

19.02 years) and 15 Chinese (seven women, M = 19.38 years) participants. All American participants were born in the United States and self-identified as European Americans. All Chinese participants were born in China and had moved to the United States less than one year prior to their scan. We restricted the time that Chinese participants spent in the United States to minimize their exposure to American culture. By recruiting both American and Chinese participants from the same site, we can use the same MRI scanner for all participants to avoid potential differences in brain activation driven by different scanners. Participants provided written consent in accordance with the University's Institutional Review Board.

Procedure

All instructions and stimulus materials were translated and then back-translated from English to Chinese by bilingual speakers (Brislin, 1980). Chinese participants completed the task and all questionnaires in Chinese. A native Mandarin speaking experimenter conducted the study for all Chinese participants.

Self-Report Measures

Implicit theories of emotion. Beliefs of emotion were assessed using the Implicit Theory of Emotion Measure (Tamir et al., 2007) on a 5-point scale. There were two items for incremental beliefs (e.g., "If they want to, people can change the emotions that they have") and two items for entity beliefs (e.g., "No matter how hard they try, people can't really change the emotions that they have."). Following previous studies (Tamir et al., 2007), we reverse scored the two entity items and took the average across all items, with higher score indicating greater incremental beliefs of emotion (α = .72).

Frequency of reappraisal use. The use of cognitive reappraisal was assessed using the Emotion Regulation Questionnaire (Gross & John, 2003) on a 7-point scale. There were six items for cognitive reappraisal (e.g., "When I want to feel less negative emotion, I change the way I'm thinking about the situation." and "I control my emotions by changing the way I think about the situation I am in."). This measure has been used in previous studies to assess the frequency of reappraisal use in daily life (e.g., McRae, Jacobs, Ray, John, & Gross, 2012). Following previous studies (Gross & John, 2003; McRae et al., 2012; Tamir et al., 2007), the average of all items was taken, with higher score indicating greater frequency of cognitive reappraisal (α = .80). In addition, the use of suppression was assessed using four items from the Emotion Regulation Questionnaire, with higher score indicating greater frequency of suppression (α = .65).

Emotion Regulation Task

The emotion regulation task was modified from the task used in previous behavioral and neuroimaging studies on cognitive reappraisal (e.g., Ochsner et al., 2004), which allowed for the separation of emotional reactivity and regulation. As shown in Figure 1, each trial consisted of four events. In the beginning of each trial, participants were instructed to imagine the target person in a scene as themselves and feel their own negative emotion in that situation for an average of 2.5 s (ranging from 2 s to 5 s). Then the instruction for regulation (increase vs. decrease) appeared, during which participants either up-regulated or down-regulated their negative emotion using cognitive reappraisal for 6 s. After regulation, participants pressed a button using a 10-button box to rate their current feelings on a 10-point Likert scale, ranging from 1 (*extremely negative*) to 10 (*extremely positive*). Following the rating, a 2.5s jittered intertrial-interval (ranging from 2 s to 5 s) concluded the trial. Participants completed a total of 32 trials, with 16 trials on up-regulating (increasing) and 16 trials on down-regulating (decreasing) negative emotion.

Prior to entering the scanner, participants were provided instructions and example trials that were not used in the experiment. For the down-regulation (decrease) trials, the experimenter instructed the participant to narrate aloud his or her self-generated reinterpretation using cognitive reappraisal, such as things will become better with time (e.g., some positive events will happen over time) and things may not be that bad. For the up-regulation (increase) trials, the experimenter instructed the participant to narrate aloud his or her self-generated reinterpretation of the image using cognitive reappraisal, such as things will become even worse with time (e.g., some worse events will happen over time) and things will have more negative consequences. If participants used a noncognitive strategy (such as emotion suppression, or averting attention from the emotional aspects of the picture), the experimenter corrected and redirected them to use one of the strategies mentioned above.

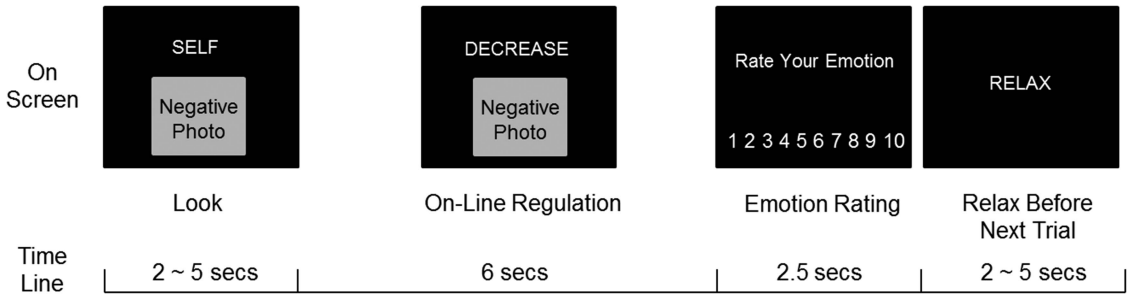

Figure 1. Illustration of emotion-regulation task. Timeline for events on each trial. Participants (a) are first instructed to imagine the target person in a scene as themselves and feel their own negative emotion in that situation, which is followed by (b) a regulation period during which participants follow the instruction to increase or decrease their emotion. Participants then (c) provide a rating of their current affect and (d) relax before the onset of the next trial.

All stimuli used in the fMRI task were naturalistic visual scenes (350 pixels × 280 pixels) depicting either European or Asian individuals in an emotionally negative situation (e.g., crying in a funeral). A total of 32 scenes (16 scenes of European individuals and 16 scenes of Asian individuals) were selected. All photos were standardized for size, luminosity, and background color. To ensure there were no differences in perceptions of negative emotion across the scenes based on culture of the target, all scenes were rated by 21 (nine Americans and 12 East Asians) raters for the valence and arousal of feelings when they observed the target person in the scene on a 7-point Likert scale. There were no significant differences in ratings for scenes between the European American and East Asian raters, and the scenes depicting European and Asian individuals were matched on valence and arousal.

fMRI Data Acquisition and Analysis

fMRI data acquisition. Imaging data were collected using a 3 Tesla Siemens Trio MRI scanner. The emotion regulation task included T2*-weighted echoplanar images (EPI) [slice thickness = 3 mm; 38 slices; TR = 2 s; TE = 25 ms; matrix = 92 × 92; FOV = 230 mm; voxel size 2.5 × 2.5 × 3 mm^3]. Structural scans consisted of a T2*weighted, matched-bandwidth (MBW), high-resolution, anatomical scan (TR = 4 s; TE = 64 ms; matrix = 192 × 192; FOV = 230 mm; slice thickness = 3 mm; 38 slices) and a T1* magnetization-prepared rapid-acquisition gradient echo (MPRAGE; TR = 1.9 s; TE = 2.3 ms; matrix = 256 × 256; FOV = 230 mm; sagittal plane; slice thickness = 1 mm; 192 slices). The orientation for the MBW and EPI scans was oblique axial to maximize brain coverage.

fMRI data preprocessing and analysis. Neuroimaging data were preprocessed and analyzed using Statistical Parametric Mapping (SPM8; Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK). Preprocessing for each participant's images included spatial realignment to correct for head motion (no participant exceeded 2 mm of maximum image-to-image motion in any direction). The realigned functional data were coregistered to the high resolution MPRAGE, which was then segmented into gray matter, white matter, and cerebrospinal fluid. The normalization transformation matrix from the segmentation step was then applied to the functional and T2 structural images, thus transforming them into standard stereotactic space as defined by the Montreal Neurological Institute and the International Consortium for Brain Mapping. The normalized functional data were smoothed using an 8-mm Gaussian kernel, full-width-at-half maximum, to increase the signal-to-noise ratio.

Statistical analyses were performed using the general linear model in SPM8. Each trial was convolved with the canonical hemodynamic response function. High-pass temporal filtering with a cutoff of 128 s was applied to remove low-frequency drift in the time series. Serial autocorrelations were estimated with a restricted maximum likelihood algorithm with an autoregressive model order of 1.

In each participant's fixed-effects analysis, a general linear model (GLM) was created with the regressors of interest to separate different events, which included look (i.e., participants looked at the photos), decrease (i.e., participants down-regulated their negative emotion using cognitive reappraisal), and increase (i.e., participants up-regulated their negative emotion using cognitive reappraisal). The task was modeled as an event-related design. Null events, consisting of the jittered intertrial intervals were not explicitly modeled and therefore constituted an implicit baseline. The parameter estimates resulting from the GLM were used to create linear contrast images comparing each of the conditions of interest.

The individual-level contrast images were used in random-effects, group-level analyses, which were run using GLMflex. GLMflex uses partitioned error terms, corrects for variance-covariance inequality, removes outliers and sudden changes in brain activation, and analyzes all voxels that have data (http://mrtools.mgh.harvard.edu/index.php/GLM_Flex). At the group level, we focused on neural activation when participants actively decreased or increased their negative emotion compared with when they looked at the photos (i.e., decrease-look and increase-look). To this end, we conducted whole-brain, two-sample *t* test (American Chinese) analyses to explore neural regions that show differential activation across the two cultures. To examine cultural similarities in neural activation during emotion regulation, we also conducted one-sample *t* test across the whole sample, controlling for participants' culture. To correct for multiple comparisons, we conducted a Monte Carlo simulation implemented using 3dClustSim in the software package AFNI (Ward, 2000). We used our group-level brain mask combined with the gray mask in SPM, therefore representing neural coverage in our sample that corresponded to gray matter. Results of the simulation indicated a voxel-wise threshold of $p < .005$ combined with a minimum cluster size of 34.9 voxels, corresponding to $p < .05$, False Wise Error corrected.

Results

Cultural Differences in Beliefs and Practices of Emotion Regulation

We first examined cultural differences in beliefs and practices in emotion regulation. In line with our hypotheses, Chinese participants held greater incremental beliefs of emotion ($M = 3.62$, $SD = .55$) than did their American counterparts ($M = 3.04$, $SD = .69$), $t(27) = 2.51$, $p = .018$, Cohen's $d = 0.96$, 95% confidence interval (CI) of the difference = [.11, 1.06], suggesting that Chinese individuals tend to see emotion as more flexible and malleable. Moreover, Chinese participants reported greater use of cognitive reappraisal in daily life ($M = 4.92$, $SD = .74$) than did American participants ($M = 4.16$, $SD = 1.07$), $t(27) = 2.25$, $p = .033$, Cohen's $d = 0.86$, 95% CI of the difference = [.07, 1.46]. Chinese participants reported the same level of using suppression in daily life ($M = 4.03$, $SD = 1.02$) as American participants ($M = 4.09$, $SD = 1.12$), $t(27) = .14$, $p = .889$.

Beliefs of Emotion Mediate Cultural Differences in Practices

We further tested if cultural differences in beliefs (i.e., implicit theories of emotion) explain cultural differences in practices of emotion regulation (i.e., frequency of reappraisal use). To this end, we ran mediation analyses using bias-corrected bootstrapping resampling techniques (Preacher & Hayes, 2008). Based on 1,000 bootstrap resamples, beliefs of emotion mediate cultural differences in practices. The indirect path from culture to incremental theory of emotion to frequency of reappraisal use was significant (Indirect effect = .19, $SE = .12$, 95% CI [.02, .51], with a 73% reduction in the total effect; see Figure 2). The link between culture and frequency of reappraisal

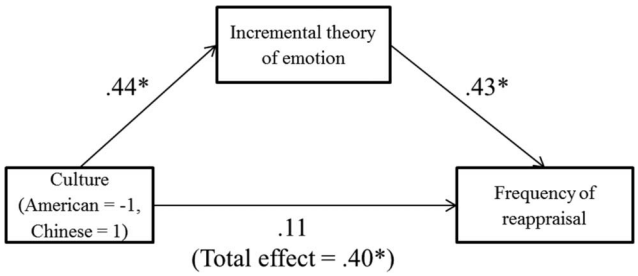

Figure 2. Incremental theory of emotion mediated cultural differences in frequency of reappraisal use. * $p < .05$.

use was no longer significant after taking into account implicit theories of emotion. Thus, cultural differences in implicit theories explain, in part, the tendency for Chinese (vs. American) participants to use more cognitive reappraisal in daily life.

Cultural Differences in Behavioral Ratings on the Cognitive Reappraisal Task

To explore whether American and Chinese participants differ in their subjective ratings during the emotion regulation task, we conducted a 2 (culture) × 2 (types of emotion regulation: increase vs. decrease) analysis of variance (ANOVA) on emotion ratings. There was a significant main effect of emotion regulation, $F(1, 27) = 136.30$, $p < .001$, 95% CI of the difference = [2.40, 2.75], such that participants reported less negative emotion when decreasing their emotion ($M = 4.53$) compared with when increasing their emotion ($M = 1.95$). However, there was no main effect of culture, $F(1, 27) = 0.12$, $p = .731$, or Culture × Regulation interaction, $F(1, 27) = 0.42$, $p = .522$, suggesting that when being asked to regulate their emotion, American and Chinese participants changed their feelings to a similar extent.

In addition, participants' behavioral ratings on the cognitive reappraisal task were not influenced by culture of the target person. When instructed to decrease negative emotion, American and Chinese participants showed similar ratings to American targets, $t(27) = -.52$, $p = .610$, and to Chinese targets, $t(27) = .14$, $p = .889$. Similarly, when instructed to increase negative emotion, American and Chinese participants showed similar ratings to American targets, $t(27) = -.93$, $p = .362$, and to Chinese targets, $t(27) = .84$, $p = .406$. We also conducted a 2 (culture of participant) × 2 (group membership of the target person: ingroup vs. outgroup) ANOVA on emotion ratings. There was no interaction effect when decreasing negative emotion, $F(1, 27) = .58$, $p = .452$, and when increasing negative emotion, $F(1, 27) = .95$, $p = .339$. Together, these results suggest that American and Chinese participants' behavioral ratings are not modulated by ingroup/outgroup status of the target.

Cultural Differences and Similarities in Neural Activation During Emotion Regulation

We next investigated if culture modulates the neural correlates of emotion regulation. As done in prior studies on cognitive reappraisal (e.g., McRae et al., 2008; McRae et al., 2012; Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner et al., 2004; Phan et al., 2005), these contrast models compared emotion regulation (using cognitive reappraisal to dampen or increase negative feelings) to emotion arousal (experiencing the emotion as if one is in the emotional scene). To this end, we focused on neural activation when participants actively regulated their negative emotion compared with when they looked at the photos (i.e., decrease-look and increase-look). In whole brain, two-sample t test analyses, we examined whether American and Chinese participants show different neural patterns during emotion regulation. As shown in Figure 3, American participants showed greater activation in the VLPFC than did Chinese participants when decreasing negative emotions, $t(27) = 4.48$, $p < .005$, 39 contiguous voxels. We also examined cultural differences in neural activation when increasing negative emotion (increase-look contrast). Similar to the findings for decrease-look contrast, Chinese participants showed less activation in the right VLPFC than did their American counterparts when increasing their negative emotion using cognitive reappraisal, $t(27) = 3.79$, $p < .005$, 39 contiguous voxels.

Given that prior studies have suggested that neural basis of emotion processing, mentalizing, and empathy may differ due to the ingroup versus outgroup status of the target person in the images (e.g., Adams et al., 2010; Cheon et al., 2011), we also examined whether the cultural differences in brain activation remain evident when the targets are ingroup versus outgroup members. Results showed that when decreasing negative emotion, American participants showed greater right VLPFC activation than did Chinese participants when the targets are ingroup members, $t(27) = 4.43$, $p < .001$, and when the targets are outgroup members, $t(27) = 2.69$, $p = .012$. Similarly, when increasing negative emotion, American participants showed

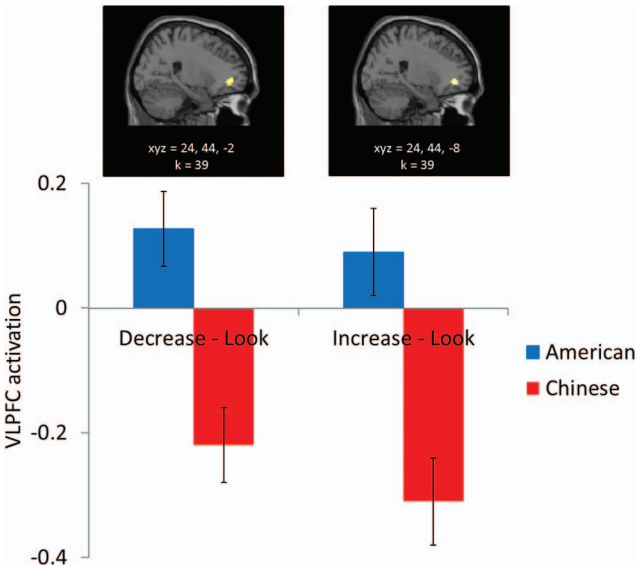

Figure 3. American (vs. Chinese) participants showed greater ventrolateral prefrontal cortex (VLPFC) activation during decreasing and increasing negative emotion. See the online article for the color version of this figure.

greater right VLPFC activation than did Chinese participants when the targets are ingroup members, $t(27) = 3.45$, $p = .002$, and when the targets are outgroup members, $t(27) = 3.56$, $p = .001$. We also conducted a 2 (culture of participant) × 2 (group membership of the target person: ingroup vs. outgroup) ANOVA on the VLPFC activation. There was no interaction effect when decreasing negative emotion, $F(1, 27) = 2.18$, $p = .151$, or when increasing negative emotion, $F(1, 27) = .28$, $p = .600$. These results suggest that cultural differences in VLPFC activation during emotion regulation are not modulated by ingroup/outgroup status of the target.

Whole brain analyses also indicated that Chinese participants showed greater activation in the right precentral gyrus than did American participants for both decrease-look and increase-look contrast (xyz: 24, −22, 70; $t(27) = 5.18$, $p < .005$, 63 contiguous voxels and xyz: 24, −19, 67; $t(27) = 4.19$, $p < .005$, 51 contiguous voxels, respectively). No other regions showed differential activation between American and Chinese participants. Finally, we investigated cultural similarity in neural basis of emotion regulation. To this end, we conducted a whole brain, one-sample t test, controlling for culture of the participants. Neural regions that show similar effects across participants are presented in Table 1.

Associations Between Beliefs, Practices, and Neural Activation

We further explored the associations between beliefs, practices, and neural correlates of emotion regulation. As shown in the aforementioned mediation analysis, more incremental theory of emotion was associated with greater use of cognitive reappraisal, $r = .52$, $p < .01$. We tested whether cultural beliefs and practices of emotion regulation are correlated with VLPFC activation when down-regulating or up-regulating negative emotions. To this end, we tested the associations between implicit theories of emotion, frequency of reappraisal use, and VLPFC activation. For decrease-look, higher incremental theory of emotion was associated with lower VLPFC activation, $r = -.49$, $p = .006$; Figure 4a. Similarly, more frequent use of cognitive reappraisal was associated with lower VLPFC activation, $r = -.41$, $p = .028$; Figure 4b. Moreover, the VLPFC activation for increase-look was also associated with the beliefs and practices of emotion regulation. Specially, lower VLPFC activation is significantly associated with more frequent use of cognitive reappraisal, $r = -.40$, $p = .034$ and marginally related to higher incremental theory of emotion, $r = -.32$, $p = .090$. Together, these findings suggest that when individuals see emotion as flexible and malleable, they use cog-

Table 1
Brain Regions Showing Similar Activation During Emotion Regulation Between American and Chinese Participants

Anatomical region	BA	x	y	z	*t*	*k*
decrease-look (positive activation)						
Left DLPFC	10	−45	41	22	4.64	240
Right DLPFC	10	18	53	25	7.42	440
Left insula		−45	−1	4	4.95	165
Right insula		51	−1	1	6.65	265
ACC	24, 32	3	38	13	6.84	480
Cuneus		−9	−76	22	4.35	367
Calcarine		18	−76	4	5.42	330
Left precentral		−36	−16	58	5.59	334
Right precentral		36	−19	55	6.93	403
Left postcentral		−51	−22	43	8.06	666
Right postcentral		33	−28	64	8.95	648
decrease-look (negative activation)						
Left fusiform		−36	−52	−14	−9.61	433
Right fusiform		36	−43	−20	−9.56	435
increase-look (positive activation)						
Right DLPFC	10	24	50	22	6.13	217
Left insula		−39	5	−2	4.48	184
Right insula		48	−1	1	6.91	306
ACC	24	0	38	13	6.71	464
Cuneus		−9	−76	22	4.68	391
Calcarine		−12	−82	7	6.01	345
Left precentral		−33	−13	64	5.90	336
Right precentral		36	−22	58	10.42	400
Left postcentral		−33	−13	64	5.90	590
Right postcentral		24	−40	67	6.41	625
increase-look (negative activation)						
Left fusiform		−36	−49	−17	−9.55	394
Right fusiform		36	−49	−17	−7.26	412

Note. BA = putative Broadman's areas. x, y, and z refer to MNI coordinates; t = the t-score at those coordinates (local maxima); k = the number of voxels in each significant cluster; DLPFC = dorsolateral prefrontal cortex; ACC = anterior cingulate cortex.

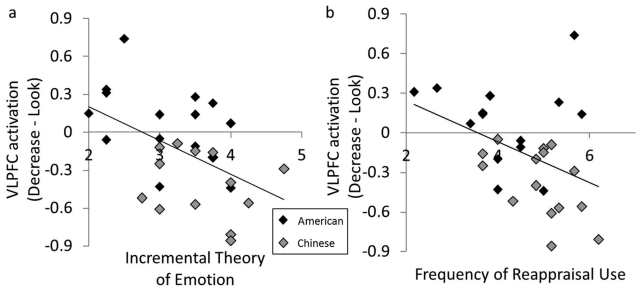

Figure 4. Lower ventrolateral prefrontal cortex (VLPFC) activation during decrease—look was associated with (a) higher incremental theory of emotion and (b) more frequent use of cognitive reappraisal.

nitive reappraisal in daily life more often and also recruit the VLPFC to a lesser extent when regulating negative emotion.

Discussion

Although much attention has been paid to how individuals perceive and engage in emotion regulation, most studies focus on Western populations. The present study examined how culture modulates individuals' beliefs, practices, and neural correlates of emotion regulation. Our findings suggest that Chinese individuals use reappraisal more frequently in their daily lives than their American counterparts, which is explained, in part, by their beliefs that emotion is more changeable. Moreover, the neural basis of emotion regulation also differs across cultures: Chinese participants recruit the VLPFC less than American participants when regulating their emotion, with lower VLPFC activation associated with greater incremental beliefs of emotion and more frequent use of cognitive reappraisal. Taken together, our findings suggest that culture modulates individuals' beliefs, practices, and neural correlates of emotion regulation.

Collectivistic orientation in East Asian culture emphasizes maintaining group harmony, encouraging people to modify their behaviors and feelings (Markus & Kitayama, 1991). Therefore, East Asian individuals are motived to change their emotion to match those around them. Over time, such daily practice may lead them to see emotion as changeable and controllable. The present study is the first to show cultural differences in theories of emotion, such that Chinese participants reported higher incremental theory of emotion than their American counterparts, suggesting that culture plays a key role in shaping how individuals view emotion. Importantly, cultural differences in how individuals view emotion (i.e., implicit theory of emotion) contributed to differences in how they engage in emotion regulation (i.e., use of cognitive reappraisal) in daily life. By believing that emotion is changeable and controllable, Chinese participants also reported greater use of cognitive reappraisal than their American counterparts. This finding is consistent with prior research showing that individuals who endorse more incremental theory of emotion tend to use cognitive reappraisal more frequently in daily life (Tamir et al., 2007). Our findings extend this work and highlight important cultural differences underlying beliefs and practices of emotion regulation. Prior research suggests that American individuals use cognitive reappraisal to regulate their emotion less often than what researchers expect (Suri et al., 2015), which is counterintuitive given the positive effects of cognitive reappraisal on fostering emotional well-being. Our findings indicate that the lower frequency of reappraisal use among American individuals may be driven by their beliefs that emotion is less changeable and controllable through effort.

Cultural differences also emerged in the neural correlates involved in emotion regulation. American and Chinese participants showed differential neural activation: American participants showed greater right VLPFC activation than their Chinese counterparts when regulating their negative emotion. It is important to note that such differences are evident for both down-regulation (i.e., decrease) and up-regulation (i.e., increase) of negative emotion. This suggests that culture modulates the neural basis of cognitive reappraisal in general, and is not specific to either down- or up-regulation.

The VLPFC is involved in cognitively reappraising negative emotion (Goldin, McRae, Ramel, & Gross, 2008; Levesque et al., 2004; McRae et al., 2008; McRae et al., 2012; Ochsner et al., 2002; Ochsner et al., 2004; Phan et al., 2005). Prior work comparing the neural basis of cognitive reappraisal between males and females shows that although males and females did not differ in their affective ratings after regulation, males showed less activation in the VLPFC compared with females. Researchers have argued that the lower VLPFC activation suggests that males need less effort in this process and use cognitive reappraisal in a more automatic manner (McRae et al., 2008). Our findings are consistent with this literature: Although American and Chinese participants did not differ in their behavioral performance on the emotion regulation task, Chinese participants showed less VLPFC activation during regulation than did their American counterparts. Given that American and Chinese participants did not differ in their subjective rating during the emotion regulation task, this finding indicates that Chinese individuals may need to recruit less right VLPFC activity in order to regulate their emotion to a similar extent as their American counterparts. The lower VLPFC activation among Chinese participants may be influenced by how they perceive and engage in emotion regulation. That is, by believing that emotions are changeable, and practicing more emotion regulation in their daily lives, Chinese participants may recruit the VLPFC to a lesser extent to regulate their emotions. Indeed, both greater incremental theory of emotion and more frequent use of cognitive reappraisal were associated with less recruitment of the VLPFC when engaging in cognitive regulation. Thus, cultural beliefs and practices may improve Chinese individuals' ability to engage in more effective emotion regulation. These results advance our knowledge on the role of VLPFC in emotion regulation, especially in terms of cultural differences, and associations with beliefs and practices.

In addition to cultural differences, it is important to note that American and Chinese participants also showed similarities in neural activation during emotion regulation, with several regions (e.g., dorsolateral prefrontal cortex and anterior cingulate cortex) that have been found in previous studies on American samples (e.g., Ochsner et al., 2004). These findings provide preliminary evidence that some psychological and neural processes underlying emotion regulation—for example, cognitive reappraisal—may also be shared by different cultural groups. Therefore, by documenting both cultural differences and similarities, the current study

provides a more comprehensive perspective on how culture shapes psychological and neural mechanisms of emotion regulation.

Limitations and Future Directions

The current study highlights the role of culture in shaping cognitive, behavioral, and neural mechanisms involved in emotion regulation. However, given that most studies focus on negative emotion, little is known about cultural differences in the regulation of positive emotion. Recent research indicates that culture may shape how individuals regulate their positive emotion, such that East Asians tend to dampen their feelings of positive emotion to a greater extent than Americans (Miyamoto & Ma, 2011). Therefore, research is needed to examine whether American and East Asian people differ in their neural processing involved in regulation of positive emotion.

In addition, although this study examined how culture influences the way that individuals engage in emotion regulation by focusing on cognitive reappraisal, individuals also use other types of strategies to regulate their emotion. For example, one common way suggested by previous research is suppression (Gross & John, 2003), which involves inhibiting ongoing emotion-expressive behavior (Gross, 1998). Cross-cultural research has documented differences in the use of suppression between Western and East Asian cultures. Given the cultural emphasis on maintaining group harmony, East Asian individuals are more likely to use emotional suppression than Western individuals (Matsumoto et al., 2008; Tsai et al., 2002). However, in our study, participants also reported on their use of suppression in daily life, which did not differ across the two cultural groups: Chinese participants reported the same level of using suppression in daily life as American participants. Moreover, the implicit beliefs of emotion were not associated with self-reported use of suppression. Given that the emotion regulation task used in our study is designed to examine neural basis of reappraisal, future research is needed to investigate how culture affects the neural basis of emotion suppression, which can provide more insights into the role of culture in shaping emotion regulation.

Finally, the current study highlights the role of cultural beliefs in affecting the practices and neural correlates of emotion regulation. Better understanding the transmission and socialization of cultural beliefs may help us understand the plasticity of the brain. Thus, it is important to delineate how cultural beliefs of emotion are transmitted and socialized to individuals. Developmental research has suggested that parents may convey their views on emotion to their children via practices or conversations (Eisenberg, Cumberland, & Spinrad, 1998; Morris, Silk, Steinberg, Myers, & Robinson, 2007). Further research can investigate the socialization process of emotion regulation from a developmental perspective.

Conclusions

Prior neuroimaging research on emotion regulation has largely been conducted in Western samples. Although this line of research provides fruitful evidence on the neural correlates of emotion regulation, little is known about whether culture plays a role in this process. By taking a cultural neuroscience approach, we examined how culture modulates American and Chinese individuals' beliefs, practices, and neural correlates of emotion regulation. Our results suggest that compared to their Western counterparts, East Asians believe that emotion is more changeable, use reappraisal to change their emotion more often in daily life, and, ultimately, recruit less neural resources when regulating emotion. The findings make a novel contribution to a growing literature on cultural neuroscience, highlighting the key role of culture in shaping individuals' brain, beliefs, and behavior.

References

Adams, R. B., Jr., Rule, N. O., Franklin, R. G., Jr., Wang, E., Stevenson, M. T., Yoshikawa, S., . . . Ambady, N. (2010). Cross-cultural reading the mind in the eyes: An fMRI investigation. *Journal of Cognitive Neuroscience, 22,* 97–108. http://dx.doi.org/10.1162/jocn.2009.21187

Brislin, R. W. (1980). Translation and content analysis of oral and written materials. In H. C. Triandis & J. W. Berry (Eds.), *Handbook of cross-cultural psychology Vol. 2. Methodology* (pp. 389–444). Boston, MA: Allyn & Bacon.

Cheon, B. K., Im, D. M., Harada, T., Kim, J. S., Mathur, V. A., Scimeca, J. M., . . . Chiao, J. Y. (2011). Cultural influences on neural basis of intergroup empathy. *NeuroImage, 57,* 642–650. http://dx.doi.org/10.1016/j.neuroimage.2011.04.031

Chiao, J. Y., & Ambady, N. (2007). Cultural neuroscience: Parsing universality and diversity across levels of analysis. In S. Kitayama & D. Cohen (Eds.), *Handbook of cultural psychology* (pp. 237–254). New York, NY: Guilford Press.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., . . . Iidaka, T. (2009). Neural basis of individualistic and collectivistic views of self. *Human Brain Mapping, 30,* 2813–2820. http://dx.doi.org/10.1002/hbm.20707

Chiao, J. Y., & Immordino-Yang, M. H. (2013). Modularity and the cultural mind: Contributions of cultural neuroscience to cognitive theory. *Perspectives on Psychological Science, 8,* 56–61. http://dx.doi.org/10.1177/1745691612469032

Cohen, J. R., & Lieberman, M. D. (2010). The common neural basis of exerting self-control in multiple domains. *Self control in society, mind, and brain* (pp. 141–161). New York, NY: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780195391381.003.0008

Dandoy, A. C., & Goldstein, A. G. (1990). The use of cognitive appraisal to reduce stress reactions: A replication. *Journal of Social Behavior & Personality, 5,* 275–285.

Dweck, C. S. (1999). *Self-theories: Their role in motivation, personality, and development*. New York, NY: Psychology Press.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95,* 256–273. http://dx.doi.org/10.1037/0033-295X.95.2.256

Egloff, B., Schmukle, S. C., Burns, L. R., & Schwerdtfeger, A. (2006). Spontaneous emotion regulation during evaluated speaking tasks: Associations with negative affect, anxiety expression, memory, and physiological responding. *Emotion, 6,* 356–366. http://dx.doi.org/10.1037/1528-3542.6.3.356

Eisenberg, N., Cumberland, A., & Spinrad, T. L. (1998). Parental socialization of emotion. *Psychological Inquiry, 9,* 241–273. http://dx.doi.org/10.1207/s15327965pli0904_1

Gevins, A., Smith, M. E., McEvoy, L., & Yu, D. (1997). High-resolution EEG mapping of cortical activation related to working memory: Effects of task difficulty, type of processing, and practice. *Cerebral Cortex, 7,* 374–385. http://dx.doi.org/10.1093/cercor/7.4.374

Goldin, P. R., McRae, K., Ramel, W., & Gross, J. J. (2008). The neural bases of emotion regulation: Reappraisal and suppression of negative emotion. *Biological Psychiatry, 63,* 577–586. http://dx.doi.org/10.1016/j.biopsych.2007.05.031

Gross, J. J. (1998). The emerging field of emotion regulation: An integrative review. *Review of General Psychology, 2,* 271–299. http://dx.doi.org/10.1037/1089-2680.2.3.271

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85,* 348–362. http://dx.doi.org/10.1037/0022-3514.85.2.348

Han, S., & Ma, Y. (2014). Cultural differences in human brain activity: A quantitative meta-analysis. *NeuroImage, 99,* 293–300. http://dx.doi.org/10.1016/j.neuroimage.2014.05.062

Ji, L. J., Nisbett, R. E., & Su, Y. (2001). Culture, change, and prediction. *Psychological Science, 12,* 450–456. http://dx.doi.org/10.1111/1467-9280.00384

Kelly, A. M. C., & Garavan, H. (2004). Human functional neuroimaging of brain changes associated with practice. *Cerebral Cortex, 15,* 1089–1102. http://dx.doi.org/10.1093/cercor/bhi005

Lévesque, J., Joanette, Y., Mensour, B., Beaudoin, G., Leroux, J.-M., Bourgouin, P., & Beauregard, M. (2004). Neural basis of emotional self-regulation in childhood. *Neuroscience, 129,* 361–369. http://dx.doi.org/10.1016/j.neuroscience.2004.07.032

Markus, H. R., & Kitayama, S. (1991). Culture and the self: Implications for cognition, emotion, and motivation. *Psychological Review, 98,* 224–253. http://dx.doi.org/10.1037/0033-295X.98.2.224

Matsumoto, D., Yoo, S. H., & Nakagawa, S. (2008). Culture, emotion regulation, and adjustment. *Journal of Personality and Social Psychology, 94,* 925–937. http://dx.doi.org/10.1037/0022-3514.94.6.925

Mauss, I. B., Cook, C. L., Cheng, J. Y. J., & Gross, J. J. (2007). Individual differences in cognitive reappraisal: Experiential and physiological responses to an anger provocation. *International Journal of Psychophysiology, 66,* 116–124. http://dx.doi.org/10.1016/j.ijpsycho.2007.03.017

McRae, K., Gross, J. J., Weber, J., Robertson, E. R., Sokol-Hessner, P., Ray, R. D., . . . Ochsner, K. N. (2012). The development of emotion regulation: An fMRI study of cognitive reappraisal in children, adolescents and young adults. *Social Cognitive and Affective Neuroscience, 7,* 11–22. http://dx.doi.org/10.1093/scan/nsr093

McRae, K., Jacobs, S. E., Ray, R. D., John, O. P., & Gross, J. J. (2012). Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. *Journal of Research in Personality, 46,* 2–7. http://dx.doi.org/10.1016/j.jrp.2011.10.003

McRae, K., Ochsner, K. N., Mauss, I. B., Gabrieli, J. J. D., & Gross, J. J. (2008). Gender differences in emotion regulation: An fMRI study of cognitive reappraisal. *Group Processes & Intergroup Relations, 11,* 143–162. http://dx.doi.org/10.1177/1368430207088035

Miyamoto, Y., & Ma, X. (2011). Dampening or savoring positive emotions: A dialectical cultural script guides emotion regulation. *Emotion, 11,* 1346–1357. http://dx.doi.org/10.1037/a0025135

Morris, A. S., Silk, J. S., Steinberg, L., Myers, S. S., & Robinson, L. R. (2007). The role of the family context in the development of emotion regulation. *Social Development, 16,* 361–388. http://dx.doi.org/10.1111/j.1467-9507.2007.00389.x

Norenzayan, A., Choi, I., & Nisbett, R. E. (2002). Cultural similarities and differences in social inference: Evidence from behavioral predictions and lay theories of behavior. *Personality and Social Psychology Bulletin, 28,* 109–120. http://dx.doi.org/10.1177/0146167202281010

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking feelings: An FMRI study of the cognitive regulation of emotion. *Journal of Cognitive Neuroscience, 14,* 1215–1229.

Ochsner, K. N., Ray, R. D., Cooper, J. C., Robertson, E. R., Chopra, S., Gabrieli, J. D., & Gross, J. J. (2004). For better or for worse: Neural systems supporting the cognitive down- and up-regulation of negative emotion. *NeuroImage, 23,* 483–499. http://dx.doi.org/10.1016/j.neuroimage.2004.06.030

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

Peng, K., & Nisbett, R. E. (1999). Culture, dialectics, and reasoning about contradiction. *American Psychologist, 54,* 741–754. http://dx.doi.org/10.1037/0003-066X.54.9.741

Phan, K. L., Fitzgerald, D. A., Nathan, P. J., Moore, G. J., Uhde, T. W., & Tancer, M. E. (2005). Neural substrates for voluntary suppression of negative affect: A functional magnetic resonance imaging study. *Biological Psychiatry, 57,* 210–219. http://dx.doi.org/10.1016/j.biopsych.2004.10.030

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40,* 879–891. http://dx.doi.org/10.3758/BRM.40.3.879

Suri, G., Whittaker, K., & Gross, J. J. (2015). Launching reappraisal: It's less common than you might think. *Emotion, 15,* 73–77. http://dx.doi.org/10.1037/emo0000011

Tamir, M., John, O. P., Srivastava, S., & Gross, J. J. (2007). Implicit theories of emotion: Affective and social outcomes across a major life transition. *Journal of Personality and Social Psychology, 92,* 731–744. http://dx.doi.org/10.1037/0022-3514.92.4.731

Tsai, J. L., Chentsova-Dutton, Y., Freire-Bebeau, L., & Przymus, D. E. (2002). Emotional expression and physiology in European Americans and Hmong Americans. *Emotion, 2,* 380–397. http://dx.doi.org/10.1037/1528-3542.2.4.380

Wager, T. D., Davidson, M. L., Hughes, B. L., Lindquist, M. A., & Ochsner, K. N. (2008). Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron, 59,* 1037–1050. http://dx.doi.org/10.1016/j.neuron.2008.09.006

Ward, B. D. (2000). *Simultaneous inference for fMRI data*. Retrieved from http://afni.nimh.nih.gov/pub/dist/doc/manual/AlphaSim.pdf

Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-representation. *NeuroImage, 34,* 1310–1316. http://dx.doi.org/10.1016/j.neuroimage.2006.08.047