Neuropsychologia 51 (2013) 1177–1186

Contents lists available at SciVerse ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Cultural modulation of the neural correlates of emotional pain perception: The role of other-focusedness

Bobby K. Cheon [a,*,1], Dong-Mi Im [b], Tokiko Harada [a,2], Ji-Sook Kim [b], Vani A. Mathur [a,3], Jason M. Scimeca [a,4], Todd B. Parrish [c], HyunWook Park [b], Joan Y. Chiao [a,d]

[a] Department of Psychology, Northwestern University, 2029 Sheridan Road, 102 Swift Hall Evanston, IL 60208-2710, USA
[b] Korea Advanced Institute of Science and Technology, Daejon, Republic of Korea
[c] Department of Radiology, Northwestern University, 737 N Michigan Ave, Chicago, IL, USA
[d] Northwestern Interdepartmental Neuroscience Program, Evanston, IL 60208, USA

ARTICLE INFO

Article history:
Received 30 October 2012
Received in revised form
26 March 2013
Accepted 26 March 2013
Available online 6 April 2013

Keywords:
Cross-cultural comparisons
Empathy
Pain processing
Emotion
fMRI

ABSTRACT

Cultures vary in the extent to which they emphasize group members to habitually attend to the needs, perspectives, and internal experiences of others compared to the self. Here we examined the influence that collectivistic and individualistic cultural environments may play on the engagement of the neurobiological processes that underlie the perception and processing of emotional pain. Using cross-cultural fMRI, Korean and Caucasian-American participants passively viewed scenes of others in situations of emotional pain and distress. Regression analyses revealed that the value of other-focusedness was associated with heightened neural response within the affective pain matrix (i.e. anterior cingulate cortex and insula) to a greater extent for Korean relative to Caucasian-American participants. These findings suggest that mindsets promoting attunement to the subjective experience of others may be especially critical for pain-related and potentially empathic processing within collectivistic relative to individualistic cultural environments.
© 2013 Elsevier Ltd. All rights reserved.

1. Introduction

Culture shapes how we navigate the social world. While Western cultures (e.g. Europe, North America) generally endorse higher levels of individualism, east-Asian cultures (e.g. China, Japan, Korea), typically endorse relatively higher levels of collectivism (Fincher, Thornhill, Murray, & Schaller, 2008; Hofstede, 2001; Suh, Diener, Oishi, & Triandis, 1998). Individualistic cultures place greater emphasis on autonomy and independence, uniqueness of the self, personal choice, and pursuit of aspirations. Conversely, collectivistic cultures place greater emphasis on interdependence and connectedness of the self to others, as well as the maintenance of social harmony, fitting in, and the fulfillment of duties and obligations (Markus & Kitayama, 1991; Nisbett et al., 2001; Oyserman, Coon, & Kemmelmeier, 2002; Triandis, 1994). The pursuit of socially-sanctioned values and selves promoted by collectivistic and individualistic cultural contexts may be associated with distinct profiles of processing socially-relevant information and navigating the social world, such that members of collectivistic and individualistic cultures may habitually be attentive and attuned to the perspectives, needs, and outcomes of others (other-focusedness) or the self (self-focusedness), respectively (Chiao & Blizinsky, 2010; Oyserman et al., 2002; Wong & Hong, 2005; Wu & Keysar, 2007).

Consequently, collectivistic cultural environments may demand individuals to maintain an "outsider" perspective in social situations, readily focusing on and attending to the internal processes of others and adopting a third-person perspective of the self. On the other hand, members of individualistic cultures may be more likely to maintain an "insider" perspective in social situations, preferentially processing and attending to their own internal experiences and adopting a first-person perspective of the self (Cohen & Gunz, 2002; Cohen, Hoshino-Browne, & Leung, 2007; Wu & Keysar, 2007). This cultural variation in subjective experience and perception during social interaction may be necessary given the discrepant social demands and constraints placed upon the self between collectivistic and individualistic cultures. While being other-focused and attentive to the feelings and perspectives of others may be an important information processing strategy for pursuing the social goals of fitting in, maintaining harmony, and fulfilling obligations prevalent in collectivistic cultures, the tendency to recognize one's own feelings and experiences during social interactions may be an important

* Corresponding author. Tel.: +65 6790 4642.
E-mail address: Bobbycheon2012@u.northwestern.edu (B.K. Cheon).
[1] Present adderess: Nanyang Business School, Nanyang Technological University, Nanyang Ave, Singapore 639798.
[2] Present adderess: National Institute for Physiological Sciences, Okazaki, Japan.
[3] Present adderess: Department of Psychiatry & Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, MD 21287, USA.
[4] Present adderess: Department of Cognitive, Linguistic, and Psychological Sciences, Brown University, 75 Waterman St. Providence, RI 02906, USA.

0028-3932/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.neuropsychologia.2013.03.018

processing strategy for fulfilling the social goals of being unique, assertive, and pursuing personal preferences promoted in individualistic cultures (Cohen et al., 2007; Heine, 2005; Markus & Kitayama, 1991).

These cultural variations in self- versus other-focused perspectives in social perception have been demonstrated across various contexts. Cohen and Gunz (2002) showed that when reflecting upon personal memories of social situations where the participant was the center of attention, European-Americans were more likely to remember the memories through a first-person perspective, while Asian-Americans were more likely to remember the memories through a third-person perspective. Similarly, when reading and constructing models around social narratives, European-American participants were more likely to adopt a first-person perspective when reading about themselves and a third-person perspective when reading about a friend. Conversely, Asian-American participants were more likely to adopt a first-person perspective when reading about a friend and a third-person perspective when reading about themselves (Cohen et al., 2007). Moreover, when completing a cooperative task that required taking the perspective of one's partner for coordination and success, Chinese participants were significantly more attentive and attuned to the perspectives of their partners relative to American participants, who made significantly more errors on the task and required more time for completion (Wu & Keysar, 2007). Even the phenomenal experience and manifestations of social anxiety may vary as a function of self-focused and other-focused orientations. While social anxiety may typically arise in Western cultures (i.e. United States) from the fear of being rejected or negatively evaluated based on one's perceived shortcomings, social anxiety may be more likely to manifest in Eastern cultures (i.e. Japan, Korea) from fear or shame that one's perceived shortcomings may offend or trouble others (Nakamura, Kitanishi, Miyake, Hashimoto, & Kubota, 2002; Norasakkunkit, Kitayama, & Uchida, 2011).

These findings suggest that the phenomenal manner in which social situations may be experienced and encoded may be critically shaped by the cultural context, with relatively more collectivistic east-Asian cultural environments encouraging social understanding through adopting the perspectives and internal experiences of others to a greater extent than relatively more individualistic Western cultural environments. Importantly, prior studies on culture and perspective do not claim that members of Eastern and Western cultures are incapable of adopting first- or third-person perspectives, respectively (see Cohen et al., 2007; Wu & Keysar, 2007). Given that adopting the perspective and viewpoints of others is a general necessity of social interaction, other-focusedness is likely accessible and engaged by members of both collectivistic and individualistic cultures. Rather, based on these prior studies, members of such cultures may vary in the spontaneity and readiness whereby they focus on the self relative to others, or their 'default' mode of experiencing social contexts, given the distinct demands and constraints of collectivistic and individualistic cultural environments on the self.

In sum, the outsider and insider perspective respectively prevalent in collectivistic and individualistic cultural contexts may shape how readily and spontaneously one experiences the subjective and phenomenal states of others in social contexts. One interpersonal process that may be modulated by this cultural distinction is empathy. Empathy has been defined as the ability to subjectively experience and respond to the feelings of another (Preston & de Waal, 2003; de Waal, 2008), and consists of component processes that include affective mechanisms that allow the perceiver to feel and adopt the affective experiences of others, as well as cognitive mechanisms that allow the perceiver to adopt the perspective and mental states of others (Davis, 1994; Decety & Jackson, 2006; Hein & Singer, 2008). Successfully engaging in these processes to adopt the subjective experiences and perspectives of another involves not only accurately interpreting and understanding the internal states of another, but also suppressing and overcoming one's own egocentric perspectives and affective states (Gilovich, Medvec, & Savitsky 2000; Lin, Keysar, & Epley 2010; Vorauer & Ross, 1999; Wu & Keysar, 2007).

Individual variation in propensity for other-focusedness may modulate empathic processes in distinct ways within the different cultural contexts. Within collectivistic cultural environments, where an outsider perspective is favored and emphasis is placed upon mindfulness of the internal experiences of others, greater levels of attentiveness to others' subjective experiences relative to the self may be predictive of facilitated empathic processing. But, in individualistic cultural environments, where an insider perspective is favored and empathy may be more influenced by subjective experiences of the self, greater attentiveness to others may be less critical for empathic processing.

Furthermore, cultural variation in how automatically or spontaneously one focuses on the internal states, outcomes, and needs of others relative to the self may reflect a specific dimension of interdependence. Though interdependence and independence has been traditionally examined as broad constructs, more recent evidence suggests a multidimensional structure of interdependent and independent self-construal styles (Hardin, 2006; Hardin, Leong, & Bhagwat 2004; Oyserman et al., 2002). For instance, interdependence may be distinguished by relational or collective forms (Gabriel & Gardner, 1999). Moreover, factor analysis of the dimensions of independence and interdependence by Hardin et al. (2004) revealed that interdependence consists of two factors (esteem for group and relational interdependence), and independence consists of four factors (autonomy/assertiveness, individualism, behavioral consistency, and primacy of self). Given that an other-focused mindset may be underlied by the tendency for sensitivity to the subjective experiences and outcomes of another, as well as the ability to overcome egocentric attention to personal experiences and outcomes, specific components of interdependence and independence related to sensitivity towards others and minimization of attention to personal outcomes may be especially important predictors of how spontaneously empathic processes are engaged across these two cultural environments.

At the neurobiological level, facilitated empathic processing of others' suffering may be represented by greater response within the affective pain matrix, a network consisting of the anterior cingulate cortex (ACC) and bilateral anterior insula (AI), which are activated when processing personally experienced or observed pain. The social neuroscience of empathy has consistently reported that the pain matrix is reactive to the perception of pain across a variety of contexts, such as observing pain inflicted on close others (Singer et al., 2004), observing facial expressions of pain (Botvinick et al., 2005), or viewing bodily harm (Jackson, Meltzoff, & Decety, 2005; Lamm, Batson, & Decety, 2007). Moreover, this network is also sensitive to the perception of others' emotional pain, which involves facial and bodily expressions of suffering and distress in the absence of visible physical insult or injury (Chiao, Mathur, Harada, & Lipke, 2009; Mathur, Harda, Lipke, & Chiao, 2010). As such, within collectivistic east-Asian relative to individualistic Western cultures, other-focusedness may be an important predictor of how readily and spontaneously reactivity is engaged in the ACC and insula when viewing the suffering of others in interpersonal contexts.

Here, we present a cross-cultural fMRI study of the role that other-focusedness may play on the engagement of neural processes underlying emotional pain perception within collectivistic (i.e. Korea) and individualistic (i.e. North America) cultural contexts. We hypothesize greater levels of other-focusedness will be associated with stronger reactivity within neural structures within the pain matrix (ACC and insula) among participants in Korea relative to the United States. To examine the influence of cultural environment on automatic recruitment of pain-related neural

Fig. 1. Sample stimuli.

processing, participants completed a task in which they viewed others in scenes of emotional pain and distress, without being given the explicit goal or demand to engage in empathic processing. Based on the objective of the experiment to compare the role of other-focusedness on the neural correlates of pain perception between two distinct cultural environments, native Korean and Caucasian-American participants were recruited and scanned within their respective countries and societies.

2. Materials and methods

2.1. Participants

Twenty-seven right-handed participants, 13 Native Koreans living in South Korea (5 female; $M=23.08$ years, $SD=4.35$), and 14 Caucasian-Americans living in the United States (7 female; $M=25.14$ years, $SD=4.82$), with normal or corrected-to-normal vision completed this study and were compensated $25 or ₩20,000 for their participation. All participants provided informed consent prior to participation.

2.2. Stimuli

Stimuli consisted of naturalistic visual scenes (640 pixels × 480 pixels) depicting either Korean or Caucasian-Americans in an emotionally painful (e.g. in the midst of a natural disaster) or non-painful (e.g. attending an outdoor picnic) situation (Fig. 1). A total of 96 scenes (24 for each of the four conditions) were selected. Photos were standardized for size and luminosity across task conditions. To ensure there were no differences in perceptions of pain across the scenes based on ethnicity of the target, all scenes were rated by 25 (14 Caucasian-American and 11 Korean) raters for the amount of pain the person/people in the scene appeared to be in on a 7-point Likert scale. There were no significant differences in ratings for scenes that comprised each of the four conditions between the Caucasian-American and Korean raters (all $ps>0.05$).

2.3. Procedure

All instructions, stimulus materials, and questionnaires were translated and then back-translated from English to Korean by a bilingual speaker (Brislin, 1970).

Prior to entering the scanner participants were provided instructions and example stimuli. The task involved a block design consisting of sixteen counter-balanced blocks within the functional run. Each block consisted of six unique trials of that block type. There were four block types depicting either Native Koreans or Caucasian Americans in emotional pain or non-painful scenes. Each of these four block types was presented four times during the functional run. During each trial, a complex visual scene was displayed for 2500 ms, followed by a centered fixation cross for 500 ms.

Participants were instructed to make a single button-press with their right index finger at the presentation of each scene, but to pay close attention to each scene throughout the entirety of its presentation. Trials were displayed in a fixed random order. Control blocks were interleaved between task blocks, in which participants made a button press with their right index finger when a simple gray square appeared. These control blocks served as a baseline condition to subtract common primary processes (e.g. primary visual and motor responses) and also to serve as a hypothesis-neutral control condition that could be modeled to examine variations in fMRI signal between the American and Korean scanning sites.

Upon completion of scanning, participants completed the self-construal scale (SCS; Singelis, 1994). We conceptualized other-focusedness as consisting of two factors underlying interdependence and independence (Hardin et al., 2004). The first factor consists of relational interdependence, reflecting the propensity to be attentive, connected, and affected by the internal states and outcomes of others relative to the self. As accurate perspective-taking and empathy require not only attentiveness to others, but also the suppression of egocentrism (Cohen et al., 2007; Gilovich et al., 2000; Wu & Keysar, 2007), the second factor consists of the primacy of self, or the tendency to focus on personal outcomes or well-being. Based on these criteria, we computed an index of other-focusedness by averaging participants' responses for the relational interdependence items and the reverse-score of the primacy of self items established by Hardin et al. (2004)[5] for the SCS.

2.4. fMRI parameters

Scanning at the U.S. site occurred at the Northwestern Center for Advanced Magnetic Resonance Imaging (CAMRI; Chicago, IL, USA) on a 3.0 T Siemens TIM Trio-MRI scanner, while scanning at the Korean Advanced Institute of Science and Technology (KAIST; Daejon, South Korea) was conducted on a comparable 3.0 T ISOL-FORTE MRI scanner, using similar scanner parameters.

At CAMRI, functional images were acquired using T2*-weighted, gradient echo, echo planar imaging sequences [repetition time (TR)=2000 ms; echo time (TE)=25 ms; flip angle=70°; FOV =20 cm, 64 × 64 matrix; 34 slices; 3 mm slice thickness (no gap); in-plane resolution=3.0 × 3.0 mm]. A high-resolution anatomical T1-weighted image was also acquired [TR=2300 ms; TE=2.91 ms; flip angle=9°; FOV=256 mm; 256 × 256 matrix; 160 slices; voxel size=1.0 × 1.0 × 1.0 mm] for each participant. At KAIST, functional images were acquired using T2*-weighted, gradient echo, echo planar imaging sequences [repetition time (TR)=2000 ms; echo time (TE)=35 ms; flip angle=70°; FOV =22 cm, 64 × 64

[5] Sample items from the self-construal scale comprising the 'other-focusedness' index:

Relational Interdependence:

"I will sacrifice my self-interest for the benefit of the group I am in."

"If my brother or sister fails, I feel responsible."

"I often have the feeling that my relationships with others are more important than my own accomplishments."

"My happiness depends on the happiness of those around me."

Primacy of Self (reverse-scored):

"Being able to take care of myself is a primary concern for me."

"I value being in good health above everything."

matrix; 24 slices; 4 mm slice thickness (no gap); in-plane resolution = 3.4 × 3.4 mm]. A high-resolution anatomical T1-weighted image was also acquired [TR = 10 ms; TE = 5.7 ms; flip angle = 10°; FOV = 220 mm; 256 × 256 matrix; 128 slices; voxel size = 0.86 × 0.86 × 0.86 mm] for each participant. All stimuli were presented using Presentation software (Neurobehavioral Systems, Albany, CA) and projected onto a half-transparent viewing screen located behind the head coil in the U.S. and displayed onto a small LCD display mounted on the head coil in Korea.

2.5. Data analysis

Functional images were analyzed using SPM2 software (Wellcome Department of Imaging Neuroscience, London, UK) implemented in Matlab (Mathworks, Cherborn, MA, USA). The first six volumes were discarded to allow the MR signal to reach a steady state, and all of the remaining volumes were realigned spatially to the first volume and a mean image was created. After a high-resolution image was coregistered onto the mean image, all volumes were normalized to the MNI (Montreal Neurological Institute) space using a transformation matrix obtained from the normalization process of the high-resolution image of each individual participant to the MNI template. The normalized images were then spatially smoothed with an 8 mm Gaussian kernel.

After preprocessing, statistical analysis for each individual participant was conducted using the general linear model (Friston et al., 1995). At the first level, each block was modeled by convolving with a hemodynamic response function. For each participant, a linear regressor was applied to filter noise from linear drift. In the subtraction analysis, the four task conditions ($\text{Korean}_{\text{Pain}}$, $\text{Korean}_{\text{NoPain}}$, $\text{Caucasian-American}_{\text{Pain}}$, $\text{Caucasian-American}_{\text{NoPain}}$) were modeled separately, including fixation. Random effects analyses were conducted by taking the individual contrast images to the second level for statistical analysis.

To examine the culturally-overlapping neural structures involved in processing the painful relative to non-painful scenes, a whole-brain voxel-wise one-sample analysis was performed on the whole sample using the contrast for the main effect of emotional pain, $[(\text{CA}_{\text{Pain}}+\text{Korean}_{\text{Pain}}) > (\text{CA}_{\text{NoPain}}+\text{Korean}_{\text{NoPain}})]$. To compare cultural variations in neural responses underlying the perception of emotional pain between native Koreans and Caucasian-Americans, the contrast for the main effect of emotional pain was subjected to two between-subject contrasts as a function of participant culture: (Korean > CA) and (CA > Korean).

To examine the culturally-shared regions recruited when observing others in painful relative to non-painful situations as a function of other-focusedness, a whole-brain regression was conducted on the entire sample using other-focusedness as a covariate on the contrast for painful relative to non-painful conditions $[(\text{Korean}_{\text{Pain}}+\text{CA}_{\text{Pain}})–(\text{Korean}_{\text{NoPain}}+\text{CA}_{\text{NoPain}})]$. To examine culture-specific regions recruited when observing others in painful relative to non-painful situations as a function of other-focusedness, a similar whole-brain regression was conducted using other-focusedness as a covariate independently among the Korean and American samples on the contrast for painful relative to non-painful conditions. To determine whether there were differences in the patterns of activity across the whole brain as a function of other-focusedness between the two participant groups, we conducted multiple regression analyses to directly compare the contrasts of the whole-brain regression of other-focusedness during the viewing of painful (vs. non-painful) scenes between the Korean and American samples (CA > K and K > CA). Whole-brain regressions of other-focusedness on painful relative to non-painful conditions compared between the Korean and American groups using multiple-regression in SPM with participant group as a contrast-coded covariate (American = −1, Korean = +1), and other-focusedness as a continuous covariate.

Given our special focus on potential sensitivity of responses in the ACC and AI to participant culture and other-focusedness, the statistical threshold was set at $p < .05$, using family-wise error (FWE) correction for multiple comparisons especially for a whole-brain regression analysis. Applying this correction across the whole brain did not yield any suprathreshold voxels. Given that our primary emphasis of this study is to examine how participant cultural background and individual differences in other-focusedness may specifically modulate activity in the ACC and AI during pain perception, rather than more generally comparing which regions across the brain vary in activity as a function of culture, other-focusedness, or mutual influence of the two, we set a relatively more liberal threshold of $p < 0.005$, extent threshold = 5 voxels to overview a whole-brain activation patterns through the all analyses. Based on our a priori hypotheses, a small-volume correction for multiple comparisons was performed using an independently-defined spherical ROI with a 6-mm radius for the a priori regions of interest, namely ACC and bilateral AI. A sphere was centered around an averaged coordinate within ACC ($X = 3$, $Y = 18$, $Z = 31$), right AI ($X = 43$, $Y = 14$, $Z = 3$), and left AI ($X = -44$, $Y = 16$, $Z = -3$) defined based on prior neuroimaging literatures of pain perception and empathy for pain (Botvinick et al., 2005; Chiao et al., 2009; Jackson et al., 2005; Lamm et al., 2007; Mathur et al., 2010; Singer et al., 2004). Corrected p values (FWE) reported later refer to this small volume correction procedure. Region of interest analyses (ROI) were conducted on the ACC and right AI clusters identified in the whole brain regression of the main effect of pain contrast with other-focusedness as a covariate by creating a 6 mm-radius sphere around the peak voxels of activity within the ACC ($X = 3$ $Y = 22$, $Z = 29$) and right AI ($X = 48$, $Y = 18$, $Z = 5$). Percent signal change was extracted from these ROIs with Marsbar software (http://marsbar.sourceforge.net/).

To test the potential interaction of participant culture and other-focusedness on activity within the ACC and R-AI, multiple regression was conducted using SPSS statistical analysis package (SPSS, IBM Corp.). Participant culture, other-focusedness index, and the interaction term of culture and other-focusedness were entered as predictors of percent signal change in the ACC and R-AI using multiple regression.

MNI coordinates were converted to Talairach using a non-linear transformation (http://imaging.mrc-cbu.cam.ac.uk/imaging/MniTalairach). Brodmann areas and brain regions were identified based on the Talairach Atlas (Talairach & Tournoux, 1988).

2.6. Scanner comparison

Prior cross-site and cross-cultural neuroimaging studies have demonstrated the viability of analyzing fMRI data collected from multiple scanner sites (Chiao et al., 2008; Friedman & Glover, 2006; Sutton et al. 2008). To confirm that fMRI signal quality was comparable across the two scanner sites in the present study, we compared susceptibility related signal drop out due to B_0 inhomogeneity across the CA and Korean participant groups (Chiao et al., 2008; Ojemann et al., 1997). These analyses were conducted within our primary region of interests, the ACC and R-AI, by drawing spheres with a radius of 6 mm around peak voxels within the ACC ($X = 3$ $Y = 22$, $Z = 29$) and R-AI ($X = 48$, $Y = 18$, $Z = 5$), and within control regions neutral to our hypotheses across the visual cortices with ROI masks for the bilateral calcarine fissure and the inferior, mid, and superior occipital lobes provided in the MarsBaR AAL library (Tzourio-Mazoyer et al., 2002). The activity within these regions was compared between participant groups during the control blocks of the task that consisted of making a button-press when viewing grey squares.

3. Results

3.1. Survey results

Analysis of the SCS responses indicated that the American and Korean participants did not significantly differ in independence (CA: $M = 4.64$, $SD = 0.73$; K: $M = 4.87$, $SD = 0.71$), interdependence (CA: $M = 4.63$, $SD = 0.68$; K: $M = 4.82$, $SD = 0.55$) or a composite index of interdependence minus independence ratings (CA: $M = -0.01$, $SD = 1.05$; K: $M = -0.05$, $SD = 0.53$). Groups also did not significantly differ in other-focusedness ratings (CA: $M = 3.13$, $SD = 0.80$; K: $M = 3.27$, $SD = 0.59$), all $ps > 0.05$.

3.2. Scanner comparison

Results from the ROI analyses conducted for scanner site comparison revealed no significant difference between CA and Korean participants in activity in the ACC, R-AI, or visual cortices during the control blocks of the task [*ACC*: CA, $M = 0.14$; $SD = 0.06$; K, $M = 0.02$, $SD = 0.26$; $t(25) = 0.11$;*R-AI*: CA, $M = 0.11$, $SD = 0.07$; K, $M = 0.12$, $SD = 0.23$; $t(25) = -0.14$; *Visual Cortices*: CA, $M = -0.36$, $SD = 0.09$; K, $M = -0.35$, $SD = 0.16$; $t(25) = -0.05$], all $ps > 0.05$. Furthermore, activity in these ROIs during the control blocks was not correlated with the other-focusedness index, $p > 0.05$. Given there was no significant group difference in signal change within ROIs during the hypothesis-neutral control condition (i.e. the control blocks) and no relationship between signal change and the other-focusedness index during the control blocks or within the control ROIs, we conclude that there was comparable fMRI signal quality across the two scanner sites. Thus, we consider differences in activity in the ROIs and relationships between the ROIs and other-focusedness during the experimental blocks as a product of task demands rather than SNR variations between sites.

3.3. Main effect of pain perception (whole brain contrasts)

The main effect of emotional pain comparing neural response during the perception of painful scenes relative to non-painful scenes revealed that across cultures, participants recruited greater patterns of activity in regions involved in social cognition, empathic/pain processing, and mirroring/imitation, such as the MPFC, ACC, R posterior insula, and L inferior frontal gyrus (Table 1)[6] .

Comparisons of activity during the perception of painful relative to non-painful scenes between cultures revealed that participants of the two cultures did not generally differ in activity in regions involved in social cognition and empathy, though Korean participants recruited greater activity in regions associated with mirroring/imitation, such as the bilateral inferior frontal gyrus, and emotion-processing regions, such as the right amygdala, compared to Caucasian-American participants (Table 2).

3.4. Whole-brain regression (other-focusedness covariate)

As predicted, across cultures, individual differences in other-focusedness were significantly and positively correlated with greater neural response within ACC and right insula. Participants also recruited significant activity in the left putamen and the right parahippacampal gyrus as a function of other-focusedness (Table 3) when viewing scenes of others in painful relative to non-painful situations.

To test our hypotheses of whether other-focusedness had discrepant influences on activity within the pain matrix (ACC and R-AI) between cultures when viewing the pain of others, we extracted the percent signal change within the ACC and R-AI during the contrast of painful relative to non-painful conditions and tested an interaction of culture and other-focusedness on activity in these regions.

Participant culture, other-focusedness index, and the interaction term of culture and other-focusedness were entered as predictors of percent signal change in the ACC and R-AI using multiple regression. As predicted, there was a significant interaction of culture and other-focusedness observed in the ACC, $R^2=0.58$, $F(3,26)=10.48$, $p<0.001$, $Beta=2.63$, $p=0.001$, and in the R-AI, $R^2=0.50$, $F(3,26)=7.75$, $p=0.001$, $Beta=2.01$, $t(22)=2.54$, $p<0.05$, such that other-focusedness was a stronger predictor of reactivity in the ACC and R-AI during the presentation of painful (vs. non-painful) scenes among Korean relative to American participants (Fig. 2). Among Korean participants, greater levels of other-focusedness corresponded to greater levels of reactivity in the ACC, $r(11)=0.80$, $p<0.005$, and in the R-AI, $r(11)=0.75$, $p<0.005$, when viewing others in painful relative to non-painful situations. Among American participants, greater levels of other-focusedness corresponded to higher levels of reactivity in the R-AI, $r(12)=0.56$, $p<0.05$, but not the ACC (*n.s.*).

To further investigate whether other-focusedness influences emotional pain processing to a greater extent within a collectivistic relative to an individualistic cultural context, we conducted whole-brain regressions with other-focusedness as a covariate independently among the Korean and American samples (Fig. 3). As expected, the analysis revealed that for the Korean participants, greater levels of other-focusedness corresponded to greater reactivity in the ACC and bilateral AI, as well as other regions associated with affective and social-cognitive processing, such as the right amygdala and MPFC (Table 4). Conversely, among the American participants, greater levels of other-focusedness did not correspond to greater activity within the networks associated with pain or empathic processing, but instead was reflected by greater levels of activity in the L orbitofrontal cortex, L putamen, and R inferior frontal cortex (Table 5).

When directly comparing activity across the whole brain as a function of greater levels of other-focusedness between the two participant groups, we observed patterns of activity that resembled the results of the whole-brain regression of other-focusedness for separately within each participant group. For the Korean > CA comparison, the analyses revealed a pattern similar to whole-brain regression of other-focusedness independently among the Korean sample. Relative to American participants, the Koreans exhibited greater activity in the right AI, bilateral amygdala, and MPFC as a function of greater levels of other-focusedness, though the right AI cluster did not survive the small volume correction (see Table 6). Furthermore, though no between-group differences were observed in ACC activity, Koreans exhibited greater activity in the posterior cingulate cortex than the American participants. Conversely, relative to the Korean participants, the American participants did not exhibit greater patterns of activity in regions typically associated with pain-relevant or empathic processing as a function of other-focusedness (see Table 6).

Table 1
fMRI results for the whole sample for the main effect of pain [$(CA_{Pain}+Korean_{Pain})>(CA_{NoPain}+Korean_{NoPain})$], $p<0.005$, extent threshold = 5 voxels.

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
56	−46	0	5.36	1820	22	R middle temporal gyrus
39	24	21	4.39	188	9	R middle/inferior frontal gyrus
−36	25	−16	3.85	8	47	L inferior frontal gyrus
−51	24	15	3.82	21	45	L inferior frontal gyrus
−48	21	5	3.63	43	45	L inferior frontal gyrus
−45	−75	23	3.63	17	39	L middle temporal gyrus
12	45	34	3.55	41	9	MPFC
−30	−75	23	3.36	47	19	L middle occipital gyrus
15	28	37	3.59	63	6	MPFC
45	−40	21	3.52	12	13	R insula
−39	−30	40	3.15	13	40	L inferior parietal lobule
−45	13	27	3.12	8	9	L middle frontal gyrus
−42	2	36	3.12	11	6	L precentral gyrus
−30	−56	44	3.08	8	7	L superior parietal lobule
−12	22	38	2.98	6	32	L anterior cingulate cortex
−24	−90	16	2.92	11	18	L middle occipital gyrus
−59	−16	26	2.80	6	3	L postcentral gyrus
42	16	−29	2.79	5	38	R superior temporal gyrus
51	−57	17	2.73	8	22	R superior temporal gyrus

4. Discussion

Overall, we found support for our hypothesis that other-focusedness, or the propensity to focus on and be affected by the experiences, internal states, and needs of others over oneself in social contexts, differentially modulates emotional pain processing within individualistic and collectivistic cultural contexts. In a collectivistic cultural context, where an 'outsider' perspective of the self may be readily adopted in social contexts, other-focusedness corresponds to stronger responses within regions associated with pain and empathic processing, such as the ACC and AI, and social cognition, such as the MPFC. By contrast, in an individualistic cultural context, where an “insider” perspective of the self may be adopted in social contexts, other-focusedness was not related to reactivity in these regions. Moreover, reactivity in pain-processing regions among the Korean participants to the suffering of others as a function of other-focusedness was elicited without explicit task demands to engage in empathic or pain-related processing, suggesting that other-focusedness may not only modulate reactivity to emotional pain, but also how readily or spontaneously such processes are engaged.

Together, these findings suggest that other-focusedness may serve different functions for navigating the social world within collectivistic and individualistic cultural contexts. Given the cultural norms and values of fitting in, harmony, self-improvement,

[6] These findings demonstrate that the present task is recruiting pain-related and social cognitive processing, but perhaps less robustly in comparison to other studies of pain perception and empathy for emotional pain (Mathur et al., 2010) given the lack of explicit processing demands or empathic judgments.

Table 2
(a) fMRI results for the whole sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)] for CA participants > Korean participants, $p < 0.005$, extent threshold = 5 voxels.

X	*Y*	*Z*	*Z* **score**	**Voxels**	**BA**	**Brain area**
−24	−68	45	4.09	19	7	L superior parietal lobule
24	−68	48	4.06	49	7	R superior parietal lobule
3	−45	−18	4.02	68	NA	R cerebellum
−21	−60	−25	3.86	8	NA	L cerebellum
−9	−68	−19	3.83	22	NA	L cerebellum
48	−70	6	3.73	60	19	R middle occipital gyrus
30	−72	26	3.39	21	31	R precuneus
−39	−73	4	3.33	25	19	L middle occipital gyrus
−30	−83	24	3.32	11	19	L middle occipital gyrus
42	−60	22	3.16	9	39	R middle temporal gyrus
−30	−82	−6	3.14	8	18	L middle occipital gyrus
0	−22	−24	3.11	6	NA	No gray matter
15	−59	−22	3.20	6	NA	R cerebellum
−30	11	46	3.10	12	6	L middle frontal gyrus
36	−76	−9	3.02	6	19	R inferior occipital gyrus
−18	−96	8	2.96	5	18	L cuneus
6	−65	−22	2.83	5	NA	R cerebellum

(b) fMRI results for the whole sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)] for Korean participants > CA participants, $p < 0.005$, extent threshold = 5 voxels

X	*Y*	*Z*	*Z* **score**	**Voxels**	**BA**	**Brain area**
48	−5	−33	4.13	24	20	R inferior temporal gyrus
48	−30	−14	4.11	39	20	R fusiform gyrus
62	−18	−17	4.04	5	20	R inferior temporal gyrus
−18	−63	25	3.84	14	31	L precuneus
62	−14	12	3.68	28	41	R transverse temporal gyrus
−6	−7	−20	3.68	7	NA	Hypothalamus
−57	−12	6	3.67	12	22	L superior temporal gyrus
18	−82	−16	3.62	8	NA	R cerebellum
−59	−19	23	3.61	27	22	L postcentral gyrus
−39	−74	−14	3.52	13	NA	L cerebellum
45	−5	22	3.51	14	9	R inferior frontal gyrus
−27	35	−9	3.48	6	47	L inferior frontal gyrus
59	6	11	3.34	5	44	R precentral gyrus
54	−9	−2	3.72	17	22	R superior temporal gyrus
21	−42	−16	3.13	11	NA	R cerebellum
−62	−7	−20	3.10	6	21	L inferior temporal gyrus
-48	−18	56	3.08	8	3	L postcentral gyrus
24	24	32	3.06	16	9	R medial frontal gyrus/ACC
30	−1	−23	3.04	13	NA	R amygdala
−62	−55	0	2.96	9	21	L middle temporal gyrus
−39	−10	−20	2.87	16	20	L sub-gyral
−36	40	34	2.87	5	9	L middle frontal gyrus
−62	3	8	2.86	5	6	L precentral gyrus
24	−67	1	2.84	5	19	R lingual gyrus
36	−1	−15	2.84	5	38	R superior temporal gyrus
−21	−10	−30	2.74	5	28	L parahippacampal gyrus

Table 3
(a) fMRI results for the whole sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)] with 'other-focusedness' as a positive covariate, $p < 0.005$, extent threshold = 5 voxels. *$p < 0.05$ corrected after small-volume correction.

X	*Y*	*Z*	*Z* **score**	**Voxels**	**BA**	**Brain area**
−21	14	−11	3.29	15	–	L Putamen
48	18	5	3.06	10	45	**R Insula***
3	22	29	2.99	8	32	**ACC***
18	5	−15	2.80	5	34	R parahippacampal gyrus

(b) fMRI results for the whole sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)] with 'other-focusedness' as a negative covariate, $p < 0.005$, extent threshold = 5 voxels

X	*Y*	*Z*	*Z* **score**	**Voxels**	**BA**	**Brain area**
42	−57	28	3.66	13	39	R superior temporal gyrus
9	−51	22	2.93	7	31	Posterior cingulate Cortex

and fulfillment of obligations, being attentive and sensitive to the perspectives and needs of others may exert an especially strong influence on shaping interpersonal perception and potentially empathic processing within collectivistic cultural environments. This does not suggest that other-focusedness is unimportant for interpersonal perception in individualistic cultural environments. As suggested by our ROI analyses, other-focusedness was also positively associated with reactivity in pain/empathic-processing

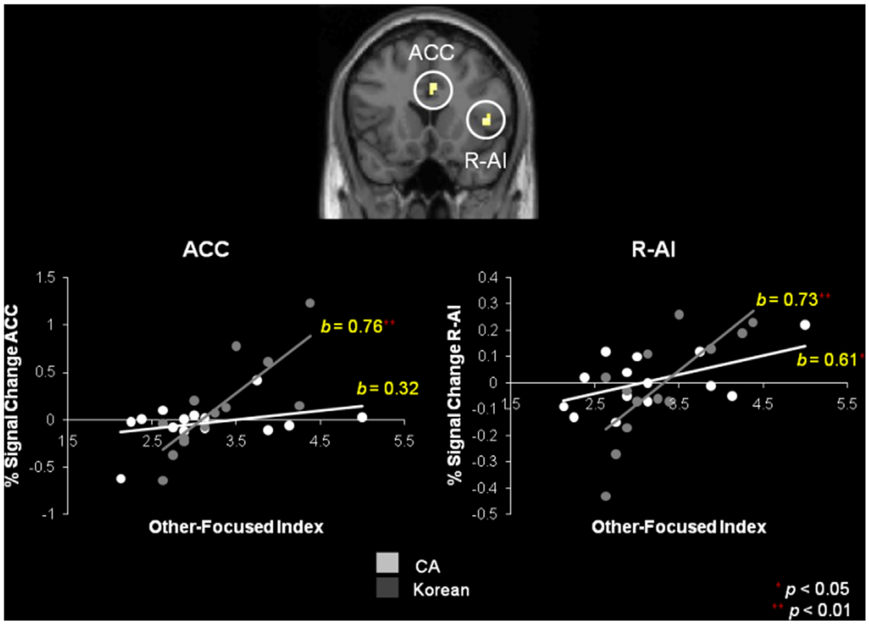

Fig. 2. Regressions analyses among the entire sample on activity within the ACC and right AI ROIs as a function of culture and other-focusedness. A significant interaction of culture and other-focusedness was observed in both the ACC, $Beta=2.63$, $p=0.001$, and in the R-AI, $Beta=2.01$, $p<0.05$, such that 'other-focusedness' was a stronger predictor of reactivity in the ACC and AI during the presentation of painful scenes among Korean relative to Caucasian-American participants.

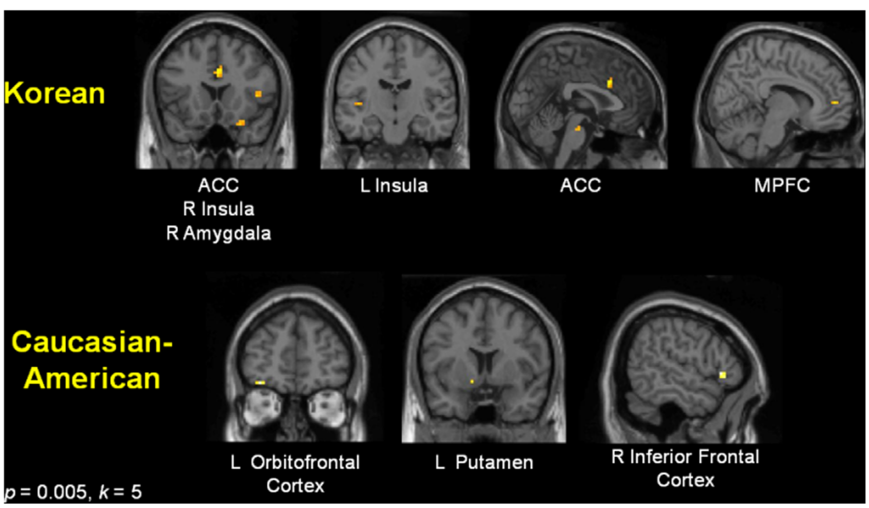

Fig. 3. Results of whole brain regressions using other-focusedness as a covariate independently among the Korean and CA participants. When viewing others in painful relative to non-painful situations, Korean participants, but not CA participants, recruit stronger activity from regions associated with pain and empathic processing, such as the ACC, bilateral insula, and MPFC as they endorse greater levels of other-focusedness.

regions among the American sample, especially the right AI, but to a significantly lesser extent compared to the Korean sample. Rather, these findings suggest that within an individualistic cultural environment where cultural norms and values of self-expression, personal choice, and pursuit of personal aspirations are promoted, attentiveness to the emotions and subjective experiences of the self may also critically contribute to the processes of interpersonal perception and empathy. Supporting this view, projection of one's own emotional and subjective states onto others and using the self as a model for understanding others is typically engaged by Americans to a greater extent than East-Asians when empathizing or seeking to understand the internal experiences of others (Cohen & Gunz, 2002; Cohen et al., 2007).

Though our participants were situated in two distinct cultural environments, they did not vary in their reported levels of interdependence, independence, or other-focusedness. This finding is not completely unexpected given that though societies may vary in cultural value and norms, there still remain marked individual differences within societies. Moreover, attentiveness and sensitivity to the perspectives and outcomes of others is an important process necessary for social functioning, and is mostly likely generally engaged within both cultures. But, this finding suggests that the discrepant influence of other-focusedness on automatic reactivity to emotional pain between the two cultures may be due to the modulation of the relationship between other-focusedness on pain perception by the cultural environment rather than by group differences in levels of other-focusedness or interdependence per se. This lends support to our hypothesis that the distinct demands and constraints to either focus on the experiences of the self or others during social interactions within individualistic and collectivistic cultural contexts may influence the relationship between other-focusedness and emotional pain perception across cultures. Though social neuroscience studies may conventionally seek to examine how group differences in

Table 4
(a) fMRI results for the Korean sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)], with 'other-focusedness' as a positive covariate, $p < 0.005$, extent threshold = 5 voxels. *$p < 0.05$ corrected after small-volume correction.

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
18	2	−18	4.15	37	34	R Amygdala
−39	35	9	3.97	22	46	L inferior frontal gyrus
3	19	27	3.35	13	24	**ACC***
27	19	−19	3.29	17	47	R inferior frontal gyrus
42	−9	0	3.27	5	–	**R Insula**
9	50	3	3.21	5	10	**Medial prefrontal cortex**
−45	−67	−2	3.2	5	37	L inferior temporal gyrus
−45	−59	−20	3.2	10	–	L cerebellum
18	23	−14	3.06	5	47	R inferior frontal gyrus
−42	−13	3	3.02	7	13	**L Insula**
45	2	−10	2.99	9	22	R superior yemporal gyrus
−48	−3	50	2.98	5	6	L precentral gyrus
45	18	5	2.98	6	45	**R Insula***
−18	8	−13	2.94	9	34	L subcallosal gyrus
3	−18	−19	6	6	–	No gray matter

(b) fMRI results for the Korean sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)], with 'other-focusedness' as negative covariate, $p < 0.005$, extent threshold = 5 voxels

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
−59	−8	17	4.32	19	43	L postcentral gyrus
59	−44	−5	3.95	8	37	R middle temporal gyrus
−39	22	−24	3.64	8	38	L temporal pole
−39	4	14	3.42	14	13	**L Insula**
24	−76	−1	3.35	5	18	R lingual gyrus
−48	2	39	3.24	5	6	L middle frontal gyrus
−12	−27	−21	2.99	5	–	L cerebellum
65	−28	32	2.76	6	40	R inferior parietal lobule

Table 5
(a) fMRI results for the Caucasian-American sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)], with 'other-focusedness' as a positive covariate, $p < 0.005$, extent threshold = 5 voxels.

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
−30	49	−15	3.69	7	11	L orbitofrontal cortex
56	23	−1	3.54	6	47	R inferior frontal gyrus
39	−57	−27	3.47	5	–	R cerebellum
−62	−45	35	3.3	8	40	L supplementary motor area
−12	3	−8	2.97	5	–	L putamen

(b) fMRI results for the Caucasian-American sample for the main effect of pain [(CA_{Pain}+$Korean_{Pain}$) > (CA_{NoPain}+$Korean_{NoPain}$)], with 'other-focusedness' as negative covariate, $p < 0.005$, extent threshold = 5 voxels

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
6	−44	49	3.77	31	7	R precuneus
−9	52	−10	3.28	6	11	**Medial prefrontal cortex**
56	−10	−22	3.18	22	20	Inferior temporal gyrus
9	−52	−43	2.98	5	–	R cerebellum
21	−54	22	2.94	35	31	R precuneus
−18	−60	31	2.83	6	31	L precuneus

cognitive, affective, or social processes may be represented neurobiologically via group differences in neural reactivity, theory and methods in cultural neuroscience proposes that even in the absence of observable cultural variation in psychological processes of interest, such processes may be represented by culturally-distinct profiles of neural activity within separate cultural contexts (Chiao & Ambady, 2007; Chiao et al., 2008; Tang et al. 2006). The current study further demonstrates the importance of incorporating neuroscience methods to examine how a psychological process, such as other-focusedness may serve distinct social functions across cultures.

The present study also demonstrates the utility of conceptualizing and measuring the dimensions of interdependence and independence as multi-dimensional constructs. Both independence and interdependence can manifest through a wide variety of cognitive, affective, and motivational processes, with each of these components being predictive of cultural variations in interpersonal processes in different social contexts (Gabriel & Gardner, 1999; Hardin et al., 2004; Oyserman et al., 2002). For instance, Asian/Asian-American and European-American samples have been noted to differ on some dimensions of independence and interdependence, but not others (Hardin et al., 2004). While attentiveness and sensitivity to the subjective experiences, needs, and outcomes of the self and others may serve as a mechanism wherein cultural environments may modulate emotional and empathic processing, other factors that define interdependence and independence more broadly, such as uniqueness, assertiveness, and consistency of behavior across contexts may be less directly relevant for shaping cultural variations in how individuals understand and empathize with the suffering of others.

In sum, we demonstrate that distinct avenues of navigating the social world promoted by individualistic and collectivistic cultural environments may modulate how readily people may process, and perhaps empathize, with the emotional pain of

Table 6
(a) fMRI results for Caucasian-American participants > Korean participants for the whole-brain regression on the main effect of pain [$(CA_{Pain}+Korean_{Pain}) > (CA_{NoPain}+Korean_{NoPain})$], with 'other-focusedness' as a positive covariate, $p < 0.005$, extent threshold = 5 voxels.

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
24	−68	48	4.58	136	7	R superior parietal lobule
−24	−68	45	4.23	30	7	L superior parietal lobule
54	−67	6	4.14	187	37	R middle temporal gyrus
3	−45	−18	3.55	29		R cerebellum
−30	−83	24	3.46	11	19	L middle occipital gyrus
51	10	22	3.36	21	44	R inferior frontal gyrus
−39	−73	1	3.21	35	19	L inferior occipital gyrus
−9	−68	−19	3.19	15		L cerebellum
−30	−82	−6	3.18	10	18	L middle occipital gyrus
−15	−93	10	3.07	6	18	Cuneus
−36	−59	−10	3.02	6		L cerebellum
48	−71	−12	2.82	7	19	R fusiform gyrus

(b) fMRI results for Korean participants > Caucasian-American participants for the whole-brain regression on the mMain effect of pain [$(CA_{Pain}+Korean_{Pain}) > (CA_{NoPain}+Korean_{NoPain})$], with 'other-focusedness' as a positive covariate, $p < 0.005$, extent threshold = 5 voxels

X	*Y*	*Z*	*Z* score	Voxels	BA	Brain area
48	−30	−14	4.88	93	20	R fusiform gyrus
18	−82	−16	4.80	23		R cerebellum
48	−5	−33	4.58	83	20	R inferior temporal gyrus extending into **Amygdala**
62	−18	−17	4.48	6	20	R inferior temporal gyrus
−18	−62	25	4.15	19	31	L precuneus
−42	−71	−14	4.14	64		L cerebellum
45	−5	22	4.10	30	9	L inferior frontal gyrus
−36	25	−16	4.07	7	47	L inferior frontal gyrus
−56	−14	6	4.04	13	22	L superior temporal gyrus
−59	−19	23	4.83	46	46	L postcentral gyrus
−27	35	−9	3.89	26	47	L inferior frontal gyrus
24	34	32	3.76	69	9	R medial frontal gyrus
−6	−7	−20	3.70	6		Hypothamalus
51	11	−23	3.62	9	38	R superior temporal gyrus
−48	−18	56	3.54	14	3	L postcentral gyrus
21	−42	−16	3.49	14		R cerebellum
−21	34	29	3.48	12	9	L medial frontal gyrus
62	−14	12	3.47	21	42	R transverse temporal gyrus
54	−9	−5	3.47	14	22	R superior temporal gyrus
−39	−10	−20	3.44	32	20	L inferior temporal gyrus extending into **Amygdala**
−62	−7	−20	3.43	10	21	L inferior temporal gyrus
−36	40	34	3.34	21	9	L middle frontal gyrus
−59	−47	−10	3.33	5	37	L middle temporal gyrus
24	−67	1	3.31	15	19	R lingual gyrus
59	6	11	3.29	5	44	R postcentral gyrus
−36	−25	34	3.29	9	2	L postcentral gyrus
12	45	34	3.27	11	9	R superior frontal gyrus extending into **MPFC**
−62	3	8	3.27	10	6	L precentral gyrus
−62	−55	3	3.25	19	21	L middle temporal gyrus
12	−39	43	3.24	6	31	R posterior cingulate cortex
−51	2	−15	3.24	5	21	L middle temporal gyrus
−42	−2	−30	3.18	9	21	L middle temporal gyrus
−42	29	4	3.08	9	13	L inferior frontal gyrus
−21	−10	−30	3.01	16	28	L uncus
−12	−39	30	2.94	12	31	L posterior cingulate cortex
36	16	19	2.84	7	13	**R anterior insula**
−56	5	33	2.82	7	6	L precentral gyrus
3	−81	7	2.79	5	18	R lingual gyrus

others. Given the varying constraints and expectations placed upon the self in social situations, sensitivity and attentiveness to the internal states and outcomes of others may be an important determinant of how readily empathic processes are engaged in collectivistic cultural contexts, but less so in individualistic ones. Importantly, these findings suggest that the cultural environment and context may be an essential modulator of the types of relational and interpersonal processing styles that may influence empathy. Promising future directions for research could involve experimentally manipulating levels of other-focusedness or self-focusedness as a culturally-tailored mechanism for respectively increasing social sensitivity and empathy among members of collectivistic and individualistic cultures.

Acknowledgements

We thank G. Bebko, D. Bridge, K. Rotella, L. Hechtman, N. Pornpattananangkul, and the KAIST Image Systems Computing Laboratory for helpful discussion. This work was supported by National Science Foundation grants BCS-0720312 and BCS-0722326 to J.Y.C and support from the National Science Foundation East Asia Pacific Summer Institute Fellowship and Korea

Science and Engineering Foundation Fellowship to B.K.C., and by the Institute of Education Sciences, U.S. Department of Education, Grant #R205B080027 to Northwestern University. The opinions expressed are those of the authors and do not represent views of the Institute or U.S. Department of Education.

References

Botvinick, M., Jha, A. P., Bylsma, L. M., Fabian, S. A., Solomon, P. E., & Prkachin, K. M. (2005). Viewing facial expressions of pain engages cortical areas involved in the direct experience of pain. *Neuroimage*, *25*, 312–319.

Brislin, R. (1970). Back-translation for cross-cultural research. *Journal of Cross-Cultural Psychology*, *1*, 185–216.

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: Guilford Press.

Chiao, J. Y., & Blizinsky, K. D. (2010): Culture-gene coevolution of individualism-collectivism and the serotonin transporter gene (5-HTTLPR). *Proceedings of the Royal Society B: Biological Sciences, 277*, 529–537.

Chiao, J. Y., Mathur, V. A., Harada, T., & Lipke, T. (2009). Neural basis of preference for human social hierarchy versus egalitarianism. *Annals of the New York Academy of Sciences*, *1167*, 174–181.

Chiao, J. Y., Iidaka, T., Gordon, H. L., Nogawa, J., Bar, M., Aminoff, E., et al. (2008). Cultural specificity in amygdala response to fear faces. *Journal of Cognitive Neuroscience*, *20*, 2167–2174.

Cohen, D., & Gunz, A. (2002). As seen by the other: Perspectives on the self in the memories and emotional perceptions of Easterners and Westerners. *Psychological Science*, *13*, 55–59.

Cohen, D., Hoshino-Browne, E., & Leung, A. K. (2007). Culture and the structure of personal experience: insider and outsider phenomenologies of the self and social world. *Advances in Experimental Social Psychology*, *39*, 1–67.

Davis, M. H. (1994). *Empathy: A social psychological approach*. Madison, WI: Brown & Benchmark.

Decety, J., & Jackson, P. L. (2006). A social-neuroscience perspective on empathy. *Current Directions in Psychological Science*, *15*, 54–58.

de Waal, F. B. M. (2008). Putting the altruism back into altruism: the evolution of empathy. *Annual Reviews Psychology*, *59*, 279–300.

Fincher, C. L., Thornhill, R., Murray, D. R., & Schaller, M. (2008). Pathogen prevalence predicts human cross-cultural variability in individualism/collectivism. *Proceedings of the Royal Society B*, *275*, 1279–1285.

Friedman, L., & Glover, G. H. (2006). Reducing interscanner variability of activation in a multicenter fMRI study: controlling for signal-to-fluctuation-noise-ratio (SFNR) differences. *Neuroimage*, *33*, 471–481.

Friston, K. J., Holmes, A. P., Worsley, K. J., Poline, J. P., Frith, C. D., & Frackowiak, R. S. J. (1995). Statistical parametric maps in functional imaging: a general linear approach. *Human Brain Mapping*, *2*, 189–210.

Gabriel, S., & Gardner, W. L. (1999). Are there "his" and "hers" type of interdependence? The implications of gender differences in collective versus relational interdependence for affect, behavior, and cognition. *Journal of Personality and Social Psychology*, *77*, 642–655.

Gilovich, T., Medvec, V. H., & Savitsky, K. (2000). The spotlight effect in social judgment: an egocentric bias in estimates of the salience of one's own actions and appearance. *Journal of Personality and Social Psychology*, *78*, 211–222.

Hardin, E. E., Leong, F. T. L., & Bhagwat, A. A. (2004). Factor structure of the self-construal scale revisited: implications for the multidimensionality of self-construal. *Journal of Cross-Cultural Psychology*, *35*, 327–345.

Hardin, E. E. (2006). Convergent evidence for the multidimensionality of self-construal. *Journal of Cross-Cultural Psychology*, *37*, 516–521.

Hein, G., & Singer, T. (2008). I feel how you feel but not always: the empathic brain and its modulation. *Current Opinion in Neurobiology*, *18*, 153–158.

Heine, S. J. (2005): Constructing good selves in Japan and North America. In R. M. Sorrentino, D. Cohen, J. M. Olson, and M. P. Zanna (Eds.), *Culture and social behavior: The 10th Ontario symposium*. Hillsdale, NJ: Lawrence Erlbaum. pp. 115–143.

Hofstede, G. (2001). *Culture's consequences: comparing values, behaviors, institutions, and organizations across nations* (2nd Ed.). Thousand Oaks, CA: Sage Publications, Inc.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of others? A window into the neural processes involved in empathy. *Neuroimage*, *24*, 771–779.

Lamm, C., Batson, C. D., & Decety, J. (2007). The neural substrate of human empathy: effects of perspective-taking and cognitive appraisal. *Journal of Cognitive Neuroscience*, *19*, 42–58.

Lin, S., Keysar, B., & Epley, N. (2010). Reflexively mindblind: Using theory of mind to interpret behavior requires effortful attention. *Journal of Experimental Social Psychology*, *46*, 551–556.

Markus, H, & Kitayama, S. (1991). Culture and the self: implications for cognition, emotion, and motivation. *Psychological Review*, *98*, 224–253.

Mathur, V. A., Harda, T., Lipke, T., & Chiao, J. Y. (2010). Neural basis of extraordinary empathy and altruistic motivation. *Neuroimage*, *51*, 1468–1475.

Nakamura, K., Kitanishi, K., Miyake, Y., Hashimoto, K., & Kubota, M. (2002). The neurotic versus delusional subtype of taijin-kyofu-sho: their DSM diagnoses. *Psychiatry & Clinical Neurosciences*, *56*, 595–601.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, *108*, 291–310.

Norasakkunkit, V., Kitayama, S., & Uchida, Y. (2011). Social anxiety and holistic cognition: self-focused social anxiety in the United States and other-focused anxiety in Japan. *Journal of Cross-Cultural Psychology*, 1–16.

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

Ojemann, J. G., Akbudak, E., Snyder, A.Z, McKinstry, R. C., Raichle, M. E., & Conturo, T. E. (1997). Anatomic localization and quantitative analysis of gradient refocused echo-planar fMRI susceptiblity artifacts. *Neuroimage*, *6*, 156–167.

Preston, S. D., & de Waal, F. B. M. (2003). Empathy: its ultimate and proximate bases. *Behavioral and Brain Sciences*, *25*, 1–20.

Singelis, T. M. (1994). The measurement of independent and interdependent self-construals. *Personality and Social Psychology Bulletin*, *20*, 580–591.

Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science*, *303*, 1157–1162.

Suh, M., Diener, E., Oishi, S., & Triandis, H. C. (1998). The shifting basis of life satisfisfaction judgments across cultures: emotions versus norms. *Journal of Personality and Social Psychology*, *74*, 482–493.

Sutton, B. P., Goh, J., Hebrank, A., Welsh, R. C., Chee, M. W. L., & Park, D. C. (2008). Investigation and validation of intersite fMRI studies using the same imaging hardware. *Journal of Magnetic Resonance Imaging*, *28*, 21–28.

Talairach, J., & Tournoux, P. (1988). *Co-planar stereotaxic atlas of the human brain: 3-dimensional proportional system – an approach to cerebral imaging*. New York, NY: Theime Medical Publishers.

Tang, Y., Zhang, W., Chen, K., Feng, S., Ji Y., Shen, J., et al. (2006): Arithmetic processing in the brain shaped by cultures. *Proceedings of the National Academy of Sciences, 103*, 10775–10780.

Triandis, H. C. (1994). *Culture and social behavior*. New York: McGraw-Hill.

Tzourio-Mazoyer, N., Landeau, B., Papathanassiou, D., Crivello, F., Etard, O., Delcroix, N., Mazoyer, B., & Joliot, M. (2002). Automated anatomical labeling of activations in SPM using a macroscopic anatomical parcellation of the MNI MRI single-subject brain. *Neuroimage*, *15*, 273–289.

Vorauer, J. D., & Ross, M. (1999). Self-awareness and feeling transparent: failing to suppress one's self. *Journal of Experimental Social Psychology*, *35*, 415–440.

Wong, R. Y.-m., & Hong, Y.-y (2005). Dynamic Influences of Culture on Cooperation in the Prisoner's Dilemma. *Psychological Science*, *16*(6), 429–434.

Wu, S., & Keysar, B. (2007). Cultural effects on perspective taking. *Psychological Science*, *18*, 600–606.