doi:10.1093/scan/nss103 SCAN (2014) 9, 73–80

Sociocultural patterning of neural activity during self-reflection

Yina Ma,[1] Dan Bang,[2] Chenbo Wang,[1] Micah Allen,[2] Chris Frith,[2,3] Andreas Roepstorff,[2,4] and Shihui Han[1]
[1]Department of Psychology, Peking University, 5 Yiheyuan Road, Beijing 100871, P. R. China, [2]Center of Functionally Integrative Neuroscience, University of Aarhus Nørrebrogade 44, Building 10G, 8000 Århus C, Denmark, [3]Wellcome Department of Imaging Neuroscience, Institute of Neurology, University College London, 12 Queen Square, London WC1N 3BG, UK, and [4]Department of Social Anthropology, University of Aarhus, Nørrebrogade 44, Building 10G, 8000 Århus C, Denmark

Western cultures encourage self-construals independent of social contexts, whereas East Asian cultures foster interdependent self-construals that rely on how others perceive the self. How are culturally specific self-construals mediated by the human brain? Using functional magnetic resonance imaging, we monitored neural responses from adults in East Asian (Chinese) and Western (Danish) cultural contexts during judgments of social, mental and physical attributes of themselves and public figures to assess cultural influences on self-referential processing of personal attributes in different dimensions. We found that judgments of self *vs* a public figure elicited greater activation in the medial prefrontal cortex (mPFC) in Danish than in Chinese participants regardless of attribute dimensions for judgments. However, self-judgments of social attributes induced greater activity in the temporoparietal junction (TPJ) in Chinese than in Danish participants. Moreover, the group difference in TPJ activity was mediated by a measure of a cultural value (i.e. interdependence of self-construal). Our findings suggest that individuals in different sociocultural contexts may learn and/or adopt distinct strategies for self-reflection by changing the weight of the mPFC and TPJ in the social brain network.

Keywords: culture; self; fMRI; medial prefrontal cortex; temporoparietal junction

INTRODUCTION

The persistent debate on self-concept in philosophy, psychology and other disciplines has inspired brain imaging studies that investigated neural representations of self-concept such as one's own personality traits (Northoff *et al.*, 2006; Lieberman, 2007). Using a self-referential task that requires trait judgments of oneself and a public figure (Rogers *et al.*, 1977), researchers found increased activity associated with self-reflection in several brain regions with the medial prefrontal cortex (mPFC) as the most consistent finding (e.g. Kelley *et al.*, 2002; Heatherton *et al.*, 2006; Moran *et al.*, 2006, 2009; see Heatherton, 2011 for a recent review). The mPFC may be involved in encoding of self-relevance of stimuli (Northoff *et al.*, 2006; Han and Northoff, 2009) since trait words rated high *vs* low in self-relevance increased mPFC activity (Moran *et al.*, 2006) and mPFC activity correlated with memory performances on recall of self-related trait words (Macrae *et al.*, 2004; Ma and Han, 2011).

As self-concept is socially constructed (Hogg, 2003), the brain activity involved in representation of the self and others may be contextually dependent and affected by sociocultural experiences. Indeed, recent functional magnetic resonance imaging (fMRI) studies have shown evidence that cultural experiences shape neural representations of personal traits of close others in relation to the self in the mPFC. Zhu *et al.* (2007) found that trait judgments of a close other (e.g. mother) *vs* a public figure activated the mPFC involved in self-referential judgments, and this effect was evident in Chinese individuals but not in English-speaking western individuals at the same threshold (the results of Chinese participants were replicated by Wang *et al.* (2012)). This finding suggests that shared neural representations of the self and a close other are influenced by an individual's sociocultural experiences. The subsequent research found that, when primed with Western compared with East Asian cultural symbols, bicultural individuals showed greater mPFC activity in the contrast of trait judgments of oneself *vs* a close other (Ng *et al.*, 2010). In addition, priming East Asian *vs* Western cultural concepts led to greater mPFC activity that differentiated between contextual *vs* general self-descriptions of personality traits in bicultural individuals (Chiao *et al.*, 2009a). These findings indicate that the neural activity engaged during self-reflection is sensitive to temporal exposure to specific cultural symbols or concepts.

The previous findings of cultural differences in neural representations of the self and close others are consistent with a psychological model proposed by Markus and Kitayama (1991, 2010) which addresses cultural differences in the relationship between the self and others. According to this model, social interactions in Western cultural contexts produce a sense of self as separate or independent from others. In contrast, social interactions in East Asian cultural contexts produce a sense of self as connected to or interdependent with others. Nevertheless, there has been no direct evidence for differences in neural representations of self-construals between Western and East Asian societies. The previous studies that scanned two cultural groups did not find significant cultural group difference in mPFC activity underlying self-reflection possibly due to the small sample size used in these studies (i.e. 13 Chinese and 13 Westerners in Zhu *et al.*, 2007; 12 Japanese and 12 Americans in Chiao *et al.*, 2009b). Thus, it remains unclear whether the brain activity engaged during self-reflection is different between individuals who grow up in Western and East Asian cultural contexts. It is also unknown to what extent putative difference in neural activity involved in self-reflection between Western/East Asian societies is mediated by specific cultural values. Finally, although it has been known since William James (1950) that self-concept consists of different dimensions such as social roles, personality traits and physical attributes, no research has examined whether brain activities engaged in different aspects of self-concept are differentially influenced by cultural contexts, though

Received 2 July 2012; Accepted 17 August 2012
Advance Access publication 5 September 2012
This work was supported by the National Natural Science Foundation of China (Project 81161120539, 91024032 and 30910103901), the National Basic Research Program of China (973 Program 2010CB833903), the Danish National Research Foundation through the Interacting Minds project and the Danish Ministry for Research and Innovation through MIND*lab*. We thank Torben Ellegaard Lund for help with fMRI data collection and Michael Varnum for proof reading of the article.
Correspondence should be addressed to Shihui Han, Department of Psychology, Peking University, 5 Yiheyuan Road, Beijing 100871, P. R. China. E-mail: shan@pku.edu.cn
Correspondence may also be addressed to Andreas Roepstorff, Department of Social Anthropology, University of Aarhus, Nørrebrogade 44, Building 10G, 8000 Århus C, Denmark.

a recent research suggests that the dorsal mPFC is more engaged for personal trait than physical appearance judgments, whereas the posterior cingulate is more engaged for appearance than personal trait judgments (Moran *et al.*, 2011).

If, as claimed by Markus and Kitayama (1991, 2010), individuals in Western cultural contexts define identity in terms of inner qualities and focus on their own attributes, such cultural practices may enhance encoding of self-related stimuli compared with East Asian cultural experiences. On the other hand, if individuals from East Asian societies to a larger degree construct self-identity with reference to social relations and emphasize others' expectations and thoughts, self-reflections may engage brain regions involved in the processing of others' thoughts and beliefs. These predictions have not been tested directly in brain imaging research despite the recent development of cultural neuroscience studies of self-reflection (Han and Northoff, 2008, 2009; Kitayama and Park, 2010; Han *et al.*, 2013).

In this study, we scanned college students using fMRI, during judgments of one's own social roles, personal traits and physical attributes in a country dominated by a cultural value of independence (i.e. Denmark; Thomsen *et al.*, 2007) and a country characterized by a high interdependent cultural value (i.e. China; Li *et al.*, 2006). We tested the hypothesis that mPFC activity linked to encoding of personal attributes of the self *vs* a public figure would be greater in Danes than in Chinese. In contrast, brain regions related to mentalizing about others may be more strongly involved in Chinese than in Danes during reflection of one's own *vs* a public figure's social roles, which are key to the connection between self and others (Raeff, 2004). A candidate brain region for this effect is the temporoparietal junction (TPJ) as it is involved in understanding of others' belief (Saxe and Kanwisher, 2003) and its lesions produce mentalizing impairments (Samson *et al.*, 2004). The TPJ is also engaged during reflection on one's own mental states in Westerners (Vogeley *et al.*, 2001; Jenkins and Mitchell, 2011). A recent fMRI study of Koreans found that combined judgments of personality traits and social identity on the self *vs* a public figure also activated the bilateral TPJ (Sul *et al.*, 2012). In addition, the activity in the TPJ was associated with a cultural value of interdependence measured using the Self-Construal Scale (SCS; Singelis, 1994). However, as these studies scanned participants from only one culture group, it remains unknown whether participants from Western and East Asian cultural societies employed distinct patterns of neural activity in the mPFC and TPJ during self-reflection.

By comparing attribute judgments of the self and a public figure, we examined if mPFC and TPJ activities during self-reflection on personal attributes would show significant differences in Chinese and Danish participants. Furthermore, to test whether different aspects of self-construals were similarly affected by cultural contexts, we scanned the participants while they made attribute judgments across three dimensions: social roles, personality traits and physical attributes. To evaluate whether cultural values regarding self-construals (i.e. interdependence) would mediate differences in brain activity involved in self-reflection between cultural groups, participants completed the SCS (Singelis, 1994) after scanning. The measure of interdepence was then used in a mediation analysis to assess whether group differences in mPFC and TPJ activity, if any, were mediated by the cultural value of interdependence. Our work recruited 30 subjects from each cultural group and this allowed us to estimate the effect of sample size on the observed cultural group differences in the neural activity engaged in self-reflection in our study.

METHODS

Participants

Thirty Chinese (15 males, 18–28 years, mean age ± s.d. = 22.7 ± 1.90 years) and 30 Danish university college students (15 males, 18–28 years, mean age ± s.d. = 25.0 ± 4.09 years) were recruited in this study. All participants were right-handed, had normal or corrected-to-normal vision and reported no neurological or psychiatric diagnoses. Informed consent approved by local ethics committees was obtained from all participants prior to the study.

Stimuli and procedure

Stimuli consisted of two sets of items in Chinese and in Danish so that stimuli were presented in native language for each participant. The Chinese and Danish items were identical in content, were created by two psychologists and were verified by a bi-lingual speaker. Stimuli used during the scanning procedure were delivered through an LCD projector onto a rear projection screen. There were three categories of words or phrases describing the mental (i.e. personality traits, e.g. 'diligent' and 'talkative'), physical (i.e. the physical appearance, e.g. 'curly hair' and 'wrinkled') and social (i.e. social roles/identities, e.g. 'tenant' and 'professor') aspects of people. Each category consisted of 80 items, and 40 items were randomly chosen for each participant (see Supplementary Table S1).

Participants judged whether a given item described the self (self-judgment), a well-known gender-/nation-matched athlete (public-figure-judgment; Liu Xiang, a male Chinese athlete, and Liu Xuan, a female Chinese athlete, were used for Chinese male and female participants, respectively. Nicklas Bendtner, a male Danish athlete, and Caroline Wozniacki, a female Danish athlete, were used for Danish male and female participants, respectively) or their mother (the results of mother-judgments will be reported in an independent paper). The responding hand and the assignment of fingers to yes/no responses were counterbalanced across subjects. A font judgment (bold- *vs* light-faced item) was included to control for the effects of low-level sensory/perceptual processing and motor responses. Thirty trials were given for practice before the scanning procedure. Each type of judgments was presented in a single block using a block design. There were five functional scans (10 blocks/scan and 8 items/block). Each item was presented for 2 s followed by a 1 s central fixation. Two successive blocks were intervened by a 10 s fixation block. Different blocks in each scan were presented in a random order. After scanning, participants completed SCS to assess their interdependence of self-construals on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). Interdependence was defined as sum score of interdependent items minus sum score of independent items. Higher scores indicate a greater cultural value of interdependence in self-construals. Participants' subjective socioeconomic status was estimated using the socioeconomic status ladder (Kilpatrick and Cantril, 1960). The Inclusion of Other in the Self (IOS) scale (Aron *et al.*, 1992) was a single-item pictorial measure to evaluate the relationship closeness of the self and public figures. Participants were presented with seven Venn-like diagrams representing different degrees of overlap of two circles and were asked to select the picture that best describes their relationship with the public figure whom participants made attribute judgments on during scanning.

Imaging parameters

As quantitative comparisons of contrast estimates derived from cognitive experiments can reliably be compared across two sites using the same type of scanner (Sutton *et al.*, 2008), we collected brain imaging data from two cultural groups using identical vendor's instrumentation and imaging parameters. Functional brain images were acquired using identical scanners (3.0-Tesla Siemens Trio) at the MRI Center for Brain Research located in the Biophysics Institute in Beijing, China, and the Center of Functionally Integrative Neuroscience located in Aarhus University Hospital in Aarhus, Denmark. Blood oxygen level

dependent gradient echo planar images (EPIs) were obtained using a 12-channel head coil ($64 \times 64 \times 32$ matrix with $3.44 \times 3.44 \times 5.0$ mm spatial resolution, repetition time (TR) = 2000 ms, echo time (TE) = 30 ms, flip angle (FA) = 90° and field of view = 24×24 cm) during the judgment tasks. A high-resolution T1-weighted structural image ($256 \times 256 \times 144$ matrix with a spatial resolution of $1 \times 1 \times 1.33$ mm, TR = 2530 ms, TE = 3.37 ms, inversion time (TI) = 1100 ms and FA = 7°) was subsequently acquired.

Imaging analysis

Preprocessing

The functional image data were analyzed by using the general linear model (GLM) for event-related designs in SPM2 (the Wellcome Trust Centre for Neuroimaging, London, United Kingdom). The functional images were realigned to the first scan to correct for head motion. Six movement parameters (translation: x, y and z; rotation: pitch, roll and yaw) were included in the statistical model. The anatomical image was co-registered with the mean realigned functional image produced during the process of realignment. The anatomical images and functional images were normalized to the standard T1 and EPI Montreal Neurological Institute (MNI) templates, respectively. Functional images were then spatially smoothed using an isotropic Gaussian kernel of 8 mm full-width half-maximum.

Region-of-interest analysis

Region-of-interest (ROI) analyses were conducted to test our hypotheses about the cultural group differences in the mPFC and TPJ activity associated with self-reflection. ROIs were defined using functionally defined brain regions in the previous research. As the coordinates of the mPFC activation were slightly different between Chinese and Westerners (Zhu *et al.*, 2007), we used the coordinates of the mPFC activation of East Asian and Westerner in Zhu *et al.* (2007) to define the mPFC for Chinese (8/55/6) and Danes (0/51/3), respectively. The same coordinates (MNI coordinates: −6/45/3; Jenkins *et al.*, 2008) were also used to define the mPFC for both participant groups. The results of ROI analyses based on the different or same coordinates were similar. The TPJ was constructed based on coordinates of the TPJ involved in mentalizing other's belief (54/−54/24 and −48/−69/21 for right and left TPJ; Saxe and Wexler, 2005). Spheres with 5 mm radii were constructed with the center at the coordinates of the mPFC and TPJ. The parameter estimates of signal intensity were calculated from each ROI using MarsBaR 0.38 (http://marsbar.sourceforge.net) and subjected to a repeated-measures analysis of variance (ANOVA) with Group (Chinese *vs* Danish) as a between-subject variable, Judgment (self-judgment *vs* public-figure-judgment) and Dimension (mental, physical and social attributes) as independent within-subject variables. The ROIs defined were also used for the following sample size analysis: discriminant analysis and mediation analysis.

Whole-brain analysis

Whole-brain analysis used a hierarchical random-effects model. In the first level, the onsets and durations of each condition were modeled using a GLM for each participant. All conditions (i.e. judgments of mental/physical/social attributes of the self/mother/public figure, font judgment and fixation) were included in the model. A box-car function was used to convolve with the canonical hemodynamic response in each condition. Contrasts between self- *vs* public-figure-judgments were calculated in the mental, social and physical blocks, respectively, to define neural activities related to processes of mental, physical and social aspects of the self. Random effect analyses were then conducted based on statistical parameter maps from each subject to allow population inference. Significant activations were identified using a threshold of $P < 0.05$ (false discovery rate (FDR) corrected for multiple comparisons).

To further examine the cultural difference in neural activity at the whole brain level, we first conducted a one-way ANOVA of the contrast images between self- and public-figure-judgments to assess the group differences at a voxel-wise threshold of $P < 0.001$ (uncorrected). This lenient threshold was used to define all potential brain regions engaged in self-reflection that can be further tested for cultural group differences. The *F*-statistic map representing differential activities between Chinese and Danes was then used as the masks for the small-volume correction using the WFU PickAtlas (Maldjian *et al.*, 2003) for subsequent two-sample *t*-test at a threshold of $P < 0.05$ (FDR corrected for multiple comparisons).

See supplementary information for methods of the sample size analysis, psychophysiological interaction analysis, discriminant analysis and mediation analysis.

RESULTS

Behavioral results

Endorsement of the cultural value of interdependence was significantly greater in Chinese than in Danes (8.13 ± 8.85 *vs* 2.45 ± 6.49, $t = 2.819$, $P = 0.007$), indicating a reliable cultural value difference between participants from the two societies. The subjective socioeconomic status did not differ between the two groups (5.92 ± 1.78 *vs* 6.10 ± 1.43, $t = -0.440$, $P > 0.6$). The rating scores of the IOS scale did not differ significantly between Chinese and Danes (Danish (1.52 ± 1.09); Chinese (1.33 ± 0.48); $t\ (58) = 0.844$, $P = 0.402$), suggesting comparable relationship closeness between the self and public figures in the two cultural groups.

The ratio of 'yes' responses and reaction times (Supplementary Table S2) were subjected to repeated-measures ANOVAs with Judgment (self *vs* public figure) and Dimensions (social, mental and physical) as independent within-subject variables and Group (Chinese *vs* Danes) as a between-subject variable. Danes and Chinese identified comparable number of items as appropriate to describe the mental/physical/social attributes of the self and the public figure ($Fs < 1$). Participants responded faster to self- than to public-figure-judgments in the mental and social blocks ($F(1, 58) = 9.905$ and 75.07, $Ps < 0.005$), but the pattern did not differ between Danes and Chinese ($Ps > 0.3$). Danes responded faster to self- than to public-figure-judgments ($F(1,29) = 6.266$, $P = 0.018$), whereas Chinese showed the reverse trend ($F(1,29) = 3.912$, $P = 0.058$) during self-reflection of physical attributes.

Brain imaging results

Socioculturally patterned activity associated with self-reflection

We first conducted ROI analyses to test whether mPFC and TPJ activities showed opposite patterns of cultural group difference. The parameter estimates of signal intensity in the mPFC and TPJ were subjected to a repeated-measures ANOVA with Group (Chinese *vs* Danish) as a between-subject variable, Judgment (self-judgment *vs* public-figure-judgment) and Dimension (mental, physical and social attributes) as independent within-subject variables. This showed that self-judgments induced significantly greater mPFC activity compared with public-figure-judgments across the three dimensions ($F(1,58) = 47.527$, $P < 0.001$). However, mPFC activity underlying self-reflection was greater in Danes than in Chinese ($F(1,58) = 17.011$, $P < 0.001$). The cultural group difference in the mPFC activity was true regardless whether participants performed judgments on mental, physical or social attributes ($F(1,58) = 6.042$, 10.582 and 5.846, $Ps < 0.05$, Figure 1A, see Supplementary Figure S1 for parameter estimates of signal intensity

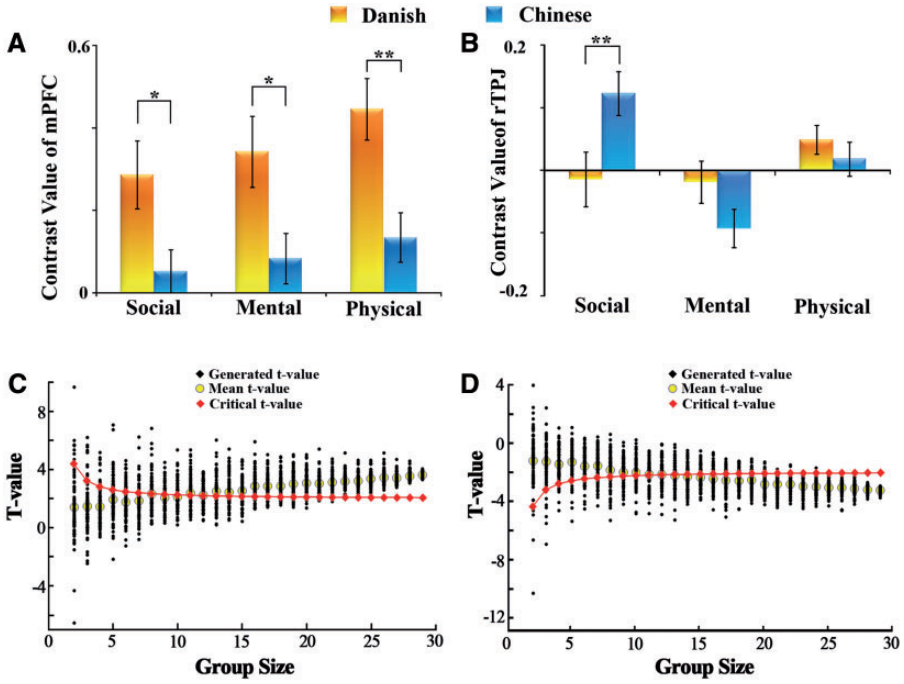

Fig. 1 Results of the ROI Analysis. (**A**) The contrast values of mPFC activity between self- and public-figure-judgments. The mPFC activity underlying self-reflection was greater in Danes than in Chinese in all the three dimensions. (**B**) The contrast values of the right TPJ activity between self- and public-figure-judgments of social roles. Relative to Danes, Chinese showed greater activity in the right TPJ. (**C**) The sample size analysis of the contrast values of mPFC activity in the social blocks. Each black dot represents a *t*-value of a two sample *t*-test conducted on the contrast values of the mPFC activity in social role judgments of the self *vs* a public figure. The yellow circle represents the mean *t*-value of the 100 two-sample *t*-tests at each group size (2–29). The positive *t*-values indicate that the mPFC activity is greater in Danes than in Chinese. The red diamond stands for the critical *t*-value of each sample size. (**D**) The sample size analysis of the contrast value of right TPJ activity in the social blocks. The negative *t*-values indicate that the TPJ activity is smaller in Danes than in Chinese. $^{*}P < 0.05$, $^{**}P < 0.01$.

to self- and public-figure-judgments relative to font judgments in mental, social and physical blocks, respectively). The ANOVAs of the bilateral TPJ activity showed a significant three-way interaction of Judgment × Dimension × Group (left TPJ: $F(2,116) = 7.245$, $P < 0.001$; right TPJ: $F(2,116) = 7.672$, $P < 0.001$). Chinese showed significantly stronger TPJ activity than Danes during self-reflection on social attributes (left TPJ: $F(1,58) = 9.308$, $P = 0.003$; right TPJ: $F(1,58) = 8.979$, $P = 0.004$, Figure 1B) but not during self-reflection on physical or mental attributes ($Ps > 0.1$, see Supplementary Figure S2 for parameter estimates of signal intensity to self- and public-figure-judgments relative to font judgments in mental, social and physical blocks, respectively). The group differences in mPFC and TPJ activities were also significant when using differential reaction times (RTs) to self- *vs* public-figure-judgments as covariates in the ANOVAs (mPFC: mental: $F(1,57) = 6.634$, $P = 0.013$; physical: $F(1,57) = 6.903$, $P = 0.011$; social: $F(1,57) = 6.325$, $P = 0.015$; left TPJ and right TPJ during social attributes judgments: $F(1,57) = 11.130$ and 10.456, $P < 0.001$ and $P = 0.002$). This suggests that the socioculturally patterned mPFC and TPJ activity was evident even after excluding the potential confound of task difficulty reflected by RT differences. The opposite pattern of mPFC and TPJ activities during self-reflection on social attributes in terms of cultural differences was further confirmed in ANOVAs with Judgment (self *vs* public figure) and Brain Region (mPFC *vs* TPJ) as within-subjects variables and Group (Chinese *vs* Danish) as a between-subjects variable that showed significant three-way interactions (left and right TPJ: $F(1,58) = 13.147$ and 11.998, $Ps < 0.001$).

We further estimated how many subjects from each group were necessary to reveal reliable cultural differences in the neural activity during self-attribute judgments in this study. As shown in Figure 1C and D, when >24 participants were recruited from each cultural group, every calculation that compared mPFC or TPJ activity between the two cultural groups produced an absolute *t*-value larger than the critical *t*-value at the threshold of $P = 0.05$. This confirmed the robust socio-cultural difference in neural activity related to self-judgments of social attributes in our samples.

To further confirm the results of ROI analyses, we conducted whole-brain analyses that compared self- *vs* public-figure-judgments in each cultural group. We also conducted whole-brain two-sample *t*-test that compared Chinese *vs* Danish participants during judgments of the social, mental and physical attributes, respectively. For Chinese, relative to public-figure-judgments, self-judgments on the social, mental and physical attributes activated the mPFC and the neighboring anterior cingulate (Figure 2A and Supplementary Table S3). Self-judgments on social attributes also increased activity in the precuneus and bilateral TPJ. For Danes, self-judgments generated increased activity in the mPFC in all attribute dimensions (Figure 2B and Supplementary Table S3). Whole-brain two-sample *t*-tests confirmed significantly greater precuneus and TPJ activity in Chinese during self-reflection on social attributes but greater mPFC activity in Danes during self-reflection on social, mental and physical attributes (Figure 2C and D).

As the aforementioned analyses showed stronger mPFC activity but weaker TPJ activity in Danish compared with Chinese participants, we next examined the relationship between mPFC and TPJ activity to assess whether the opposite pattern of mPFC and TPJ activity in terms of cultural groups also existed at the individual level. A regression analysis of all participants confirmed a significant negative correlation between the right TPJ and mPFC activity associated with self-reflection on social attributes ($r = -0.261$, $P = 0.043$).

Functional connectivity analysis was first conducted to assess the neural activity that significantly coactivated with the mPFC activity

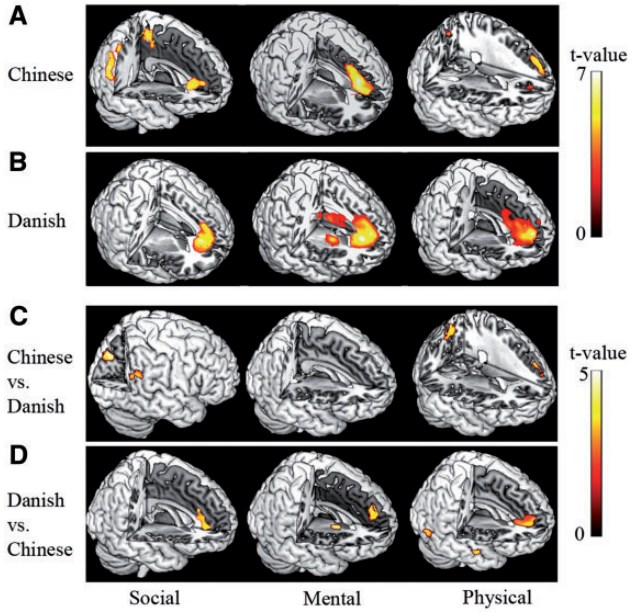

Fig. 2 Results of the whole brain analyses. The contrast between judgments of the self *vs* a public figure was shown separately for the social (left panel), mental (middle) and physical (right panel) blocks in (**A**) Chinese and (**B**) Danes. (**C**) The results of two sample *t*-tests that directly compared the contrast between self- and public-figure-judgments in Chinese *vs* Danes. Chinese participants showed greater activity in the precuneus (coordinates of the peak voxel: 4/−82/36) and bilateral TPJ (left: −62/−52/28; right: 52/−62/24) in the social block, in the precuneus (4/−74/48) and left frontal cortex (−36/46/28) in the physical block. (**D**) The results of two sample *t*-tests that directly compared the contrast between self- and public-figure-judgments in Danes *vs* Chinese. Danish participants showed greater activity in the mPFC in social (0/38/4), mental (−4/32/0) and physical (−2/48/6) blocks. Greater activity was also observed in the caudate (18/4/6) in the mental block among Danish participants.

during social attribute judgments of self *vs* public figure. We then conducted a whole-brain two-sample *t*-test to identify brain regions that differentiated between Chinese and Danes in coactivation with the mPFC during social attribute judgments of self *vs* public figure. This revealed that the functional connectivity between the mPFC and bilateral TPJ associated with self-reflection on social attributes was significantly stronger in Chinese than in Danes (Figure 3; Supplementary Table S4).

To test whether the specific pattern of mPFC and TPJ activity during self-reflection on social attributes was driven by group differences in general processes associated with attention, semantic meaning and personal attributes, ROI analyses compared mPFC and TPJ activities associated with public-figure- *vs* font judgments in the social block but failed to find significant group differences ($Ps > 0.1$). This was further confirmed by the whole-brain analysis that revealed similar neural activations in the contrast of public-figure- *vs* font judgment in Chinese and Danes (Supplementary Table S4).

Socioculturally patterned neural activity and cultural affiliation

Next, we conducted bootstrap and discriminant analysis to examine whether mPFC and TPJ activities related to judgments of one's own social attributes can be used to test an individual's cultural affiliation. Figure 4A illustrates the group specific pattern of activity in different brain regions linked to self-reflection on social attributes in a scatter plot of the mean contrast values (self- *vs* public-figure-judgments) calculated using bootstrap analysis (Davison and Hinkley, 1997). The distribution of Danes and Chinese in a space defined by the two vectors (mPFC and right TPJ activity) indicates a clear separation of the two groups. A Fisher's discriminant function was conducted to further assess if the patterns of neural activity in different brain regions

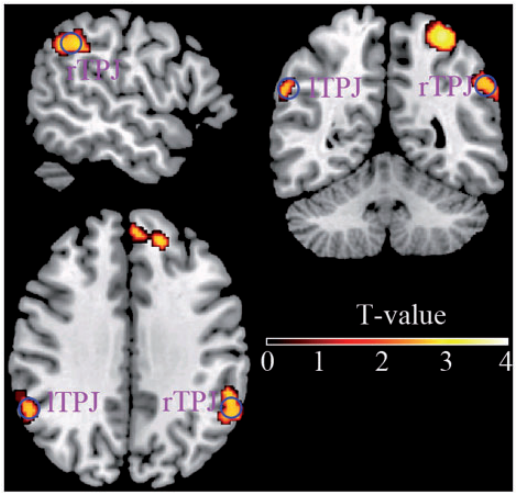

Fig. 3 Cultural group difference in functional connectivity. Relative to Danes, Chinese showed stronger functional connectivity between the mPFC and bilateral TPJ (left TPJ: −56/−50/34; right TPJ: 54/−42/38) during self- *vs* public-figure-judgments of social roles.

associated with social attributes characterized a participant's cultural affiliation. The leave-one-out cross-validation indicated that 78.3% of cross-validated subjects were correctly classified and this was significantly higher than chance level of 50% ($t(59) = 5.715$, $P < 0.001$).

Measure of interdependence mediates socioculturally patterned neural activity

Finally, we examined whether the cultural differences in mPFC and TPJ activities were mediated by the cultural value of interdependence. We first tested if individual differences in cultural value of interdependence may predict mPFC and TPJ activities. Indeed, individuals' interdependence scores were negatively correlated with mPFC activity engaged in self-reflection on social attributes ($r = -0.290$, $P = 0.025$, Figure 4B). In contrast, individuals' interdependence scores were positively correlated with bilateral TPJ activity associated with self-reflection on social attributes (left: $r = 0.353$, $P = 0.006$; right: $r = 0.370$, $P = 0.004$, Figure 4C). Then, we conducted a mediation analysis to assess whether individuals' interdependence scores mediated the sociocultural patterns of neural activity in different brain regions. The model with cultural affiliation and interdependence scores regressed on TPJ activity was significant (left TPJ: $F(2,57) = 7.514$, $P = 0.001$; right TPJ: $F(2,57) = 6.021$, $P = 0.004$). Moreover, the effect of cultural affiliation on the bilateral TPJ activity was significantly reduced by including interdependence scores (see Table 1), suggesting that the measure of interdependence significantly mediated the relationship between the cultural affiliation and the TPJ activity involved in self-reflection on social attributes. We also conducted the Sobel test to further confirm that the interdependence was a significant mediator variable of the relationship between cultural affiliation and the TPJ activity (left TPJ: $t = 2.11$, $P = 0.034$; right TPJ: $t = 1.98$, $P = 0.047$).

DISCUSSION

As predicted, Chinese showed greater value of interdependence than Danes, consistent with the previous observations of dominant cultural values in the two countries (Li *et al.*, 2006; Thomsen *et al.*, 2007). The brain imaging results demonstrated reliable group differences in mPFC and TPJ activities involved in self-reflection. The ROI analyses showed greater mPFC activity in Danes but greater TPJ activity in Chinese in the contrast of self- *vs* public-figure-judgments. The results of the sample size analysis indicate that the group differences in the brain activity associated with social role judgments were highly reliable with

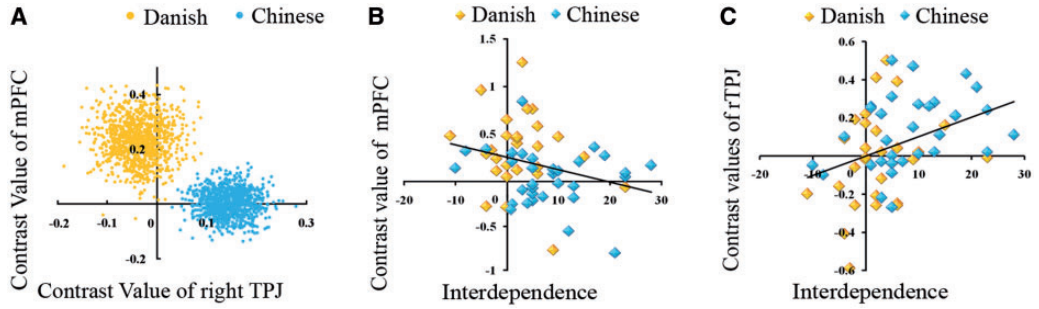

Fig. 4 Socioculturally patterned neural activity associated with social role judgments. (**A**) The scatter plot of bootstrapping analysis. The distribution of Danish and Chinese participants is shown in a two-dimension space defined by the contrast values of the right TPJ and mPFC activity during self- *vs* public-figure-judgments of social roles. The two cultural groups can be clearly dissociated in two-dimensional space. (**B**) Negative correlation between the interdependent values and the contrast values of the mPFC activity during social role judgments. (**C**) Positive correlation between the interdependent values and the contrast values of the right TPJ activity during social role judgments.

Table 1 Results of mediation analysis to test interdependence as a mediator of cultural affiliation and brain activity

Variable	*B*	SEB	*β*	R^2
Interdependence as a mediator of cultural affiliation and the left TPJ activity				
Regression model 1				
Independent: culture (dummy code)	0.164	0.054	0.369**	0.136
Dependent: left TPJ activity				
Regression model 2				
Independent: culture (dummy code)	5.681	2.015	0.347**	0.121
Mediator: interdependence				
Regression model 3				
Independent: culture (dummy code)	0.118	0.057	0.266*	0.187
Mediator: interdependence	−0.007	0.003	0.261*	
Dependent: left TPJ activity				
Interdependence as a mediator of cultural affiliation and the right TPJ activity				
Regression model 1				
Independent: culture (dummy code)	0.137	0.056	0.306*	0.093
Dependent: right TPJ activity				
Regression model 2				
Independent: culture (dummy code)	5.681	2.015	0.347**	0.121
Mediator: interdependence				
Regression model 3				
Independent: culture (dummy code)	0.094	0.058	0.207	0.174
Mediator: interdependence	0.008	0.004	0.298*	
Dependent: right TPJ activity				

*$P < 0.05$, **$P < 0.01$.

the sample size in this study. The whole-brain analysis also confirmed the opposite patterns of cultural differences in mPFC and TPJ activities. Moreover, mPFC and TPJ activities associated with social role judgments in our samples predicted cultural group affiliation of individual subjects with a high accuracy. Finally, there was stronger functional connectivity between mPFC and TPJ activities during social attribute judgments in Chinese than in Danes. Our findings demonstrate that the pattern of neural activity in different brain regions recruited during self-reflection differs significantly between the two cultural groups.

Both cultural groups showed similar patterns of response speeds during reflection of mental and social attributes. Moreover, different mPFC and TPJ activities during self-reflection on social attributes between Chinese and Danish participants were confirmed after RT differences were controlled as covariates in the ROI analysis. Thus, the group difference in mPFC and TPJ activity between Chinese and Danes cannot be attributed to differences in task difficulty of reflection on social attributes of the self and a public figure. Both ROI and whole-brain analyses showed that the mPFC and TPJ activity involved in attribute judgments of a public figure *vs* font judgments did not exhibit significant difference between Chinese and Danes. This indicates that group differences in general processes associated with language, attention or personal knowledge cannot simply account for the socioculturally patterned activity in the mPFC and TPJ associated with self-reflection. The influence of other factors such as education, subjective socioeconomic status or gender on the group differences in brain activity was kept minimal as these were matched between the cultural groups. Finally, how likely can the distinct patterns of mPFC and TPJ activities be explained by potential scanner difference in the two sites? The previous research has shown that between-subject differences accounted for nearly 10 times more variance than site effects when participants were scanned during the same task using the same type of scanner at two sites (Sutton *et al.*, 2008). Particularly in our study, scanner differences, if any, cannot explain the opposite patterns of mPFC and TPJ activities during self-reflection in Chinese and Danish participants and why such distinct pattern existed during reflection on social attributes but not during reflection on mental and physical attributes. It seems that psychological tasks rather scanning sites played a key role in generating distinct patterns of the mPFC and TPJ activity in the two cultural groups.

The mPFC has been repeatedly shown to be engaged in self-reflection on personality traits in both Western (Kelley *et al.*, 2002; Heatherton *et al.*, 2006; Moran *et al.*, 2006) and East Asian (Han *et al.*, 2008; Zhu *et al.*, 2007; Ma and Han, 2011; Wang *et al.*, 2012) cultural contexts. Our results, however, showed the first evidence that mPFC activity during self-reflection is significantly larger in individuals who grew up in a Western cultural context than those who grew up in an East Asian cultural context. This finding is consistent with our hypothesis and provides brain imaging evidence for stronger encoding of self-relevance of stimuli in the mPFC in individuals with Western cultural experiences and less interdependence compared with those with East Asian cultural experiences and more interdependence. Such cultural group differences in the mPFC activity may provide a neural basis for the independent self-construals in the Western cultural contexts and the interdependent self-construals in the East Asian cultural contexts (Markus and Kitayama, 1991, 2010).

There has so far been little evidence for cultural difference in TPJ activity engaged in encoding of one's own attributes, though TPJ activity increased during retrieval of self-related information (Lou *et al.*, 2004) and during reflection of one's own current mental states in a Western cultural context (Jenkins and Mitchell, 2011). Sul *et al.* (2012) found TPJ activations when combining judgments of personality traits and social identity on the self *vs* a public figure in Koreans using a lenient threshold (i.e. a voxel level threshold of $P < 0.001$, uncorrected, $k = 15$). It is thus unclear whether the TPJ was equally engaged in

self-judgments of personality traits and social identity, and whether cultural experience would influence the TPJ activity. Our results demonstrate that at a group level, the TPJ was significantly engaged during self-reflection on social attributes but not during self-reflection on mental/physical attributes. Moreover, we showed that the TPJ engagement in self-reflection on social attributes was more salient for individuals in Chinese context than in Danish context, providing evidence for a cultural influence on the TPJ activity related to self-reflection. The TPJ has been supposed to be involved in mentalizing about others' mental states (Saxe and Kanwisher, 2003; Samson *et al.*, 2004; Saxe and Wexler, 2005) and making judgments from others' perspective on a scene (Aichhorn *et al.*, 2006). The TPJ activation observed in our work suggests that during self-reflection on social roles, Chinese participants may take others' perspective or think about how others perceive or expect one's own social roles, consistent with the idea that self-concept in East Asian cultural contexts is constructed in reference to social relations and others' expectations and thoughts (Markus and Kitayama, 1991, 2010). The fact that the TPJ was not activated during self-reflection on mental and physical attributes suggests that the degree to which perspective taking is involved in self-reflection depends on both the dimension of the self-construal and the cultural context. It is likely that personality traits and physical attributes are thought to be more immutable compared with social roles and are thus relatively more constant across social contexts and independent of others' thoughts. Therefore, self-reflection on personality traits and physical attributes did not engage others' perspective and thus failed to activate the TPJ even in East Asian cultural contexts.

We found that, across our entire subject pool, mPFC and TPJ activities associated with self-reflection on social attributes were correlated with the measure of interdependence. The patterns of the associations between mPFC/TPJ activity and the interdependent self-construals are consistent with the cultural group differences in mPFC/TPJ activity, that is, the fact that participants with greater interdependence showed stronger TPJ but weaker mPFC activity was evident at both the group level and the individual level. In addition, the mediation analysis demonstrated that the group-level differences observed in our study were partially explained by individual differences in interdependence. This socioculturally patterned neural activity during self-reflection on social attributes was also manifested in the negative correlation between the mPFC and TPJ activity, which suggests a counterbalance of mPFC and TPJ engagement during self-reflection of social attributes. Thus specific sociocultural values seem to relate to specific patterns of neural activities in key brain regions involved in social cognition during self-reflection.

Recent research has argued that self-construals are multidimensional (Hardin, 2006). Relative to Americans, Danes have been found to self-enhance considerably less, but score higher on independence, make more autonomous scenario choices and have more individual attributions about social life (Thomsen *et al.*, 2007). Thus a one-dimensional scale may not catch all of the complexities in self-construals, neither within groups nor between large imagined communities such as 'Western' or 'East Asians'. It is therefore unlikely that one may reduce differences in selfhood between Westerners and East Asians, or between Danes and Chinese, to one measure of interdependence. However, our findings suggest that, in a controlled setting and with a sufficient number of participants, measuring differences in cultural values within and between groups may be a powerful method to explore the relation between cognitive universals, cultural patterning (Roepstorff *et al.*, 2010) and specific contexts. It is likely that the patterned neural activity underlying self-reflection seen in this study may arise from the influence of patterned practice during continuous interactions of human beings in specific sociocultural contexts (Kitayama and Uskul, 2011; Roepstorff, 2011). Priming studies further indicate that these patterns are not fixed in adults but may vary as a function of the exact context of the task (Sui and Han, 2007; Chiao *et al.*, 2009a; Ng *et al.*, 2010).

Early brain imaging studies seemed to support that 'self' and 'other' are represented in separate brain regions. For example, the ventral mPFC was claimed to represent one's own mental attribute (Kelley *et al.*, 2002; Heatherton *et al.* 2006; Moran *et al.*, 2006, 2009; Ma and Han, 2011), whereas the dorsal mPFC, TPJ and temporal pole were thought to be engaged in representation of others' mental states (Frith and Frith, 2003; Saxe and Kanwisher, 2003). However, increasing evidence suggests an overlap in neural processing of information related to the self and information related to others (Legrand and Ruby, 2009). The ventral mPFC may also be activated when representing the mental states of similar or close others (Mitchell *et al.*, 2006; Jenkins *et al.*, 2008; Krienen *et al.*, 2010) or when judging personal traits of a close other (Zhu *et al.*, 2007; Wang *et al.*, 2012). These findings indicate that representing the mind of another person may rely on reference to one's own mental characteristics. In contrast, self-reflection on personal attributes may depend on others' thoughts and expectations in certain cultural contexts. Han *et al.* (2008) found that while non-religious Chinese recruited the ventral mPFC during judgments of their own personality traits, Christian Chinese showed increased activity in the dorsal mPFC during self-reflection on personality traits. Thus beliefs and practices (e.g. Christianity) that underscore the evaluative processes of the self by others may reduce the weight of encoding stimulus self-relevance in the ventral mPFC but increase the weight of mentalizing others' mind in the dorsal mPFC during self-reflection (Han *et al.*, 2008). Therefore, self-reflection on personal attributes in a specific context may recruit both the dorsal mPFC (Han *et al.*, 2008) and the TPJ (this work).

One may notice that activity in the precuneus showed a trend toward cultural difference during judgments of social attributes in the whole-brain two-sample analysis. There have been inconsistent results regarding the engagement of the precuneus in self-referential processing. Some studies observed precuneus activation during judgments on one's own *vs* others' mental attributes (e.g. Kelley *et al.*, 2002; Moran *et al.*, 2006), whereas other studies did not (e.g. Zhu *et al.*, 2007; Han *et al.*, 2008; Wang *et al.*, 2012). The discrepancy might arise from the paradigm difference (e.g. event-related *vs* block design). The interesting finding of this work is that reflection on one's own social attributes tended to activate the precuneus to a greater degree in Chinese than in Danes. Since the precuneus is associated with retrieval of information from episodic memory (Cavanna and Trimble, 2006), it is likely that, relative to Danes, Chinese may require more effort to search for personal experiences from the episodic memory during reflection on one's own social attributes, but this must be tested in future research.

It should be noted that, while our fMRI results suggest that Westerners and East Asians may have different access to and awareness of their self, the distinct patterns of mPFC and TPJ activities in the two cultural groups may be specific to reflection on one's own attributes. Cultural differences in the processing of self-related information in other domains may not be necessarily associated with these brain regions. Indeed, our recent event-related potential research found that the neural activity involved in recognition of one's own face was different between Chinese and British individuals (Sui *et al.*, 2009, in press), but this cultural difference only focused over the frontocentral region. Thus, the distinct patterns of neural activity involved in self-related processing in Western and East Asian cultures may be domain specific.

Taken together, our findings suggest that a distributed neural network consisting of brain areas including the mPFC and TPJ can be engaged in neurocognitive processing of information about both the

self and others. Individuals in different sociocultural contexts may learn and/or adopt distinct strategies, and at a neural level, this may be implemented by increasing the weight of a specific node in the neural circuit when processing self- or other-related information. The distinct socially patterned neural activity during self-reflection found at a group level may correspond to discrepant meanings ascribed to social roles in East Asian and Western cultural contexts. Our findings thus support the idea that social cognition is particularly sensitive to cultural background and contextual effects and that the mPFC and TPJ may be key areas that are differentially evoked (Vogeley and Roepstorff, 2009).

SUPPLEMENTARY DATA

Supplementary data are available at *SCAN* Online.

REFERENCES

Aichhorn, M., Perner, J., Kronbichler, M., Staffen, W., Ladurner, G. (2006). Do visual perspective tasks need theory of mind? *NeuroImage*, *30*, 1059–68.

Aron, A., Aron, E.N., Danny, S. (1992). Inclusion of Other in Self Scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, *63*, 596–612.

Cavanna, A.E., Trimble, M.R. (2006). The precuneus: a review of its functional anatomy and behavioral correlates. *Brain*, *129*, 564–83.

Chiao, J.Y., Harada, T., Komeda, H., et al. (2009a). Dynamic cultural influences on neural representations of the self. *Journal of Cognitive Neuroscience*, *22*, 1–11.

Chiao, J.Y., Harada, T., Komeda, H., et al. (2009b). Neural basis of individualistic and collectivistic views of self. *Human Brain Mappping*, *30*, 2813–20.

Davison, A.C., Hinkley, D.V. (1997). *Bootstrap Methods and Their Application*. New York: Cambridge University Press.

Frith, U., Frith, C.D. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *358*, 459–473.

Han, S., Mao, L., Gu, X., Zhu, Y., Ge, J., Ma, Y. (2008). Neural consequences of religious belief on self-referential processing. *Social Neuroscience*, *3*, 1–15.

Han, S., Northoff, G. (2008). Culture-sensitive neural substrates of human cognition: a transcultural neuroimaging approach. *Nature Review Neuroscience*, *9*, 646–54.

Han, S., Northoff, G. (2009). Understanding the self: a cultural neuroscience approach. *Progress in Brain Research*, *178*, 203–12.

Han, S., Northoff, G., Vogeley, K., Wexler, B.E., Kitayama, S., Varnum, M.E.W. (2013). A cultural neuroscience approach to the biosocial nature of the human brain. *Annual Review of Psychology*, *64*, 335–59.

Hardin, E.E. (2006). Convergent evidence for the multidimensionality of self-Construal. *Journal of Cross-Cultural Psychology*, *37*, 516–21.

Heatherton, T.F. (2011). Neuroscience of self and self-regulation. *Annual Review of Psychology*, *62*, 363–90.

Heatherton, T.F., Wyland, C.L., Macrae, C.N., Demos, K.E., Denney, B.T., Kelley, W.M. (2006). Medial prefrontal activity differentiates self from close others. *Social and Cognitive Affective Neuroscience*, *1*, 18–25.

Hogg, M.A. (2003). Social identity. In: Leary, M.R., Tangney, J.P., editors. *Handbook of Self and Identity*. New York: The Gulford Press, pp. 462–79.

James, W. (1950). *Social Identity. The Principles of Psychology*, Vol. 1 and 2, New York: Dover(Original work published 1890).

Jenkins, A.C., Macrae, C.N., Mitchell, J.P. (2008). Repetition suppression of ventromedial prefrontal activity during judgments of self and others. *Proceedings of the National Academy of Sciences, USA*, *105*, 4507–12.

Jenkins, A.C., Mitchell, J.P. (2011). Medial prefrontal cortex subserves diverse forms of self-reflection. *Social Neuroscience*, *6*, 211–8.

Kelley, W.M., Macrae, C.N., Wyland, C.L., Caglar, S., Inati, S., Heatherton, T.F. (2002). Finding the self? An event-related fMRI study. *Journal of Cognitive Neuroscience*, *14*, 785–94.

Kilpatrick, F., Cantril, H. (1960). Self-anchoring scaling: a measure of individuals' unique reality worlds. *Journal of Individual Psychology*, *16*, 158–73.

Kitayama, S., Park, J. (2010). Cultural neuroscience of the self: understanding the social grounding of the brain. *Social and Cognitive Affective Neuroscience*, *5*, 111–29.

Kitayama, S., Uskul, A.K. (2011). Culture, mind, and the brain: current evidence and future directions. *Annual Review of Psychology*, *62*, 419–49.

Krienen, F.M., Tu, P.C., Buckner, R.L. (2010). Clan mentality: evidence that the medial prefrontal cortex responds to close others. *Journal of Neuroscience*, *30*, 13906–15.

Legrand, D., Ruby, P. (2009). What is self-specific? Theoretical investigation and critical review of neuroimaging results. *Psychological Review*, *116*, 252–82.

Li, H.Z., Zhang, Z., Bhatt, G., Yum, Y. (2006). Rethinking culture and self-construal: China as a middle land. *Journal of Social Psychology*, *146*, 591–610.

Lieberman, M.D. (2007). Social cognitive neuroscience: a review of core processes. *Annual Review of Psychology*, *58*, 259–89.

Lou, H.C., Luber, B., Crupain, M., Keenan, J.P., Nowak, M., Kjaer, T.W. (2004). Parietal cortex and representation of the mental self. *Proceedings of the National Academy of Sciences, USA*, *101*, 6827–32.

Ma, Y., Han, S. (2011). Neural representation of self-concept in sighted and congenitally blind adults. *Brain*, *134*, 235–46.

Macrae, C.N., Moran, J.M., Heatherton, T.F., Banfield, J.F., Kelley, W.M. (2004). Medial prefrontal activity predicts memory for self. *Cerebral Cortex*, *14*, 647–54.

Markus, H.R., Kitayama, S. (1991). Culture and the self: implication for cognition, emotion and motivation. *Psychological Review*, *98*, 224–53.

Markus, H.R., Kitayama, S. (2010). Cultures and selves: a cycle of mutual constitution. *Perspectives on Psychological Sciences*, *5*, 420–30.

Mitchell, J.P., Macrae, C.N., Banaji, M.R. (2006). Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron*, *50*, 655–63.

Moran, J.M., Macrae, C.N., Heatherton, T.F., Wyland, C.L., Kelley, W.M. (2006). Neuroanatomical evidence for distinct cognitive and affective components of self. *Journal of Cognitive Neuroscience*, *18*, 1586–94.

Moran, J.M., Heatherton, T.F., Kelley, W.M. (2009). Modulation of cortical midline structures by implicit and explicit self-relevance evaluation. *Social Neuroscience*, *4*, 197–211.

Moran, J.M., Lee, S.M., Gabrieli, J.D. (2011). Dissociable neural systems supporting knowledge about human character and appearance in ourselves and others. *Journal of Cognitive Neuroscience*, *23*, 2222–30.

Ng, S.H., Han, S., Mao, L., Lai, J.C.L. (2010). Dynamic bicultural brains: a fMRI study of their flexible neural representation of self and significant others in response to culture priming. *Asian Journal of Social Psychology*, *13*, 83–91.

Northoff, G., Heinze, A., de Greck, M., Bermpoh, F., Dobrowolny, H., Panksepp, J. (2006). Self-referential processing in our brain–a meta-analysis of imaging studies on the self. *NeuroImage*, *31*, 440–57.

Raeff, C. (2004). Within-culture complexities: multifaceted and interrelated autonomy and connectedness characteristics in late adolescent selves. *New Direction of Child and Adolescent Development,* 61–78.

Roepstorff, A. (2011). Culture: a site of relativist energy in the cognitive sciences. *Common Knowledge*, *17*, 37–41.

Roepstorff, A., Niewöhner, C.J., Beck, S. (2010). Enculturing brains through patterned practices. *Neural Networks*, *23*, 1051–1059.

Rogers, T.B., Kuiper, N.A., Kirker, W.S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, *35*, 677–688.

Samson, D., Apperley, I.A., Chiavarino, C., Humphreys, G.W. (2004). Left temporoparietal junction is necessary for representing someone else's belief. *Nature Neuroscience*, *7*, 499–500.

Saxe, R., Kanwisher, N. (2003). People thinking about thinking people: fMRI investigations of theory of mind. *NeuroImage*, *19*, 1835–42.

Saxe, R., Wexler, A. (2005). Making sense of another mind: the role of the right temporo-parietal junction. *Neuropsychologia*, *43*, 1391–9.

Singelis, T.M. (1994). The measurement of independent and interdependent self-construals. *Personality and Social Psychology Bulletin*, *20*, 580–91.

Sui, J., Han, S. (2007). Self-construal priming modulates neural substrates of self-awareness. *Psychological Science*, *18*, 861–6.

Sui, J., Hong, Y., Liu, C.H., Humphreys, G.W., Han, S. (in press). Dynamic cultural modulation of neural responses to one's own and friend's faces. *Social Cognitive and Affective Neuroscience,* doi: 10.1093/scan/nss001.

Sui, J., Liu, C.H., Han, S. (2009). Cultural difference in neural mechanisms of self-recognition. *Social Neuroscience*, *4*, 402–11.

Sul, S., Choi, I., Kang, P. (2012). Cultural modulation of self-referential brain activity for personality traits and social identities. *Social Neuroscience*, *7*, 280–91.

Sutton, B.P., Goh, J., Hebrank, A., Welsh, R.C., Chee, M.W., Park, D.C. (2008). Investigation and validation of intersite fMRI studies using the same imaging hardware. *Journal of Magnetic Resonance Imaging*, *28*, 21–8.

Thomsen, L., Sidanius, J., Fiske, A.P. (2007). Interpersonal leveling, independence, and self-enhancement: a comparison between Denmark and the US, and a relational practice framework for cultural psychology. *European Journal of Social Psychology*, *37*, 445–69.

Vogeley, K., Bussfeld, P., Newen, A., et al. (2001). Mind reading: neural mechanisms of theory of mind and self-perspective. *NeuroImage*, *14*, 170–81.

Vogeley, K., Roepstorff, A. (2009). Contextualising culture and social cognition. *Trends in Cognitive Sciences*, *13*, 511–6.

Wang, G., Mao, L., Ma, Y., et al. (2012). Neural representations of close others in collectivistic brains. *Social and Cognitive Affective Neuroscience*, *7*, 222–9.

Zhu, Y., Zhang, L., Fan, J., Han, S. (2007). Neural basis of cultural influence on self representation. *NeuroImage*, *34*, 1310–7.