Social Neuroscience

ISSN: 1747-0919 (Print) 1747-0927 (Online) Journal homepage: https://www.tandfonline.com/loi/psns20

Cultural modulation of self-referential brain activity for personality traits and social identities

Sunhae Sul , Incheol Choi & Pyungwon Kang

To cite this article: Sunhae Sul , Incheol Choi & Pyungwon Kang (2012) Cultural modulation of self-referential brain activity for personality traits and social identities, Social Neuroscience, 7:3, 280-291, DOI: 10.1080/17470919.2011.614001

To link to this article: https://doi.org/10.1080/17470919.2011.614001

Published online: 05 Oct 2011.

Submit your article to this journal

Article views: 497

Citing articles: 17 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=psns20

SOCIAL NEUROSCIENCE, 2012, 7 (3), 280–291

Psychology Press
Taylor & Francis Group

Cultural modulation of self-referential brain activity for personality traits and social identities

Sunhae Sul[1,2], Incheol Choi[1], and Pyungwon Kang[3]

[1]Department of Psychology, Seoul National University, Seoul, South Korea
[2]Department of Economics, University of Zurich, Zurich, Switzerland
[3]Department of Brain and Cognitive Engineering, Korea University, Seoul, South Korea

Cross-cultural studies have shown that personality traits are less central and social identities are more important to the selfhood of collectivistic people. However, most cultural neuroscience studies using the self-reference effect (SRE) paradigm have only used personality traits to explore cultural differences in the neural circuits of self--referential processes. In the present study, we used both personality traits and social identities as stimuli in the SRE paradigm and investigated whether and how one's cultural orientation (i.e., individualism vs. collectivism) affects the SRE in the brain. The results showed that the medial prefrontal cortex, anterior cingulate, bilateral temporoparietal regions, and precuneus were involved in self-representation for both personality traits and social identities. Importantly, cultural orientation predicted differential activation patterns in these regions. Collectivists showed stronger activation in the left temporoparietal regions than individualists, who mainly recruited the medial prefrontal regions. Our findings suggest that the personal and social self share common neural substrates, the activation of which can be modulated by one's cultural orientation.

Keywords: Self; Culture; Individualism; Collectivism; Self-reference effect.

Functional neuroimaging studies using the self-reference effect (SRE) paradigm (Rogers, Kuiper, & Kirker, 1977)[1] have shown that there are cultural differences in the areas of the brain that are recruited to process or represent the self (Chiao et al., 2009, 2010; Zhu, Zhang, Fan, & Han, 2007). However, it is noteworthy that these studies have only used personality traits with the SRE paradigm, despite evidence from cross-cultural studies that suggest that the personal self is less central and the social self is more important to the selfhood of collectivistic people (Cousins, 1989; Heine, 2001; Hofstede, 1980; Markus & Kitayama, 1991; Triandis, 1995; Wagar & Cohen, 2003). The present research attempted to identify brain regions associated with the personal self and the social self and to explore whether and how one's cultural orientation (individualism vs. collectivism) is associated with neural representations of the self.

The self is in large part a product of culture. An independent self, typically found in individualistic cultures (e.g., North America and Western Europe), is primarily defined by personality traits and other

Correspondence should be addressed to: Sunhae Sul, Laboratory for Social and Neural Systems Research, Department of Economics, University of Zurich, Blümlisalpstrasse 10, 8006 Zurich, Switzerland. E-mail: sunhae.sul@gmail.com

This work was supported by the Social Neuroscience Program of the National Research Foundation of South Korea funded through the South Korean government (MEST) (No. 2010-0029271). We wish to thank Sang-Hun Lee and Hackjin Kim for valuable advice on research design and comments on an earlier draft of this work, and Kuwook Cha for technical support in collecting the fMRI data.

[1]In the SRE paradigm, participants are given a series of words – personality traits in most cases – and asked to judge whether a given word describes oneself (self-condition), describes another person such as a friend or a celebrity (other-condition), or has a specific physical feature (font-condition). Behaviorally, participants tend to remember the self-referential words better than the other-referential words or the font-referential words (e.g., Rogers et al., 1977). Neurally, self-referential brain activity can be detected by contrasting the self-condition versus the other-condition (e.g., Kelley et al., 2002).

© 2012 Psychology Press, an imprint of the Taylor & Francis Group, an Informa business
www.psypress.com/socialneuroscience http://dx.doi.org/10.1080/17470919.2011.614001

internal attributes (i.e., personal self). In contrast, an interdependent self, typically found in collectivistic cultures (e.g., East Asia), mainly takes form in social identities such as roles and memberships (i.e., social self). For example, Cousins (1989) showed that when asked to describe themselves, Japanese participants listed more of their social roles and institutional memberships than their personal attributes, unlike their American counterparts. Similarly, Wagar and Cohen (2003) found that Asian-Canadians remembered words that referred to their social identities better than European-Canadians in the SRE task. In addition, numerous other studies have identified cognitive, emotional, and behavioral consequences arising from differences between an independent self and an interdependent self (e.g., Diener, Oishi, & Lucas, 2003; Markus & Kitayama, 1991; Nisbett, Peng, Choi, & Norenzayan, 2001; Triandis, 1989; Tsai, 2007).

More recently, cultural differences in self-representation in the brain have also been investigated. For example, Zhu and colleagues (2007) used the SRE paradigm with personality trait words and found that the medial prefrontal cortex (MPFC) of Chinese participants did not distinguish the self from their mothers. Western participants, however, showed a clear separation of the self and their mothers and further exhibited the same level of MPFC activation for the mother and a third person. In another study, Chiao and colleagues (2009) asked participants to judge whether a given trait adjective described themselves either in a specific context or in general. They found that the MPFC showed greater activation among interdependent participants when they were told to think about themselves in a given context (e.g., "When talking to my mother, I am . . .") than when asked to think about themselves in general (e.g., "In general, I am . . ."). The opposite was the case for independent participants. Furthermore, Chiao and colleagues (2010) conducted an fMRI study with bicultural individuals using cultural priming methods and found increased self-referential activity in the MPFC during the culture-congruent self-judgment conditions (i.e., general self-judgment with the individualism prime and context-dependent self-judgment with the collectivism prime). These findings showed that the neural representation of the self could be modulated by cultural factors.

Yet, this cultural neuroscience approach does not seem to fully take into consideration the nature of the collectivistic self. Specifically, none of the studies above included social identities *per se* as stimuli in the SRE paradigm, reflecting an assumption that personality traits are universally central to the self. However, according to findings from cultural psychology, the self of those from collectivistic cultures primarily finds form in social identities. Hence, in order to understand the neural bases of cultural differences in self, it is important to use both personality traits and social identities in the SRE paradigm.

In the present study, we conducted two experiments using the typical SRE paradigm. Study 1 was designed to confirm the existence of the SRE for both personality traits and social identities at the behavioral level. In Study 2, we assessed self-referential brain activities, using fMRI. In both studies, we measured participants' cultural orientation, using the collectivism versus individualism score (INDCOL), and explored whether cultural orientation modulated the impact of self-aspect (i.e., personality traits or social identities) on the SRE.

STUDY 1: BEHAVIORAL EXPERIMENT

Methods

Participants

Fifty undergraduate students at Seoul National University in South Korea (24 males, 26 females) were recruited for a 60-min behavioral experiment session, and were compensated with 5000 KRW (≈US$5).

Self-referential task

The self-referential task consisted of three phases: an encoding phase, a distraction phase, and a memory phase. During the encoding phase, participants were given a list of words describing either personality traits (personal words) or social identities (social words). From that list, they were asked to decide whether a given word described themselves (self-judgment), Ju-yung Chung, a famous Korean entrepreneur (other-judgment), or whether the font was boldface or not (font-judgment). In order to make it compatible with an fMRI experiment, we used a block design with six runs. There were six blocks per run, and each block used one of the six—three judgment targets (self, other, font) × two word types (personal, social)—within-subject conditions. Each block contained five trials, so there were 180 trials in total. After the instructions specifying the judgment target were presented for 3.5 s, five words were presented one by one for 1.8 s each, followed by a blank page that lasted for 1 s. Therefore, the encoding phase took approximately 12 min, including 10 min and 30 s of the experiment and self-paced breaks between the runs. The structure of a trial block is shown in Figure 1A.

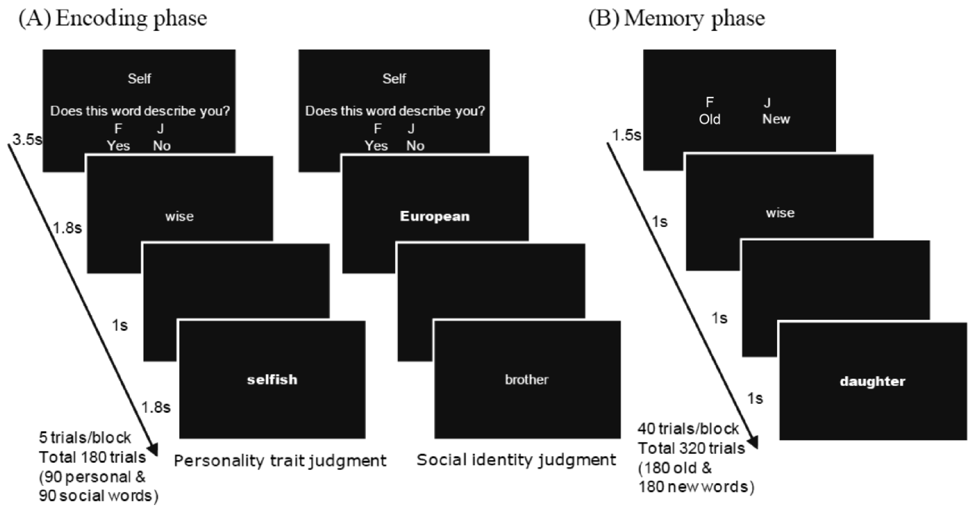

Figure 1. Structure of the self-referential task. Participants judged whether the given words were descriptive of oneself, other, and font during the encoding phase (A), and performed a recognition task during the memory phase (B).

The self-referential task included both personal and social words. For personal words, we employed 180 words out of a list of 540 personality trait adjectives that Kelley and colleagues used (Heatherton et al., 2006; Kelley et al., 2002; originally from Anderson, 1968). The valence and length of the words presented were matched across blocks. For social words, 180 words that describe either relational roles (e.g., *daughter*, *friend*) or social memberships (e.g., *student*, *European*) were selected from 16 social categories relevant to participants' social self, such as relational roles in family, gender, occupation, ethnicity, nationality, and religion, based on Cousins' (1989) definition of social self: "references to social role, institutional membership, or other socially defined status." Word length and the number of categories used were matched across blocks. Half of the 180 personality traits and 180 social identities were randomly chosen for the encoding phase, and the remaining half of the words were used for the memory phase.

Following the encoding task, participants completed a 10-min distraction task and then moved on to the recognition task. Participants were not given any prior notice that they would be completing the recognition task. A total of 180 old words (90 personal and 90 social) and 180 new words (90 personal and 90 social) were presented in random order. The participant's task was to judge whether or not each word had been presented in the encoding phase (Figure 1B); this is the typical method used in self-reference studies. Because information relevant to the self is processed and stored in a more elaborate form than other types of information, individuals tend to remember the words that appear in the self condition better than words in the other or in the font condition. This phenomenon is called the self-reference effect (SRE).

Measurements for cultural orientation

Participants filled out the 32-item INDCOL scale developed by Singelis, Triandis, Bhawuk, and Gelfand (1995), after the completion of the recognition task. Each participant's cultural orientation was measured by the relative strength of individualism and collectivism. Namely, the INDCOL index for each participant was calculated by subtracting the individualism score from the collectivism score ($M = 9.76$, $SD = 21.42$). Thus, a higher INDCOL indicated a stronger leaning toward collectivism.

Results

To assess the SRE, we used Busemeyer and Townsend's (1993) formula for quantifying the corrected recognition scores (CRS) for each condition:

$$CRS = \ln \frac{hit}{(1 - hit)} - \ln \frac{fa}{(1 - fa)}$$

hit denotes the probability of "old" responses to the old words and *fa* indicates the probability of "old" responses to the new words. In the typical SRE paradigm, the CRS should be greatest for self-referenced words and smallest for font-referenced words (Rogers et al., 1977; Wagar & Cohen, 2003).

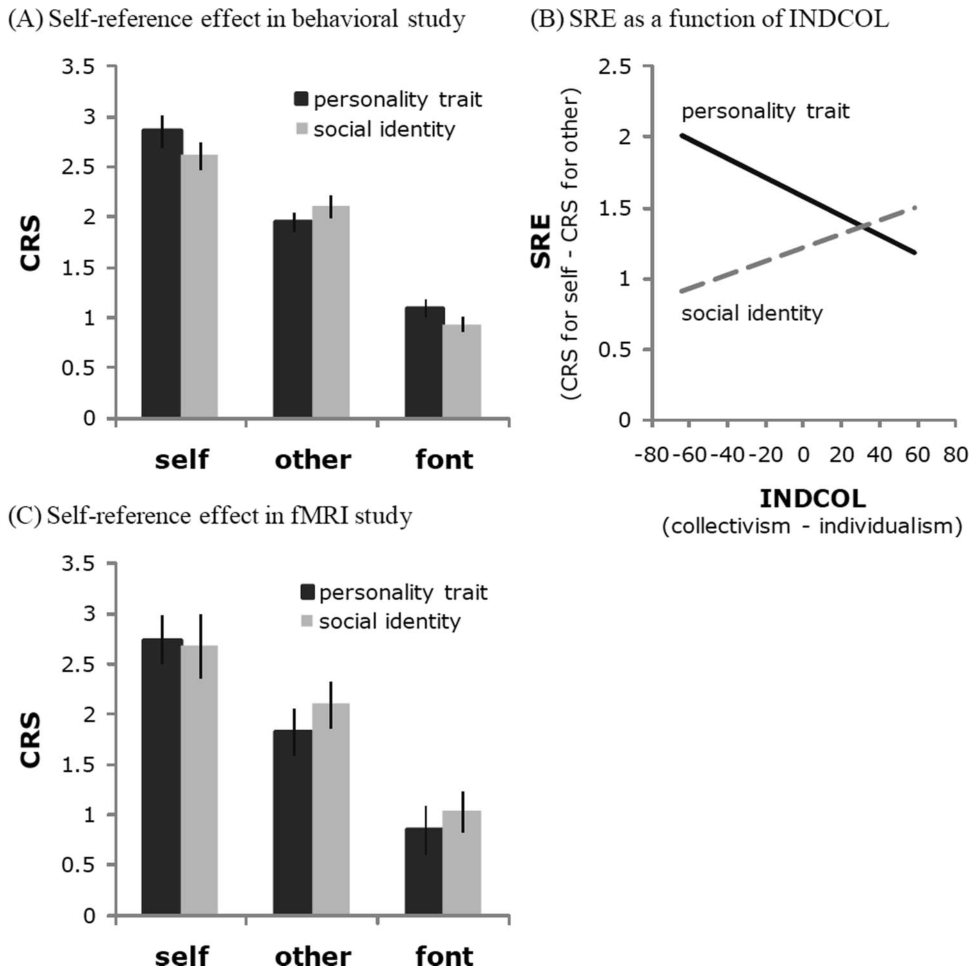

Figure 2. Behavioral results from Studies 1 and 2. (A) Corrected recognition scores for 2 (personal vs. social) × 3 (self, other, font) within-subject conditions. (B) The size of the self-reference effect (SRE) as a function of INDCOL: The solid (personality trait) and dashed (social identity) prediction lines were derived from linear regression analyses, indicating that SRE was modulated by INDCOL. (C) Behavioral results of the fMRI study confirmed the self-reference effect for both personal and social word types, but there was no effect of INDCOL.

As shown in Figure 2A, when the CRSs were subjected to a Target (self, other, font) × Word (personal, social) × INDCOL (continuous) general linear model (GLM), repeated-measures analysis, the usual SREs were observed for both personal and social words, with a main effect of Target, $F(1, 96) = 131.64$, $p < .001$, $\eta_p^2 = .73$. In other words, participants remembered self-referenced words (CRS: 2.74) better than other-referenced words (2.04) and font-referenced words (1.02). Although the SRE was modulated by word types—Target × Word interaction: $F(2, 96) = 8.05$, $p < .01$, $\eta_p^2 = .14$—the effect of Target was significant for both personal words, $F(2, 47) = 81.12$, $p < .001$, $\eta_p^2 = .78$ (CRS for self-judgment: 2.86; other-judgment: 1.96; font-judgment: 1.09), and social words, $F(2, 47) = 99.00$, $p < .001$, $\eta_p^2 = .81$ (self-judgment: 2.61; other-judgment: 2.17; font-judgment: .94). Most importantly, the three-way interaction of Target × Word × INDCOL was marginally significant, $F(2, 96) = 2.95$, $p = .057$, $\eta_p^2 = .06$, indicating that SRE was modulated by the level of individualism and collectivism.

To better understand the effect of INDCOL, we estimated the degree of SRE by subtracting the CRS for other-judgment from the CRS for self-judgment for each word type. The Word (personal, social) × INDCOL (continuous) analysis revealed a significant two-way interaction, $F(1, 48) = 6.95$, $p < .05$, $\eta_p^2 = .13$. A regression analysis further confirmed that the direction of the effect was in line with our prediction. The SRE for personality traits decreased with greater INDCOL, standardized $\beta = -0.25$, $p = .085$, whereas the opposite direction of effect was found for social identities, $\beta = 0.26$, $p = .065$ (Figure 2B).

In sum, Study 1 found that the SRE occurred for Koreans, a finding not previously reported in the literature; it occurred for both personality traits and social identities; and, most importantly, it was modulated by one's cultural orientation such that the more individualistic a participant was the stronger his/her SRE for personality traits, and the more collectivistic a participant was the stronger his/her SRE for social identities.

STUDY 2: fMRI EXPERIMENT

We conducted an fMRI experiment in Study 2 to explore the neural bases of the SRE for both the personal self and the social self, and to determine whether the brain activation patterns are modulated by cultural orientation. Particularly, we expected that the MPFC and the regions around the temporoparietal junction (TPJ) would show SRE for personality traits and social identities. The MPFC has been identified as one of the major areas for self-referential processes in the brain (Gusnard, Akbudak, Shulman, & Raichle, 2001; Johnson et al., 2006; Kelley et al., 2002; Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Mitchell, Banaji, & Macrae, 2005; Schmitz, Kawahara-Baccus, & Johnson, 2004), a finding which has also been reported by recent cultural neuroscience studies (Chiao et al., 2009, 2010; Sui & Han, 2007; Zhu et al., 2007). Given that the interdependent self is rooted in social relationships, we also searched for the workings of SRE in regions involved in the shared representation of the self and the other (Amodio & Frith, 2006; Decety & Sommerville, 2003), such as the regions around the TPJ (Saxe & Kanwisher, 2003; Uddin, Iacoboni, Lange, & Keenan, 2007). These regions have been found occasionally in studies on self-representations (Chiao et al., 2009, 2010; D'Argembeau et al., 2009; Lou et al., 2004; Northoff et al., 2006; Uddin et al., 2007) but have received relatively little attention in comparison to the MPFC, especially in the field of cultural neuroscience. We further hypothesized that self-referential activities in these regions would be correlated to one's cultural orientation.

Methods

Participants

Nineteen Korean college students (9 males, 10 females, ages 21–29, $M_{\text{age}} = 24$) participated in the study. Participants received compensation of 30,000 KRW (≈US$30). Any potential health risks were carefully screened for both with a self-report questionnaire and a verbal interview, and informed consent was obtained prior to the experiment. All participants were right-handed and had normal or corrected-to-normal vision. None of them reported having a history of neurological or psychiatric problems.

Stimuli and procedures

Participants' brain activity was measured during the encoding phase of the self-referential task. The structure of the task was exactly the same as in Study 1, except that a null block was included for a baseline trial between each experiment block. Each null block had the same length as an experiment block. Therefore, one run consisted of thirteen 17.5-s blocks (six experiment blocks and seven null blocks). In total, the encoding phase had six runs, which took approximately 30 min, including 23 min and 45 s of the experiment, short breaks between the runs, and the scanner operation time.

Before entering the scanner, participants were given instructions and performed practice trials. Afterwards, participants entered the scanner to perform the encoding phase of the self-referential task, as described in Study 1. After completing a 12-min distraction task outside the scanner, participants were ushered to a waiting room, and they conducted the recognition task and completed the INDCOL scales ($M = 4.42$, $SD = 23.67$, statistically not different from Study 1).

Image acquisition

Brain images were acquired on an ISOL Forte 3T system (ISOL Technology Co., Republic of Korea) with a standard birdcage coil at the Brain Science Research Center at the Korea Advanced Institute of Science and Technology. T2*-weighted functional images were obtained, using gradient-echo echo-planar pulse sequences (TR = 2500 ms; TE = 35 ms; FA = 90°; FOV = 220 mm; 64 × 64 matrix; 30 slices; voxel size = 3.44 × 3.44 × 3.5 mm). The stimuli were presented through an MR-compatible LCD mounted on a head coil (refresh-rate: 60 Hz, display: 640 × 480, view angle: 30°). Each functional run lasted 237.5 s, including the first four TRs that were discarded later due to unstable magnetization. Therefore, 546 sets of images were acquired through six functional runs for each participant.

fMRI analysis

Data analysis was performed with SPM8 (Wellcome Department of Imaging Neuroscience, London, UK). Head motion was corrected for by realigning functional images to the first scan, and a mean image was created for each participant. The realigned images were normalized to the Montreal Neurological Institute (MNI) EPI template, resampled to 2 × 2 × 2 mm voxels, and spatially smoothed with an 8-mm (full width at half maximum—FWHM) Gaussian filter.

The preprocessed functional images were analyzed by the GLM (Friston, Frith, Turner, & Frackowiak, 1995). Each block of the six conditions (self personal, self social, other personal, other social, font personal, and font social) was modeled with boxcar functions convoluted with a standard hemodynamic response function. Motion vectors obtained from the realignment process were included as regressors in the model to reduce noise. After the fixed effects were assessed for individual subjects, whole-brain, voxel-wise, random-effects analyses were conducted for all participants. First, a whole-brain 2 (target: self, other) × 2 (word: personal, social) ANOVA revealed the regions related to each experiment factor. In order to focus on the SRE defined by the relative difference between self- and other-judgment conditions, we did not include the font-judgment condition in the whole-brain ANOVA. The brain activations were identified at the significance level of $p < .001$ (uncorrected) and extent threshold = 15 voxels. Brodmann areas and brain regions were identified on the Talairach space (Talairach & Tournoux, 1998) with Talairach coordinates converted from the MNI coordinates by nonlinear transformation (http://brainmap.org/icbm2tal/index.html; Lancaster et al., 2007).

Region of interest (ROI) analyses were performed by SPM MarsBaR toolbox (http://marsbar.sourceforge.net/; Brett, Anton, Valabregue, & Poline, 2002). The MPFC and bilateral TPJ were functionally defined as ROIs in the analysis of the main effect of Target (self vs. other regardless of word type; "self-reference effect"). Radius spheres of 6 mm centered at the local maxima of the significant regions were used to define the ROIs: MPFC (x/ y/ z = –4/ 52/ 10), left TPJ (–44/ –56/ 20), and right TPJ (60/ –42/ 22). For further illustration of neural responses for different conditions, mean parameter estimates of neural activation for self-, other-, and font-judgment conditions for personal and social words were extracted from each ROI. Finally, the self-referential brain activity (SRE_{brain}) of each ROI was measured with the mean parameter estimates of first-level self minus other contrasts for each word condition and was correlated with INDCOL to examine the effect of cultural orientation.

Results

Behavioral results

Analysis of the recognition phase showed a significant self-reference effect for both personal and social words (one participant who pressed the wrong buttons and one who did not finish the recognition task were excluded).

As can be seen in Figure 2C, Study 2 replicated Study 1: There was a main effect of judgment Target, which confirmed the existence of the SRE, $F(2, 30) = 69.96$, $p < .001$, $\eta_p^2 = .82$. The SRE was significant both for personal words, $F(2, 30) = 57.30$, $p < .001$, $\eta_p^2 = .79$, and for social words, $F(2, 30) = 34.35$, $p < .001$, $\eta_p^2 = .70$. The effect of INDCOL on SRE found in Study 1 was not replicated in Study 2 (Fs < 1). However, there is reason to believe that the absence of the interaction between INDCOL and word type in Study 2 is an exception. Wager and Cohen (2003) compared the SRE for personality traits and social identities for individualist and collectivists and obtained the similar finding as in our Study 1. In addition, it is not rare in cultural neuroscience studies that an expected behavioral cultural difference is not obtained, yet an fMRI study finds the expected cultural difference in brain activity (Chiao et al, 2009; 2010; Hedden, Ketay, Aron, Markus, & Gabrieli, 2008). Therefore, despite the absence of the interaction between INDCOL and Word Type, we expected that the modulation effect of INDCOL on SRE would appear at the neural level.

fMRI results

Self-reference effect in the brain. We found significant main effects of Target in the regions that were previously found to be associated with self-processing (Table 1). Specifically, the MPFC, anterior cingulate cortex (ACC), superior frontal gyrus (SFG), precuneus, and bilateral TPJ, including the posterior superior temporal gyrus (STG), inferior parietal lobule (IPL), and supramarginal gyrus (SMG), showed greater activity for self-judgment than for other-judgment.

The regions demonstrating significant main effects of Word Type are shown in Table 2. Overall, processing social identities involved lateral and posterior regions (e.g., middle frontal gyrus and inferior parietal gyrus, precuneus, and posterior cingulate) more strongly than when processing the personal self. For personality traits, visual areas in the occipital cortex showed greater activation than for

TABLE 1
Coordinates and Z values for peak activations in the main effect of Target contrast

X	*Y*	*Z*	*Z score*	*K*	*Region*	*BA*
[Self_Personal +Self_Collective]-[Other_Personal + Other_Collective]						
−4	52	10	4.43	525	L. medial frontal gyrus	9/10
					L. anterior cingulate	24/32
60	−42	22	4.16	136	R. superior temporal gyrus	22
					R. inferior parietal lobule	40
14	38	52	4.06	28	R. superior frontal gyrus	8
−44	−56	20	3.99	23	L. superior temporal gyrus	22
					L. supramarginal gyrus	39
−4	−56	44	3.81	34	L. precuneus/cingulate gyrus	7/31
−18	34	54	3.80	151	L. superior frontal gyrus	6/8
					L. middle frontal gyrus	8
28	46	34	3.63	43	R. middle frontal gyrus	8
−4	−82	−4	3.49	123	L. lingual gyrus	17/18

Notes: All *Z* values correspond to $p < .001$, uncorrected. An additional extent threshold of $k = 15$ voxels was used. Coordinates are in MNI space. BA: Brodmann area.

TABLE 2
Coordinates and *Z* values for peak activations in the main effect of Word Type contrast

X	*Y*	*Z*	*Z score*	*K*	*Region*	*BA*
[Self_Personal + Other_Personal] – [Self_Collective + Other_Collective]						
−4	−16	36	5.31	494	L. cingulate gyrus	24
−12	−92	−12	4.71	971	L. lingual gyrus	18
−36	12	−26	4.69	635	L. superior temporal gyrus	38
24	−4	60	4.40	72	R. middle frontal gyrus	6
42	−22	46	4.33	180	R. postcentral gyrus	2/3
−4	62	18	4.32	129	L. medial frontal gyrus	9
−58	−30	14	4.23	79	L. superior temporal gyrus	42
16	−84	12	3.96	101	R. cuneus	17/18
−4	2	56	3.96	63	L. subgyral/middle frontal gyrus	6
46	4	−14	3.85	38	R. extranuclear	13
−18	−52	68	3.81	49	L. superior parietal lobule	7
−8	14	62	3.80	62	L. medial frontal gyrus	6
16	−34	54	3.74	26	R. precuneus	7/31
−4	36	14	3.73	51	L. anterior cingulate	24
28	−26	68	3.70	43	R. postcentral gyrus	3
−42	−18	52	3.63	93	L. postcentral gyrus	3
16	−88	42	3.59	27	R. cuneus	19
−4	28	26	3.57	64	L. cingulate gyrus	32
2	6	44	3.51	21	R. cingulate gyrus	24
[Self_Collective + Other_Collective] – [Self_Personal + Other_Personal]						
−8	−68	16	5.11	869	L. posterior cingulate	30
−30	32	46	5.02	354	L. middle frontal gyrus	8
−38	−76	34	4.92	728	L. superior occipital gyrus/superior parietal lobule	7/19
36	18	58	4.13	394	R. middle frontal gyrus	6
36	−76	44	4.01	723	R. precuneus/inferior parietal lobule	7/19
2	−38	38	4.60	151	R. cingulate gyrus	31
14	−58	10	4.00	287	R. posterior cingulate	30
32	36	−22	3.71	16	R. middle frontal gyrus	11

Notes: All Z-values correspond to $p < .001$, uncorrected. An additional extent threshold of $k = 15$ voxels was used. Coordinates are in MNI space. BA: Brodmann area.

social identities. This might have been due to the fact that there were more letters in personal words ($M = 4.62$ letters) than in social words ($M = 3.05$). In any case, we will not further address the main effect of Word Type because it is not a major focus of the present study. No region was found to be significant for the Target × Word interaction effect in the whole-brain analysis, suggesting that there is no specific region that differentiates the SRE for personality traits and social identities.

To further illustrate the activation patterns, mean parameter estimates of neural activation extracted from each ROI for self-, other-, and font-judgment in personal and social word conditions are shown in Figure 3. As shown in the whole-brain analysis, ROIs showed greater activity for the self-judgment condition than the other-judgment condition. Although Word Type did not affect this self-reference effect, the overall activation in the MPFC was greater for personal words than for social words, $F(1, 18) = 13.31$, $p < .005$, and vice versa in the left TPJ, $F(1, 18) = 11.95$, $p < .005$. In addition, the MPFC and left TPJ showed greater activation in self- and other-judgment than in font-judgment, whereas the right TPJ was least active in other-judgment. That is, the self–other contrasts in the right TPJ might be due to the suppression in other-judgment condition while those in the MPFC and left TPJ might reflect stronger activation in self-judgment than other-judgment. This will be discussed later.

Culture and self-reference effect. In order to examine the cultural influence on SRE_{brain}, we analyzed the Word (personal, social) $\times$ INDCOL (continuous) interaction. The SRE_{brain} of bilateral TPJ and the MPFC was modulated by cultural orientations (Figure 4).

First of all, the two-way interaction was significant in the left TPJ, $F(1, 17) = 6.37$, $p < .025$. To pinpoint this interaction, we tested the effect of

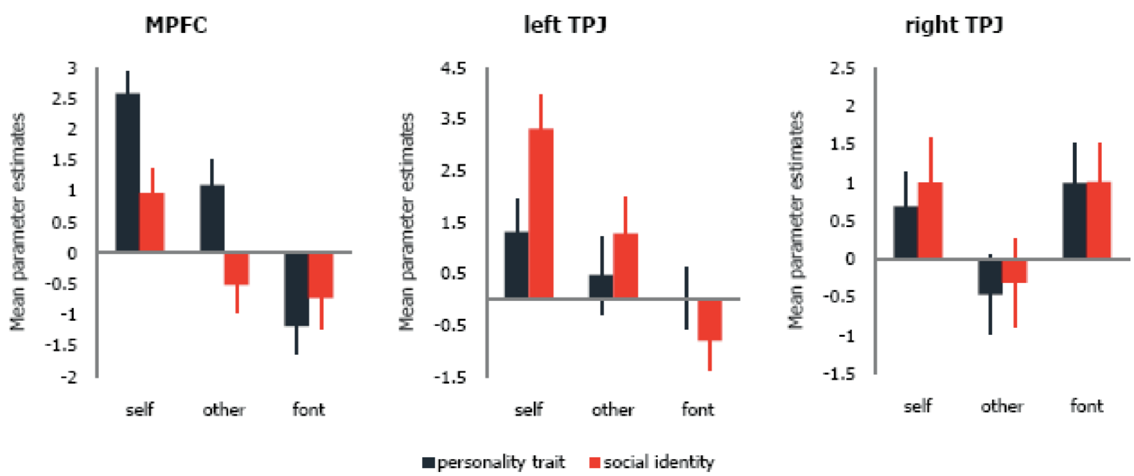

Figure 3. Mean parameter estimates extracted from the three ROIs (MPFC, left TPJ, and right TPJ) for self-, other-, and font-judgment tasks in the personal word and social word conditions.

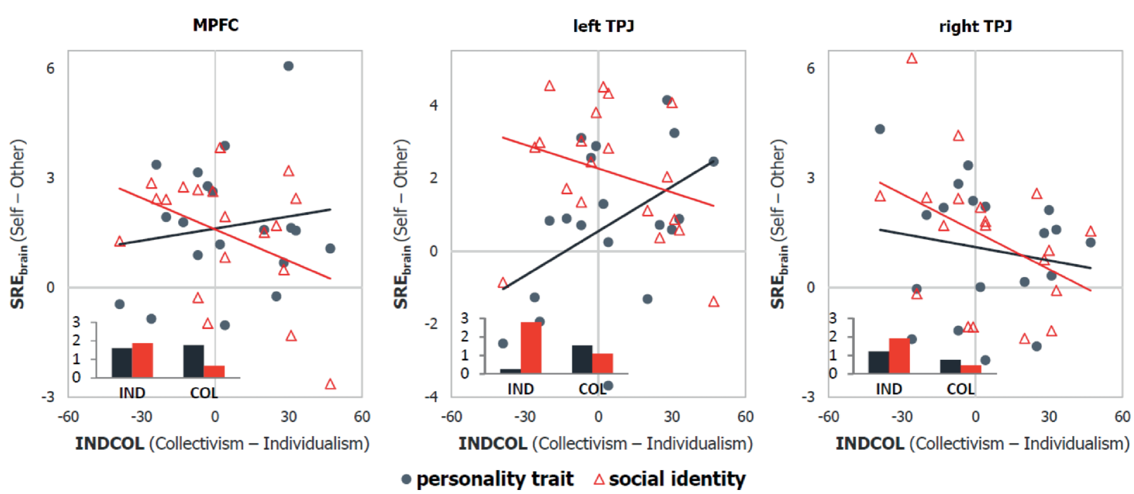

Figure 4. Scatter plots and prediction lines of the SRE in the brain (parameter estimates of self minus other contrast) as a function of the INDCOL score (collectivism – individualism) of each participant in the three ROIs. Insets: the SRE in the brain for personality traits and social identities by individualists and collectivists. The two groups were defined by a median split of INDCOL scores, for illustration purposes. Note that all statistical analyses included INDCOL as a continuous variable.

INDCOL on the SRE_{brain} separately for personal and social words. Whereas the SRE_{brain} in the left TPJ *increased* significantly with INDCOL during the personality trait judgment ($\beta = 0.46$, $p < .05$), it was not affected by INDCOL during the social identity judgment ($\beta = -0.29$, *ns*). To put it another way, the left TPJ was equally activated among individualists and collectivists for representing the *social* self, but was more likely to be used by collectivists than individualists for representing the personal self.

The reverse was true for the MPFC. The MPFC showed a marginally significant Word × INDCOL interaction, $F(1, 17) = 3.64$, $p = .073$, and the direction of interaction was the opposite of that of the left TPJ. The SRE_{brain} in this region was not influenced by INDCOL during the personality trait judgment ($\beta = 0.16$, *ns*), suggesting that this region is commonly recruited for representing the *personal* self regardless of cultural orientation. During the social identity judgment, however, the SRE_{brain} *decreased* with INDCOL scores ($\beta = -0.41$, $p = .08$), indicating that individualists showed greater SRE_{brain} than collectivists when it came to the social self. In other words, individualists displayed increased MPFC activation for both the personal and social self, while collectivists used this region mainly for representing the personal self.

In addition, the main effect of INDCOL was significant in the right TPJ, $F(1, 17) = 5.75$, $p < .05$, such that participants with more individualistic orientations showed increased SRE_{brain} in the right TPJ for both personal and social words. Neither the interaction effect nor the main effect of word type was significant.

Taken together, Study 2 confirmed the existence of SRE in the brain for both the personal self and social self. As expected, the self-referential activities in the MPFC and bilateral TPJ were modulated by one's cultural orientation, which affects how one construes the self. These results are discussed in the following sections.

DISCUSSION

The key features of our study were (1) the inclusion of social identities in the self-reference task to incorporate the social aspects of the self and (2) the inclusion of INDCOL as a measure of cultural orientation. The behavioral experiment confirmed the existence of the SRE for both the personal and the social words and showed that the SRE was moderated by one's cultural orientation. People were more likely to remember the words describing their dominant self-aspect: The more individualistic (collectivistic) they were, the better they remembered personality traits (social identities) than social identities (personality traits).

The fMRI experiment revealed that brain regions involved in the SRE consisted of the MPFC, precuneus, and temporoparietal regions, including the IPL, posterior STG, and SMG. In general, these regions seem to be shared by personal and social self-representations, as indicated by the main effect of judgment Target without any interactions. Namely, these regions did not seem to distinguish the personal self and social self. However, the inclusion of INDCOL enabled us to reveal the differential involvement of the MPFC and TPJ in representing the personal self and social self. This led us to the central finding that self-referential brain activity was influenced by cultural orientation.

Specifically, the left TPJ was commonly recruited regardless of the self-aspect that was reflected on among collectivists. In contrast, among individualists, the left TPJ was less active when personality traits were being considered than when social identities were being considered. Put differently, this region seems to play an essential role in processing the social self for both collectivists and individualists, but not in processing the personal self for individualists. This implies the possibility that the left TPJ may be more involved in representing the interdependent than independent nature of the self, as is consistent with the finding that this region is activated when subjects assimilate the self to the other (Decety, Chaminade, Grèzes, & Meltzoff, 2002; Decety & Grèzes, 2006; Decety & Sommerville, 2003).

As the large body of literature on the self indicates, social aspects of the self cannot be identified without relating others to the self (e.g., "I am a daughter of my parents," "I am Korean"). In line with this idea, Markus and Kitayama (1991) suggested that the shared representation of the self and close others is important for an interdependent self. According to social identity theory (Brewer & Gardner, 1996; Caporael & Brewer, 1995; Trafimow, Triandis, & Goto, 1991), when people think of their social self, they simultaneously experience a sense of belongingness and a sense of distinctiveness. Indeed, thinking about the social self requires people to take a third-person perspective (e.g., seeing me from my parents' view) and to assimilate themselves to other people. Therefore, it seems reasonable that the neural mechanisms that are known to be involved in shared representations of the self and the other (Ruby & Decety, 2004; Samson, Apperly, Chiavariono, & Humphreys, 2004; Saxe & Kanwisher, 2003; Vanderwal, Hunyadi, Grupe, Connors, & Schultz, 2008; Zilbovicius et al., 2006) are commonly tapped when collectivists and individualists reflect on social identities.

On the other hand, the right TPJ showed stronger SRE among individualists than collectivists regardless of the self-aspect under consideration, reflecting that the right TPJ might play a different role from the left TPJ. As shown in Figure 3, the right TPJ showed a different pattern of activation from the left TPJ: The right TPJ was equally active in the self- and font-judgment condition, but suppressed in the other-judgment condition. This finding seems to be consistent with that of a previous study indicating that the right TPJ, which includes the inferior parietal cortex and posterior superior temporal cortex, is involved in distinguishing the other from self (Decety & Grèzes, 2006; Decety & Lamm, 2007; Decety & Sommerville, 2003; Uddin et al., 2006).

Although the effect was only marginally significant, it is also worth noting that the MPFC showed an interaction that was opposite in direction to that found in the left TPJ. The MPFC seemed to be an important area representing the self among individualists in that it was equally active during the process of both the personal self and the social self. Yet, it was less likely to be activated when collectivists thought of their social self. This implies that the MPFC may be critical in processing self-relevant information among individualists, but not among collectivists. In other words, this region may represent more the independent than the interdependent aspect of the self. This partly explains why the self-related regions other than the MPFC have not received as much attention in previous studies: The studies were conducted with participants from individualistic cultures, using only personality traits. Given that MPFC activities are mainly involved in differentiating the self from the other (Heatherton et al., 2006; Kelley et al., 2002; Zhu et al., 2007), the greater SRE in the MPFC during social-identity judgments among individualists (versus collectivists) may indicate that individualists tend to regard even the social self as a distinctive entity due to their independent self-construal.

In addition to the cultural difference in self-construal, there is another potential explanation for our findings. Namely, a difference in perspective taking may underlie the culturally different self-referential brain activity. Evidence from cultural psychology has suggested that collectivists tend to view the self from the perspective of the generalized other in an attempt to act in socially desirable ways, to satisfy social expectations of close others, and to achieve harmony with in-group members (Cohen & Gunz, 2002; Heine, Lehman, Markus, & Kitayama, 1999; Triandis, 1989; Wu & Keysar, 2007). Additionally, the left temporoparietal regions have been known to be involved in perspective-taking processes, and a stronger activation has been observed for the third-person perspective than the first-person perspective (Jackson, Meltzoff, & Decety, 2006; Lamm, Batson, & Decety, 2007; Ruby & Decety, 2001, 2004; Samson et al., 2004). Hence, we speculate that the recruitment of the left TPJ among collectivists during the personality judgment task is a reflection of the third-person perspective on the self. Likewise, the greater MPFC activation among individualists during the social identity judgment task may indicate that they tend to take a first-person perspective, even on the social self. This possibility is in line with recent findings linking anterior medial frontal areas to an inward-directed view and posterior areas to an outward-directed view (Jackson et al., 2006; Johnson et al., 2006; Lamm et al., 2007).

Before concluding, we note that there are several limitations that raise interesting questions for future studies. First, the present study tested the effect of cultural orientations among Korean participants and did not test cross-cultural differences. This might impose a limitation to the generalization of the findings. An ideal way to show the effect of culture would be to study both the cross-cultural difference and the effect of a core factor (e.g., self-construal, cultural orientation, thinking style) at the individual level. However, it has been also suggested that studying people in the same cultural affiliation or nationality can be more convincing when investigating the underlying psychological mechanism, since the various sources other than the core factor can be controlled (e.g., Chiao et al., 2009; Oyserman et al., 2002; Uskul, Kitayama, & Nisbett, 2008). It is sometimes the core concept (e.g., self-concept), not the nationality, that explains cultural differences in brain activity (Chiao et al., 2009). Thus, testing the effect of cultural orientation at the individual level is a viable way to investigate the neural mechanism of self-referential processes.

Second, the block design we used here made it unfeasible for us to examine the direct relationship between the SRE at the behavioral level and the neural level. We conducted a correlation analysis between the average memory performance and the SRE in the brain but could not find any effect. As Macrae and colleagues (2004) have shown that greater MPFC activity predicts better memory performance on self-related words, it would be interesting to see whether this would also be the case for the social aspects of the self and whether this relationship would be modulated by one's cultural orientation. Third, the growing body of literature has revealed further divisions within the social selves: a type of social self derived from interpersonal relationships with close others (relational self) and another derived from impersonal social memberships (collective self) (Brewer & Gardner, 1996; Chen, Boucher, & Tapias, 2006; Kashima & Hardie, 2000). We did not consider the relational self and the collective self as separate constructs in the present study. However, we think that the neural bases of these two social selves should be investigated in the future. Lastly, further exploration of the neural bases of cultural differences in perspective-taking on the self and functional connectivity among the self-regions in the medial prefrontal and the temporoparietal regions is also needed. Research in these areas will likely provide a more comprehensive understanding of the neural underpinnings of self-identity.

CONCLUSION

The present study adds to the cultural neuroscience literature on the self by extending the SRE paradigm to include words that reflect social identity. We confirmed the existence of the SRE for both personality traits and social identities at both the behavioral level and the neural level. Moreover, self-referential brain activity was modulated by one's cultural orientation (individualistic vs. collectivistic), revealing whether the personal self or the social self is central to a person's identity. We expect further cultural neuroscience studies to provide a broader understanding of the self.

Original manuscript received 6 April 2011
Revised manuscript accepted 28 July 2011
First published online 4 October 2011

REFERENCES

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: The medial frontal cortex and social cognition. *Nature Reviews Neuroscience*, *7*, 268–277.

Anderson, N. H. (1968). Likableness ratings of 555 personality-trait words. *Journal of Personality and Social Psychology*, *9*, 272–279.

Brett, M., Anton, J. L., Valabregue, R., & Poline, J. B. (2002). Region of interest analysis using an SPM toolbox [abstract]. Presented at the 8th International Conference on Functional Mapping of the Human Brain, 2–6 June 2002, Sendai,Japan. Available on CD-ROM in *NeuroImage*, *16* (2).

Brewer, M. B., & Gardner, W. (1996). Who is this "we"? Levels of collective identity and self representations. *Journal of Personality and Social Psychology*, *71*, 83–93.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review*, *100*, 432–459.

Caporael, L. R., & Brewer, M. B. (1995). Hierarchical evolutionary theory: There is an alternative, and it's not creationism. *Psychological Inquiry*, *6*, 31–34.

Chen, S., Boucher, H. C., & Tapias, M. P. (2006). The relational self revealed: Integrative conceptualization and implications for interpersonal life. *Psychological Bulletin*, *132*, 151–179.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., et al. (2009). Neural basis of individualistic and collectivistic views of self. *Human Brain Mapping*, *30*, 2813–2820.

Chiao, J. Y., Harada, T., Komeda, H., Li, Z., Mano, Y., Saito, D., et al. (2010). Dynamic cultural influences on neural representations of the self. *Journal of Cognitive Neuroscience*, *22*, 1–11.

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.

Cousins, S. D. (1989). Culture and self-perception in Japan and the United States. *Journal of Personality and Social Psychology*, *56*, 124–131.

D'Argembeau, A., Stawarczyk, D., Majerus, S., Collette, F., Van der Linden, M., & Salmon, E. (2009). Modulation of medial prefrontal and inferior parietal cortices when thinking about past, present, and future selves. *Social Neuroscience*, *21*, 1–14.

Decety, J., Chaminade, T., Grèzes J., & Meltzoff, A. N. (2002). A PET exploration of the neural mechanisms involved in reciprocal imitation. *NeuroImage*, *15*, 265–272.

Decety, J., & Grèzes, J. (2006). The power of simulation: Imagining one's own and other's behavior. *Brain Research*, *1079*, 4–14.

Decety, J., & Lamm, C. (2007). The role of the right temporoparietal junction in social interaction: How low-level computational processes contribute to metacognition. *Neuroscientist*, *13*, 580–593.

Decety, J., & Sommerville, J. A. (2003). Shared representations between self and others: A social cognitive neuroscience view. *Trends in Cognitive Sciences*, *7*, 527–533.

Diener, E., Oishi, S., & Lucas, R. E. (2003). Personality, culture, and subjective well-being: Emotional and cognitive evaluations of life. *Annual Review of Psychology*, *54*, 403–425.

Friston, K. J., Frith, C. D., Turner, R., & Frackowiak, R. S. (1995). Characterizing evoked hemodynamics with fMRI. *NeuroImage*, *2*, 157–165.

Gusnard, D. A., Akbudak, E., Shulman, G. L., & Raichle, M. E. (2001). Medial prefrontal cortex and self-referential mental activity: Relation to a default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America*, *98*, 4259–4264.

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

Hedden, T., Ketay, S., Aron, A., Markus, H. R., & Gabrieli, J. D. E. (2008). Cultural influences on neural substrates of attentional control. *Psychological Science*, *19*, 12–16.

Heine, S. J. (2001). Self as cultural product: An examination of East Asian and North American selves. *Journal of Personality*, *69*, 881–906.

Heine, S. J., Lehman, D. R., Markus, H. R., & Kitayama, S. (1999). Is there a universal need for positive self-regard? *Psychological Review*, *106*, 766–794.

Hofstede, G. (1980). Motivation, leadership, and organization – Do American theories apply abroad? *Organizational Dynamics*, *9*, 42–63.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2006). Neural circuits involved in imitation and perspective-taking. *NeuroImage*, *31*, 429–439.

Johnson, M. K., Raye, C. L., Mitchell, K. J., Touryan, S. R., Greene, E. J., & Nolen-Hoeksema, S. (2006). Dissociating medial frontal and posterior cingulate activity during self-reflection. *Social Cognitive and Affective Neuroscience*, *1*, 56–64.

Kashima E. S., & Hardi, E. A. (2000). The development and validation of the Relational, Individual, and Collective self-aspects (RIC) Scale. *Asian Journal of Social Psychology*, *3*, 19–48.

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*, 785–794.

Kitayama, S., Duffy, S., Kawamura, T., & Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. *Psychological Science*, *14*, 201–206.

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.

Lancaster, J. L., Tordesillas-Gutiérrez, D., Martinez, M., Salinas, F., Evans, A., Zilles, K., et al. (2007). Bias between MNI and Talairach coordinates analyzed using the ICBM-152 brain template. *Human Brain Mapping*, *28*, 1194–1205.

Lou, H. C., Luber, B., Crupain, M., Keenan, J. P., Nowak, M., Kjaer, T. W., et al. (2004). Parietal cortex and representation of the mental self. *Proceedings of the National Academy of Sciences of the United States of America*, *101*, 6827–6832.

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*, 647–654.

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

Mitchell, J. P., Banaji, M. R., & Macrae, C. N. (2005). The link between social cognition and self referential thought in the medial prefrontal cortex. *Journal of Cognitive Neuroscience*, *17*, 1306–1315.

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

Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain—a meta-analysis of imaging studies on the self. *NeuroImage*, *31*, 440–457.

Oyserman, D., Coon, H.M., & Kemmelmeier, M. (2002). Rethinking individualism and collectivism: Evaluation of theoretical assumptions and meta-analyses. *Psychological Bulletin*, *128*(1), 3–72.

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

Ruby, P., & Decety, J. (2001). Effect of subjective perspective taking during simulation of action: A PET investigation of agency. *Nature Neuroscience*, *4*, 546–550.

Ruby, P., & Decety, J. (2004). How would you feel versus how do you think she would feel? A neuroimaging study of perspective-taking with social emotions. *Journal of Cognitive Neuroscience*, *16*, 988–999.

Samson, D., Apperly, I. A., Chiavariono, 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 – the role of the temporoparietal junction in "theory of mind". *NeuroImage*, *19*, 1835–1842.

Schmitz, T. W., Kawahara-Baccus, T. N., & Johnson, S. C. (2004). Metacognitive evaluation, self-relevance, and the right prefrontal cortex. *NeuroImage*, *22*, 941–947.

Singelis, T. M., Triandis, H. C., Bhawuk, D., & Gelfand, M. J. (1995). Horizontal and vertical dimensions of individualism and collectivism: A theoretical and measurement refinement. *Cross-Cultural Research*, *29*, 240–275.

Sui, J., & Han, S. (2007). Self-construal priming modulates neural substrates of self-awareness. *Psychological Science*, *18*(10), 861–866.

Talairach, J., & Tournoux, P. (1988). *Co-planar stereotaxic atlas of the human brain*. New York, NY: Thieme.

Trafimow, D., Triandis, H. C., & Goto, S. G. (1991). Some tests of the distinction between the private self and the collective self. *Journal of Personality and Social Psychology*, *60*, 649–655.

Triandis, H. C. (1989). The self and social behavior in differing cultural contexts. *Psychological Review*, *96*, 506–520.

Triandis, H. C. (1995). *Individualism and collectivism*. Boulder, CO: Westview Press.

Tsai, J. L. (2007). Ideal affect: Cultural causes and behavioral consequences. *Perspectives on Psychological Science*, *2*, 242–259.

Uddin, L. Q., Iacoboni, M., Lange, C., & Keenan, J. P. (2007). The self and social cognition: The role of cortical midline structures and mirror neurons. *Trends in Cognitive Sciences*, *11*, 153–157.

Uskul, A. K., Kitayama, S., & Nisbett, R. E. (2008). Ecocultural basis of cognition: Farmers and fishermen are more holistic than herders. *Proceedings of the National Academy of Sciences of the United States of America*, *105*, 8552–8556.

Vanderwal, T., Hunyadi, E., Grupe, D. W., Connors, C. M., & Schultz, R. T. (2008). Self, mother and abstract other: An fMRI study of reflective social processing. *NeuroImage*, *41*, 1437–1446.

Wagar, B. M., & Cohen, D. (2003). Culture, memory, and the self: An analysis of the personal and collective self in long-term memory. *Journal of Experimental Social Psychology*, *39*, 468–475.

Wu, S., & Keysar, B. (2007). The effect of culture on perspective taking. *Psychological Science*, *18*, 600–606.

Zhu, Y., Zhang, L., Fan, J., & Han, S. (2007). Neural basis of cultural influence on self-representation. *NeuroImage*, *34*, 1310–1316.

Zilbovicius, M., Meresse, I., Chabane, N., Brunelle, F., Samson, Y., & Boddaert, N. (2006). Autism, the superior temporal sulcus and social perception. *Trends in Neurosciences*, *29*, 359–366.