Dynamic Cultural Influences on Neural Representations of the Self

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Abstract

■ People living in multicultural environments often encounter situations which require them to acquire different cultural schemas and to switch between these cultural schemas depending on their immediate sociocultural context. Prior behavioral studies show that priming cultural schemas reliably impacts mental processes and behavior underlying self-concept. However, less well understood is whether or not cultural priming affects neurobiological mechanisms underlying the self. Here we examined whether priming cultural values of individualism and collectivism in bicultural individuals affects neural activity in cortical midline structures underlying self-relevant processes using functional magnetic resonance imaging. Biculturals primed with individualistic values showed increased activation within medial prefrontal cortex (MPFC) and posterior cingulate cortex (PCC) during general relative to contextual self-judgments, whereas biculturals primed with collectivistic values showed increased response within MPFC and PCC during contextual relative to general self-judgments. Moreover, degree of cultural priming was positively correlated with degree of MPFC and PCC activity during culturally congruent self-judgments. These findings illustrate the dynamic influence of culture on neural representations underlying the self and, more broadly, suggest a neurobiological basis by which people acculturate to novel environments. ■

INTRODUCTION

It is said to be the age of the first person singular. (Ralph Waldo Emerson)

Now then, Venerable Gotama, is there a self? When this was said, the Blessed One was silent. (Buddhist scripture)

When in Rome, do as the Romans do. (St. Ambrose)

A fundamental way in which cultural values, practices, and artifacts shape psychological processes is in how people define themselves and their relation to others in their environment (Nisbett, Peng, Choi, & Norenzayan, 2001; Triandis, 1995; Markus & Kitayama, 1991). In particular, cultural psychologists have identified two primary cultural schemas, *individualism* and *collectivism* (Nisbett et al., 2001; Triandis, 1995; Markus & Kitayama, 1991), to explain cultural differences in basic psychological processes, most notably between Westerners and East Asians, respectively. Individualists think of people as independent of each other and describe individuals using stable personality traits (e.g., I am honest) rather than situation-specific attributes. By contrast, collectivists think of people as highly interconnected to one another and describe themselves and others as embedded in a specific social context or situations (e.g., When talking to my mother, I am honest) rather than using generic trait adjectives. Cultural psychologists posit that the concepts of individualism and collectivism originate from divergences in notions of self and its relation to the environment introduced by early Western and Eastern philosophers (Nisbett et al., 2001; Triandis, 1995; Markus & Kitayama, 1991).

Although some aspects of cultures remain stable across time, other cultural traits are dynamic, evolving across macro- (e.g., generations, lifespan) and even micro-level (e.g., situations) time scales (Chiao & Ambady, 2007; Mesoudi, Whiten, & Laland, 2006; Li, 2003). A major source of cultural change within a given sociocultural environment is the human propensity for migration and population movement (Manning, 2005). Since the beginning of human history, people have migrated in large and small groups, across large and small distances, often in response to different kinds of evolutionary pressures (e.g., scarcity in quantity or quality of ecological resources) (Manning, 2005). When large numbers of individuals

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immigrate from one culture into another, the kinds of cultural values, practices, and beliefs existent within a given social system systematically diversifies affording people novel exposure to and opportunities for identifying with multiple cultural schemas. As a means for adapting to culturally diverse social environments, bicultural individuals may rely more on or psychologically ''switch'' between either an individualistic or collectivistic cultural schema to a greater extent in order to think and behave in a manner congruent with their current sociocultural context (Hong, Morris, Chiu, & Benet-Martinez, 2000). This adaptive ability to switch between cultural schemas depending on one's cultural context is akin to bilinguals who readily alternate between different languages depending on who they are speaking with (Klein et al., 2006) or biracials who attend to Black or White faces to differing extents depending on whether they think of themselves as Black or White (Chiao, Heck, Nakayama, & Ambady, 2006).

Evidence from cultural psychology indicates that cultural context dynamically influences how bicultural individuals think of themselves and their relation to others. A number of different kinds of cultural primes have been shown to reliably elicit either an individualistic or collectivistic cultural orientation within the individual, such as reading a story about a Sumerian Warrior chosen either for merit or familial relations (Oyserman & Lee, 2008; Trafimow, Triandis, & Goto, 1991) or thinking for a short time about what makes one unique or similar to their friends and family (Oyserman & Lee, 2008; Trafimow et al., 1991). These classic cultural priming studies have shown that biculturals primed with an individualistic orientation were more likely to describe themselves using general descriptions (e.g., I am honest), whereas biculturals primed with a collectivistic orientation showed a stronger propensity to describe themselves using contextual self-descriptions (e.g., When talking to my mother, I am honest) (Oyserman & Lee, 2008; Gardner, Gabriel, & Lee, 1999; Trafimow et al., 1991). Remarkably, individuals from both individualistic and collectivistic nations (e.g., United States and Hong Kong) have shown similar effects of cultural prime on self-concept (Gardner et al., 1999). Taken together, these behavioral studies demonstrate that regardless of nationality or cultural affiliation, people can readily acquire and carry knowledge of multiple kinds of cultural schemas simultaneously. Hence, when primed to orient more toward either an individualistic or collectivistic schema, people will think about themselves in a way that is consistent with the cultural schema temporarily brought to mind.

What neural mechanisms support this remarkable ability to adapt one's sense of self to the immediate cultural context? Activity within cortical midline structures, including the anterior rostral portion of medial prefrontal cortex (MPFC) and posterior cingulate cortex (PCC) are thought to comprise two components of a network of cortical midline structures underlying self-relevant processes, particularly in the verbal domain (Moran, Heatherton, & Kelley, in press; Amodio & Frith, 2006; Northoff et al., 2006; Gillihan & Farah, 2005; Northoff & Bermpohl, 2004; Kelley et al., 2002). MPFC response reliably increases when evaluating general trait descriptions about one's self (e.g., I am honest) relative to general trait descriptions about familiar others such as Bill Clinton (e.g., Bill Clinton is honest) (Kelley et al., 2002). Additionally, PCC is thought to subserve the integration of self-referential information within the larger autobiographical context of a person, such as their attitudes, goals, and personality (Northoff & Bermpohl, 2004). For instance, neural activity within PCC reliably increases during evaluation of self-relevant traits (Moran et al., in press; Northoff & Bermpohl, 2004) as well as during retrieval of memories that are autobiographical in nature (e.g., one's name vs. familiar names) (Northoff & Bermpohl, 2004). In addition to self-evaluation, MPFC and PCC regions are recruited during other processes important to social interaction, including emotional and moral judgments, perspective taking, and theory of mind (Northoff & Bermpohl, 2004).

Although the influence of cultural priming on self-concept is well established at the behavioral level, less well understood is how cultural priming affects neural mechanisms underlying the self. Recent neuroimaging evidence suggests that culture shapes neural representations of the self. A prior neuroimaging study comparing East Asians and Westerners living in China found no difference in MPFC activation in Chinese subjects when they viewed general trait descriptions of one's self or a close other, such as one's mother (e.g., Your mother is honest) (Zhu, Zhang, Fan, & Han, 2007). More recently, a cross-cultural neuroimaging study comparing Caucasian Americans living in the United States and native Japanese living in Japan found that degree of MPFC activity in response to general (e.g., I am honest) relative to contextual (e.g., When talking to my mother, I am honest) self-descriptions positively correlated with degree of individualism and collectivism, respectively, across both cultural groups (Chiao et al., 2008). Notably, participants' cultural values (e.g., individualism or collectivism), and not necessarily their cultural affiliation (e.g., being Caucasian American or native Japanese), modulated neural response within MPFC during self-judgments. Hence, results from Chiao et al. (2008) indicate that neural representations of self in Westerners and East Asians are not inherently different, but instead reflect cultural values of individualism and collectivism that are endorsed by the individual, a process that is likely malleable to influence across multiple time scales.

Although provocative in their demonstration of cultural influences on neural representations of the self, these prior cultural neuroscience investigations are limited given their conceptualization of culture as a stable characteristic of an individual, rather than an attribute shaped by one's immediate sociocultural context. None of these prior studies have examined neural processing

of self-relevant information in people who identify with and possess knowledge of both individualism and collectivism, such as bicultural individuals. It remains unknown the extent to which temporarily heightening one's cultural orientation of individualism or collectivism in bicultural individuals modulates neural activity during self-evaluation. For instance, cortical midline structures, such as MPFC and PCC, may show increased activity during the evaluation of culturally congruent self-descriptions. Additionally, prior neuroimaging research has shown that inferior frontal gyri and occipito-temporal cortices tend to deactivate in response to conceptual priming, such as reading pairs of semantically related words (Wheatley, Weisberg, Beauchamp, & Martin, 2005). Given that classic cultural priming techniques heighten awareness of cultural schemas by activating semantically related concepts (e.g., reading a story about merit or familial relations to activate individualistic and collectivistic values, respectively), it is possible that brain regions associated with conceptual priming may show decreased activity during the evaluation of culturally congruent self-descriptions.

Here we used functional magnetic resonance imaging to examine whether or not cultural priming of individualism and collectivism in bicultural individuals affects neural activity in cortical midline structures underlying the self. Specifically, we sought to determine whether temporarily heightening awareness of a particular cultural frame (e.g., individualism or collectivism) would result in enhanced processing of culturally congruent self-representations (e.g., general or contextual) within cortical midline regions critical to the self. We predicted that bicultural participants primed with individualism would show a greater response for general self-descriptions relative to contextual self-descriptions, whereas bicultural participants primed with collectivism would show a greater response for contextual relative to general self-descriptions within MPFC and PCC regions. Additionally, we predicted decreases in neural activity for culturally congruent self-descriptions within brain regions sensitive to conceptual priming, specifically inferior frontal gyrus and occipito-temporal cortices.

METHODS

Participants

Thirty right-handed university students with normal or corrected-to-normal vision participated in this study for payment. All 30 participants were Asian-American[1] young adults living in Chicago, IL. All participants self-identified as bicultural[2] as defined by the Suinn–Lew Asian Self-Identity Acculturation Scale (Suinn, Rickard-Figueroa, Lew, & Vigil, 1987) ($M = 3.19$, $SD = 1.60$). Fifteen participants (6 men, 9 women; $M = 22.9$ years, $SD = 4.2$ years) were randomly assigned to the individualistic prime (IND-PRIME) group, whereas the remaining 15 participants were randomly assigned to the collectivistic prime (COL-PRIME) group (6 men, 9 women; $M = 24.8$ years, $SD = 5.3$ years). Informed written consent was obtained from each participant prior to the experiment.

Definition of Individualistic and Collectivistic Prime Groups

In a room outside of the scanner, participants completed a 10-min priming procedure consisting of two priming tasks, the Sumerian Warrior Story task (Trafimow et al., 1991) and a modified version of the Similarities and Differences with Family and Friends (SDFF) task (Trafimow et al., 1991), both of which have been previously shown to reliably impact self-concept (Gardner et al., 1999; Trafimow et al., 1991) (see Figure 1A). In the Sumerian Warrior Story priming task, participants read a story describing a dilemma where Sostoras, a military general, is deciding which warrior to send to a king. In the IND-PRIME condition, participants read a version of the story where Sostoras chooses a warrior who is the best qualified for the job. In the COL-PRIME condition, participants read a version of the story where Sostoras chooses a warrior who is a member of his own family. After reading the story, all participants made a judgment about whether they admire the general (e.g., ''Do you admire Sostoras?'') by circling one of three options (e.g., ''yes,'' ''no,'' or ''maybe'').

Next, participants completed a modified version of the SDFF priming procedure. In the IND-PRIME condition, participants were asked to think for 2 min about what makes them different from their family and friends and then write a short essay about what they expect themselves to do for 8 min. In the COL-PRIME condition, participants were asked to think for 2 min about what they have in common with their family and friends and then write a short essay about what their family and friends expect them to do for 8 min.

Stimuli

For the self-judgment task, stimuli consisted of 72 text descriptions (512 pixels × 384 pixels; see Figure 1B) consisting of 24 general self-descriptions, 24 contextual self-descriptions, and 24 self-descriptions in either italicized on nonitalicized font, written in English.

Procedure

After the priming procedure, participants were scanned while performing the self-judgment task (see Figure 1B). We employed a block design consisting of 12 blocks within a functional run. There were three types of blocks consisting of either general self-descriptions, contextual self-descriptions, or self-descriptions that varied in font style (i.e., italicized or plain). Each block consisted of six unique trials of that block type. For each trial, a general

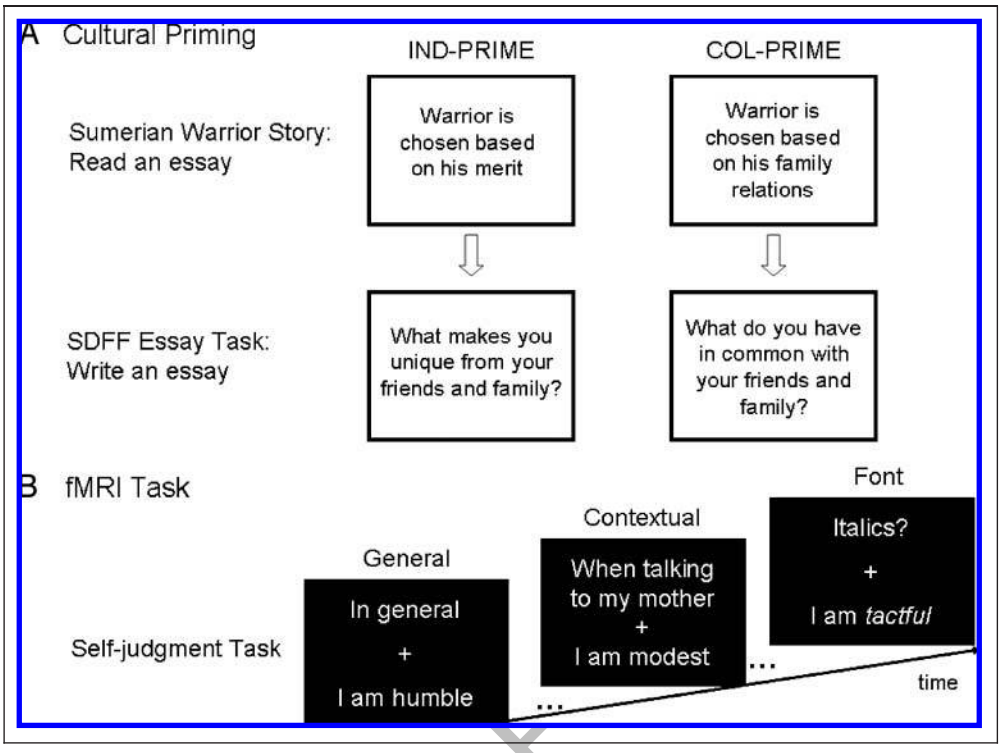

Figure 1. (A) Example of two cultural primes used in the current study, the Sumerian Warrior Story task and the Similarities and Differences with Friends and Family (SDFF) task, given to participants prior to scanning. (B) Example of self-judgment task employed during scanning.

self, contextual self, or font description was displayed for 4000 msec. Trials were separated by a centered fixation cross which was presented in a jittered manner ranging from 2000 to 6000 msec (average duration of ITI for each block = 4000 msec).

During scanning, participants completed two types of self-judgments, a general self-task (e.g., in general, does this sentence describe you?) and contextual self-task (e.g., does this sentence describe you when you are talking to your mother?), as well as a font judgment task which served as a control (e.g., is this sentence written in italics?). Prior to entering the scanner, participants were shown examples of each type of task and given a practice trial in order to become familiar all three tasks.

Imaging Parameters

Functional brain images were acquired at the Center for Advanced Magnetic Resonance Imaging (CAMRI) facility located at the Northwestern University Medical School in Chicago, IL, USA. Scanning at CAMRI occurred on a 3.0-Tesla Siemens TIM Trio MRI scanner. We acquired functional images by using T2*-weighted, gradient-echo, echo-planar imaging sequences [repetition time (TR) = 2000 msec; echo time (TE) = 25 msec; flip angle = 70°; FOV = 20 cm, 64 × 64 matrix; 34 slices; voxel size = 3.0 × 3.0 × 3.0 mm]. A high-resolution anatomical T1-weighted image was also acquired [TR = 2300 msec; TE = 2.91 msec; flip angle = 9°; FOV = 256 mm; 256 × 256 matrix; 176 slices; voxel size = 1.0 × 1.0 × 1.0 mm] for each subject. All stimuli were presented using Presentation software (Neurobehavioral Systems, Albany, CA) and projected onto a half-transparent viewing screen located behind the head coil.

Imaging Processing and Statistical Analysis

Functional images were analyzed using SPM2 software (Wellcome Department of Imaging Neuroscience, London, UK) implemented in Matlab (Mathworks, Cherborn, MA, USA). The first 6 volumes were discarded due to unsteady magnetization, and all of the remaining volumes were realigned spatially to the first volume and a mean image was created. After a high-resolution image was co-registered onto the mean image, all volumes were normalized to the Montreal Neurological Institute (MNI) space using a transformation matrix obtained from the normalization process of the high-resolution image of each individual subject to the MNI template. The normalized images were then spatially smoothed with an 8-mm Gaussian kernel.

After preprocessing, statistical analysis for each individual subject was conducted using the general linear model (Friston et al., 1995). At the first level, each block of trials was modeled by convolving with a hemodynamic response function. For each subject, a linear regressor was applied to filter noise. In the subtraction analysis, three task conditions [font, general, contextual] were modeled separately, including fixation. Random effects analyses were conducted by averaging the contrast images for each effect of interest. Because neuroimaging research examining neural priming effects has previously reported increases (Eddington, Dolcos, Cabeza, Krishnan, & Strauman, 2007; Fiebach, Gruber, & Supp, 2005) and

decreases (Schacter, Wig, & Stevens, 2007; Grill-Spector, Henson, & Martin, 2006) in neural response as a function of conceptual priming, we tested for both increases and decreases in MPFC and PCC activity as a function of cultural priming. We used whole-brain voxelwise interaction analyses to identify brain regions that showed increases and decreases in neural activity during self-judgments that were congruent and incongruent with cultural primes. To assess whether neural activity within MPFC and PCC increases during self-judgments congruent with cultural primes and decreases for self-judgments incongruent with cultural primes, a whole-brain voxelwise analysis was performed on the main interaction contrast of interest [(IND-PRIME$_{general}$ + COL-PRIME$_{contextual}$) − (IND-PRIME$_{contextual}$ + COL-PRIME$_{general}$)] with a threshold of $p < .005$, extent threshold = 5 voxels (Table 2). To assess whether neural activity within MPFC and PCC decreases during self-judgments congruent with cultural primes and increases for self-judgments incongruent with cultural primes, a whole-brain voxelwise analysis was performed on the reverse interaction contrast of interest [(IND-PRIME$_{contextual}$ + COL-PRIME$_{general}$) − (IND-PRIME$_{general}$ + COL-PRIME$_{contextual}$)] with a threshold of $p < .005$, extent threshold = 5 voxels (Table 3). Small-volume correction for multiple comparisons was performed using a sphere with an 8-mm radius (16 mm diameter) for the a priori regions of interest, namely, MPFC and PCC (Amodio & Frith, 2006; Northoff et al., 2006). A sphere with an 8-mm radius (16 mm diameter) was centered around a peak voxel within MPFC [$x = -6, y = 63, z = 18$] and PCC [$x = 0, y = -13, z = 31$] as defined by prior neuroimaging literature of the self (Moran, Macrae, Heatherton, Wyland, & Kelley, 2006; Zysset, Huber, Ferstl, & von Cramon, 2002). Additionally, regions-of-interest analyses were performed within this spherical region of interest using Marsbar software (http://marsbar.sourceforge.net/). MNI coordinates were converted to Talairach using a nonlinear transformation (http://imaging.mrc-cbu.cam.ac.uk/imaging/MniTalairach). Brodmann's areas and brain regions were identified based on the Talairach and Tournoux (1988) Atlas.

To determine the relationship between cultural priming and neural response during prime compatible self-judgments, correlation analyses were performed between a self-construal priming index calculated from ratings of valued uniqueness (IND-PRIME) and similarity (COL-PRIME) to others from the SDFF task [IND-PRIME − COL-PRIME] and activity within MPFC and PCC regions of interest during self-judgments [general − contextual].

RESULTS

Behavioral Results

Cultural Prime Manipulation Check

To assess the effectiveness of the priming procedures, two priming manipulation checks were conducted on participant responses from both the Sumerian Warrior Story priming task and the modified SDFF priming task. In the Sumerian Warrior Story task, a majority of participants in the IND-PRIME condition (agree = 46.7%, maybe = 33.3%, don't agree = 20%) and COL-PRIME condition (agree = 60%, maybe = 20%, don't agree = 20%) did not disagree with the general who chose the warrior who was either the best qualified or a family member, respectively. There was no significant difference in degree of participants' admiration for the general between the IND-PRIME and COL-PRIME groups [$t(28) = 0.99$, $p > .05$], indicating that the prime was similarly effective in both priming conditions.

To evaluate the effectiveness of the modified SDFF priming task, four independent raters (4 women, M = 19.75 years, SD = 1.5 years) were recruited after completion of the study to read and rate the essays. All four raters independently read the 30 essays and rated each on how much they thought that the author valued their uniqueness as an individual and their similarity to their friends and family using a Likert scale from 1 (*not at all*) to 7 (*very much*). Raters were not told the prime condition of the authors and read the essays in random order. Raters judged IND-PRIME participants as more likely to value their uniqueness from friends and family ($M = 5.10$, $SD = 1.3$) relative to COL-PRIME participants ($M = 2.63$, $SD = 1.1$), whereas COL-PRIME participants were judged as more likely to value their similarity to their friends and family ($M = 6.10$, $SD = 1.3$) relative to IND-PRIME participants ($M = 3.66$, $SD = 1.1$) [$F(1, 28) = 33.81$, $p < .0001$]. Intraclass correlation coefficient indicated high interrater reliability (ICC = .91). These results demonstrate that the essay writing priming manipulation was effective in priming IND-PRIME and COL-PRIME participants to temporarily bring to mind either individualistic or collectivistic values, respectively.

Reaction Time

There was a significant main effect of judgment type on reaction time during self-judgments [$F(2, 52) = 38.75$, $p < .0001$; Table 1]. Participants were fastest when performing the font judgments relative to the contextual [$t(29) = 9.31$, $p < .0001$] and general self-judgments [$t(29) = 6.18$, $p < .0001$]. However, there were no other significant between-group main effects ($p = .98$) or two-way interactions between cultural priming and judgment type ($p = .20$) on reaction time.

Proportion Agreement

There was a significant main effect of judgment type on proportion agreement during self-judgments [$F(2, 52) = 137.77$, $p < .0001$; see Table 1]. Participants agreed with general statements significantly more than with contextual [$t(29) = 5.21$, $p < .0001$] and font statements [$t(29) = 5.95$, $p < .0001$]. Participants also agreed significantly more

Table 1. Behavioral Performance during Self-judgment Task ($M \pm SE$)

	IND-PRIME	*COL-PRIME*
Proportion Agreement		
General	0.83 (0.03)	0.85 (0.03)
Contextual	0.71 (0.03)	0.73 (0.03)
Font	0.48 (0.01)	0.49 (0.01)
Reaction Time (msec)		
General	1843 (157)	1697 (157)
Contextual	2194 (212)	2139 (212)
Font	1178 (132)	1388 (132)

Table 2. fMRI Results of Interaction Contrast of Interest [(IND-PRIME$_{general}$ + COL-PRIME$_{contextual}$) − (IND-PRIME$_{contextual}$ + COL-PRIME$_{general}$)]

x	*y*	*z*	*Z Score*	*BA*	*K*	*Brain Area*
−6	−58	66	3.58	7	12	L superior parietal cortex
−6	**62**	**14**	**3.50**	**10**	**15**	**L medial prefrontal cortex**
−42	−73	−11	3.16	37	10	L fusiform gyrus
−6	−41	2	2.99		16	L cerebellum
0	**−24**	**37**	**2.92**	**31**	**8**	**Posterior cingulate gyrus**

with contextual statements relative to font statements [$t(29) = 10.53$, $p < .0001$]. However, there were no other significant between-group main effects ($p = .57$) or two-way interactions between cultural priming and judgment type ($p = .93$) on proportion agreement.

Neuroimaging Results

Consistent with our neural predictions, there was a significant interaction between self-construal prime and type of self-judgment in neural response within MPFC ($x = -6$, $y = 62$, $z = 14$; $p < .05$, corrected) and PCC regions ($x = 0$, $y = -24$, $z = 37$; $p < .05$, corrected) (Figure 2A and B; Table 2 and Figure 2A). Within the MPFC region, participants primed with individualism showed significantly greater activation for general relative to contextual self-descriptions, whereas participants primed with a collectivism demonstrated significantly greater activation for contextual compared to general self-descriptions (Figure 2B). Similarly, within the PCC region, participants primed with individualism showed significantly greater activation for general relative to contextual self-descriptions, whereas participants primed

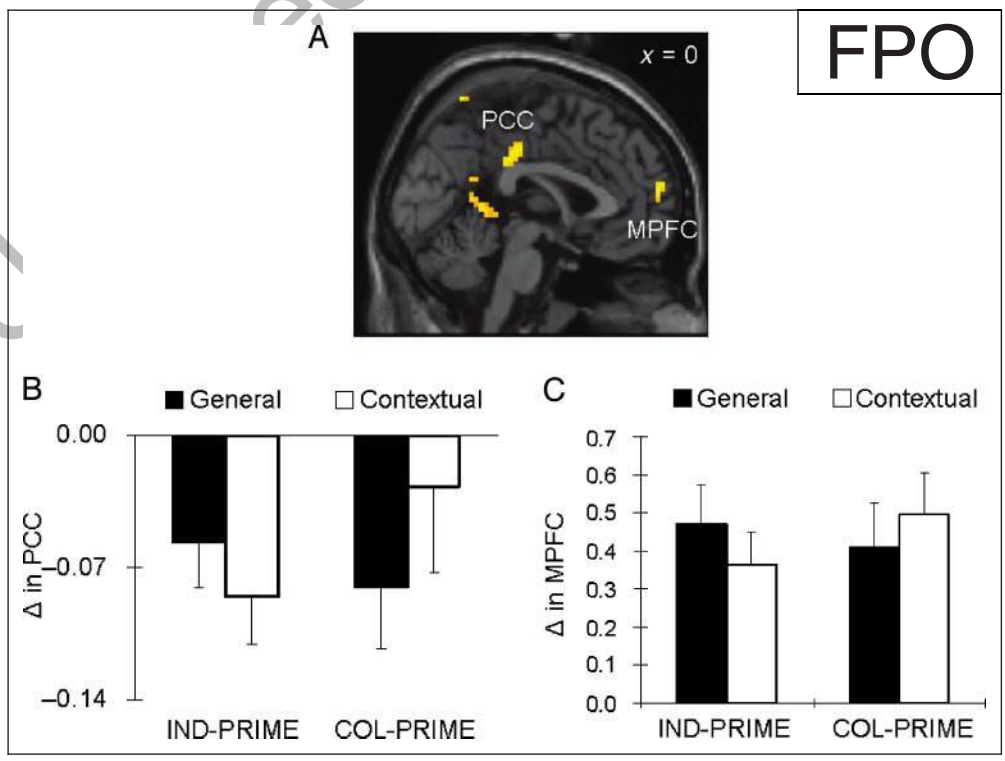

Figure 2. (A) fMRI result of interaction contrast of interest [(IND-PRIME$_{general}$ + COL-PRIME$_{contextual}$) − (IND-PRIME$_{contextual}$ + COL-PRIME$_{general}$)] reveals increased activity in the anterior rostral portion of medial prefrontal cortex (MPFC) (peak coordinate: $x = -6$, $y = 62$, $z = 14$) and posterior cingulate cortex (PCC) (peak coordinate: $x = 0$, $y = -24$, $z = 37$). (B) fMRI region-of-interest analysis within the PCC region. In the individualistic prime group (IND-PRIME), participants show greater PCC response for general relative to contextual trait descriptions. In the collectivistic prime group (COL-PRIME), participants show greater PCC response for contextual relative to general trait descriptions. (C) fMRI region-of-interest analysis within the MPFC region. In the individualistic prime group (IND-PRIME), participants show greater MPFC response for general relative to contextual trait and font descriptions. In the collectivistic prime group (COL-PRIME), participants show greater MPFC response for contextual relative to general trait and font descriptions.

with collectivism demonstrated significantly greater activation for contextual compared to general self-descriptions (Figure 2C). Additional brain regions that showed significant increases in neural activity during self-judgments as a function of cultural prime included left superior parietal cortex, left fusiform gyrus, and left cerebellum (Table 2). By contrast, a network of brain regions within the bilateral inferior frontal gyri and right posterior temporal cortices showed significant decreases in neural activity for general relative to contextual self-descriptions depending on whether one was primed with individualistic or collectivistic cultural values, respectively (Table 3).

Relationship between Cultural Priming and Neural Activity

Correlation analyses revealed a significant and positive relationship between degree of cultural priming (uniqueness rating minus similarity rating) and degree of neural activity within MPFC and PCC regions during self-judgments (general minus contextual). Across all participants, individuals who were primed to a greater extent to value uniqueness (IND-PRIME) compared to similarity (COL-PRIME) to others showed greater neural response for general relative to contextual self-descriptions within MPFC [r = .46, $p < .005$] (Figure 3A) and PCC [r = .31, $p < .05$] regions (Figure 3B). There were no significant relationships between cultural priming and proportion agreement (p = .18) or reaction time (p = .21). Similarly, there were no significant relationships between neural activity in MPFC or PCC and proportion agreement or reaction time (all ps > .05).

DISCUSSION

Here we show that temporarily heightened awareness of individualistic or collectivistic orientations is sufficient to elicit greater activation within the anterior rostral portion of the MPFC and PCC regions during general or contextual self-descriptions, respectively. People primed with individualistic cultural values showed greater activation in dorsal MPFC and PCC regions to general self-descriptions, whereas people primed with collectivistic

Table 3. fMRI Results of Reverse Interaction Contrast [(IND-PRIME$_{contextual}$ + COL-PRIME$_{general}$) − (IND-PRIME$_{general}$ + COL-PRIME$_{contextual}$)]

x	*y*	*z*	*Z Score*	*BA*	*K*	*Brain Area*
68	−37	18	4.02	22	13	R superior temporal gyrus
45	**15**	**−1**	**3.86**	**47**	**25**	**R inferior frontal gyrus**
39	**−12**	**−15**	**3.58**	**21**	**65**	**R middle temporal gyrus**
45	**−44**	**−10**	**3.56**	**37**	**170**	**R fusiform gyrus**
21	0	61	3.53	6	13	R superior frontal gyrus
30	−61	6	3.45	19	21	R middle occipital gyrus
12	39	23	3.37	32	19	R cingulate gyrus
−12	−17	67	3.28	6	31	L superior frontal gyrus
−45	**9**	**11**	**3.27**	**44**	**12**	**L inferior frontal gyrus**
−39	−49	11	3.26	22	60	L superior temporal gyrus
36	−33	38	3.20	40	103	R inferior parietal cortex
30	44	−2	3.14	10	70	R inferior frontal gyrus
12	−13	37	3.11	24	6	R cingulate gyrus
9	−14	67	3.00	6	12	R superior frontal gyrus
15	0	3	2.99		8	R thalamus
−24	−41	60	2.98	7	17	L superior parietal cortex
48	−11	3	2.96	22	12	R superior temporal gyrus
−15	−61	56	2.94	7	9	L superior parietal cortex
−15	27	15	2.84	24	6	L cingulate gyrus

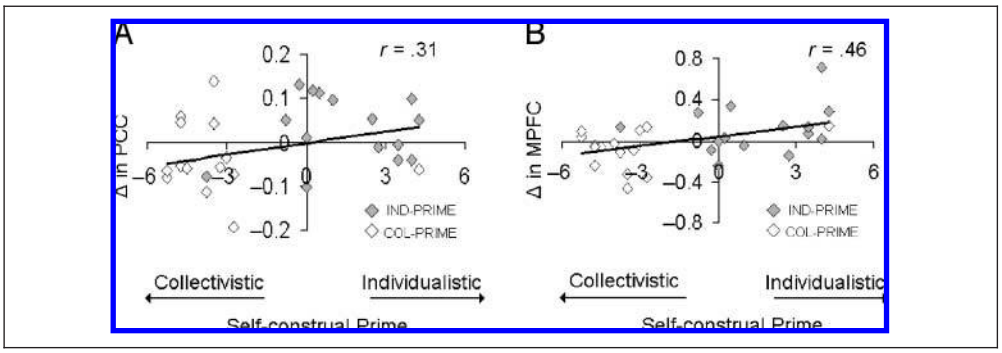

Figure 3. (A) Scatterplot of the correlation of PCC activity [Δ for general − contextual] with self-construal priming index [IND-PRIME − COL-PRIME] for each participant. (B) Scatterplot of the correlation of MPFC activity [Δ for general − contextual] with self-construal priming index [IND-PRIME − COL-PRIME] for each participant.

cultural values showed greater dorsal MPFC and PCC activation to contextual self-descriptions. Furthermore, degree of cultural priming of individualistic or collectivistic values was associated with degree of MPFC and PCC response to general or contextual self-descriptions, respectively. We observed decreases in activation in lateral prefrontal and occipito-temporal regions for general or contextual self-descriptions depending on whether or not an individualistic or collectivistic cultural orientation was temporarily enhanced. Behavioral results indicate this modulation of activity within cortical midline and lateral prefrontal and occipito-temporal regions by cultural priming is not due to either task difficulty or degree of agreement with general or contextual self-descriptions, more generally.

Modulation of MPFC and PCC activity by cultural priming most likely reflects enhanced evaluation and integration of culturally congruent self-representations. Prior neuroimaging research indicates that both MPFC and PCC regions are critical to directing attention toward and evaluating information that is relevant to one's self (Amodio & Frith, 2006; Northoff et al., 2006). We suggest that priming cultural values of individualism or collectivism temporarily orients individuals to attend to and evaluate general or contextual self-representations as more or less self-relevant. Our findings compliment prior cultural psychological evidence that multicultural individuals have the capacity to alternate between different cultural schemas depending on the situation (Oyserman & Lee, 2008; Hong et al., 2000) and broaden this notion by demonstrating how switching toward one cultural frame over another is associated with fluctuations in brain activity within two cortical midline structures critical to the evaluation and integration of self-relevant verbal information. Our results provide converging evidence of the notion that distinct neural representations of self between individualists and collectivists observed in prior cultural neuroscience studies are not likely due to inherent neural differences between Westerners and East Asians, but instead reflect cultural values of individualism and collectivism that are endorsed by the individual, a process that is susceptible to dynamic influences across macro- and micro-time scales (e.g., ontogeny and situation, respectively).

These findings provide further insight into an important distinction between kinds of priming (e.g., perceptual, conceptual, cultural) and their contrasting effects on neural functioning. Conceptual and perceptual priming, or repetition priming, have previously been shown to induce an improvement or change in the identification, production or classification of a stimulus due to exposure to the same or similar type of stimulus (Schacter et al., 2007; Grill-Spector et al., 2006). Repetition priming often leads to decreases in neural activity across different brain regions such as lateral occipito-temporal and prefrontal regions (Schacter et al., 2007; Grill-Spector et al., 2006). Decreased neural activity during repetition suppression may reflect a number of computational processes including less overall neural activation, fewer neurons firing, or less processing time (Grill-Spector et al., 2006). However, increases in neural activity after priming have also been observed particularly when repeating stimuli that are unfamiliar (Fiebach et al., 2005; Henson, Shallice, & Dolan, 2000) or priming a top–down social–cognitive style such as promotion and prevention focus, rather than a specific stimulus per se (Eddington et al., 2007; Cunningham, Raye, & Johnson, 2005). Importantly, cultural priming is more akin to priming a top–down social–cognitive style (e.g., prevention and promotion focus) rather than perceptual or conceptual repetition of an external stimulus or category of stimuli (e.g., individual words or pictures). Consistent with this distinction of neural priming effects, here we observed relative increases in activity within cortical midline structures engaged with the evaluation of self-relevant attributes that were congruent with the cultural prime. Specifically, PCC showed less deactivation whereas MPFC showed increased activation for culturally congruent self-descriptions. Given the tendency of cortical midline structures to show highest levels of neural activity during the psychological resting state, we speculate that such increased response within PCC and MPFC observed here indicates that the default mode for individualists is to think of themselves in a general manner, and for collectivists is to think of themselves in a contextual manner (Northoff & Bermpohl, 2004).

Notably, we also observed significant decreases in neural activity during self-judgments as a function of cultural prime, particularly within lateral prefrontal and lateral occipito-temporal regions previously shown to demonstrate sensitivity to conceptual components of repetition priming irrespective of modality or domain of the stimulus (Schacter et al., 2007). For instance, neural priming has been shown in these regions when participants view semantically related word pairs (Wheatley et al., 2005) and objects (Simons, Koustaal, Prince, Wagner, & Schacter, 2003). We suggest that deactivation in the bilateral inferior frontal gyrus and the right middle temporal gyrus observed in the current study is associated with sensitivity to the conceptual similarity between cultural primes and culturally congruent self-representations. We further speculate that the decreases in neural activity observed in the current experiment may reflect enhanced synchronization with brain regions within prefrontal and occipito-temporal cortices enabling more efficient processing of general versus contextual self-descriptions, presumably due to increased exposure to individualistic versus collectivistic self-schemas, respectively. Hence, cultural priming of individualistic and collectivistic values may serve as both a general and specific top–down influence on neural functioning, enhancing activity within brain regions specific to self-processing and reducing cortical activity within brain regions sensitive to conceptual processing of repeated or related stimuli irrespective of the knowledge domain, more generally.

Intriguingly, cultural priming effects on neural activation during self-judgments were observed despite a lack of behavioral differences between cultural priming groups. This lack of correspondence between cultural priming and agreement with self-descriptions at a behavioral level in the current study is somewhat surprising given prior studies showing a positive association between self-relevant neural activity within MPFC and behavioral assays, such as enhanced recognition for self-relevant information (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004). We suggest that this lack of correspondence is likely due to a much smaller sample size relative to comparable large-scale cultural priming behavioral studies (Oyserman & Lee, 2008) and a reluctance in people familiar with collectivistic cultural norms, such as bicultural individuals, to disclose personal information in experimental settings in an overt manner (Kitayama, 2002).

Our findings reveal at least three advantages of studying cultural priming of self-construal style at the neural level. First, cultural priming effects on neural activity were observed with a much smaller sample size relative to comparable large-scale cultural priming behavioral studies (Oyserman & Lee, 2008). Second, cultural priming group effects were observed at a neural level despite an absence of difference between the cultural priming groups at a behavioral level. Third, individual variation in degree of cultural priming across groups corresponded to individual variation in degree of neural response, but not behavioral response, to culturally congruent self-judgments.

Neural assays may be better situated to illuminate cultural influences on mental processes relative to behavioral measures for several reasons (Chiao, Li, & Harada, in press; Han & Northoff, 2008; Chiao & Ambady, 2007). First, defining self-construal style using behavioral measures assumes that participants from different cultures agree with the meaning assigned to response choices, such as ''very much agree'' or ''very important'' (Heine, Lehman, Peng, & Greenholtz, 2002; Peng, Nisbett, & Wong, 1997). Prior behavioral studies suggest that researchers cannot readily assume that response choices offered in self-construal style measures are interpreted in the same way across cultures (Heine et al., 2002; Peng et al., 1997). Additionally, participants may not have conscious access to knowledge about their self-construal style, and thus, may not be able to accurately answer related questions (Kitayama, 2002). Depending on cultural display rules about appropriate public and private behavior, participants may feel reluctant to disclose information about themselves and close others within an experimental setting (Kitayama, 2002). Studying culture at the neurobiological level of analysis may provide a novel and powerful tool for examining how cultural values, such as individualism and collectivism, dynamically influence self-relevant social cognition, within the same cultural group and even within the same individual. For instance, in a recent study of native Chinese participants, activity within right middle frontal cortex was greater when participants viewed their own face relative to another familiar face and this difference was more pronounced when participants were primed with individualism relative to collectivism (Sui & Han, 2007). These findings complement the current evidence illustrating the utility of directly measuring or manipulating cultural values when studying the dynamic process by which culture shapes the mind and brain (Oyserman & Lee, 2008; Chiao & Ambady, 2007).

Given the increasing opportunities afforded by modern industrialization and globalization for people to become more exposed to and to identify with diverse cultural values, practices, and beliefs, the importance of dynamic cultural influences on mental processes and behavior has become more widely acknowledged (Oyserman & Lee, 2008; Hong et al., 2000; Gardner et al., 1999). Yet, how the brain gives rise to the ability to acculturate or culturally adapt to novel sociocultural contexts remains an empirical question that has been virtually unexplored (Chiao et al., in press; Chiao & Ambady, 2007). Here we demonstrate that temporarily heightening awareness of individualistic and collectivistic values modulates neural functioning within brain regions underlying self-representations and domain-general conceptual processing. People primed with individualistic values showed enhanced evaluation of general self-representations, whereas people primed with collectivistic values showed enhanced processing of contextual self-representations within cortical midline structures. Our findings provide novel insight into the way that culture dynamically shapes neurobiological mechanisms of the self as well as how the brain may enable people to acculturate to novel cultural environments. Future research in cultural neuroscience examining the bidirectional dynamic influences of culture and brain function has the potential to contribute to our theoretical understanding of how top–down factors, such as cultural priming, affect basic neural functioning and how relatively low-level characteristics of neural mechanisms, such as repetition suppression, may facilitate higher-order social processes such as acculturation.

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Notes

1. All participants self-reported as either first- or second-generation Asian-American (e.g., parents were born in an Asian country, not in the United States).
2. Biculturalism in the Suinn–Lew Self-Identity Acculturation Scale was defined as a composite score averaging responses to three primary questions: (1) how much a person believes in Asian or Western values; (2) how much they fit in with other Asians or Westerners; (3) whether they would describe themselves as an Asian, American, or Asian-American (Suinn et al., 1987).

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