Neuroscience Letters 705 (2019) 60–66

Contents lists available at ScienceDirect

Neuroscience Letters

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

Research article

Finding the vanished self: Perspective modulates neural substrates of self-reflection in Buddhists

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ARTICLE INFO

Keywords:
Self-reflection
Buddhism
Medial prefrontal cortex
Perspective

ABSTRACT

Asians' self-views are flexible and influenced by short-term situational and long-term cultural factors. Due to the long-term religious cultural influence of Chinese Buddhism, Buddhists showed no self-advantage in behavioral and neural level in many previous studies. However, it is unclear whether Chinese Buddhists really have no self-awareness or self-concept. The beliefs of illusionary self and thinking of others first might suggest that the self of Buddhists comes from others' perspective. The present study examined the self of Buddhists in first- and third-person perspective through the self-referential processing paradigm, comparing the behavioral and neural difference when they make self-, friend- and famous-judgment. The behavioral data showed that there were no different recognition ratios between self-, friend-, and famous-processing for participants in first- and third-person perspective. However, the neural results showed that people in third-person perspective group showed significant difference between self- and famous-processing in ventral medial prefrontal cortex, whereas people in first-person perspective group did not show any significant difference in activation between self-, friend-, and famous-processing in these regions. These findings suggested that Buddhists have self-referential processing only in third-person perspective, not in first-person perspective. This study provides neuroimaging evidence for the influence of perspective on Buddhists' self-reflection, and provide empirical evidence supporting and extending culture as situated cognition model of Asia by considering perspective factor.

1. Introduction

Humans' perceptions of the self can be based on their reflections on their own behaviors or on others' perceptions [1,2]. Meanwhile, numerous cross-cultural studies have found that there were differences between Westerners and Easterners when reflecting on themselves [3–6]. European Americans tend to view the self as an autonomous entity that is separated from others and take a first-person perspective (1PP) to understand themselves. In comparison, East Asians tend to view the self as a socially embedded entity with strong interconnectedness with others and take a third-person perspective (3PP) to reflect themselves [7–9]. These cultural differences, nonetheless, do not mean that East Asians are simply sharing themselves with others or passive recipients of others' judgments of the self. Previous studies have found that East Asians' self-concepts are contextual or cultural dependent. According to the views of "culture as situated cognition model", Asians' self-views are not fixed, but fluid and flexible [10,11]. More specifically, these dynamic self-views could be influenced by short-term situational factors and long-term cultural factors.

Previous studies on self-reflection have temporarily manipulated the situations or contexts, which requires participants to assess themselves in a specific perspective or cultural priming condition [12–14]. Research showed that East Asian participants can use 1PP or 3PP to think of themselves [13]. The self-processing in 3PP might be consistent with the collectivistic cultural context [12]. More importantly, they provided further evidence for the influence of short-term situation on Asians' flexible self-views [14]. This study adopted a western or eastern contextual priming and their participants were asked to complete a self-reflection task. The neural activity pattern showed that participants primed by individualistic context showed increased activation within medial prefrontal cortex (mPFC) and posterior cingulate cortex (PCC) during general self-reflection relative to contextual self-reflection,

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https://doi.org/10.1016/j.neulet.2019.04.024
Received 12 December 2018; Received in revised form 8 April 2019; Accepted 9 April 2019
Available online 09 April 2019
0304-3940/

whereas participants primed by collectivistic context showed increased activation within mPFC and PCC during contextual self-reflection relative to general self-reflection. These findings indicated that the neural correlates of self could be dynamically modulated by contextual priming, which activated different cultural self-reflection styles. It suggested a strong powerful basis of short-term situations. Neuroimaging studies also found that the activity of the brain region related to self-referential processing is influenced by long-term religious cultural factors [15]. Although the situation or context can temporarily modulate self-reflection pattern, the individuals shaped by religious belief of Buddhism can show a typical Asian pattern acquiescently [16,17]. In Han and his colleague's study, Chinese Buddhists did not activate the ventral medial prefrontal cortex (vmPFC) in self-judgment condition relative to other conditions when they took 1PP to complete self-referential processing [16]. This suggested that Buddhist participants failed to generate increased self-advantage effect. These results could be explained by the Buddhist doctrine of No-self. As a typical Asian religion——Buddhism advocates that people should put down obsessiveness about self and follow the power of the external world [18–20].

Despite these findings, it remains unclear whether the behavioral and neural activity patterns really mean that Chinese Buddhists have no self-awareness or self-concept. Lutz [21] emphasized "although self-awareness is universal, cultures differ in how the self is conceptualized and experienced". However, all the previous studies required participants to use 1PP when they completed the self-referential memory task [16,17]. According to the findings and the model we mentioned previously, although previous studies failed to find self-related advantage or neural activity in Buddhists, there is also an alternative explanation——Buddhists, shaped by long-term religious cultural environment of Asia, have a special thinking style when they reflect the self. On one hand, Buddhism makes unique claims about nature of the self [19,20], wherein the self, as experienced in the physical world, is illusionary and artificial. On the other hand, Buddhism also claims that individual should think of others first [20,22], that is to say Buddhists should always put the interest of others above their own. Based on these views, we suspect that Buddhists may have a typical eastern self-view, that is toning down the self and taking another person's perspective to consider the world or even themselves. However, to date, we know very little about the behavioral patterns or neural substrates of self-referential processing in Buddhists under 3PP condition.

Previous studies have found that the non-Buddhist's self-reflection pattern is clear and stable [3,21,23], and Buddhist have a different pattern in 1PP condition [16,17]. Based on these findings the current study mainly focused on the self-reflection of Buddhist, and found the influence of perspective **(i.e., 1PP vs. 3PP)** on Buddhists' self-processing.

The purpose of the current study is to investigate the behavioral and neural activity differences between 1PP and 3PP when Buddhists considered themselves. To address the unexplored problem, the current study adopted an established self-referential memory task previously used during functional magnetic resonance imaging (fMRI) with Chinese Buddhists [16,17]. To examine the effect of perspective on the self-processing of Buddhists, we manipulated the perspective in the self-referential memory processing paradigm. Participants were asked to make adjective judgments under 1PP or 3PP separately. Based on prior work and theory, we hypothesized that Buddhists with different types of perspective should engage in different behavioral and neural activity patterns when reflecting the self: Buddhists would exhibit reduced self-reference effect or regional activation under 1PP condition. However, under 3PP condition, they would exhibit significant increased self-reference effect or regional activation in brain regions associated with self-referential processing, including mPFC and ACC [3,17,24]. We used a region-of-interest (ROI) based analytical approach to focus on activity in these specific areas to test this hypothesis.

2. Materials and methods

2.1. Participants

40 college students participated this experiment. All participants were born and lived in a district with Buddhism belief, and also were self-identified Buddhists. All were right-handed and had normal or corrected-to-normal vision. None of them had a history of neurological or psychiatric disorders. Informed consent were acquired prior to the experiment in accordance with Peking University's Psychology Ethics Committee. Participants were paid for their participation. Half of them were assigned to the 1PP condition (10 females and 10 males, 19.6 ± 1.0 years old), the other half were assigned to the 3PP condition (10 females and 10 males, 19.5 ± 1.2 years old).

2.2. Materials and procedures

Stimuli were selected from those used in our previous study [17]. A total of 384 adjectives were divided into 32 lists of 12 words which were presented in each session. Half of the words were positive adjectives and half were negative adjectives. Sixteen lists of words were pseudo randomly selected for the judgment tasks, while the remaining sixteen lists of words were used in the memory test.

Participants were first asked to make trait judgments based on the 1PP or 3PP condition in the scanner. In the 1PP condition, participants were asked to judge in their own opinion, whether an adjective could describe a particular person. The persons included were self, a friend, and someone famous (Gen ga, a famous Buddhist singer). In the 3PP condition, the participants were asked to take a close friend's perspective and judge whether an adjective can describe a particular person, including self, a friend, and a famous person. Furthermore, participants were also asked to judge the font of the words (bold- or light-faced characters). The stimuli were presented through an LCD project onto a rear projection screen above participant's head. The screen was viewed with an angled mirror positioned on the head coil.

The trait judgment task included four scans, each containing four blocks. In each block participants completed twelve trials of one specific condition. The order of the blocks were counterbalanced using a Latin Squire design. Each session of every condition lasted for 38 s, including a 2 s instruction and 12 trials. Amongst the task blocks were the null session that lasted for 30 s, in which participants passively viewed the asterisks on the screen. All of the stimuli were presented in their native language. Participants used their left and right index fingers to make judgments by pressing buttons. After trait judgment task, structural scan was obtained.

After the scanning procedure, participants were asked to make a recognition memory task. 192 previously seen words and 192 never-seen words were randomly presented, participants were asked to judge whether they were "old" or "new" through pressing the keyboard. If an "old" response was selected, they were asked to make a remember/know (R/K) judgment. If participants can consciously recollect the memory of seeing the word in the trait judgment stage and retrieve the word in detail, they were instructed to make a "remember" response, if they could not recollect any detail information about the word and simply have a feeling of knowing, they were asked to make a "know" response. There are two types of memory of words [25–27]: the subjective recollection experience (remember) and the feeling of familiarity (know). Conway and Pleydell-Pearce suggested that the memory performance of R-judgment was a solid index to reflect self-referential cognition [28].

2.3. fMRI data acquisition

Functional MRI data was collected using a 3 T Siemens Trio scanner with a 12-channel phase-array coil. In the scanner, the stimuli were back-projected via a video projector (refresh rate: 60 Hz; spatial resolution: 1024 × 768) onto a translucent screen placed inside the scanner bore. Participants viewed the stimuli through a mirror mounted on the head coil. The viewing distance was 90 cm. Blood oxygen level-dependent (BOLD) signals were acquired with an echo-planar imaging sequence (TR = 2000 ms, TE = 30 ms, FOV = 240 mm, flip angle = 90°, slice thickness = 3.5 mm, number of slices = 32, 64 × 64 matrix with 3.1 × 3.1 × 3.5 mm spatial resolution). A high-resolution structural image was acquired using a standard 3D T1-weighted sequence with 1.0 × 1.0 mm in plane resolution and 1 mm slice thickness (256 × 256 matrix, 1.0 × 1.0 × 1.0 mm spatial resolution, TR = 2600 ms, TE = 3.02 ms).

2.4. Data analyses

Behavioral data. Response time for judgments made in the trait judgment stage was analyzed using a 2 (group) × 4 (condition) repeated measures analysis of variance. Accuracy of font-judgment was compared between two groups. Post-hoc comparisons were performed with Bonferroni correction.

In the recognition stage, hit rate was analyzed using a 2 (group) × 4 (condition) repeated measures analysis of variance, also hit rate was analyzed for "remember" and "know" condition separately.

fMRI data. Statistical Parametric Mapping software (SPM8, Wellcome Department of Cognitive Neurology, UK) was used for imaging data processing and analysis. Functional images were realigned to correct for head movement between scans and co-registered with each participant's anatomical scan. Functional images were transformed into a standard anatomical space (3 × 3 × 3 mm^3 voxel size) based on the Montreal Neurological Institute (MNI) template. Normalized data were then spatially smoothed with an 8-mm full-width at half-maximum Gaussian kernel. Two participants were removed from data analysis for the head movement above 3.0, this left 19 participants for each group.

On the individual level, a general linear model was used to compute parameter estimates and t-contrast images for each comparison at each voxel. The contrasts of self-, friend- and other-processing were defined in each participant. These individual contrast images were then submitted to a second-level random-effect analysis. A Monte Carlo stimulation using the AlphaSim program (http://afni.nimh.nih.gov/pub/dist/doc/manual/AlphaSim.pdf) was conducted to determine an appropriate cluster threshold. Assuming an individual voxel type I error of $p < 0.005$, a cluster extent of 39 continuous voxels was indicated as necessary to correct for multiple voxel comparisons at $p < 0.05$. The SPM coordinates were converted from MNI template to Talairach coordinates [29] using a non-linear transform method.

To confirm the results of GLM analysis, we performed region of interest (ROI) analysis. The ROI regions were defined using previous defined ROIs, with a radius of 3 mm and centered at coordinates 0/40/18 for mPFC and -6/36/20 for ACC [3,30]. The BOLD signal of voxels in the ROIs were calculated and subjected to an ANOVA analysis.

3. Results

3.1. Behavioral data

Trait judgment stage. Data can be found in Table 1 and Fig. 1. A two-way repeated measure ANOVA of reaction time analysis showed that there was a significant main effect of condition, $F(3, 114) = 19.568$, $p < 0.001$, famous-judgment was faster than self-judgment ($p < 0.01$), and was marginally and significantly faster than friend-judgment ($p = 0.054$), font-judgment was faster than self- ($p < 0.001$), friend- ($p < 0.001$) and famous-judgment ($p < 0.05$), and there was also a significant interaction effect of condition and group, $F(3, 114) = 4.557$, $p < 0.01$, but no main effect of group was found. Simple effect analysis showed that there was a significant main effect of condition for 1PP ($F(3,114) = 6.06$, $p < 0.001$) and 3PP ($F(3,114) = 18.06$, $p < 0.001$) group. Post-hoc comparison showed that famous-judgment of 3PP was marginally and significantly faster than that of 1PP ($p = 0.053$). For 1PP group, font-judgment was faster than self-judgment ($p < 0.01$) and famous-judgment ($p < 0.05$). For 3PP group, famous-judgment was faster than self- and friend-judgment, $p < 0.001$, also font-judgment was faster than self- and friend-judgment, $p < 0.001$. These results indicated that font-judgment was relatively easier than three trait judgments, and 3PP was better than 1PP to some extent, with faster reaction time in the famous condition.

Table 1
Behavioral data in the trait judgment stage. Including mean reaction time and SD of self-, friend-, famous-, and font-judgment, and the accuracy of font-judgment. SD = Standard deviation.

	1PP		3PP	
	Mean (ms)	SD	Mean (ms)	SD
self	428.0	13.7	428.8	13.8
friend	420.2	15.0	418.2	15.0
famous	426.1	15.0	383.5	15.0
font	392.1	14.8	367.7	14.8
font accuracy (%)	0.69	0.03	0.63	0.04

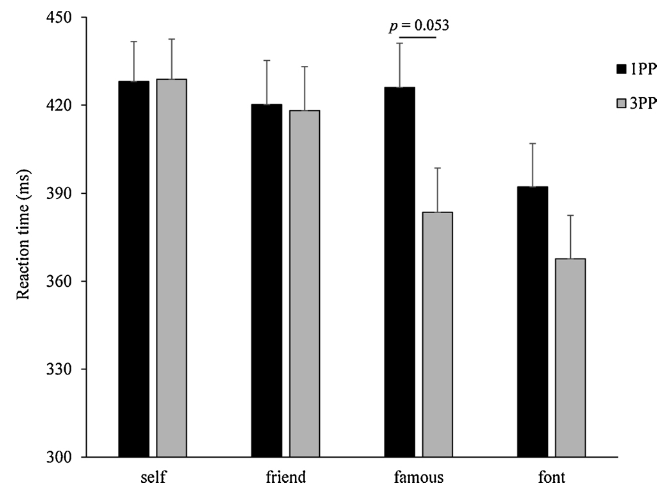

Fig. 1. Results of Reaction time on self-, friend, famous, and font-judgment in first- and third-person perspective in the trait judgment stage.

Accuracy of font-judgment showed that there was no difference between 1PP (0.69) and 3PP (0.63), $t = 1.250$, $p = 0.219$. The environmental setting in the fMRI room (e.g., the distance between the eyes of the subjects and the stimuli was 90 cm, the light of the room was dim) might influence the visual recognition of the stimuli, increasing the difficulty of font judgment which was related with the visual information of stimuli. Therefore we ran the item analysis. Results showed that accuracy of 44 items (11.5% of all items) were lower than 0.5. After deleting these items, the accuracy of 1PP and 3PP were 0.74 and 0.67, and t-test showed that there was no difference between the two groups ($t = 1.431$, $p = 0.161$).

Recognition stage. Mean hit rate and SD of retrieval stage are in Table 2. Repeated measure ANOVA of total hit rate showed a significant condition main effect, $F(3, 114) = 53.449$, $p < 0.001$, self-, friend- and famous-judgment was higher than font-judgment, $ps < 0.001$, there were no significant group main effect or interaction effect.

Also, hit rate of "remember" and "knowing" judgment was analyzed separately, and the results of "remember" judgment was similar with the result of total hit rate, showed a significant condition main effect, $F(3, 114) = 36.962$, $p < 0.001$, self-, friend- and famous-judgment was higher than font-judgment, $ps < 0.001$, there were no significant group main effect or interaction effect. However, results of hit rate of "know" judgment showed no significant main effect or interaction effect.

Table 2
Mean hit rate and SD of retrieval stage. There are total hit rate (total), recognition hit rate (remember), and know hit rate (know) for self-, friend, famous- and font-judgment. SD = Standard deviation.

	1PP			3PP		
	total	remember	know	total	remember	know
self	0.65(0.03)	0.42(0.05)	0.23(0.05)	0.58(0.03)	0.36(0.04)	0.22(0.04)
friend	0.64(0.04)	0.40(0.05)	0.24(0.05)	0.59(0.04)	0.37(0.04)	0.22(0.04)
famous	0.64(0.04)	0.37(0.05)	0.27(0.05)	0.56(0.04)	0.35(0.04)	0.21(0.04)
font	0.46(0.04)	0.23(0.03)	0.22(0.03)	0.40(0.04)	0.22(0.04)	0.17(0.04)

Table 3
Regions activated in comparison of self- vs friend-, self- vs famous-, and self- vs font-judgment in first- and third-person perspective group in while brain analysis. Also, the Braodmann's area, Talairach coordinates, Z scores of activated clusters and cluster size are shown.

Condition/Regions	BA	MNI				Voxel no.
		x	y	z	Z	
1PP						
self vs friend						
no significant activation area						
self vs famous						
no significant activation area						
self vs font						
L. Superior medial frontal gyrus	8	−6	38	55	10.14	682
L. Supplementary motor area	6	−6	23	64	6.96	
L. Superior Frontal gyrus	9	−15	47	40	6.27	
L. Posterior cingulate cortex	31	−6	−52	31	5.93	462
L. Posterior cingulate cortex	29	−9	−52	7	3.49	
R. Calcarine sulcus	23	6	−76	7	5.08	219
L. Middle cingulate cortex	24	0	−13	43	4.68	62
L. Middle frontal cortex	6	−39	11	46	4.28	113
3PP						
self vs friend						
L. Anterior cingulate cortex	32	−3	41	16	2.96	81
R. Anterior cingulate cortex	32	6	38	13	2.86	
R. Medial prefrontal gyrus	9	3	50	22	2.78	
self vs famous						
L. Parahippocampal gyrus		−15	−28	−15	4.69	87
L. Inferior frontal gyrus	13	−33	11	−17	4.64	87
L. Inferior frontal gyrus	47	−33	23	−11	3.25	
L. Anterior cingulate cortex	32	−6	41	19	3.77	332
R. Medial prefrontal gyrus	9	6	56	34	3.69	
R. Middle frontal gyrus	10	24	50	31	3.69	
L. Thalamus		−6	−13	13	3.41	79
R. Thalamus		12	−7	13	2.97	
self vs font						
L. Inferior frontal gyrus	47	−42	29	−8	6.44	1487
L. Inferior frontal gyrus	45	−57	26	10	6.27	
L. Middle frontal gyrus	6	−36	5	49	4.98	
L. Superior medial frontal gyrus	9	−3	56	31	6.28	1443
L. Superior medial frontal gyrus	6	−9	26	61	5.48	
L. Superior medial frontal gyrus	8	−9	44	52	5.14	
R. Posterior cerebellum		21	−79	−38	6.16	338
L. Superior temporal gyrus	39	−42	−58	28	5.27	365
L. Inferior parietal lobe	40	−54	−43	25	4.25	
L. Posterior cingulate cortex	31	−9	−49	28	4.33	243
L. Parahippocampal gyrus	30	−9	−46	1	3.52	
R. Middle temporal gyrus	21	54	11	−29	4.04	108
R. Inferior frontal gyrus	47	30	17	−14	3.75	40
R. Inferior frontal gyrus	47	36	26	−14	3.32	
R. Superior temporal gyrus	38	36	17	−26	2.94	
L. Putamen		−18	5	4	3.16	51
L. Putamen		−27	−1	−2	2.87	
L. caudate		−15	8	19	2.84	

L = Left, R = Right, BA = Brodmann's area, as identified in Talairach and Tournoux (1988), Z-value = significant value, Voxel no. = number of voxels in a cluster.

Results of total hit rate and "remember" hit rate suggested that three trait-judgments might be processed more specific than font-judgment, leading to better memory performance.

3.2. Image data

Whole brain analysis. Brain activation data are shown in Table 3 and Fig. 2.

For 1PP participants, the comparison of three trait-judgment condition showed no significant activation. However, the comparison of self- vs font-judgment activated left superior frontal gyrus, left middle frontal gyrus and so on, which were related with language processing. For 3PP participants, self- vs font-judgment also activated language related regions, such as left inferior frontal gyrus, left superior frontal gyrus and so on. Compared to friend-judgment, self-judgment activated right medial prefrontal cortex, left and right anterior cingulate cortex. Compared to famous-judgment, self-judgment activated right medial prefrontal gyrus, left anterior cingulate cortex, left inferior frontal gyrus, left parahippocampal gyrus, left and right thalamus. We used the mPFC region activated in the self- vs famous-judgment in 3PP participants as mask and extracted the beta values of self-, friend-, and famous-judgment, the ANOVA analysis showed that the main effect was significant, $F(2, 36) = 7.592$, $p < 0.01$, post-hoc comparison showed that self-judgment was activated higher than friend- ($p < 0.05$) and famous-judgment ($p < 0.05$). The mPFC region were considered to be related with self processing [3,31,32]. These results might suggest that the self processing would only appear in 3PP for participants.

ROI analysis. ROI analysis of 3PP participants were conducted to further confirm the self processing effect. The mPFC and ACC regions were centered at 0/40/18 for mPFC, and -6/36/20 for ACC [3,30], and the sphere was 3 mm. For mPFC, there was a significant condition main effect, $F(2, 36) = 4.694$, $p < 0.05$, post-hoc comparison showed that fMRI signal of self-judgment was significantly larger than that of friend-judgment, $p < 0.05$. For ACC, there was a significant condition main effect, $F(2, 36) = 4.747$, $p < 0.05$, post-hoc comparison showed that fMRI signal of self-judgment was significantly larger than that of friend-judgment, $p < 0.05$ (Fig. 3).

4. Discussion

The current study explored potential influence of perspective on behavioral and neural substrates of Buddhist's self-referential processing. To meet this objective, we assigned participants to perform self-referential processing task in 1PP or 3PP group, with self-reference effect and self-related neural activity indicating the extent of self-awareness during the self-reflection. The behavioral data partly replicated results from our previous study among Buddhist participants [17], which showed that there were no different recognition ratios between self-, friend-, and famous-processing for Buddhist participants in 1PP group. In addition, we also observed that there were no different recognition ratios between each type of processing in 3PP group. These behavioral results are partly consistent with our hypothesis that Buddhists should exhibit reduced self-reference effect in 1PP group. However, we had also hypothesized that Buddhists' self-reference effect

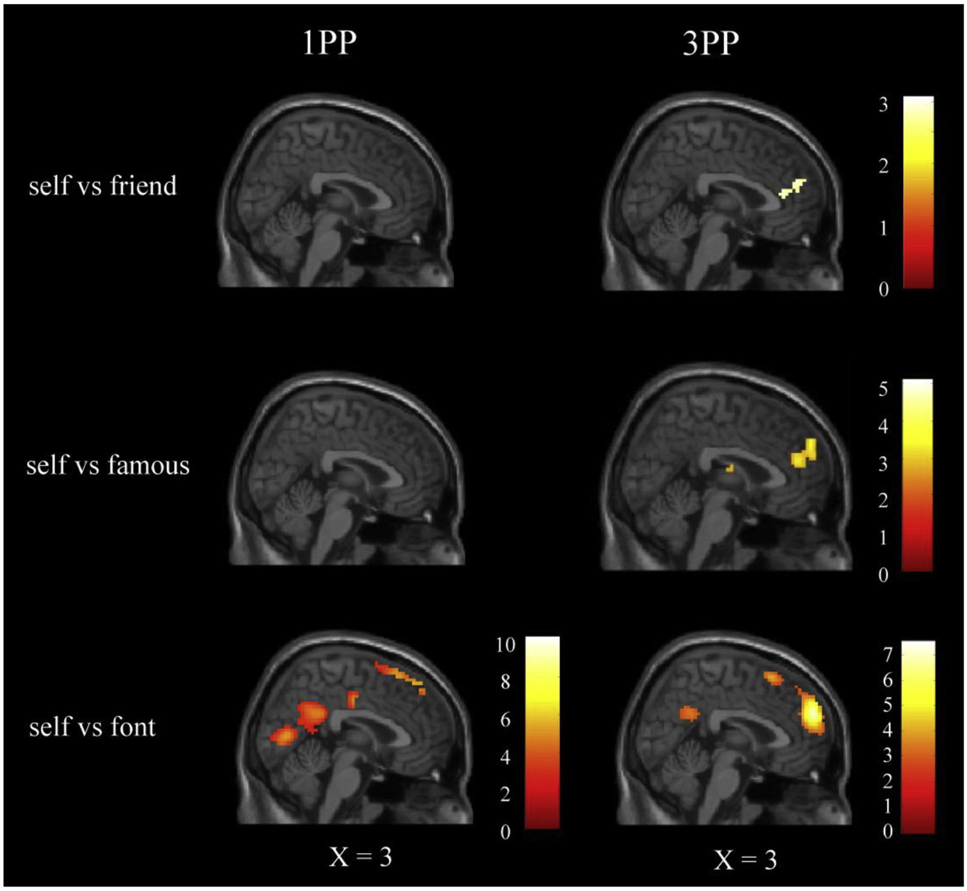

Fig. 2. Regions activated in comparison of self- vs friend-, self- vs famous-, and self- vs font-judgment in first- and third-person perspective group. MPFC/ACC were significantly activated in comparison of self vs friend, and self vs famous, different from previous studies.

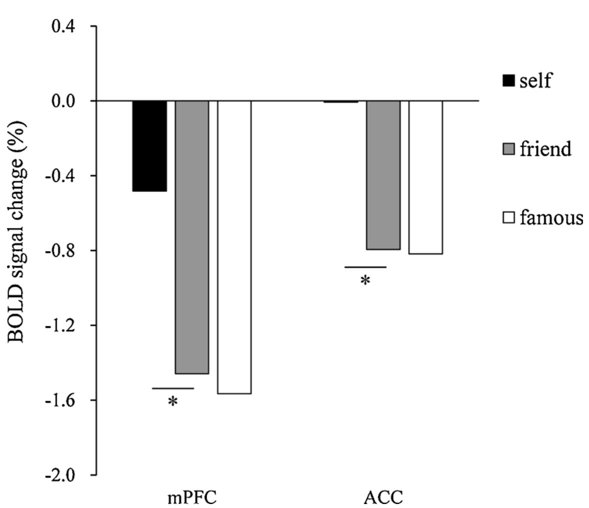

Fig. 3. The results of ROI analysis in third-person perspective group. BOLD signal changes at the mPFC and ACC were presented separately for self-, friend- and famous-judgment.

would not be affected when they used 3PP, but the results showed otherwise. These results suggest that, from behavioral level, Buddhists exhibited a specific unusual self-processing pattern when they reflected themselves [16,17], and there were no significant differences between 1PP and 3PP group.

In terms of neuroimaging data, consistent with our hypothesis, participants in 1PP group failed to generate greater BOLD activity during the self-condition relative to the other condition across ROIs [3,17]. However, the activation patterns were different across the groups. Specifically, 3PP group showed significant difference between self- and famous-processing in ventral mPFC, whereas 1PP group did not show any significant difference in activation between self-, friend- and famous-processing in ventral mPFC or ACC. These results are consistent with our hypothesis that Buddhists with different types of perspective should have different patterns of self-reflection. These results suggested that, from neural level, although Buddhists showed a No-self tendency in 1PP group, they demonstrated significant divergence in relation to 3PP, which lead to differences in self-related activity pattern.

Buddhism makes unique claims about the nature of the self. Previous studies have shown that the Buddhism belief exerts a powerful effect over the Buddhists [19]. The Buddhist participants showed no significant ventral mPFC activation in self-reflection under 1PP condition [16,17]. Based on previous studies, we may deduce that the neural substrates of self-reflection are mainly represented in the activation of ventral mPFC. Indeed, our fMRI data also revealed specific patterns of neural underpinnings of self-referential processing for Buddhists in different perspective. First, our results confirmed that the ventral mPFC, which has been demonstrated to engage in self-related judgment in non-religious participants [3,32], failed to differentiate between self-, friend-, and famous-judgments in Chinese Buddhists under 1PP condition. This suggested that the self-referential processing was different from that of non-religious participants in 1PP. More interestingly, Buddhists engaged the ventral mPFC during self-related judgment under 3PP, which was not been observed in 1PP group. This result may have important implication for the notion that Buddhists have no self-awareness or self-concept. Buddhists, who shaped by long-term religious cultural environment, may have a very special thinking style when they reflect the self. Although the self-related activation disappeared under 1PP, Buddhists' self-reflection existed integrallty under 3PP condition.

The most striking finding was that the pattern of the self-reflection under the 1PP condition contrasted with that under the 3PP condition, and this pattern also differed from the pattern observed in the previous findings [16,17]. To our knowledge, the present study is the first to examine self-reflection of Buddhists that is modulated by perspective. These results have important implications for broadening investigations of self-reflection in religious cultural environment. Most of the previous research on self-evaluation in religious cultural environment has primarily focused on identifying the behavioral performance and neural activation under 1PP condition and concluded that Buddhist people have no self [16,17], which can be regarded as a religious belief influence. The current study further investigated another typical type of perspective and suggests that whether a Buddhist participant shows his or her self-awareness in self-referential processing largely depends on how the participant adopts perspective. That is, the previous conclusion may apply merely to the participants who hold a first-person perspective. If the Buddhist participants hold a third-person perceptive, they would tend to show their self-advantage and self-related neural activations. Some researchers think that what Buddhism denies is not that "I" exist, but that "I" exist in the subjective or first-person manner in which "I" conceive of myself as existing. In contrast, according to Buddhism, "I" am an objectively existing being in the sense that all of the facts about "me" are accessible from a third-person perspective [20]. For Buddhist participants, self is not in a privileged position to know about their body or bodily states. The body and self are fully present to outside observers. For this reason, all the facts about Buddhist participants are accessible from a third-person perspective. Furthermore, on a much grander scale, the current study also used a special Asian sample to investigate the views of "culture as situated cognition model". This model suggested that Asians' self-views are not fixed, but fluid and flexible, Our results confirmed that the dynamic self-views could be influenced by perspective [10,11].

The comparison of self- vs font-judgment in 1PP and 3PP group both activated left frontal region, which were also found in previous studies [3,33], this region was similar with studies that needs semantic processing of verbal materials [34]. In our experiment, participants needed to understand the meaning of every trait adjectives and make decisions in self-judgment, however, in font-judgment participants do not need to understand the meaning of the word. Therefore, compared with font-judgment, self-judgment encouraged semantic processing of the trait adjectives and induced greater activation in left frontal region. The posterior cingulate cortex was also activated in this comparison for both groups, which were also found in self-referential processing in other studies [23,35]. Han et al [16] found the midcingulate activation in self-judgment on Buddhists, anterior to the posterior cingulate cortex. They suggested that, this region might be involved in resolving cognitive and affective conflicts. For Buddhists, self-judgment was conflict with their religious belief that deny the existence of self, this might cause the activation of posterior cingulate cortex.

The current work has some limitations. First, the current study didn't recruit non-religious participants and compare their magnitude of self-related effect with Buddhist participants within one experiment. In order to justify how religion affects the self-referential processing modulated by perspective, future studies should recruit the religious and non-religious samples and compare them directly. Second, we did not find any significant differences between self- and others judgment at behavioral level. It is unclear whether the self-referential memory task was too difficult for the Buddhist participants (i.e., floor effect). In our previous study, we also found the Buddhist participant got undesired results in the memory task [17]. Follow-up studies could use other easier paradigms (e.g., physical self-identity task) to assess the present results [36–38]. Third, the accuracy of font-judgment condition was low. It was possible that the typeface of the stimuli was not optimal for people to distinguish the bold-faced characters from the light-faced characters in the present study. However, we recognize that it might not affect the conclusion of the current study since the conclusion was based mainly on the trait-judgment conditions. In the end, we used a mixed design with between-subject measures concerning a perspective factor, in which a participant only needs to adopt one kind of perspective. This design reduces the difficulty of 3PP, given that the participants do not need to repeatedly change their perspectives within the experimental task [37]. Future studies should design experiment and compare results from 1PP and 3PP in one study.

5. Conclusion

In summary, the current work provides preliminary fMRI evidence suggesting that Buddhist belief lead to ventral mPFC and ACC activation of self-reflection only under 3PP. Together with our previous study of Buddhists [17], the current work lends further support to the proposal that although Buddhists' self-related activation of disappeared under 1PP, their self-reflection existed integrallty under 3PP condition. The findings indicate that whether the Buddhist participants show self-advantage or self-related activation largely depends on which perspective they adopt, and these findings may provide initial empirical evidence toward supporting and extending culture as situated cognition model of Asia by considering religious belief and perspective factors.

Funding

This work was supported by the National Program on Key Basic Research Project (973 Program, 973-2015CB351800), the National Natural Science Foundation of China (61690205; 31771205; 31800907), the Natural Science Foundation of Jiangsu Province (BK20160316), and the Philosophy & Social Science Foundation of Jiangsu Higher Education Institutions (2018SJA1325).

Declaration of Interest

The authors declare that they have no conflict of interest.

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