

Dynamic bicultural brains: fMRI study of their flexible neural representation of self and significant others in response to culture primes

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We examined the neural representation of the self and significant others in response to culture primes in a dynamic bicultural brain. We used functional magnetic resonance imaging (fMRI) to examine the neural representation of the self and significant others in response to culture primes in a dynamic bicultural brain. We found that the medial prefrontal cortex (MPFC) was activated in response to both the self and significant others, and this activation was modulated by culture primes. Specifically, the MPFC activation was more pronounced for the self than for significant others in response to independent self-construal primes, and vice versa for interdependent self-construal primes. These findings suggest that the dynamic bicultural brain is able to flexibly represent the self and significant others in response to culture primes.

Key words: culture priming, independent self-construal, interdependent self-construal, functional magnetic resonance imaging (fMRI), medial prefrontal cortex, self-inclusiveness.

Introduction

When people from different cultures interact, they often experience cognitive conflicts because of their different ways of thinking and perceiving the world (Ng & Zhou, 2000). In particular, the cross-cultural differences in self-construal have been implicated in the cognitive conflicts between individuals from independent and interdependent cultures (Triandis, 1995). The independent self-construal emphasizes the individual's autonomy, independence, and self-reliance, whereas the interdependent self-construal emphasizes the individual's interconnectedness with other people (Hwang, 1998). The independent self-construal is associated with a sense of self-inclusiveness, whereas the interdependent self-construal is associated with a sense of self-exclusiveness (Ng, Zhou, & Zhou, 2000).

Self-inclusiveness and self-other differentiation: Evidence from social and cultural psychology

Self-inclusiveness has been shown to be associated with the self-other differentiation in social and cultural psychology (Ng, Zhou, & Zhou, 2000).

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Psychological research has shown that the self-inclusiveness of the self is associated with the self-other differentiation (Ng, Zhou, & Zhou, 2000). Specifically, the self-inclusiveness of the self is associated with the self-other differentiation in social and cultural psychology (Ng, Zhou, & Zhou, 2000). This research was supported by grants from the Research Grant Council of Hong Kong (CityU 1233/05H) and the National Natural Science Foundation of China (30570670). The authors would like to thank Dr. Ming Tang and Dr. Liyan Wang for their help in this research. The authors also thank the anonymous reviewers for their valuable comments and suggestions.

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and self-other differentiation, and the prefrontal cortex and amygdala were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right amygdala (W^R) ($100, 100, 100$, T₁, L₁, R₁) and the left amygdala (W^L) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right amygdala (W^R) ($100, 100, 100$, T₁, L₁, R₁) and the left amygdala (W^L) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right amygdala (W^R) ($100, 100, 100$, T₁, L₁, R₁) and the left amygdala (W^L) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right amygdala (W^R) ($100, 100, 100$, T₁, L₁, R₁) and the left amygdala (W^L) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right amygdala (W^R) ($100, 100, 100$, T₁, L₁, R₁) and the left amygdala (W^L) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right amygdala (W^R) ($100, 100, 100$, T₁, L₁, R₁) and the left amygdala (W^L) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991).

Self-inclusiveness and self-other differentiation: Evidence from cultural neuroscience

Cultural differences in self-inclusiveness and self-other differentiation have been found in the prefrontal cortex and amygdala. In the prefrontal cortex, the right dorsolateral prefrontal cortex ($DLPFC^R$) ($100, 100, 100$, T₁, L₁, R₁) and the left dorsolateral prefrontal cortex ($DLPFC^L$) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right dorsolateral prefrontal cortex ($DLPFC^R$) ($100, 100, 100$, T₁, L₁, R₁) and the left dorsolateral prefrontal cortex ($DLPFC^L$) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right dorsolateral prefrontal cortex ($DLPFC^R$) ($100, 100, 100$, T₁, L₁, R₁) and the left dorsolateral prefrontal cortex ($DLPFC^L$) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right dorsolateral prefrontal cortex ($DLPFC^R$) ($100, 100, 100$, T₁, L₁, R₁) and the left dorsolateral prefrontal cortex ($DLPFC^L$) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right dorsolateral prefrontal cortex ($DLPFC^R$) ($100, 100, 100$, T₁, L₁, R₁) and the left dorsolateral prefrontal cortex ($DLPFC^L$) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991). The right dorsolateral prefrontal cortex ($DLPFC^R$) ($100, 100, 100$, T₁, L₁, R₁) and the left dorsolateral prefrontal cortex ($DLPFC^L$) ($100, 100, 100$, T₁, R₁, L₁) were found to be involved in self-inclusiveness and self-other differentiation (Ng & Hwang, 1991).

Self-inclusiveness and self-other differentiation in the bicultural brain: Bicultural frame switching model

Ng et al. (2000) proposed a bicultural frame switching model to explain the self-inclusiveness and self-other differentiation in the bicultural brain. According to this model, the bicultural brain has two frames, the Chinese frame and the Western frame. The Chinese frame is characterized by the concept of 'self-inclusiveness' and the Western frame is characterized by the concept of 'self-other differentiation'. The bicultural brain can switch between the Chinese frame and the Western frame depending on the context. When the bicultural brain is in the Chinese frame, it processes information in a more holistic and integrated way, emphasizing the interconnectedness of the self and others. When the bicultural brain is in the Western frame, it processes information in a more individualistic and differentiated way, emphasizing the distinction between the self and others. The bicultural brain can switch between the Chinese frame and the Western frame based on various factors such as social context, cultural background, and personal preference. This model provides a framework for understanding the complex nature of self-inclusiveness and self-other differentiation in the bicultural brain.

Method

A fMRI study was conducted to explore the neural correlates of self-inclusiveness and self-other differentiation in the bicultural brain. The study used a within-subjects design, where each participant performed both Chinese and Western tasks. The Chinese task involved processing Chinese characters and the Western task involved processing English words. The participants were asked to identify the target character or word while ignoring the distracter characters or words. The fMRI data were collected using a GE Signa 3.0T scanner. The brain regions of interest were identified using a region of interest (ROI) analysis. The results showed that the right dorsolateral prefrontal cortex ($DLPFC^R$) and the left amygdala (W^L) were activated during the Chinese task, while the left dorsolateral prefrontal cortex ($DLPFC^L$) and the right amygdala (W^R) were activated during the Western task. These findings support the bicultural frame switching model and provide evidence for the neural basis of self-inclusiveness and self-other differentiation in the bicultural brain.

Bicultural participants

Participants were recruited from the Western and Chinese communities in Hong Kong. All participants were born in Hong Kong and spoke Cantonese at home. They were all university students (mean age = 19.7, SD = 0.00). They had been living in Hong Kong for at least 10 years (Tse et al., 2000; Tse & Yiu, 2000). They were all bilingual, speaking English and Cantonese fluently (Tse & Yiu, 2000). They were all bicultural (Tse & Yiu, 2000), and had been living in Hong Kong for at least 10 years (Tse et al., 2000; Tse & Yiu, 2000).

The mean age of the participants was 19.7 (SD = 0.00) and they had been living in Hong Kong for at least 10 years (Tse et al., 2000; Tse & Yiu, 2000). They were all bilingual, speaking English and Cantonese fluently (Tse & Yiu, 2000). They were all bicultural (Tse & Yiu, 2000), and had been living in Hong Kong for at least 10 years (Tse et al., 2000; Tse & Yiu, 2000).

Western and Chinese culture primes

Participants were presented with Western culture primes (e.g., *self*, *brave*, *childish*) and Chinese culture primes (e.g., *self*, *brave*, *childish*) in a randomised order. The Western culture primes were presented in English and the Chinese culture primes were presented in Chinese. The Western culture primes were presented in English and the Chinese culture primes were presented in Chinese.

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Scanning procedure

Participants were presented with Western culture primes (e.g., *self*, *brave*, *childish*) and Chinese culture primes (e.g., *self*, *brave*, *childish*) in a randomised order. The Western culture primes were presented in English and the Chinese culture primes were presented in Chinese. The Western culture primes were presented in English and the Chinese culture primes were presented in Chinese.

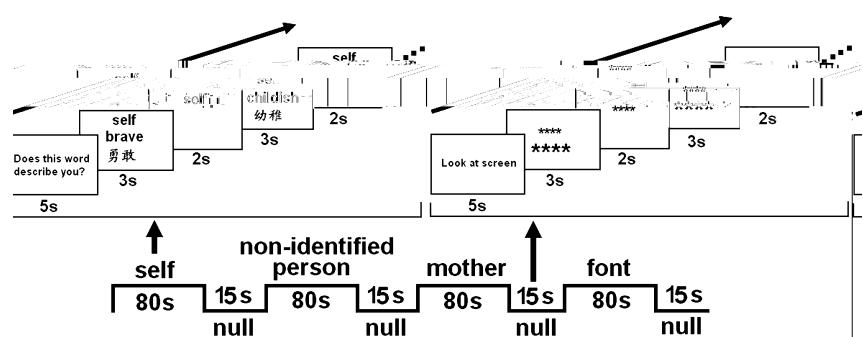


Figure 1 Illustration of the stimuli and procedure.

and \hat{Y}_1 is the support of T_1 .
 $\hat{Y}_1 \cap \{0\}$ is the support of b_1
 $\hat{Y}_1 \cap \{1\}$ is the support of b_2
 $\hat{Y}_1 \cap \{2\}$ is the support of b_3
 $\hat{Y}_1 \cap \{3\}$ is the support of b_4

Let $\mathbf{r} = (r_1, r_2, r_3, r_4)$ and $\mathbf{b} = (b_1, b_2, b_3, b_4)$ be two vectors in \mathbb{R}^4 .
 \mathbf{r} and \mathbf{b} are called equivalent if $r_i = b_i$ for all $i \in \{1, 2, 3, 4\}$.
 \mathbf{r} and \mathbf{b} are called \mathbb{Z}_2 -equivalent if $r_i \equiv b_i \pmod{2}$ for all $i \in \{1, 2, 3, 4\}$.
 \mathbf{r} and \mathbf{b} are called \mathbb{Z}_3 -equivalent if $r_i \equiv b_i \pmod{3}$ for all $i \in \{1, 2, 3, 4\}$.
 \mathbf{r} and \mathbf{b} are called \mathbb{Z}_4 -equivalent if $r_i \equiv b_i \pmod{4}$ for all $i \in \{1, 2, 3, 4\}$.

T_1 and T_2 are called \mathbb{Z}_2 -equivalent if $b_1 \equiv b_2 \pmod{2}$, $b_3 \equiv b_4 \pmod{2}$
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\hat{Y}_1 and \hat{Y}_2 are called \mathbb{Z}_2 -equivalent if $b_1 \equiv b_2 \pmod{2}$, $b_3 \equiv b_4 \pmod{2}$
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$(1, 1), T_1$ and T_2 are called \mathbb{Z}_2 -equivalent if

$T_{\text{self}} > T_{\text{mother}}$ ($b = 0.01$, $p < 0.05$), $T_{\text{self}} > T_{\text{NIP}}$ ($b = 0.01$, $p < 0.05$). $T_{\text{NIP}} < T_{\text{mother}}$ ($b = -0.01$, $p < 0.05$). $T_{\text{self}} > T_{\text{font}}$ ($T_{\text{self}} > T_{\text{font}}$ & $T_{\text{font}} < T_{\text{NIP}}$) ($b = 0.01$, $p < 0.05$). $T_{\text{NIP}} < T_{\text{font}}$ ($b = -0.01$, $p < 0.05$).

Results

Brain imaging

$T_{\text{self}} > T_{\text{font}}$ ($b = 0.01$, $p < 0.05$) was significant in the left fusiform gyrus, left amygdala, left hippocampus, left parahippocampal gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus (Table 1). $T_{\text{NIP}} < T_{\text{font}}$ ($b = -0.01$, $p < 0.05$) was significant in the right fusiform gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus.

$T_{\text{self}} > T_{\text{mother}}$ ($b = 0.01$, $p < 0.05$) was significant in the left fusiform gyrus, left amygdala, left hippocampus, left parahippocampal gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus (Table 1). $T_{\text{NIP}} < T_{\text{mother}}$ ($b = -0.01$, $p < 0.05$) was significant in the right fusiform gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus. $T_{\text{self}} > T_{\text{NIP}}$ ($b = 0.01$, $p < 0.05$) was significant in the left fusiform gyrus, left amygdala, left hippocampus, left parahippocampal gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus (Table 1). $T_{\text{NIP}} < T_{\text{mother}}$ ($b = -0.01$, $p < 0.05$) was significant in the right fusiform gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus.

Table 1 Regions of significant increased activation in comparison between self, mother and NIP with font judgments (corrected, $p < 0.05$)

	V	X	Y	Z
$T_{\text{self}} > T_{\text{font}}$				
Left fusiform gyrus	3	-4	-4	4.0
Left amygdala	3	-4	0	4.0
Left hippocampus	0	-4	-1	4.0
Left parahippocampal gyrus	4.1	4	-2	4.4
Right amygdala	1	-10	4	4.0
Right hippocampus	14	4	-0	4.0
Right parahippocampal gyrus	1	-4	-1	4.1
Left fusiform gyrus	11	4	-2	4.1
Left amygdala	0	-4	1	4.4
Left hippocampus	1	-4	1	4.0
Left parahippocampal gyrus	4	4	-1	4.1
Right amygdala	2	1	-1	4.0
Right hippocampus	4.0	4	0	4.0
Right parahippocampal gyrus	4.0	4	1	4.4
$T_{\text{NIP}} < T_{\text{font}}$				
Left fusiform gyrus	4.0	4.0	1	-1
Left amygdala	4	-1	-1	4.0
Left hippocampus	4.0	4.0	1	-11
Left parahippocampal gyrus	1.1	4	0	4.4
Right amygdala	1	-4	-1	1
Right hippocampus	4.0	4	1	4.0
Right parahippocampal gyrus	10.0	4	1	4.1
Left fusiform gyrus	10.0	4	0	4.4
Left amygdala	10.0	4	0	4.0

$T_{\text{self}} > T_{\text{mother}}$ ($b = 0.01$, $p < 0.05$) was significant in the left fusiform gyrus, left amygdala, left hippocampus, left parahippocampal gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus.

$T_{\text{NIP}} < T_{\text{mother}}$

($b = -0.01$, $p < 0.05$) was significant in the right fusiform gyrus, right amygdala, right hippocampus, and right parahippocampal gyrus.

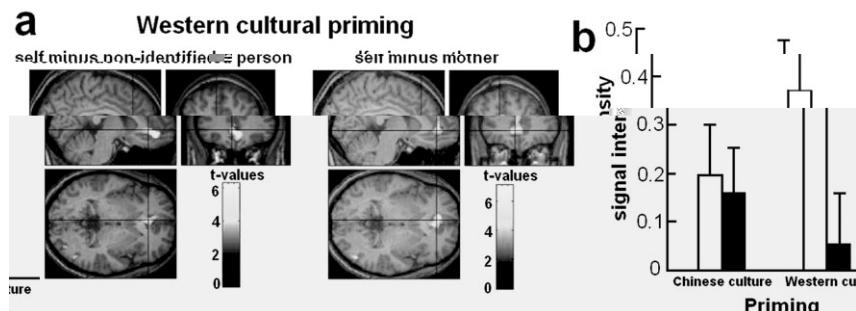


Figure 2 (a) Brain activation observed in the contrasts between self vs non-identified person and between self vs mother after Western cultural priming. (b) Results of region-of-interest analysis of the parameter estimates of signal intensity in the ventral medial prefrontal cortex. ■, non-identified person; □, self.

Table 2 Mean behavioural performances (*SD*) during the scanning procedure

	1	2	3	4	5	6
Y _W (%)	4.2 (1.1)	4.4 (1.1)	4.4 (1.1)	4.0 (0.8)	4.4 (1.1)	4.4 (1.1)
Z _W (%)	4.1 (1.1)	4.1 (1.1)	4.1 (1.1)	4.1 (1.1)	4.1 (1.1)	4.1 (1.1)
Y _C (%)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)
Z _C (%)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)	1.8 (0.8)

ANOVA revealed significant effects of culture ($F(1,12) = 14.4$, $p < 0.001$), task ($F(1,12) = 14.4$, $p < 0.001$), and culture \times task interaction ($F(1,12) = 14.4$, $p < 0.001$). Tukey's HSD post-hoc test showed significant differences between Chinese and Western cultures in all six tasks (all $p < 0.001$).

For the task effect, ANOVA revealed significant effects of task ($F(5,60) = 14.4$, $p < 0.001$). Tukey's HSD post-hoc test showed significant differences between Y_W and Z_W ($p < 0.001$), Y_C and Z_C ($p < 0.001$), Y_W and Y_C ($p < 0.001$), and Z_W and Z_C ($p < 0.001$). There was no significant difference between Y_W and Z_C ($p = 0.05$), and between Z_W and Y_C ($p = 0.05$).

Behavioural performance

Table 2 shows mean behavioural performances and standard deviations for each task. The results indicated that Chinese participants performed better than Western participants in all six tasks.

For the culture effect, ANOVA revealed significant effects of culture ($F(1,12) = 14.4$, $p < 0.001$). Tukey's HSD post-hoc test showed significant differences between Chinese and Western cultures in all six tasks (all $p < 0.001$).

Discussion

Joyce et al. (2000) conducted a fMRI study to examine the neural mechanism underlying the self-referential processing in Chinese and Western cultures. They found that Chinese participants showed more activation in the left amygdala and right hippocampus than Western participants. In contrast, the present study found that Chinese participants showed less activation in the left amygdala and right hippocampus than Western participants. This discrepancy may be due to the different experimental paradigms used in the two studies. Joyce et al. (2000) used a self-referential task, while the present study used a social cognition task. The self-referential task requires participants to evaluate their own personality traits, while the social cognition task requires participants to evaluate the personality traits of others. Therefore, the results of the two studies cannot be directly compared.

V^W and T^W were also found to be associated with the degree of biculturalism (Lee et al., 2000). In addition, the degree of biculturalism was negatively correlated with V^W and positively correlated with T^W (Lee et al., 2000; Lee & Choi, 2000; Lee et al., 2000).

The results of the present study support the hypothesis that the degree of biculturalism is associated with the degree of self-representation in the brain. Specifically, the results showed that the degree of biculturalism was negatively correlated with V^W and positively correlated with T^W . These findings are consistent with those of Lee et al. (2000), Lee and Choi (2000), and Lee et al. (2000). The results of the present study also support the hypothesis that the degree of biculturalism is associated with the degree of self-representation in the brain.

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