

# Why We Respond Faster to the Self Than to Others? An Implicit Positive Association Theory of Self-Advantage During Implicit Face Recognition

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Human adults usually respond faster to their own faces rather than to those of others. We tested the hypothesis that an implicit positive association (IPA) with self mediates self-advantage in face recognition through 4 experiments. Using a self-concept threat (SCT) priming that associated the self with negative personal traits and led to a weakened IPA with self, we found that self-face advantage in an implicit face-recognition task that required identification of face orientation was eliminated by the SCT priming. Moreover, the SCT effect on self-face recognition was evident only with the left-hand responses. Furthermore, the SCT effect on self-face recognition was observed in both Chinese and American participants. Our findings support the IPA hypothesis that defines a social cognitive mechanism of self-advantage in face recognition.

*Keywords:* face recognition, hemisphere, implicit positive association, self

The “self” is unique and different from others. The distinctiveness of the self is reflected in both perception of and behavioral responses to the self. For example, humans before age of 2 years

(2003) also reported a split-brain patient who showed more true-positive and fewer false-positive responses when searching for the self-face among morphed faces with the right versus the left hemispheres (but see Turk et al., 2002, for a split-brain patient showing a reverse pattern).

Recent functional magnetic resonance imaging (fMRI) studies also showed evidence for distinct neural substrates underlying self-face recognition. Relative to famous or personally familiar faces, recognition of self-face results in increased activity in the right frontal and parietal lobes and the left middle temporal gyrus (Devue et al., 2007; Platek, Keenan, Gallup, & Mohamed, 2004; Platek et al., 2006; Sugiura et al., 2005). Similarly, self-face induces increased activation in the right frontal cortex relative to a personally familiar face in the implicit face-recognition task (Sui & Han, 2007). Inhibition of the right (but not the left) inferior parietal cortex by transcranial magnetic stimulation (TMS) disrupted the performance on self–other discrimination of morphed images (Uddin, Molnar-Szakacs, Zaidel, & Iacoboni, 2006). Taken together, although studies of self-face recognition have yielded inconsistent localizations (e.g., Kircher et al., 2001; Turk et al., 2002), most of the brain imaging studies have supported that a neural circuit mainly in the right hemisphere underpins self-face recognition in human adults (Uddin, Iacoboni, Lange, & Keenan, 2007).

### **An IPA Theory of Self-Face Recognition**

Although previous findings indicate that specific neural mechanisms engage in self-face recognition, it is still unclear why the self-advantage in behavioral performances occurs in face-recognition tasks. The ERP results (Sui et al., 2006) suggested that the self-face advantage is mediated by a cognitive mechanism that occurs after face structure encoding. Here we propose an IPA theory of self-face recognition that emphasizes a social cognitive mechanism involved in self-face recognition. We hypothesize that self-face recognition and the concomitant self-awareness activate positive attribute in self-concept, which facilitates behavioral responses to self-face and thus results in self-advantage in face recognition.

Beside the aforementioned behavioral and neuroimaging findings regarding self-face recognition, our IPA theory of self-face recognition is grounded in the findings of three lines of research. First, research using different types of stimuli has demonstrated shorter choice RTs to positive than to negative stimuli. Positively toned words were categorized faster than negatively toned words (Feyereisen, Malet, & Martin, 1986; Osgood & Hoosain, 1983; Stenberg, Wiking, & Dahl, 1998). Similarly, participants responded faster to names of “good” people than those of “bad” people when the names were categorized based on the valence of the stimuli or on the valence of irrelevant features (Cunningham, Johnson, Gatenby, Gore, & Banaji, 2003). Responses were faster to faces with positive emotions (i.e., happiness) than to those with negative emotions such as sadness (Kirita & Endo, 1995) and disgust (Stalans & Wedding, 1985) even when low-level physical differences were well controlled (Leppänen & Hietanen, 2004). Leppänen, Tenhunen, and Hietanen (2003) further measured onsets of the lateralized readiness potentials (LRP), which originates from the primary motor cortex (Leuthold & Jentsch, 2002) and indexes the time of response selection. Leppänen et al. used the

difference between RTs and LRP onsets to indicate the response selection times and found shorter response selection times for positive relative to negative faces, suggesting that positive faces facilitates response selection. These findings indicate that cognitive functions are biased such that positive attributes of stimuli facilitate motor responses in a more efficient way compared with negative stimuli.

demonstrated the existence of an IPA with self and the modulation of the primary motor cortex by self-related stimuli, the current study investigated the cause–effect relation between the IPA with self and the self-advantage of face recognition. Our IPA hypothesis of self-face recognition has several predictions. First and most important, if the IPA with self plays a key role in self-face advantage, the self-face advantage should be reduced once the IPA with self is broken or weakened. Second, because the right hemisphere dominates self-face recognition (Keenan et al., 1999; Sui & Han, 2007; Uddin et al., 2006) and self-related stimuli modulate the right motor activity (Keenan et al., 2001; Molnar-Szakacs et al., 2005; Theoret et al., 2004), a manipulation that weakens the IPA with self should mainly influence left-hand responses to self-face and familiar faces. Third, as positive self-regard is culturally universal (Heine, 2005; Heine, Lehman, Markus, & Kitayama, 1999), we would expect the IPA with self plays a similar role in self-face advantage in different cultures and thus a manipulation that weakens the IPA with self should influence self-face advantage in a similar fashion in different cultures.

### An Overview of the Present Study

To test the predictions of our IPA hypothesis of self-face advantage, we employed a paradigm of self-concept threat (SCT) priming that has been shown to influence the IPA with self. The experimental manipulation to threat self-concept was developed by Jones et al. (2002) who required participants to write about personal flaws (an SCT priming) before rating preferences for letters. They found that, relative to nonthreat priming that asked participants to write sentences to describe a recently viewed movie, the SCT priming resulted in enhancement of the degree of own name-letter liking. The observations reflect unconscious self-enhancement as compensation for weakened IPA with self induced by the SCT priming. We modified Jones et al.'s SCT priming procedure by asking participants to judge if a number of negative personal traits were appropriate to describe themselves. The nature of the SCT priming is to assign negative traits to the self and to render access of negative association of the self to participants' awareness. To control for the semantic processing during the SCT priming, we designed a nonthreat priming task that asked participants to judge the valence (positive or negative) of the same number of personal traits. Such a design ensured that the SCT and nonthreat priming procedure took the same time and that each individual participant underwent the SCT priming for the same period of time.

Experiment 1 first provided empirical evidence that the SCT priming indeed weakens the IPA with self by using the typical IAT paradigm that assesses RTs to self-face paired with positive or negative trait words. Experiment 2 then examined whether the SCT priming results in weakened self-advantage in face recognition, verifying the first prediction of our IPA hypothesis of self-recognition. Similar to previous studies (Sui & Han, 2007; Sui et al., 2006), we measured RTs in an implicit face-recognition task (i.e., to discriminate head orientations of self-face or a personally familiar face) after the SCT and nonthreat priming procedure. RTs to self-face or a familiar face were compared to identify the self-face advantage. RTs to the discrimination of left- or right-located gray bars in scrambled faces were also measured to assess the SCT effect on general motor responses. If the self-face advantage

originated from the IPA with self, it should be weakened by the SCT priming procedure relative to the nonthreat priming condition. To examine whether the SCT effect on self-face advantage took place in the right or left hemispheres, Experiment 3 asked participants to respond to the face stimuli using the left or right hands, respectively. If the IPA with self mediates self-face advantage, then weakening the IPA should mainly affect the mechanisms underlying self-face advantage in the right hemisphere, which leads to the prediction that the SCT priming should modulate the left-hand response but not the right-hand responses to self-face and familiar faces, verifying the second prediction of our IPA hypothesis. To test the third prediction of our IPA hypothesis of self-face advantage, Experiment 4 recruited participants from a different cultural group (i.e., Americans). If the role of IPA with self in self-face advantage is culturally universal, one would predict that the SCT priming weakens or eliminates self-face advantage in both Chinese in Experiment 3 and Americans in Experiment 4.

### Experiment 1: SCT Weakens Positive Associations With Self-Face

Experiment 1 adopted the IAT (Greenwald et al., 1998) to examine how SCT priming affects the IPA with self. We measured responses to self-face paired with positive and negative personal trait words after participants underwent the SCT and nonthreat priming. If the SCT priming indeed weakens the IPA with self, we would expect that, relative to a nonthreat condition in which responses should be faster to a self-face paired with positive than negative words, the IAT effect would be smaller after participants undergo the SCT priming.

### Method

**Participants.** Six pairs of Chinese undergraduate and graduate students (4 men, 8 women, 20 to 25 years of age, mean age  $\pm$   $SD = 22.2 \pm 2.14$ ) participated in Experiment 1 as paid volunteers. Each pair of the participants was gender-matched friends or roommates and had known each other for about 2 years. All participants were right-handed and had normal or corrected-to-normal vision. Informed consent was obtained prior to the study, which was approved by a local ethics committee.

#### Stimuli and procedure

**Priming procedure.** We selected 120 Chinese personality-trait adjectives from an established personality trait adjective pool (Liu, 1990). Of those words, 90 words were unambiguously negative (e.g., greedy, lazy, impolite) and 30 were positive (e.g., brave, smart, generous). The frequency distribution of these trait adjectives reflects the overall characteristics of the frequency distribution of the original list. We used 60 negative adjectives in the SCT priming, and 30 of these adjectives were randomly selected for each participant. During the SCT priming procedure, each adjective was presented for 4 s at the center of a computer monitor followed by a 2-s interval during which participants had to judge whether the trait adjective presented described his/her own personality. Each word prompted a "yes" or "no" response by pressing a button on a standard keyboard with the left or right index finger. The priming procedure lasted for 3 min. A different set of 30 negative and 30 positive trait adjectives was used in the non-

threat priming procedure, in which 15 negative and 15 positive adjectives were randomly chosen for each participant. The non-threat priming was identical to the SCT priming except that participants had to judge the valence of each adjective by pressing one of two buttons. The assignment of “yes” and “no,” “positive” and “negative” responses to the left and right hands was counterbalanced across participants. Each participant underwent both the SCT and the nonthreat priming procedure and the order of the SCT and nonthreat priming were counterbalanced across participants.

**IAT procedure.** Immediately after the SCT and nonthreat priming procedure, participants performed an IAT task. Similar to that in Greenwald and Farnham (2000), there were four kinds of stimuli in the IAT task, that is, me items, not me items, positive items, and negative items. However, the me items and not me items consisted of face images of each participant and one of his/her friends. Ten face images of each participant and a gender/age matched friend, with a neutral facial expression, were taken using a digital camera before the experiment. Their heads were oriented to the left (from 0° to 45°) in five images and to the right in the others. We chose 10 positive and 10 negative words for the positive/negative items.

The IAT was introduced as a “categorization task” in which participants had to categorize a variety of items that appeared on a computer screen. There were seven blocks of trials after the SCT priming and the nonthreat priming procedure. Each practice block consisted of 20 trials and each data-collection block consisted of 40 trials (see Table 1 for the design in details). Each block was preceded by an instruction that informed participant of the type of items that they had to categorize as well as the meaning of the keys (key labels remained on the screen throughout each block). Each stimulus was presented for 300 ms at the center of the screen and was followed by a fixation with a duration varying between 900 to 1,500 ms ( $M = 1,200$  ms). For each trial participants responded to the stimulus item by pressing a key on a standard keyboard using the left or right index finger. The IAT effect was measured as the difference in RTs between me + positive items in Block 4 and me + negative items in Block 7. The order of Blocks 2 through 4 and Blocks 5 through 7 and the assignment of different items to the left and right hand responses were counterbalanced across participants. Both the priming and IAT conditions were manipulated using a within-subjects design. Instructions emphasized both response speed and accuracy.

## Results and Discussion

Participants identified  $10.3 \pm 4.58$  negative adjectives that matched their own personality in the SCT priming procedure, and

were 100% correct in the valence judgment task during the non-threat priming procedure.

Only RTs with correct responses that did not exceed the mean by three standard deviations were analyzed and reported throughout this paper. To examine whether the SCT priming weakens the IAT effect, repeated-measure analyses of variance (ANOVAs) were conducted on both response accuracies and RTs with association (me + positive vs. me + negative items) and priming (nonthreat vs. SCT priming) as independent within-subjects variables. Table 2 shows the response accuracies in each condition. The ANOVA of response accuracies did not show any significant main effect ( $p > .05$ ). The ANOVA of RTs showed a reliable interaction of association and priming,  $F(1, 11) = 5.562, p < .04, \eta^2 = 0.336$ . Post hoc analysis confirmed that responses were faster to me + positive than me + negative trials in the nonthreat priming condition,  $F(1, 11) = 9.698, p < .01, \eta^2 = 0.469$ ; whereas responses did not differ significantly between the two conditions after the SCT priming,  $F(1, 11) = 1.295, p = .279$ , Figure 1a.

The ANOVAs of RTs to familiar faces showed a significant main effect of association,  $F(1, 11) = 7.490, p < .02, \eta^2 = 0.405$ ; participants responded faster to familiar faces associated with negative than positive items. However, the interaction of Association  $\times$  Priming did not reach significance,  $F(1, 11) = 1.424, p = .258$  (Figure 1b), suggesting that the SCT priming did not affect the RT difference between not me + positive and not me + negative items.

We also calculated the correlation between RT advantage of self-face over familiar faces (i.e., RTs to self-face minus RTs to the familiar face in Block 1) and IPA with self-face indexed by the IAT effect in the nonthreat priming condition. There was a marginally significant correlation ( $r = .524, p = .081$ ), suggesting a trend that the stronger the IPA with self-face, the greater the self-face advantage.

Experiment 1 showed faster responses to self-face when it was associated with positive rather than negative trait words in the nonthreat condition. This IAT effect indicates that an IPA with self existed when self-awareness was induced by self-face, consistent with previous observations that positive words facilitate responses to self-relevant information relative to negative words (Greenwald & Farnham, 2000). These findings demonstrate implicit positive attitudes toward the self that is independent of the domain of self-relevant information. More important, we found that the IAT effect was eliminated by the SCT priming, providing evidence that the SCT priming weakened the IPA with self. Thus the SCT priming is an efficient way to weaken the IPA with self and

Table 1  
*A List of the Categorization Tasks in Implicit Association Test in Experiment 1*

Block	Category labels 1	Category labels 2
1. (practice block, 20 trials)	Me items	Not me items
2. (practice block, 20 trials)	Positive items	Negative items
3. (practice block, 20 trials)	Me + positive items	Not me + negative items
4. (critical block, 40 trials)	Me + positive items	Not me + negative items
5. (practice block, 20 trials)	Negative items	Positive items
6. (practice block, 20 trials)	Me + negative items	Not me + positive items
7. (critical block, 40 trials)	Me + negative items	Not me + positive items

Table 2  
Mean Response Accuracy (%) in Experiment 1

Priming	Nonthreat		Self-concept threat	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Me + positive	95.8	3.97	96.5	4.08
Me + negative	96.3	5.42	96.3	3.37

provides a basis for using SCT priming to manipulate the IPA with self in the following experiments.

### Experiment 2a: SCT Priming Weakens Self-Advantage in Face Recognition

To examine the cause–effect relation between the IPA with self and the self-advantage in face recognition, Experiment 2a measured performances in an implicit face-recognition task that required discrimination of head orientations of self-face and a familiar face after participants were primed the SCT procedure. The IPA hypothesis of self-face advantage predicts that differential RTs to self-face and a familiar face is reduced by the SCT priming relative to the nonthreat priming. To control for the SCT priming effect on general motor responses, a scrambled face was also used in the implicit face-recognition task.

### Method

**Participants.** Six pair of Chinese undergraduate and graduate students (4 men, 8 women, 19 to 27 years of age, mean age  $\pm$   $SD = 22.08 \pm 2.39$ ) participated in Experiment 2a as paid volunteers. Each pair of the participants was gender-matched friends or roommates and had known each other for about 2 years. All participants were right handed and had normal or corrected-to-normal vision. Informed consent was obtained prior to the study.

**Stimuli and procedure.** The SCT and nonthreat priming were identical to those used in Experiment 1. Immediately after the priming procedure, participants performed an implicit face-orientation identification task, as illustrated in Figure 2, which employed a 3 (self, familiar other, or scrambled faces)  $\times$  2 (SCT

or nonthreat priming) within-subjects design. Ten photos with neutral facial expressions were taken for each participant and a personally familiar other matched for gender and age using a digital camera. Participants' heads were oriented to the left (from 30° to 90°) in five images and to the right in the others. These face stimuli were used as both self-face and personally familiar faces across participants so that the face stimuli were identical in the self- and familiar face conditions. The scrambled faces were made by cutting the images of the self and other faces into  $10 \times 10$  arrays and reorganizing them randomly into an image as large as the face stimuli. A vertical gray bar was located at the right or left edge of the scrambled face. All images were calibrated for luminance and contrast and were converted into JPG format.

The face-orientation identification task consisted of 20 self-faces, 20 familiar faces, and 16 scrambled faces, which were presented in a random order. Each stimulus was presented for 200 ms at the center of the screen and was followed by the presentation of a fixation cross with a duration varying between 800 to 1,200 ms. Participants were asked to identify head orientations of self-face and familiar faces and the locations (left or right) of the gray bar in the scrambled faces. They pressed a left key to left-oriented faces or left-located gray bar in scrambled faces and a right key to right-oriented stimuli using the left and right index fingers. The order of the SCT and nonthreat priming was counterbalanced across participants. Instructions emphasized both response speed and accuracy.

### Results and Discussion

Participants identified  $10.5 \pm 5.47$  negative adjectives that matched their own personality in the SCT priming procedure, and were 100% correct in the valence judgment task during the nonthreat priming procedure.

Table 3 shows the mean response accuracies in each stimulus condition of the face orientation identification task. The ANOVAs with face (self-face, familiar face, or scrambled faces) and priming (SCT vs. nonthreat priming) as independent within-subjects variables were conducted on both response accuracies and RTs. The analysis of response accuracies showed only a significant main effect of face,  $F(2, 22) = 4.929$ ,  $p < .02$ ,  $\eta^2 = 0.309$ ; suggesting

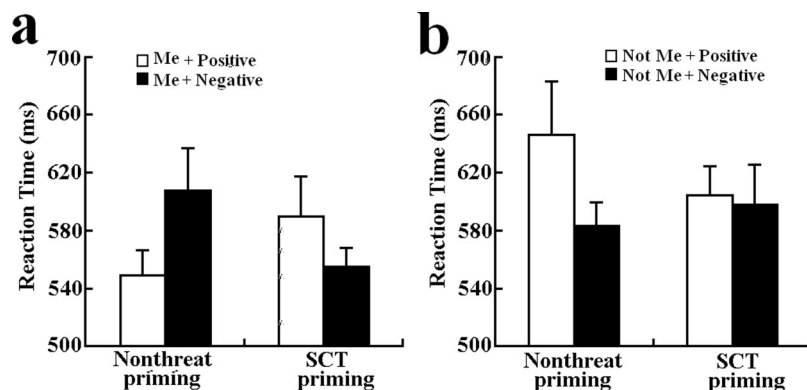
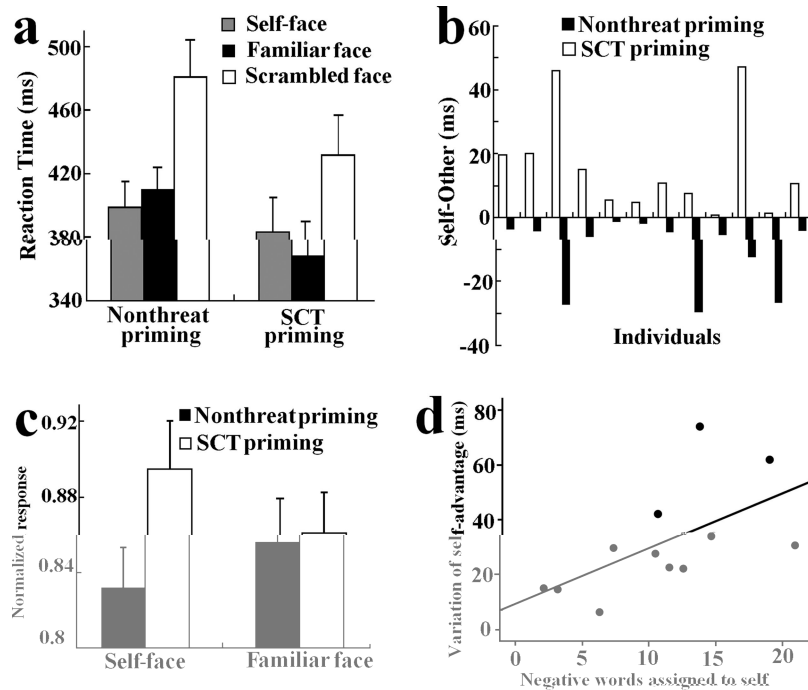


Figure 1. Reaction time (RT) results in Experiment 1. (a) RTs to self-face. (b) RTs to familiar faces. The Implicit Association Test effect is indexed by faster responses to me + positive than me + negative items in the nonthreat priming condition. Error bars represent standard errors. SCT = self-concept threat.







**Figure 3.** Reaction time (RT) results in Experiment 2a. (a) Mean RTs for the identification of head orientations of self-face and familiar faces or gray-bar locations in the scrambled face. Error bars represent standard errors. (b) RT differences between self and familiar faces from each individual participant in nonthreat and SCT conditions. The Y-axis represents the difference in RTs between self- and familiar faces (i.e., self minus familiar faces). The negative values index faster responses to the self than to familiar faces (i.e., the self-face advantage). (c) The results of normalized responses. The Y-axis represents the ratio of (self- or familiar faces):scrambled faces. (d) The results of correlation analysis in Experiment 2a. The X-axis represents the number of negative traits identified as appropriate to describe the self in the SCT priming procedure. The Y-axis represents the decrease of self-advantage in the SCT relative to the nonthreat priming conditions. SCT = self-concept threat.

### Experiment 2b: Self-Referential Processing Is Essential for the SCT Effect

Because the SCT priming in Experiment 2a used only negative traits whereas the nonthreat priming used half negative and half positive traits, one may argue that exposure to more negative traits itself might induce a negative mood (even without relating the traits to the self) and thus resulted in elimination of self-face advantage. To assess if self-referential processing was essential to the SCT effect observed in Experiment 2a, Experiment 2b applied a friend-concept threat (FCT) priming that asked participants to judge if a number of negative personal traits were appropriate to describe their friends. This design made participants exposed to the same negative trait words as those in Experiment 2a, although they were referenced to the friend rather than to the self. If general negative effects induced by exposure to negative traits influenced the self-face advantage, we would expect that the FCT priming also reduced self-face advantage relative to the nonthreat priming.

### Method

**Participants.** Eight pair of Chinese undergraduate and graduate students (4 men, 12 women, 19 to 24 years of age, mean age  $\pm$  SD = 22.44  $\pm$  1.55) participated in Experiment 2b as paid volunteers. Each pair of the participants was gender-matched friends or roommates and

had known each other for about 2 years. All participants were right handed and had normal or corrected-to-normal vision. Informed consent was obtained prior to the study.

**Stimuli and procedure.** These were identical to those in Experiment 2a except that the SCT priming was replaced by the FCT priming in Experiment 2b that asked participants to judge whether each of 30 negative trait adjectives was suitable to describe his/her friend whose pictures were used as friend stimuli. The order of the FCT and nonthreat priming was counterbalanced across participants.

### Results and Discussion

Participants identified 10.1  $\pm$  3.01 negative adjectives that matched their friend's personality in the FCT priming procedure, and were 97.8% correct in the valence judgment task during the nonthreat priming procedure.

Table 4 and Figure 4 show the mean response accuracies and RTs in each stimulus condition of the face orientation identification task. The ANOVAs with face (self-face, familiar face, or scrambled faces) and priming (FCT vs. nonthreat priming) as independent within-subjects variables were conducted on both response accuracies and RTs. The ANOVA of response accuracies did not show any significant effect ( $F < 1$ ).

The ANOVA of RTs showed a significant main effect of face,  $F(2, 14) = 8.195$ ,  $p < .004$ ,  $\eta^2 = 0.539$  (Figure 4a); but neither the main

Table 4  
Mean Response Accuracy (%) in Experiment 2b

Priming	Nonthreat		Friend-concept threat	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Self-face	95.6	2.66	95.0	2.37
Familiar face	94.9	2.70	95.9	1.50
Scrambled face	95.5	3.83	95.0	4.00

effect of priming ( $F < 1$ ) nor its interaction with face,  $F(2, 30) = 2.130$ ,  $p = .136$  was significant. A 2 (self-face vs. familiar face)  $\times$  2 (FCT vs. nonthreat priming) ANOVA showed a significant main effect of face,  $F(1, 15) = 12.99$ ,  $p < .003$ ,  $\eta^2 = 0.464$ ; whereas the interaction of Face  $\times$  Priming was not significant,  $F(1, 15) = 1.674$ ,  $p = .215$ ; indicating comparable self-face advantage in the FCT condition,  $F(1, 15) = 9.826$ ,  $p < .007$ ,  $\eta^2 = 0.396$ ; and the nonthreat condition,  $F(1, 15) = 6.676$ ,  $p < .03$ ,  $\eta^2 = 0.308$ .

Similar to Experiment 2a, normalized responses to self-face and familiar faces were defined by calculating the RT ratios of self/scrambled and familiar/scrambled faces (Figure 4b). A 2 (self-face vs. familiar face)  $\times$  2 (nonthreat vs. FCT priming) ANOVA revealed a significant main effect of face,  $F(1, 15) = 12.58$ ,  $p < .003$ ,  $\eta^2 = 0.455$ . However, neither the main effect of priming,  $F(1, 15) = 1.978$ ,  $p = .180$ ; nor its interaction with face,  $F(1, 15) = 1.386$ ,  $p = .257$  was significant.

Similar to Experiment 2a, Experiment 2b showed a reliable self-advantage in the implicit face-recognition task after the nonthreat priming procedure. However, the self-face advantage was not affected by the FCT priming. This excludes the account that simply being exposed to negative traits induces negative mood and eliminates self-face advantage. The results indicate that self-referential processing induced by the SCT priming is essential to the modulation of self-face advantage. In contrast to the negative mood account, RT results even showed a trend to increase self-face advantage in the FCT compared to the nonthreat priming condition. This is consistent with the IPA hypothesis because the FCT priming reduced IPA with familiar others and result in enhanced IPA with self relative to the friend and thus increase the self-face

advantage. Taken together, the results of Experiments 2a and 2b indicate that self-referential judgment of negative personal traits is necessary for the modulation of self-face advantage.

### Experiment 3: The Right Hemisphere Dominates the SCT Effect

The findings of Experiment 2 support the proposition that the IPA with self underpins self-face advantage. As mentioned earlier, prior behavioral (Keenan, Freund, Hamilton, Ganis, & Pascal-Leone, 2000; Keenan et al., 1999), neuroimaging (Platek et al., 2004, 2006; Sui & Han, 2007), and brain lesion studies (Keenan et al., 2001) suggested right hemisphere dominance in self-face recognition. To examine whether the self-face advantage is also dominated by the right hemisphere in the implicit face-recognition task, Experiment 3 replicated Experiment 2a but asked participants to respond to self-face, familiar faces, and scrambled faces using the left hand in one block but using the right hand in another block. If self-face advantage is observed only with the left-hand responses, we could further predict that the SCT priming that weakens the IPA with self mainly should affect the mechanisms underlying self-face recognition in the right hemisphere, which then result in modulation of the left-hand responses but not right-hand responses to self-face.

### Method

**Participants.** Eight pairs of Chinese participants were recruited in Experiment 3 (6 men, 10 women, 21 to 28 years of age, mean age  $\pm$   $SD = 22.94 \pm 1.65$ ). Each pair of participants consisted of gender-matched friends or roommates who had known each other for about 2 years. All participants were right handed and had normal or corrected-to-normal vision. Informed consent was obtained prior to the study.

**Stimuli and procedure.** All aspects of Experiment 3 were the same as those in Experiment 2a except that each participant was asked to conduct two blocks of trials of the face-orientation identification task after each priming condition. Participants responded with the left index and middle fingers in one block of trials but with the right index and middle fingers in another block. The order of the blocks with the left- or right-hand response and the order of the SCT and nonthreat priming were counterbalanced across participants.

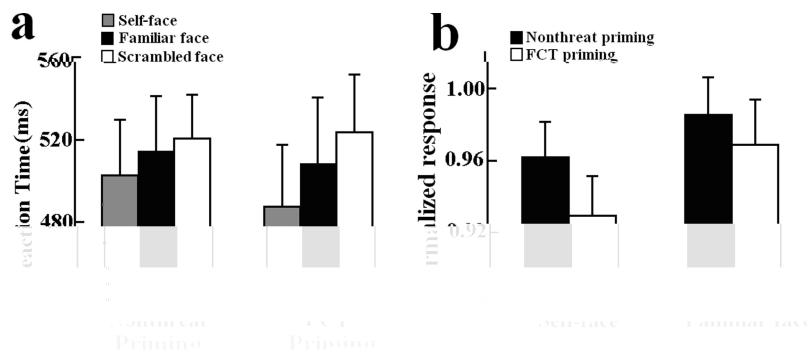


Figure 4. Reaction time (RT) results in Experiment 2b. (a) Mean RTs for the identification of head orientations of self-face and familiar faces or gray-bar locations in the scrambled face. (b) The results of normalized responses. The Y-axis represents the ratio of (self- or familiar faces):scrambled faces. Error bars represent standard errors. FCT = friend-concept threat.



## Results and Discussion

Participants identified  $9.88 \pm 5.28$  negative traits that could be applied to their own personality in the SCT priming procedure. They were 100% correct in the valence judgment task during the nonthreat priming procedure.

Table 5 shows the mean response accuracies in the face orientation identification task. RTs and response accuracies were subjected to ANOVA with hand (left vs. right hand), face (self-face, familiar face, or scrambled face), and priming (SCT vs. nonthreat) as within-subjects independent variables. The ANOVAs of response accuracies showed only a significant main effect of face,  $F(2, 30) = 3.688$ ,  $p < .05$ ,  $\eta^2 = 0.197$ ; suggesting lower response accuracies to the scrambled face than to self-face and familiar faces.

The ANOVA of RTs showed a significant main effect of face,  $F(2, 30) = 34.34$ ,  $p < .001$ ,  $\eta^2 = 0.696$ ; indicating faster responses to self-face and familiar faces than to the scrambled face. Responses were faster when participants responded with the right hand than with the left hand,  $F(1, 15) = 10.80$ ,  $p < .005$ ,  $\eta^2 = 0.419$ . RTs in the SCT priming condition did not differ significantly from the nonthreat priming condition,  $F(1, 15) = 2.530$ ,  $p = .132$ . There was a reliable interaction of Priming  $\times$  Face,  $F(2, 30) = 5.321$ ,  $p < .01$ ,  $\eta^2 = 0.262$ ; suggesting that responses to self-face were faster than to familiar faces after the nonthreat priming condition and a reverse pattern was true after the SCT priming. This basically replicates the results of Experiment 2a. The facilitation of motor responses by the SCT was greater when participants responded with their left hand as opposed to their right hand, resulting in a reliable interaction of Priming  $\times$  Hand,  $F(1, 15) = 10.58$ ,  $p < .005$ ,  $\eta^2 = 0.413$ . The interaction of Face  $\times$  Hand was not significant ( $F < 1$ ). Because there was a significant triple interaction of Hand  $\times$  Face  $\times$  Priming,  $F(2, 30) = 4.010$ ,  $p < .03$ ,  $\eta^2 = 0.211$ ; separate analyses were conducted with the left- and right-hand responses, respectively.

The ANOVA of RTs with the left hand showed a significant main effect of face,  $F(2, 14) = 12.99$ ,  $p < .001$ ,  $\eta^2 = 0.650$ ; and priming,  $F(1, 15) = 26.73$ ,  $p < .001$ ,  $\eta^2 = 0.641$ . In addition, there was a significant interaction of Face  $\times$  Priming,  $F(2, 14) = 33.26$ ,  $p < .001$ ,  $\eta^2 = 0.826$ . A 2 (self-face vs. familiar face)  $\times$  2 (SCT vs. nonthreat priming) ANOVA also showed a reliable interaction,  $F(1, 15) = 47.27$ ,  $p < .001$ ,  $\eta^2 = 0.759$ ; because RTs were shorter to self-face than to familiar faces in the nonthreat priming condition,  $t(15) = -6.008$ ,  $p < .001$ ; but a reverse pattern was true in the SCT priming condition,  $t(15) = 2.726$ ,  $p < .02$  (Figure 5a). Similar to Experiment 2a, we calculated the ratios of self:scrambled, familiar:scrambled faces to index normalized responses

that are independent of motor facilitation by the SCT priming (Figure 5b). ANOVAs of the normalized responses failed to show significant effects of face and priming ( $F < 1$ ). However, there was a reliable interaction of Face  $\times$  Priming,  $F(1, 15) = 40.95$ ,  $p < .001$ ,  $\eta^2 = 0.732$ . Post hoc analysis confirmed that the SCT priming effect was reliable for responses to self-face,  $t(15) = 2.71$ ,  $p < .02$ ; but not for responses to familiar faces,  $t(15) = -0.466$ ,  $p = .648$ ; indicating that the SCT priming inhibited the responses to self-face but did not affect responses to familiar faces.

Similar to Experiment 2a, there was a significant correlation between the number of negative traits identified as appropriate to describe the self and the decrease of self-face advantage shown in the left-hand responses ( $r = .583$ ,  $p < .02$ , Figure 5c), suggesting that the more negative traits participants identified as self-referential, the greater the decrease of the self-advantage in face recognition shown in the left-hand responses.

The ANOVA of the right-hand responses showed a significant main effect of face,  $F(2, 30) = 31.17$ ,  $p < .001$ ,  $\eta^2 = 0.675$ ; suggesting shorter RTs to self-face and familiar faces compared to scrambled faces (Figure 5d). Post hoc analysis confirmed that RTs did not differ between self-face and familiar faces in both nonthreat,  $t(15) = -1.113$ ,  $p = .283$ ; and SCT priming conditions,  $t(15) = -0.847$ ,  $p = .411$ . Moreover, neither the main effect of priming ( $F < 1$ ) nor its interaction with face ( $F < 1$ ) was significant, indicating that the difference in the right-hand responses between self, familiar, and scrambled faces did not vary as a function of the priming procedures. ANOVAs of normalized right-hand responses to self- and familiar faces did not show any significant effects (all  $p > .05$ , Figure 5e). As no self-face advantage was observed and the SCT priming did not change self–other differences in right-hand responses, we did not analyze the correlation between self-reported negative evaluation and the variation of self-face advantage.

The results of the left-hand responses in Experiment 3 replicated those in Experiment 2a. First, RTs were shorter to self-face than to familiar faces after the nonthreat priming. Second, this self-advantage in face recognition was eliminated because responses to self-face were delayed by the SCT priming. Third, the SCT effect size was correlated with the number of negative traits participants identified as self-applied in the SCT priming procedure. Fourth, the SCT priming led to faster responses to all the stimuli relative to the responses after the nonthreat priming. More interesting, these effects were evident with the left-hand responses but not with the right-hand responses. The contrast between the left- and right-hand responses observed in Experiment 3 has two implications. First, the self-face advantage shown in the left-hand response is consistent with the previous observations (Keenan et al., 1999) and lends support to the right-hemisphere dominance in implicit self-face recognition. Second, the SCT effect on self-face advantage was mediated by the right hemisphere because this effect was evident only with the left-hand responses, which are predominantly controlled by the right hemisphere. Thus the results of Experiment 3 support the view that the SCT priming modulates self-face recognition due to activity in the right hemisphere.

## Experiment 4: Cultural Similarity in the SCT Effect on Self-Face Recognition

Because only Chinese participants were recruited in the previous studies of self-face advantage using the implicit face-recognition task (e.g., Sui & Han, 2007; Experiments 2 and 3 in

Table 5  
Mean Response Accuracy in Experiment 3

Priming	Left hand		Right hand	
	Nonthreat, % (SD)	SCT, % (SD)	Nonthreat, % (SD)	SCT, % (SD)
Self-face	95.3 (5.31)	94.2 (8.17)	94.3 (5.46)	94.4 (6.01)
Familiar face	93.9 (7.34)	94.1 (6.11)	93.9 (6.01)	94.7 (4.14)
Scrambled face	91.1 (3.78)	90.4 (3.50)	90.3 (4.23)	91.9 (4.48)

Note. SCT = self-concept threat.

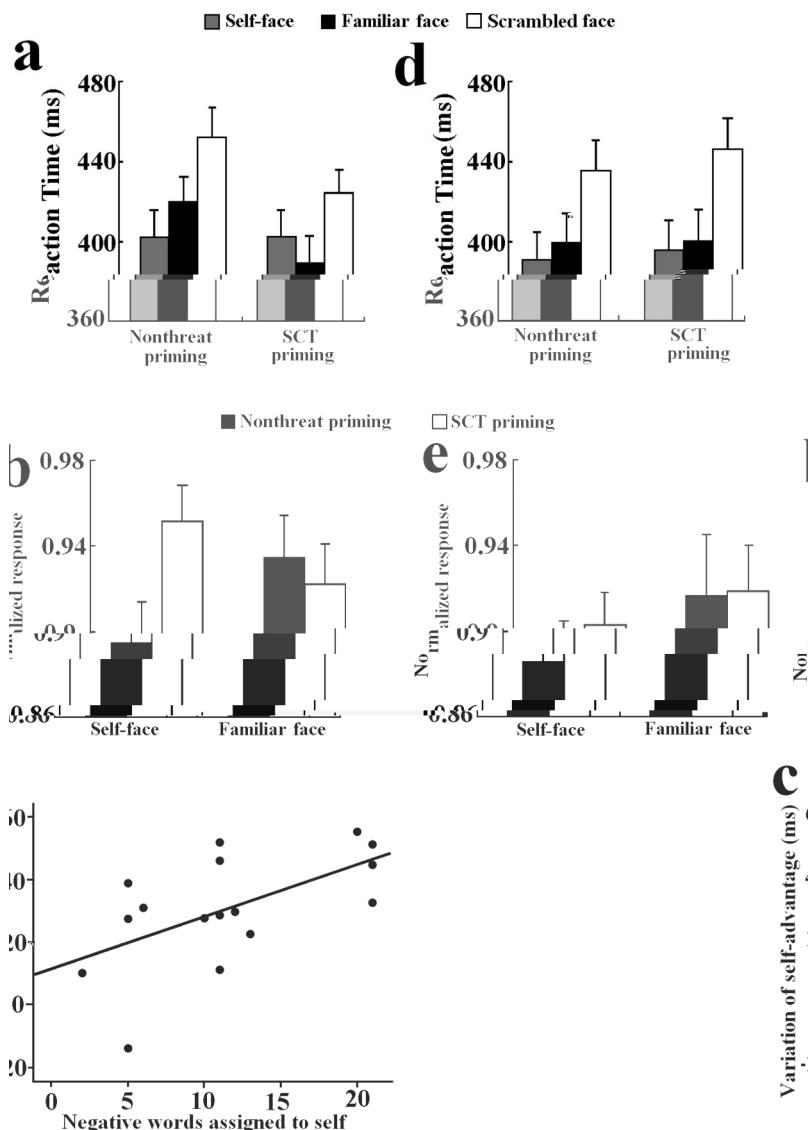


Figure 5. Reaction time (RT) results in Experiment 3. (a) Left-hand RTs to the identification of head orientations of self-face and familiar faces or gray-bar locations in the scrambled face. (b) The results of normalized left hand responses. The Y-axis represents the ratio of (self- or familiar faces):scrambled faces. (c) The results of correlation analysis of the left-hand responses. The X-axis represents the number of negative traits identified as appropriate to describe the self in the SCT priming procedure. The Y-axis represents the decrease of self-advantage in the SCT relative to the nonthreat priming conditions. (d) Right-hand RTs for the identification of head orientations of self-face and familiar faces or gray-bar locations in the scrambled face. (e) The results of normalized right-hand responses. The Y-axis represents the ratio of (self- or familiar faces):scrambled faces. Error bars represent standard errors. SCT = self-concept threat.

this article), it is unknown whether such effect is culturally universal. To address this issue, Experiment 4 measured behavioral performances from a different cultural group (i.e., American) in the implicit face-recognition task. The SCT priming was also applied in Experiment 4 to uncover whether the IPA with self similarly underlies self-advantage in the implicit face-recognition tasks in Americans.

However, self-concept is a product emerging in sociocultural context and people in different cultures possess distinct self-

concepts. Specifically, most individuals in Western (e.g., American) cultures seek to maintain their independence from others and emphasize their unique inner attributes, leading to the independent construal of the self. In contrast, most people in East Asia (e.g., Chinese) cultures place emphasis on the fundamental connectedness of human beings to each other to adjust the self to maintain harmony with social contexts, resulting in the interdependent construal of the self (Markus & Kitayama, 1991; 2003). Because the key difference between the two types of self-concepts is that the

interdependent self is connected with social contexts and flexible whereas the independent self is separated from social contexts and stable, it is likely that the self-face advantage of the independent self is less vulnerable to manipulations that weaken the IPA with self. This was examined by comparing the SCT effect on self-face advantage across two cultural groups.

## Method

**Participants.** Seven pairs of American undergraduate and graduate students (6 men, 8 women, 19 to 31 years of age, mean age =  $22.79 \pm 3.72$ ) who studied in Beijing participated in Experiment 4 as paid volunteers. Each pair of participants was gender-matched friends or roommates and had known each other for about 2 years. All were White and native English speakers. All participants were right handed and had normal or corrected-to-normal vision. Informed consent was obtained prior to the study.

**Stimuli and procedure.** All aspects were the same as those in Experiment 3 except that the instructions and trait adjectives were in English.

## Results and Discussion

Participants identified  $9.14 \pm 4.11$  negative traits that reflected their own personalities in the SCT priming procedure. The number of self-identified negative traits did not differ between American participants in Experiment 4 and Chinese participants in Experiment 3 ( $F < 1$ ). Participants were 100% correct in the valence judgment task during the priming procedure.

Table 6 shows the mean response accuracies in the face orientation identification task. RTs and response accuracies were subjected to ANOVAs with hand (left vs. right hand), face (self-face, familiar face, or scrambled face), and priming (SCT vs. nontreat priming) as within-subjects independent variables. ANOVAs of response accuracies did not show any significant effects ( $p > .05$ ). ANOVAs of RTs showed a significant main effect of face,  $F(2, 26) = 52.59, p < .001, \eta^2 = 0.802$ ; suggesting faster responses to self-face and familiar faces than to the scrambled face. There was a significant interaction of Priming  $\times$  Face,  $F(2, 26) = 4.418, p < .02, \eta^2 = 0.254$ . Because there was a reliable triple interaction of Hand  $\times$  Face  $\times$  Priming,  $F(2, 26) = 3.356, p < .02, \eta^2 = 0.206$ ; RTs with left and right hands were analyzed separately.

The ANOVA of RTs with the left hand showed a significant main effect of face,  $F(2, 26) = 22.92, p < .001, \eta^2 = 0.638$  (Figure 6a); suggesting faster responses to self-face and familiar faces than to the scrambled face. The main effect of priming was

not significant ( $F < 1$ ). However, there was a significant interaction of Face  $\times$  Priming,  $F(2, 12) = 7.501, p < .01, \eta^2 = 0.556$ . A  $2$  (self vs. familiar face)  $\times 2$  (SCT vs. nontreat priming) ANOVA showed a reliable interaction of face and priming,  $F(1, 13) = 14.19, p < .002, \eta^2 = 0.522$ ; because responses were faster to self-face than to familiar faces in the nontreat priming condition,  $t(1,13) = -3.334, p < .005$ ; but did not differ in the SCT priming condition,  $t(1,13) = 0.135, p = .895$ . Similar to the analysis in Experiment 2a, we analyzed the correlation between the number of negative traits identified as appropriate to describe the self and the decrease of self-advantage, but in this case, did not find a significant correlation between the two measurements ( $r = -.077, p = .793$ ).

The ANOVA of RTs with the right hand showed a significant main effect of face,  $F(2, 12) = 20.460, p < .001, \eta^2 = 0.773$  (Figure 6b); suggesting faster responses to self-face and familiar faces than to the scrambled faces. However, neither the main effect of priming ( $F < 1$ ) nor its interaction with face,  $F(2, 26) = 1.979, p = .159$ ; was significant, indicating that the RT differences between self-, familiar, and scrambled faces were not influenced by the SCT priming.

To assess the differential SCT effect on self-face advantage between American and Chinese participants, left-hand responses were compared across Experiments 3 and 4 with face (self-face, familiar face, or scrambled face) and priming (SCT vs. nontreat priming) as within-subjects variables and participant group (Chinese vs. American) as a between-subjects factor. The main effect of priming did not reach significance,  $F(1, 28) = 2.699, p = .112$ ; but its interaction with participant group was significant,  $F(1, 28) = 5.735, p < .05, \eta^2 = 0.170$ ; suggesting larger SCT effect on general motor responses in Chinese than American participants. The main effect of face was significant,  $F(2, 27) = 29.26, p < .001, \eta^2 = 0.684$ ; whereas its interaction with participant group was not significant ( $F < 1$ ), suggesting that self-face advantage was comparable in Chinese and American participants. There was a reliable interaction of Face  $\times$  Priming,  $F(2, 27) = 28.34, p < .001, \eta^2 = 0.677$ ; because the self-face advantage over the familiar face was smaller in the SCT than nontreat priming conditions. Most important, the SCT effect on self-face advantage was larger in Chinese than American participants, resulting in a reliable triple interaction of Face  $\times$  Priming  $\times$  Participant Group,  $F(2, 27) = 6.658, p < .005, \eta^2 = 0.330$ . The difference in SCT effects on self-face advantage (RTs to familiar faces minus RTs to self-face) between the two cultural groups is illustrated in Figure 7.

Experiment 4 confirmed the self-face advantage in implicit face-recognition task in American participants and this was evident only with the left-hand responses, suggesting the right hemisphere dominance in self-face recognition in Americans. In addition, we showed that the SCT priming eliminated the self-face advantage in Americans, similar to that observed in Chinese participants. This suggests that the IPA with self plays a key role in self-face advantage in both Americans and Chinese, suggesting the cultural universal nature of the mechanism of IPA with self in face recognition. However, the comparison between Experiments 3 and 4 indicated a weaker SCT effect on the self-face advantage in American than in Chinese participants, suggesting that self-related processing in Chinese participants is more vulnerable to SCT relative to that in Americans.

Table 6  
Mean Response Accuracy in Experiment 4

Priming	Left hand		Right hand	
	Nontreat, % (SD)	SCT, % (SD)	Nontreat, % (SD)	SCT, % (SD)
Self-face	94.3 (6.78)	93.5 (5.68)	95.3 (5.46)	93.8 (6.31)
Familiar face	93.3 (6.29)	94.0 (6.77)	96.1 (6.35)	95.2 (6.56)
Scrambled face	92.4 (5.34)	93.5 (6.58)	94.9 (6.93)	93.3 (6.27)

Note. SCT = self-concept threat.

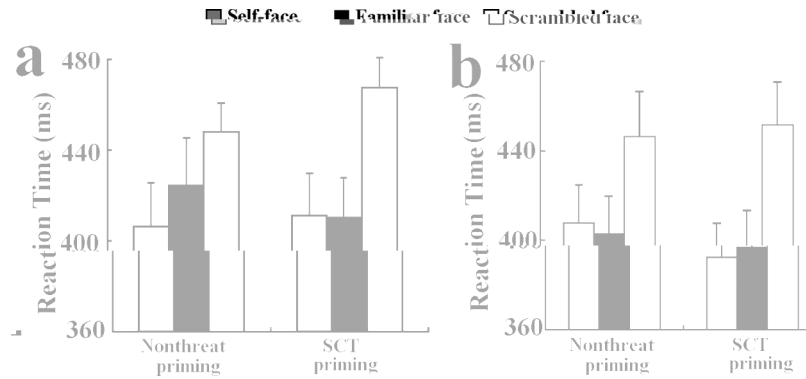


Figure 6. Reaction time (RT) results in Experiment 4. (a) Left-hand RTs to the identification of head orientations of self-face and familiar faces or gray-bar locations in the scrambled face. Error bars represent standard errors. (b) Right-hand RTs to the identification of head orientations of self-face and familiar faces or gray-bar locations in the scrambled face. Error bars represent standard errors. SCT = self-concept threat.

## General Discussion

### The IPA Theory of Self-Advantage in Face Recognition

Because perceptual mechanisms such as face familiarity cannot explain self-face advantage over personally familiar others in behavioral performances associated with face recognition, this study examined a potential social cognitive mechanism that underlies self-face advantage. We proposed an IPA hypothesis to explain self-face advantage in an implicit face-recognition task, which claims that perception of self-face implicitly activates positive attribute in self-concept that in turn facilitates behavioral responses to self-face relative to familiar faces. Experiment 1 adopted the typical IAT to demonstrate that the SCT priming developed in our study indeed weakened the IPA with self when self-awareness was induced by self-face perception, providing methodological basis for the current study. Experiment 2a first

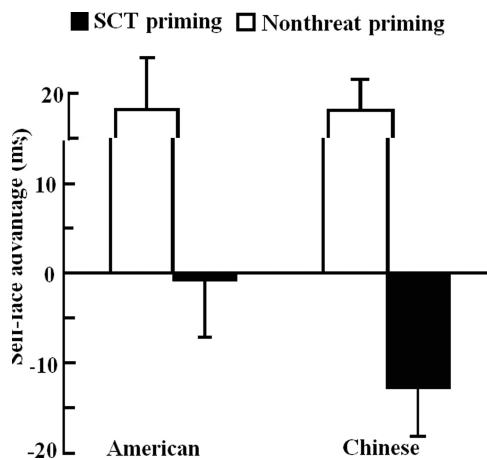


Figure 7. The difference in SCT effects on self-face advantage between American and Chinese participants. Self-face advantage is defined by the difference in reaction times (RTs) to the familiar face and self-face (i.e., RTs to familiar faces minus RTs to self-face). SCT = self-concept threat.

showed evidence for faster responses to the discriminations of head orientations of self-face compared with that of a personally familiar face in Chinese participants after the nonthreat priming. The self-face advantage in the implicit self-face-recognition task is consistent with previous observations of self-face advantage in explicit self-face search (Tong & Nakayama, 1999) and face owner recognition tasks (Keenan et al., 1999). Experiment 2a then demonstrated that the SCT priming eliminated self-face advantage and the correlation analysis showed a quantified relationship between SCT priming and the variation of self-advantage in face recognition. Experiment 2b ruled out the possibility that the SCT effect on self-face recognition simply arose from general negative effect (e.g., negative mood) induced by exposure to negative traits. These results provide strong evidence that the IPA with self mediates self-face advantage during implicit face recognition and verifies the first prediction of our IPA hypothesis of self-face recognition.

Experiment 3 found that self-face advantage was salient with the left-hand responses but not with the right-hand responses. Consistent with the previous work (Keenan et al., 1999), the behavioral results support the right hemisphere dominance in self-face recognition that is possibly mediated by a neural circuit consisting of the right frontal and parietal cortices (Platek et al., 2006; Sui & Han, 2007; Uddin et al., 2006). Similarly, Platek, Myers, Critton & Gallup (2003) found faster left-hand than right-hand responses to self-descriptive adjectives, suggesting that the right hemisphere dominance of self-related processing is independent of the carrier of self-information. More important, Experiment 3 demonstrated that the SCT effect on self-face advantage was specific to the left-hand responses, providing evidence for the second prediction of our IPA hypothesis. Finally, Experiment 4 identified the SCT effect on self-face advantage in American participants, which was also evident only with the left-hand responses. This provides evidence that, although self-concept styles are different between Americans and Chinese, the IPA with self contributes to self-face advantage in the implicit face-recognition task in a similar vein in the two cultures.

In addition, the SCT effect observed in American participants was not as strong as that observed in Chinese participants, supporting that the independent self is less vulnerable to the influence

of social contexts relative to the interdependent self. Taken together, the results of the current research fit well with the IPA hypothesis of self-advantage during implicit face recognition.

How is the IPA with self accomplished in the human brain? A recent TMS study showed that, although participants produced more desirable and fewer undesirable ratings for themselves as compared to their best friends, this self-enhancement was reduced by disruption of the medial prefrontal cortex (Kwan et al., 2007). Thus the medial prefrontal cortex is a candidate engaged in modulation of the IPA with self. Consistent with this, Todorov, Ida Gobbini, Evans, and Haxby (2007) found that descriptions of positive or negative (aggressive or disgusting) behaviors associated with unfamiliar faces resulted in modulations of neural activities in the brain areas linked to social cognition and emotion such as the anterior paracingulate cortex and the anterior insula. Perception of faces of

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self-recognition task. These results support the IPA hypothesis of self-face recognition that proposes a social cognitive mechanism subserving the self-advantage in face recognition. We demonstrated that the SCT effect on self-face recognition was evident with the left-hand responses but not with the right-hand responses, providing neural constraints on the IPA theory of self-recognition. We also showed evidence that the SCT effect on self-face advantage was stronger in Chinese than in Americans, providing cultural constraints on the IPA theory of self-recognition. Recently, there has been accumulating evidence that previously assumed low-level perceptual processes are modulated by sociocultural contexts (Han & Northoff, 2008). The current study provides further evidence that social cognitive mechanisms contribute to a seemingly perceptual phenomenon—self-face recognition.

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### Correction to Kornblum et al. (1999)

In the article “The Effects of Irrelevant Stimuli: 1. The Time Course of Stimulus–Stimulus and Stimulus–Response Consistency Effects With Stroop-Like Stimuli, Simon-Like Tasks, and Their Factorial Combinations,” by Sylvan Kornblum, Gregory T. Stevens, Anthony Whipple, and Jean Requin (*Journal of Experimental Psychology: Human Perception and Performance*, 1999, Vol. 25, No. 3, pp. 688–714), a key reference for coauthor Gregory T. Stevens’s PhD dissertation was omitted and appears below.

Stevens, G. T. (2000). *The locus of Ericksen, Simon and Stroop effects: New data and comparison of models* (Unpublished doctoral dissertation). University of Michigan, Ann Arbor.

In his dissertation, Stevens develops the computational version of the Dimensional Overlap Model, which is an essential part of the Kornblum et al. (1999) article.

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