



# The influence of self-construals on the ERP response to the rewards for self and mother

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## Abstract

Individual self-construal (independent vs. interdependent) could be temporarily modulated by the priming effect. Our previous studies have found that when Chinese participants gambled for mother and for self, outcome feedback evoked comparable neural responses between two conditions. However, it remains unclear if the response to rewards for mother and for self would differ after independence self-construal priming. In this study, we manipulated participants' self-construal (independent vs. interdependent) before a simple gambling task. The event-related potential (ERP) results reveal that when an interdependent self-construal was primed, the participants exhibited a comparable feedback-related negativity (FRN) elicited by outcome feedback for self and for mother. In contrast, independent self-construal priming resulted in a greater FRN elicited by outcome feedback for self than for mother. Meanwhile, the P3 component was insensitive to self-construal manipulation. These findings indicate the modulation effect of self-construal priming on the response to rewards for others.

**Keywords** Self-construals · Self · Mother · Outcome evaluation · Feedback-related negativity

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## Introduction

Vicarious reward means that observing someone else receiving reward is rewarding in itself (Mobbs et al., 2009). The ability to vicariously experience the reward for others is critical in prosocial behaviors, but that experience is not as strong as the experience of the reward for oneself (Lockwood, Apps, Valton, Viding, & Roiser, 2016). However, the mother in Chinese culture is a notable exception, as two of our event-related potential (ERP) studies have found that when Chinese participants gambled for mother and for self, outcome feedback evoked a comparable ERP response between two conditions (X. Zhu, Wang, et al., 2016; X. Zhu, Zhang, et al., 2015). This finding is consistent with the fact that in East Asian cultures, the neural representation of the self and that of mother largely overlap. For instance, the medial prefrontal cortex (mPFC) is an important brain region involved in self-processing (Macrae, Moran, Heatherton, Banfield, & Kelley, 2004). Previous studies have observed comparable activations in the mPFC between making judgments about self and about mother in Chinese participants (G. Wang et al., 2012; Wuyun et al., 2014; Y. Zhu, Zhang, Fan, & Han, 2007), but not in Western participants (Heatherton et al., 2006; Ray et al.,

2010). In our opinion, the undifferentiated neural representation between self and mother may contribute to the comparable ERP response to reward for mother and for self in Chinese culture.

Meanwhile, self-construal can modulate the response to rewards for self versus for others. Self-construal refers to how individuals define and make meaning of the self (Cross, Hardin, & Gercek-Swing, 2011; Han & Humphreys, 2016). Markus and Kitayama (1991) proposed two types of self-construals. Specifically, the independent self is a self-contained and autonomous entity that is context-independent and includes salient internal attributes; in contrast, the interdependent self is treated as a member of a group, highlighting the belonging to and dependence on a context. Both independent and interdependent self-construal can coexist inside the same individual (Gardner, Gabriel, & Lee, 1999). Remarkably, individuals from both individualistic and collectivistic nations have shown similar effects of self-construal on self-concept (Gardner et al., 1999). The self-construal type that is salient at one specific moment can modulate cognitive processing at both behavioral and neural levels (Colzato, de Bruijn, & Hommel, 2012; Obhi, Hogeveen, & Pascual-Leone, 2011; Sui, Hong, Hong Liu, Humphreys, & Han, 2013; Van Baaren, Maddux, Chartrand, De Bouter, & van Knippenberg, 2003).

In a recent functional magnetic resonance imaging (fMRI) study, Varnum, Shi, Chen, Qiu, and Han (2013) have found that participants were more sensitive to wins when gambling for self than for a friend after independent self-construal priming; in contrast, when participants were primed with interdependent self-construal, winning money for themselves and for a friend evoked comparable activations in the ventral striatum, which is an important brain region for reward processing. However, the flexibility of the influence of self-construal on the response to rewards for self versus for others needs further investigations. Although people experience rewards for a friend as strongly as for themselves under the interdependence priming, it remains unclear whether transient independent self-construal priming can differentiate the neural response to rewards for mother versus for self in Chinese culture.

We predicted that independent self-construal would make Chinese individuals to be more sensitive to their own reward than to mother's reward. This prediction is supported by the following facts: first, compared with interdependent self-construal priming, independent self-construal priming can enhance the level of self-awareness, making individual self to be more salient. For example, neural activity in the right medial frontal cortex was stronger when participants made judgments about their own face compared to another familiar face, and this difference was larger when participants were primed with independent self-construal compared to interdependent self-construal (Sui & Han, 2007). Second, individuals are more sensitive to their reward when their uniqueness is emphasized.

One of our recent studies reported that outcome feedback in a gambling task evoked a larger difference wave of the feedback-related negativity (dFRN; see below) in the independent self-construal condition than in the interdependent self-construal condition (X. Zhu, Wu, Yang, & Gu, 2017). Third, self-construal can also modulate the difference in brain activation between the “mother” and “self” conditions. For instance, Ng, Han, Mao, and Lai (2010) have found that the priming of Chinese culture decreased mPFC activations that differentiated between trait judgments about self and about mother, whereas the priming of Western culture produced the opposite effect.

For the purpose of the current study, the ERP technique was applied, which is well suited to investigate the dynamics of cognitive and social processes regarding its exquisite temporal resolution (Amodio, Bartholow, & Ito, 2014). The feedback-related negativity (FRN) is one of the major ERP components associated with the outcome evaluation process (Gehring & Willoughby, 2002; Miltner, Braun, & Coles, 1997). The FRN is a medial frontal negative-flowing deflection that peaks approximately 250 ms following outcome feedback, being larger following negative compared to positive performance feedback (Miltner et al., 1997) and also larger following monetary losses compared to wins (Gehring & Willoughby, 2002). This component may represent a cognitive system evaluating outcomes along a good–no good continuum (Foti, Weinberg, Bernat, & Proudfit, 2015), which therefore makes it a useful tool for probing individual reward sensitivity (Bress & Hajcak, 2013; Lange, Leue, & Beauducel, 2012). A large body of ERP research has linked the FRN with the processing of reward prediction error (for a review, see Sambrook & Goslin, 2015). Localization studies suggest that the FRN is generated in the mPFC (M. X. Cohen, Wilmes, & van de Vijver, 2011; Walsh & Anderson, 2012), which is consistent with fMRI findings about the role of mPFC in performance monitoring (e.g., Nieuwenhuis et al., 2005).

The P3 component is another ERP component related to outcome evaluation (San Martín, 2012; Yeung & Sanfey, 2004). This component is sensitive to the emotional significance of an ongoing event; heightened P3 amplitudes indicate stronger emotional impact of an event (Hajcak, Dunning, & Foti, 2009; Polezzi, Sartori, Rumiati, Vidotto, & Daum, 2010). With regard to outcome evaluation, the P3 component is sensitive to reward magnitude and outcome uncertainty in monetary gambling tasks (San Martín, 2012). Previous studies that explored the ways in which self-construal affects the ERPs suggest that temporal self-construal priming modulates the early automatic components (e.g., the N1 component) but does not affect the late controlled components in the P3 time window (Jiang, Varnum, Hou, & Han, 2014; C. Wang, Ma, & Han, 2014). More relevant to the present study, two of our previous ERP studies have found that the P3 amplitude is insensitive to the contrast between self-reflection and other-

reflection, indicating that the self-reflection priming effect does not occurred at the late stage of outcome evaluation (X. Zhu, Gu, Wu, & Luo, 2015a; X. Zhu et al., 2017).

We hypothesized that the neural responses to rewards for mother and for self can be modulated by self-construal manipulation. Specifically, the neural responses to rewards for mother and self would be similar in the interdependent self-construal condition, but these responses would be weaker for mother than for self in the independent self-construal condition. In the present study, participants received independent and interdependent priming in different task blocks. After the priming stage, they performed a gambling task in which they were asked to gamble for themselves or their mothers. We predicted that interdependent self-construal priming would lead to similar FRN responses to rewards for self and mother, whereas independent self-construal priming would lead to stronger FRN responses to rewards for self than for mother. In addition, we predicted that the P3 component would not be modulated by self-construal priming.

## Methods

### Participants

A priori power analysis with G\*Power (version 3.1.7; Faul, Erdfelder, Lang, & Buchner, 2007) revealed that a total sample size of 24 participants would provide about 82 % statistical power for small-to-medium effect sizes. According to the suggestion from Vazire (2016), researchers should ensure that the power value does not fall short of 80 %.

Twenty-four college students (mean age:  $21.6 \pm 0.6$  years, age range: 20–23; 14 males) participated in this study. All participants were from Henan province, which is located in inner China. The experiment was approved by the Ethics Committee of the Department of Psychology in Henan University and was conducted in accordance with the 1964 Declaration of Helsinki. Informed consent was obtained prior to the experiment. All had normal vision (with correction), and none had a history of neurological disease or brain injury. All participants were right-handed.

### Procedure

This study employed the priming of temporary self-construal, which has been widely used in previous research (e.g., Chiao et al., 2010; Krishna, Zhou, & Zhang, 2008; Obhi et al., 2011; van Prooijen & Zwenk, 2009). Also, the validity of this method has been confirmed in Chinese participants (e.g., Sui & Han, 2007; Sui et al., 2013; Varnum et al., 2013; C. Wang et al., 2014).

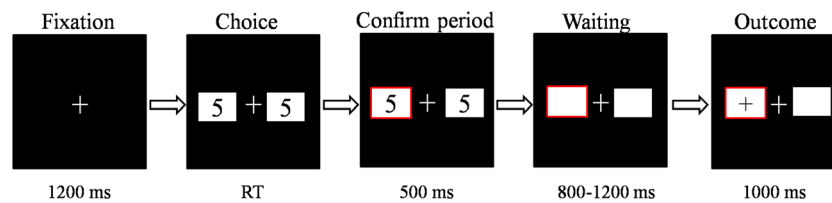
There were two within-subject factors in the experiment, that is, Self-construal Type (two levels: independent/

interdependent self-construal) and Beneficiary (two levels: gamble for self/for mother). This  $2 \times 2$  task design resulted in four separate blocks, the sequences of which were counterbalanced across participants. The use of a within-subjects design is common in self-construal research field (Sui & Han, 2007; Sui et al., 2013; Varnum et al., 2013).

Before the beginning of each block, one Chinese essay was presented for the self-construal priming procedure. The contents of the essays in four blocks were not the same, but they all consisted of two paragraphs describing a trip to the countryside (about 300–350 words) (Sui & Han, 2007). The independent self-construal essays contained independent pronouns (e.g., I, mine), and the interdependent self-construal essays contained interdependent pronouns (e.g., we, ours). Participants were required to read each essay and to circle specific pronouns. All the essays used in the task were adopted from Sui and Han (2007).

Participants were told that the reading of essays was not related to the follow-up task, which was a forced-choice gambling game (Gu, Wu, Jiang, & Luo, 2011). Before the experiment, participants were instructed about the rules and the meanings of the symbols in the gambling task. They were encouraged to respond in a way that would maximize the total score amount. The higher the score they earned, the more bonus money they or their mothers would receive after the experiment.

During the task, participants sat comfortably in an electrically shielded room approximately 80 cm from a computer screen. Stimulus display and behavioral data acquisition were conducted using E-Prime software (Version 1.1, Psychology Software Tools, Inc.). After the self-construal priming (see above), a beneficiary cue (“gamble for self/for mother”) was presented (3,000 ms) at the beginning of each gambling block. Each trial began with the presentation of two white rectangles ( $2.5^\circ \times 2.5^\circ$  of visual angle) in which an Arabic number (“5”) was individually presented to indicate two alternative options on the left and right sides of a fixation point. The number “5” represents 0.5 Chinese RMB Yuan. Participants were asked to make a selection by pressing the “F” or “J” key on the keyboard with the left or right index finger, respectively. The alternatives remained on the screen until the participants chose a rectangle, which was then highlighted by a thick red outline for 500 ms. Thereafter, the outcome feedback of the participants’ choice was presented such that its valence was displayed, with a 800- to 1,200-ms interval between them (see Fig. 1). Each block consisted of 96 trials. At the end of each block, participants completed a 7-point Likert scale (1: very unhappy; 7: very happy) to indicate how happy they felt when the beneficiary (self/mother) of the past block won, and another 7-point scale to indicate how unhappy they felt when the beneficiary lost. In total, each participant completed eight scales to measure happiness associated with outcome feedback in each condition.



**Fig. 1** The sequences of events within a single trial of the monetary gambling task. *RT* response time

There were two kinds of outcomes: “+5” and “–5,” indicating the points the participants won and lost in the current trial, respectively. Unbeknown to the participants, the outcome feedback was provided according to a pre-determined pseudorandom sequence, such that each participant received exactly 48 of each kind of outcome regardless of their selection (left/right).

After participants finished the task, they were briefed that there was no optimal strategy for the task. Each participant and his/her mother were both paid 40 Chinese RMB Yuan (approximately US\$6) for remuneration. Regarding the reward for mothers, participants were asked to provide their mothers’ cellphone number, and then the experimenter refilled 40 Yuan to that number via online service. The reliability of this method has been proved in our previous studies (e.g., X. Zhu, Wang, et al., 2016; X. Zhu, Wu, Yang, & Gu, 2016b). Also, participants completed the Self-Construal scale, which is a 7-point Likert scale consisted of 24 items (Singelis, 1994). Internal consistency and test-retest reliability of the Chinese version of this scale were 0.88 and 0.78, respectively (Y. Wang, Yuan, & Xu, 2008). This scale has been successfully used to measure the levels of independent and interdependent self-construals of Chinese college students (Varnum et al., 2013).

### Electrophysiological recording and measures

Electroencephalogram (EEG) activity was recorded from 63 scalp sites using tin electrodes mounted in an elastic cap (Brain Products) with an online reference to the middle at FCz, and the data were off-line re-referenced to the global average reference. Electrode FCz was re-instated (Zendel & Alain, 2014). Horizontal electro-oculogram (HEOG) was recorded from an electrode placed at the outer canthi of the right eye. Vertical electro-oculogram (VEOG) was recorded from an electrode placed above the left eye. All inter-electrode impedance was maintained at < 10 k $\Omega$ . EEG and EOG signals were amplified with a bandpass from 0.05 Hz to 100 Hz and continuously sampled at 500 Hz/channel.

Off-line analysis of the EEG was performed using Brain Vision Analyzer software (Brain Products). The first step in data preprocessing was the correction of ocular artifacts using Independent Component Analysis (ICA) of the continuous data. The ocular-artifact-free EEG data were low-pass filtered below 30 Hz (48 dB/oct) and high-pass filtered above 0.05 Hz

(48 dB/oct). Separate EEG epochs of 1,000 ms (including a baseline of 200 ms) were extracted offline for the stimuli. All trials in which EEG voltages exceeded a threshold of  $\pm 75 \mu\text{V}$  during the recording epoch were excluded from data analysis. On average, about three trials per condition were excluded for each participant.

According to previous studies, the FRN amplitude can be calculated in essentially two ways: using grand-averaged waveforms or creating a difference wave between error and correct trials (Holroyd, Pakzad-Vaezi, & Krigolson, 2008; Leng & Zhou, 2010; Wu & Zhou, 2009). The current study employed the difference-wave approach for two reasons. First, the main advantage of this method is the minimization of potential overlaps between the FRN and other ERP components, particularly the P3 (for detailed discussions, see Hajcak, Moser, Holroyd, & Simons, 2007; Holroyd & Krigolson, 2007). Indeed, the application of the difference wave method generates a clear FRN (Proudfit, 2015). Second, our previous studies have consistently used difference waves to measure the FRN (X. Zhu, Gu, et al., 2015; X. Zhu, Wang, et al., 2016; X. Zhu, Wu, et al., 2016; X. Zhu et al., 2017). Therefore, applying the same method would facilitate comparisons between the current data and our previous findings. Accordingly, we created the dFRN by subtracting the mean ERP amplitude in gain trials from that in loss trials within the 220- to 320-ms time window (Gu, Huang, & Luo, 2010b; X. Zhu, Gu, et al., 2015). The electrode at which the dFRN reached their maximum was detected in the fronto-central area (FC1, FCz, FC2, C1, Cz, and C2). Arithmetical means were averaged across the six sites for data analyses. The dFRN amplitude analysis included two within-subjects factors, that is, Self-construal Type (independent/interdependent self-construal) and Beneficiary (self/mother).

We also evaluated the P3 (350–550 ms) amplitude by identifying its mean amplitude at the Pz electrode position where this ERP component typically reaches its maximum (e.g., Gu et al., 2017; Gu, Ge, Jiang, & Luo, 2010a). The P3 amplitude analysis included three within-subject factors, that is, Outcome (win/loss), Self-construal Type (independent/interdependent self-construal), and Beneficiary (self/mother).

Statistical analysis was performed using IBM SPSS 19.0 (IBM Corporation). For all the analyses, the results of descriptive statistics were reported as mean  $\pm$  standard deviation (SD). The significance level was set at  $p = .05$ . The  $p$  values were corrected for deviations according to Greenhouse and



Geisser (1959). Partial eta-squared ( $\eta_p^2$ ) was reported to demonstrate the effect size of the variance of analysis (ANOVA), where 0.05 represents a small effect, 0.1 represents a medium effect, and 0.2 represents a large effect (J. Cohen, 1973).

## Results

### Behavioral results

Participants were highly accurate (more than 90 %) regarding their pronoun judgments in both the independent and interdependent self-construal conditions; therefore we did not further analyze the accuracy rate across conditions.

A  $2 \times 2$  repeated-measures ANOVA involving Self-construal Type and Beneficiary was conducted on the reaction times (RTs) during the gambling task ( $836 \pm 124$  ms). The results did not reveal any difference across conditions ( $ps > 0.1$ ).

Regarding the Self-Construal scale, the participants were more prone to be interdependent rather than independent ( $5.09 \pm 0.56$  vs.  $4.56 \pm 0.69$ ,  $t(23) = 3.04$ ,  $p = 0.006$ ). This result should be considered as a manifestation of the collectivistic cultural orientation among Chinese people.

Finally, regarding the subjective reported degree of happiness associated with gambling outcomes, a  $2 \times 2 \times 2$  ANOVA involving Self-construal Type, Beneficiary, and Outcome was conducted. The participants felt happier for wins ( $5.02 \pm 0.15$ ) than for losses ( $4.28 \pm 0.23$ ) ( $F(1, 23) = 12.82$ ,  $p = 0.002$ ,  $\eta_p^2 = 0.25$ ). Moreover, we found a significant interaction between Self-construal Type and Beneficiary ( $F(1, 23) = 11.66$ ,  $p = 0.002$ ,  $\eta_p^2 = 0.24$ ). Simple effect analysis indicated that when gambling for self, there was no difference between self-construal priming conditions (independent:  $4.54 \pm 1.08$ , interdependent:  $4.75 \pm 1.12$ ;  $p = 0.153$ ); in contrast, gambling for mother evoked a marginally significantly higher score in the independent self-construal condition ( $4.88 \pm 1.23$ ) than in the interdependent self-construal condition ( $4.44 \pm 1.43$ ;  $p = 0.065$ ).

### ERP results

**The dFRN component** For the dFRN amplitude, a repeated-measures ANOVA showed that the main effect of Self-construal Type was not significant,  $F(1, 23) = 0.44$ ,  $p = 0.51$ ,  $\eta_p^2 = 0.02$ , such that independent self-construal ( $-2.46 \pm 1.50$   $\mu\text{V}$ ) and interdependent self-construal ( $-2.58 \pm 1.27$   $\mu\text{V}$ ) evoked a comparable dFRN. The main effect of Beneficiary was not significant,  $F(1, 23) = 1.30$ ,  $p = 0.27$ ,  $\eta_p^2 = 0.05$ , with gambling for self ( $-2.66 \pm 1.35$   $\mu\text{V}$ ) and gambling for mother ( $-2.39 \pm 1.51$   $\mu\text{V}$ ) evoking a comparable dFRN. The

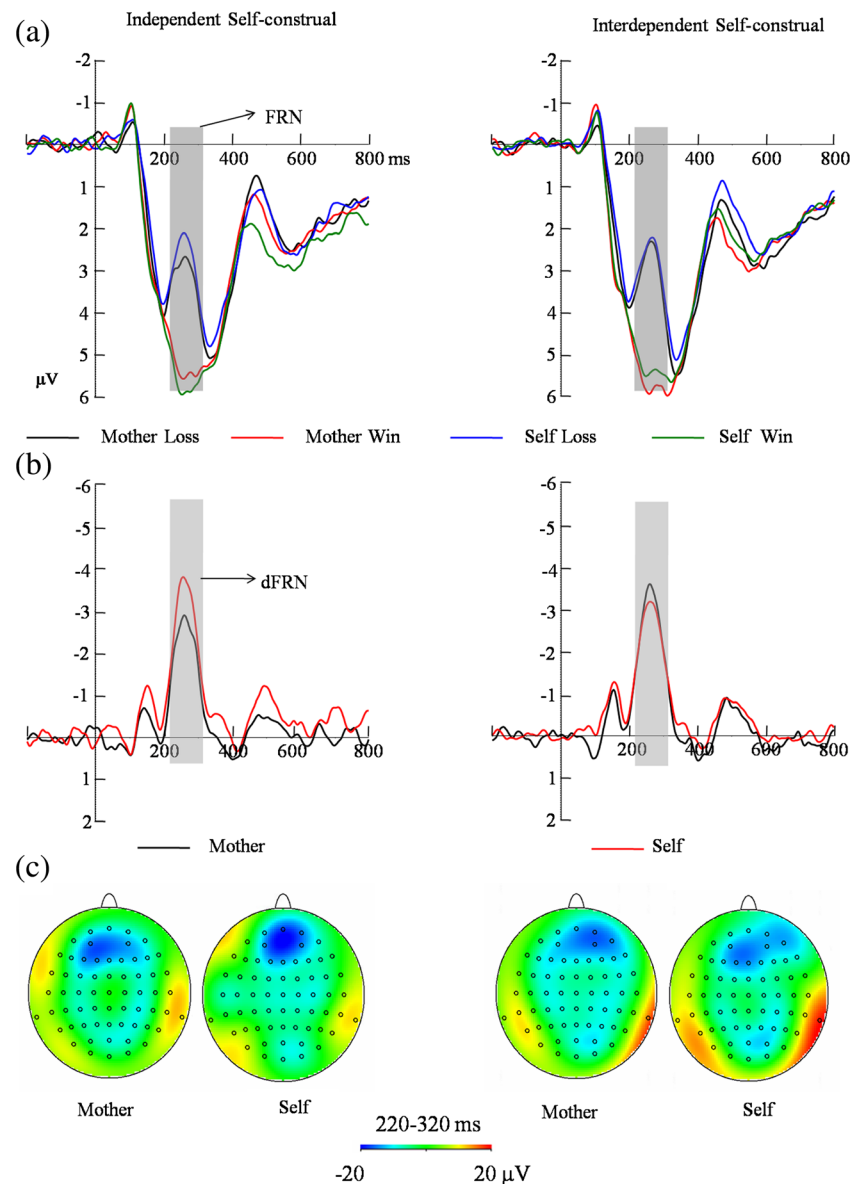
interaction between Self-construal Type and Beneficiary was significant,  $F(1, 23) = 8.15$ ,  $p = 0.009$ ,  $\eta_p^2 = 0.26$ . Simple effect analysis indicated that in the Interdependent self-construal condition, gambling for self ( $-2.53 \pm 1.45$   $\mu\text{V}$ ) and for mother ( $-2.63 \pm 1.37$   $\mu\text{V}$ ) evoked a comparable dFRN ( $p = 0.70$ ); in the Independent self-construal condition, gambling for self ( $-2.78 \pm 1.87$   $\mu\text{V}$ ) evoked a larger dFRN than for mother ( $-2.14 \pm 1.42$   $\mu\text{V}$ ;  $p = 0.03$ , Cohen's  $d = 0.31$ ; see Fig. 2). From another perspective, when gambling for self, the dFRN showed no difference between the two self-construal conditions ( $p = 0.41$ ); when gambling for mother, the dFRN was larger in the interdependent self-construal condition than in the independent self-construal condition ( $p = 0.002$ ).

**The P3 component** For the P3 amplitude, a repeated-measure ANOVA showed that none of the main effects and the interactions were significant ( $ps > 0.10$ ).

## Discussion

The aim of the present study was to investigate whether the response to rewards for self versus for mother would be affected by the way in which people construe the self at a given moment. The results of the self-construal scale showed that the participants were more prone to be interdependent than independent, confirming the collectivistic cultural orientation of the Chinese people (Varnum et al., 2013). In the gambling task, interdependent self-construal priming resulted in an equal FRN response to rewards for self and for mother, whereas independent priming induced a greater FRN response to rewards for self than for mother. Altogether, while previous studies have reported that gambling for self and mother evoked a comparable FRN (X. Zhu, Wang, et al., 2016; X. Zhu, Zhang, et al., 2015), the present study found that the FRN elicited by one's own rewards was larger than that elicited by mothers' rewards when the uniqueness of the self was highlighted. These findings suggest that the modulation of self-construal priming on the response to rewards for self versus for others is flexible and beneficiary-specific. Inducing the notion of the self that includes close others leads to similar response to rewards for self and for friends (Varnum et al., 2013), whereas inducing the notion of the self as autonomous and bounded leads to a stronger response to personal rewards than to mothers' rewards (this study).

Generally, watching close others receiving rewards activates the same neural network for the processing of one's own rewards, but the activation of reward circuit is weaker in the "close other" condition than the self condition (for a review, see Morelli, Sacchet, & Zaki, 2015). As mentioned in the Introduction, Varnum et al. (2013) showed that when participants were primed with the connections with close



**Fig. 2** **Left panel:** Independent self-construal conditions. **Right panel:** Interdependent self-construal conditions. **(a)** The grand-average ERP waveforms evoked by the presentation of outcome feedback (averaged across channels FC1, FCz, FC2, Cz, C1, and C2). **(b)** The ERP difference

waves (also averaged across the six channels). For both **(a)** and **(b)**, the gray-shaded areas indicate the time window (220–320 ms) in which the dFRN was measured. **(c)** Topographical maps of the dFRN

others (i.e., interdependent self-construal), the difference in the ventral striatum activation between “winning for close others” and “winning for oneself” disappeared. The value of interdependence is emphasized in Chinese cultural contexts, and close others are incorporated into the self-concept (Markus & Kitayama, 1991). Regarding that, one might expect that the neural response to rewards for mother and for self would be equal in Chinese culture whatsoever. Indeed, two of our previous ERP studies have demonstrated that Chinese people experience rewards for mother as strongly as they experience rewards for themselves (X. Zhu, Wang, et al., 2016; X. Zhu, Zhang, et al., 2015). However, the present study reveals that the ERP response to reward for mother and for self

differentiated among Chinese participants when the uniqueness of self was emphasized.

In the present study, the patterns of the FRN results in the interdependent self-construal condition was consistent with our previous studies in which no self-construal priming was used (X. Zhu, Wang, et al., 2016; X. Zhu, Zhang, et al., 2015). This consistency across studies suggests that the default self in Chinese people is an interdependent self (Sui, Zhu, & Chiu, 2007). However, independent priming induced a greater FRN response to rewards for self than for mother. In our opinion, the independent priming in this study has momentarily changed the dominant self-construal type from the default interdependent self to an independent self. The present results

extend the findings of our previous studies (X. Zhu, Wang, et al., 2016; X. Zhu, Zhang, et al., 2015) that the switching towards independent self-construal is associated with changes in neural responses to rewards for mother versus self. In other words, although the neural response to rewards for mother and for self is similar in Chinese culture, this phenomenon is changeable and sensitive to the self-construal context.

What neural mechanisms have accounted for the observed modulation effect of self-construal on the FRN response to rewards for mother? Given the nature of the self-construal priming in the present study, a tentative explanation for the current results lies in the brain areas that are associated with both reward processing and self-processing. One of the most likely candidates is the mPFC, which is not only involved in outcome evaluation but also self-processing. The response of the mPFC in self-processing is flexible and dynamic in nature (Chen, Wagner, Kelley, Powers, & Heatherton, 2013; Chiao et al., 2009). For example, one fMRI study found that exposing to Chinese pictorial cultural icons decreased the neural difference between the mother and the self conditions, while the priming of Western culture showed a reversed effect (Ng et al., 2010). ERP localization studies have suggested that the FRN is generated around the mPFC (M. X. Cohen et al., 2011; Walsh & Anderson, 2012). Seeing that the mPFC is involved in both self-construal and outcome feedback processing, we infer that the enhanced sensitivity to individual self enlarged the difference of mPFC activation between “gambling for mother” and “gambling for self” after independent self-construal priming.

Previous fMRI studies have indicated that different kinds of cultural primes reliably elicit an individualistic or a collectivistic cultural orientation within the same individual (Chiao et al., 2010; Ng et al., 2010). However, it remains unclear whether individualistic or collectivistic cultural primes (e.g., pictorial cultural icons) would influence the neural response to rewards for mother in the same way as self-construal priming in this study. If the individualistic cultural primes can also differentiate the neural response to rewards for mother and for self, then one could conclude that reward processing is influenced not only by individual self-representation, but also the broader cultural values.

One limitation is that the present study did not examine the individual difference in self-construal. Chiao et al. (2009) found that self-processing within the mPFC varies as a function of self-construal type: the participants were divided into “individualists” and “collectivists” groups based on the self-construal scale score; individualists showed greater mPFC activation to general self-descriptions, whereas collectivists showed greater mPFC activation to contextual self-descriptions (i.e., judging their traits relative to their mothers). It remains unclear whether the self-construal priming effect on the rewards for mother varies as a function of self-construal type. Additionally, we only included Chinese people in the present study. For Chinese people, interdependence is the default self-construal orientation; in contrast, independence is

the dominant self-construal orientation in Western culture. In our opinion, the current findings have general implications about the role of self-construal in the processing of outcome feedback for self and for others. This study, however, has only investigated a specific interdependent culture (Chinese) and a specific other (mother). Due to limitations in resources, we currently are unable to examine whether the same results could also be found in Western culture and for non-specific others in a full-factor design. Therefore, the generalizability of our conclusions remains to be clarified by future studies.

Another potential problem is that we asked participants to finish the Self-Construal scale after the formal task, because we were afraid that this scale *per se* might induce the priming effect, and therefore would become a confounding factor. However, we could not rule out the possibility that the standard self-construal priming has affected the self-report scores of the Self-Construal scale. Follow-up studies may address this procedure issue with alternative task designs. Finally, the limited sample size might have prevented us from discovering more interesting findings, such as the role of individual difference in self-construal. Future research with a larger sample size would be helpful to revisit the negative results in the current study.

Finally, the results of self-report happiness rating of outcome feedback were surprising, since the happiness level associated with outcome feedback of gambling for mother showed a tendency to be higher in the independent self-construal condition than in the interdependent self-construal condition. However, this tendency failed to reach significance, and follow-up studies might be needed to examine its reliability. If this tendency really existed, one might question why it showed different pattern with the FRN results. Our explanation is that the FRN reflects the bottom-up, automatic stage of outcome evaluation (Yang, Tang, Gu, Luo, & Luo, 2015), and therefore its pattern might deviate from conscious self-reports.

To sum up, the present ERP study indicated that emphasizing the independence of the self enhances the distinction between self and mother during outcome evaluation, while emphasizing the interdependence of the self diminishes this distinction. Combining the results of two of our previous studies (X. Zhu, Wang, et al., 2016; X. Zhu, Zhang, et al., 2015), we suggest that the neural responses to reward for mother and for self are dynamic by nature.

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