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Exposure to money modulates neural responses to outcome evaluations involving social reward

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Abstract

Recent research suggests that exposure to monetary cues strengthens an individual's motivation to pursue monetary rewards by inducing the 'market mode' (i.e. thinking and behaving in accordance with market principles). Here, we examined the effect of market mode on social reward processes by means of event-related potentials (ERPs). Participants primed with monetary images or neutral images acted as advisors who selected one of two options for a putative advisee. Subsequently, all participants passively observed the advisee accepting or rejecting their advice and receiving a gain or loss outcome. After money priming, the feedback-related negativity (FRN) to the advisee's gain/loss outcome was larger following incorrect as compared to correct advice irrespective of whether the advice had been accepted or rejected. A smaller P3 following incorrect advice showed only when the advice was rejected. After neutral priming, the FRN was larger for incorrect relative to correct advice only when the advice had been rejected. However, the P3 was larger for correct relative to incorrect advice irrespective of the advisee's final choice. These findings suggest that the market mode facilitates early and automatic feedback processing but reduces later and controlled responding to outcomes that had been accepted.

Key words: market mode; social reward; outcome evaluation; event-related potential (ERP); feedback-related negativity (FRN); P3

Introduction

Human beings pursue rewards that consist of not only material rewards such as food or money but also of social rewards (i.e. desirable social outcomes without any material payoffs) such as social approval from others or reputation enhancement (Gu *et al.*, 2019). The processes underlying the pursuit of rewards can be influenced by contextual social cues (Xin *et al.*, 2016; Gunia, 2017). For example, emerging evidence suggests that exposure to monetary cues (e.g. simply seeing images of banknotes or thinking about money in a prior unrelated task) leads people to exert more effort to obtain material rewards when conducting social behaviors (Zaleskiewicz and Gasiorowska, 2016). Studies suggested that this kind of thinking and behavior is in accordance with market principles (Gąsiorowska and Hełka, 2012; Sarial-Abi and Vohs, 2012; Zaleskiewicz and Gasiorowska, 2016) and has been called the 'market mode' (Fiske, 1992; Vohs *et al.*, 2008; Gasiorowska *et al.*, 2016). Generally, individuals in the market mode are reported to have a stronger motivation for obtaining personal rewards and to become more sensitive to their own rewards when engaging in interpersonal behaviors (Vohs *et al.*, 2006; Guéguen and Jacob, 2013; Vohs, 2015).

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Research has uncovered the effects of market mode on material rewards such as the processing of monetary payoffs (Heyman and Ariely, 2004; Garret *et al.*, 2015; Mead and Stuppy, 2014), yet the effects of market mode on processing of social rewards have not been fully characterized. To the best of our knowledge, this is the first study that focuses on how the market mode modulates the processing of social rewards. Izuma *et al.* (2008) suggested that individuals engage in social decisions for social rewards. Social decision-making consists of three stages: (i) formation of preferences among options, (ii) selection and execution and (iii) evaluation of outcomes (Ernst and Paulus, 2005). Outcome evaluation is closely associated with social rewards (Izuma *et al.*, 2010). For example, if the outcome of decisions made by a decision-maker is evaluated as beneficial to the other people, the decision-maker will have a sense of obtaining social rewards (Izuma *et al.*, 2010; Falco *et al.*, 2019).

In real life, giving advice to others may be a way for an individual to obtain social rewards because if the advice provided is evaluated to be correct and helpful, advisors will feel a sense of reward through self-reputation enhancement (Cialdini *et al.*, 1976; Mobbs *et al.*, 2015; Li *et al.*, 2018). Several neuroimaging studies also demonstrated that having advisor's advice accepted and the advisee winning can result in advisor's enhanced activity in the ventral striatum and the medial prefrontal cortex (MPFC)—brain areas known to be activated by the acquisition of rewards for participants (Izuma *et al.*, 2010, 2012). However, advice-giving does not always lead to receiving social rewards (Mobbs *et al.*, 2015). Research on advice-giving repeatedly uses the two-option advice task (cf. Mobbs *et al.*, 2015; Zhu *et al.*, 2017). In this task, there are two advice options for advisors to select from. One option could result in a gain, whereas the other could lead to a loss. Advisors are required to select one of two advice options to the advisee, and the advisee can choose to accept or reject the selection recommended by the advisor. Thus, there are four possible situations after an advisor has given advice to the advisee: (i) the advisor might be rewarded if their advice is accepted, and this leads to the success of the advisee (Jonas *et al.*, 2005; Helm and Salminen, 2010; Mobbs *et al.*, 2015); (ii) the advisor fails to obtain social rewards if their choices cause the advisee to fail (e.g. giving the wrong advice) (Mobbs *et al.*, 2015; Zhu *et al.*, 2017); (iii) the advisee rejects the advisor's recommendation but obtains a positive outcome, leading to reputation depreciation of the advisor (Tangney *et al.*, 2007; Zhu *et al.*, 2017); and (iv) the advisee disapproves the advisor's recommendation and receives an unfavorable outcome. In this latter situation, advisors have a sense of obtaining social rewards in the two-option advice game because the outcome implies that their advice is correct after all and they still have the opportunity to be approved by others (Mobbs *et al.*, 2015). In brief, such four situations can roughly be classified into two different outcomes for the advisor. (i) The advice is correct, and the advisor has a sense of obtaining the social reward. This is the case when the advisor's choice is accepted, and this advice leads to the advisee's gain or when the advisor's choice is rejected by advisee but the advisee loses. (ii) The advice is incorrect, and the advisor will not obtain the social reward. This is the case when the advisor's choice is accepted but the advice causes the advisee's loss or when the advisor's choice is rejected but the advisee wins.

Humans' motivation for obtaining rewards is stronger under the market mode, and they execute more mental operations when engaging in pursuing personal rewards (Vohs *et al.*, 2008; Gasiorowska *et al.*, 2016; Zaleskiewicz *et al.*, 2017; Li *et al.*, 2018). When evaluating the outcome of advice, the advisor also might be more responsive to obtaining or being unable to obtain the social reward in the market mode. In this study, we examined these assumptions by applying the event-related potential (ERP) method. The ERP is an excellent technique for examining the spontaneous evaluation of outcomes involving rewards due to its high temporal resolution. Previous ERP studies on evaluative feedback involving rewards have mainly focused on two ERP components: the feedback-related negativity (FRN) and P3 components (Luo *et al.*, 2011; Pornpattananangkul *et al.*, 2017; Glazer *et al.*, 2018). The FRN is a negative, fronto-central deflection ERP component peaking at around 200–350 ms after the onset of feedback (Miltner *et al.*, 1997; Gehring and Willoughby, 2002). The FRN reflects the binary evaluation of positive *vs* negative outcomes (Simons, 2010; Hauser *et al.*, 2014), such that the FRN is reported to be larger in response to negative (unrewarding) than positive (rewarding) outcomes (Hajcak *et al.*, 2006; Gu *et al.*, 2011b; Pornpattananangkul *et al.*, 2017). Several studies have shown that the FRN is also influenced by the relationship between expected and actual outcome and that it is more negative following unexpected feedback (Pfabigan *et al.*, 2011). Another ERP component implicated in reward outcome following FRN is P3, which is a positive wave peaking at approximately 300–600 ms at central and parietal electrodes (Johnson and Donchin, 1977; Polich, 2007). P3 is generally thought to be related to processes of attention allocation (Gray *et al.*, 2004) and/or high-level motivational/affective evaluation (Nieuwenhuis *et al.*, 2005; Yeung *et al.*, 2005). The findings regarding the processing of feedback in the P3 component are not always consistent. Several studies demonstrated that the P3 amplitude is larger for positive than for negative feedback (Hajcak *et al.*, 2006; Yang *et al.*, 2018), suggesting that the positive feedback signals higher psychological significance and demand for more motivational or attentional resources. However, there are also studies showing larger P3 amplitudes for negative rather than positive feedback (Olofsson *et al.*, 2008; Hong *et al.*, 2019). These studies suggest that negative (*vs* positive) feedback receives preferential access to attentional resources. Some studies have claimed that the P3 encodes only the magnitude (i.e. large *vs* small) of reward feedback, not the valence (i.e. positive *vs* negative) of feedback (Sato *et al.*, 2005; Leng and Zhou, 2010); hence, there is no P3 differentiation between positive and negative feedback.

In this study, we expected that the monetary priming would induce the market mode and thereby, neural responses to outcome evaluations involving the social reward indexed by FRN and P3 components would be modulated by prime stimuli, either monetary or neutral primes. This pattern of predicted results would reflect sensitivity to social rewards as reflected in FRN and P3. First, at the early stage (FRN), prior studies have suggested that the FRN shows greater negativity after unfavorable outcomes/feedback (Holroyd *et al.*, 2006; Gu *et al.*, 2011a; Wang *et al.*, 2017). In the case of 'accepted' trials, the advisor's advice led to the advisee's losses implied a negative feedback for advisors, and it was predicted to induce a more negative FRN amplitude than the advice that led to the advisee's gains. On the other hand, when the advice was rejected, advisee's gains suggested a negative feedback and it was expected to elicit a more negative FRN. We predicted that the money-primed advisors' FRN effect (loss minus win difference wave, Holroyd *et al.*, 2006) in response to the advisees' outcomes would be stronger relative to the neutral stimuli-primed advisors' either in the 'accepted' or 'rejected' trials. Second, at the later stage (P3), for advisors, both in 'accepted' and 'rejected' trials, the difference between the outcomes indicative of obtaining and being unable to obtain the social reward might be more pronounced in the money prime condition. However, studies regarding the processing of feedback in P3 have not reached a consensus. Thus, we did not have a concrete prediction here.

Methods

Experimental design

The experiment had a 2 ('feedback from the advisee': participant's selection was accepted *vs* rejected) × 2 ('outcome for the advisee': led to the advisee's gain *vs* loss) × 2 ('prime stimuli': money prime *vs* neutral stimuli prime) mixed design. Prime stimuli served as a between-subjects factor, and the other two factors were within-subjects factors. Notably, existing work on 'money prime effect' has always considered the 'prime stimuli' as the between-subjects factor (cf. Vohs *et al.,* 2006, 2008; Zhou *et al.,* 2009; Caruso *et al.,* 2013) because the cognitive operations elicited by the market mode are difficult to relinquish once adopted, indicating that it may be difficult to shift from the market mode to the non-market mode in a full/balanced within-subjects design experiment (Gasiorowska *et al.,* 2016). We hence regarded the prime stimuli as a between-subjects factor.

Participants

A power analysis (G∗Power 3.1) suggested that 46 participants would ensure 90% statistical power in the case of small- to medium-effect sizes (Faul *et al.,* 2007; Vazire, 2016). As a result, we recruited 50 healthy undergraduates (26 women; $M_{age} = 21.70$ years, s.d.$_{age} = 1.73$) from Hunan Normal University to participate in this study as EEG participants. All EEG participants were right-handed, had a normal or corrected-to-normal vision and reported no history of traumatic brain injury, brain surgery, mental or neurological diseases. Participants provided their written informed consent after being informed of their rights according to the Declaration of Helsinki before they participated in the experiment. Acting as the advisor, participants were paid 50 Chinese RMB (∼£5.6) for participation regardless of the correctness of their advice. This study was approved by the Institutional Review Board of Hunan Normal University, Department of Psychology. Participants were randomly assigned to one of the two conditions, money prime condition or control (i.e. neutral stimuli prime) condition such that there were 25 (14 women) participants, respectively, in the money prime and 25 (12 women) in the control condition. Data of three participants with too few valid trials (invalid trials >25%) to be accepted for data analysis were excluded (Marco-Pallares *et al.,* 2011; Hu *et al.,* 2017; Luck and Gaspelin, 2017). Thus, valid data of 24 participants in the money prime (13 women, $M_{age} = 20.12$ years, s.d.$_{age} = 1.04$) and 23 participants in the control condition (12 women, $M_{age} = 21.22$ years, s.d.$_{age} = 0.98$) were analyzed.

Procedure

Priming stimuli. The priming stimuli used in this study have been used in a previously published study by the authors (Li *et al.,* 2018). We selected the front image of Chinese 100 RMB banknotes as the prime stimuli in the money prime condition as previously described (Ma *et al.,* 2015; Yang *et al.,* 2015; Li *et al.,* 2018). We used the image of common tropical fish as the neutral prime stimuli in the priming phase of the control condition (Vohs *et al.,* 2008; Yang *et al.,* 2015; Li *et al.,* 2018). Participants in the money prime condition or control condition saw 10 images of the banknote or common tropical fish in the priming phase, respectively. The 10 priming images in each condition were presented in random positions on a black background, such that the distance between the images ranged from 2 to 6.5 cm. See more details in Supplementary Material 1.1.

The card-guessing task. A modified version of the card-guessing task (Meshi *et al.,* 2013; Mobbs *et al.,* 2015; Hu *et al.,* 2017) was adopted to achieve our experimental goals. We recruited participants from a large pool of adults. They participated in the experiment in gender-matched pairs (always man–man or woman–woman). Care was taken that participants did not know each other before the experiment or had any kind of relationship. For the paired participants, one was an EEG participant (Player A acted as the advisor), whereas the other was assigned the role of a confederate of the experimenter (Player B pretended as the advisee, although feedback from the advisee were pre-programmed). The two participants were told that they would play a card-guessing game together in a separate room, such that one of them would be the advisor (Player A), and the other would be the advisee (Player B). In this task, there would be two cards to select from. They were told that one card could result in a gain, whereas the other could lead to a loss. Player A would provide their selection to Player B such that B would be able to achieve a gain. Player B had the choice of accepting or rejecting the selection recommended by Player A. Finally, the outcome for Player B (gain or loss) was shown to Player A. The advisor and advisee were decided by drawing lots, although the EEG participant was always drawn to be selected as the advisor (Player A). As introduced in the introduction section, from the participant (advisor)'s point of view, there were four kinds of outcomes each participant would receive: (i) Her/his selection is accepted and this selection leads to Player B's gain, 'selection accepted–advisee's gain'; (ii) her/his selection is accepted and this selection leads to Player B's loss, 'selection accepted–advisee's loss'; (iii) her/his selection is rejected and rejection of this selection leads to Player B's gain, 'selection rejected–advisee's gain'; and (iv) her/his selection is rejected and rejection leads to Player B's loss: 'selection rejected–advisee's loss'. Specifically, participants were informed that the outcome was shown for Player B's responses which would align with those of participants in 'accepted' trials but be opposite in 'rejected' trials. The feedback and implications are shown in Table 1. Overall, from the participant's point of view, the participant was rewarded in the condition where the advice was accepted and led to advisee's gains or where the advice was rejected and led to advisee' losses; the participant was not rewarded in the condition where the advice was accepted and led to advisee's losses or where the advice was rejected and led to advisee' gains.

At the start of the experiment, each EEG participant who was an advisor (Player A) was given the following instructions:

'You are expected to conduct a task consisting of many identical rounds. In each round, you need to carefully view images on screen and then play a card-guessing game as an advisor to Player B. In this game, there will be two cards to choose from. One card can result in the advisee (Player B) winning 10 Yuan; whereas the other card can result in Player B losing 10 Yuan. You have to make a decision which of the two cards Player B should select to win 10 Yuan. Subsequently, you will see whether Player B accepted or rejected the card you recommended. Finally, the outcomes of Player B, either winning or losing 10 Yuan, will be shown to you.'

As shown in Figure 1, each round (trial) consisted of two phases: the priming phase (Figure 1A) and the card-guessing task phase (Figure 1B). In each trial, after a presentation of a white cross (200 ms), participants in each of the two prime conditions viewed 10 priming stimuli on the screen for 1000 ms

Table 1. Four kinds of outcomes participants received and their implications

Outcomes for participant (P)		Implications
Advisee accepts P's selection	Leads to the advisee's gain	Advice is correct/P obtains the social reward (rewarded)
	Leads to the advisee's loss	Advice is incorrect/P is unable to obtain the social reward (not rewarded)
Advisee rejects P's selection	Leads to the advisee's gain	Advice is incorrect/P is unable to obtain the social reward (not rewarded)
	Leads to the advisee's loss	Advice is correct/P obtains the social reward (rewarded)

consisting either images of banknotes or tropical fish. Then, a fixation cross was presented for 500 ms on a black background. Subsequently, all participants were presented with two green squares ($2.5 \times 2.5°$) representing two cards, which appeared on the left and right sides of the fixation cross. They were required to choose one of the two cards to give to Player B by pressing a corresponding key ('F' or 'J' key) with their left or right index finger, respectively. After making the choice, the chosen card was highlighted by a red border for 500 ms. After a variable interval of 600–800 ms, participants passively observed whether Player B accepted or rejected their selection by displaying the statements: 'Player B Accepts' or 'Player B Rejects' on the screen for 1000 ms. Then, the outcome for Player B was displayed on the screen after a variable interval of 600–800 ms by presenting the statements: 'Player B + 10' or 'Player B − 10', which was shown for 1000 ms, with the '+' suggesting the advisee player won 10 Yuan and the '−' indicating the advisee lost 10 Yuan. The inter-trial interval lasted for 1000 ms. Unbeknownst to participants, all feedback and outcomes from Player B were pre-programmed and presented in a random sequence. Each participant received an equal number of trials for each condition (i.e. 2 [participant's selection was accepted *vs* rejected] × 2 [led to the advisee's gain *vs* loss]). The entire task consisted of 320 trials divided into eight blocks so that each condition contained 80 trials. Before the formal experiment, participants were given 12 practical trials with 3 trials in each condition. At the end of each block, all participants completed the 'market-mode' manipulation check (see Supplementary Material 1.3). The money prime and control conditions all shared the same procedure except for the different priming stimuli. The whole experiment lasted for ∼45–50 min. Finally, based on the study conducted by Hu *et al.* (2017), we asked all participants about the credibility of the scenario and the cover story simply (i.e. 'Do you believe that you really have played the guessing card game with Player B?' Answer: Yes or No). None of them expressed doubts (all answered yes).

EEG recording and analysis

Continuous electroencephalograph (EEG) signals were recorded using an 'EEGo Sports' EEG system (ANT Neuro, Enschede, Netherlands) with 64 Ag/AgCl electrodes arranged in an international 10/10 system layout. The online reference was CPz. Offline, data were re-referenced to the average of left and right mastoid electrodes. The electrooculogram (EOG) was recorded from four electrodes placed lateral to each eye and above and below the right eye. Electrode impedances were maintained below 5 kΩ. The signals were recorded with a sampling rate of 500 Hz/channel for offline analysis. The EEG data were preprocessed by the EEGLAB toolbox (Delorme and Makeig, 2004). The recordings were filtered at 0.1 and 30 Hz with 24-dB/octave slopes by Hamming windowed sinc finite impulse response (FIR) filter, which is an embedded function of EEGLAB. We visually inspected the EEG data and removed data segments containing high-amplitude noise, such as large body movements and other readily identifiable artifacts such as sudden electrode drifts and jumps. Then, eyeblinks, saccades and any other consistent artifacts were removed using the independent component analysis (ICA) algorithm (Delorme and Makeig, 2004; Plöchl *et al.*, 2012). Then epochs were extracted from the continuous data files from 200 ms before to 800 ms after the stimuli (i.e. onset of 'Player B + 10' or 'Player B − 10') presentation. The data were baseline-corrected according to the 200 ms interval before stimulus onset. ERP trials with residual artifacts (mean voltage exceeding ±70 μV) were excluded from averaging. On average, there was no significant difference across the mean number of remaining trials in each of four conditions ('selection accepted–advisee's gain', 71.69 ± 5.24; 'selection accepted–advisee's loss', 70.58 ± 4.71; 'selection rejected–advisee's gain', 69.46 ± 4.60; 'selection rejected–advisee's loss', 70.84 ± 4.92), F (3, 138) = 1.14, $P = 0.447$, $\eta_p^2 = 0.019$. The number of trials in each condition was sufficient for analyzing the FRN and P3 (Cohen and Polich, 1997; Marco-Pallares *et al.*, 2011; Yang *et al.*, 2018). Statistical analyses were conducted using IBM SPSS Statistics 22 (IBM Corp., Armonk, NY, USA).

We mainly focused on the FRN and P3 components to test our hypothesis. The FRN between 280 and 350 ms and the P3 between 350 and 450 ms were measured based on visual inspection of the grand-averaged ERPs and previous studies (Hu *et al.*, 2017; Luck and Gaspelin, 2017; Yang *et al.*, 2018). Different sets of electrodes were chosen for the FRN and the P3. According to the topographical distribution (Figures 2A and 3A) and previous studies (Nieuwenhuis *et al.*, 2005; Holroyd and Krigolson, 2010; Hu *et al.*, 2017), the FRN was calculated across nine electrode sites in a fronto-central region (F3, Fz, F4, FC3, FCz, FC4, C3, Cz, C4), and the P3 was calculated across nine electrode sites in a cento-parietal region (C3, Cz, C4, CP3, CPz, CP4, P3, Pz and P4). Mean amplitude values were extracted and averaged for all the selected electrode sites per ERP component. Mixed three-way repeated measures analysis of variance (ANOVA) of 2 × 2 × 2 was conducted for each component. Statistical differences were considered significant at $P < 0.05$. *Post hoc* comparisons were Bonferroni-corrected at $P < 0.05$, and partial eta-squared (η_p^2) was reported as a measure of effect size.

Results

ERP results

FRN (280–350 ms). Figure 2A shows grand-averaged ERP waveforms at FCz and the differences in FRN voltage topographies between observing the advisee's gain and loss separately for 'accepted' and 'rejected' trials. The main effect of 'feedback from the advisee' was significant for the mean FRN amplitude, F (1, 45) = 21.55, $P < 0.001$, $\eta_p^2 = 0.33$, suggesting that the FRN was more negative following the participant's advice was rejected ($M \pm SE = 1.42 \pm 0.25$ μV) than when the advice was accepted ($M \pm SE = 2.32 \pm 0.28$ μV). The main effect of 'outcome for the advisee' was also significant, F (1, 45) = 16.11, $P < 0.001$, $\eta_p^2 = 0.26$,

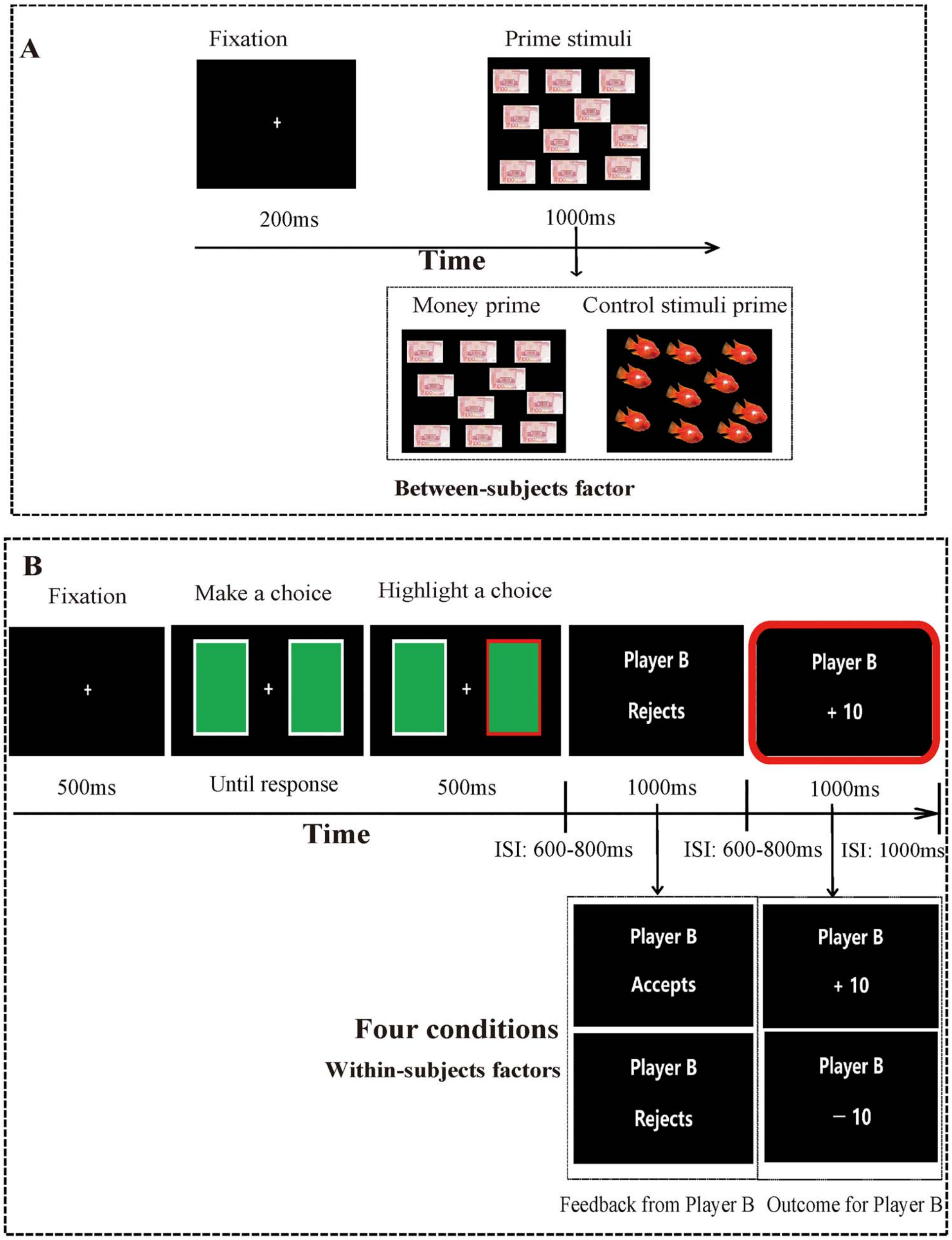

Fig. 1. An illustration of the task sequence in a single trial for Player A (i.e. the EEG participant). Each trial contained two sessions: the priming phase (Figure 1A) and the card-guessing task phase (Figure 1B). First, after a presentation of a white cross (200 ms), participants in each of the two prime conditions viewed 10 priming stimuli on the screen for 1000 ms consisting either images of banknotes or tropical fish. Then, a fixation cross was presented for 500 ms on a black background. Subsequently, all participants were presented with two green squares ($2.5 \times 2.5°$) representing two cards, which appeared on the left and right sides of the fixation cross. They were required to choose one of the two cards to give to Player B by pressing a corresponding key ('F' or 'J' key) with their left or right index finger, respectively. After making the choice, the chosen card was highlighted by a red border for 500 ms. After a variable interval of 600–800 ms, participants were informed whether Player B accepted or rejected their selection by displaying 'Player B Accepts' or 'Player B Rejects' on the screen for 1000 ms. Then, the outcome for Player B was displayed on the screen after a variable interval of 600–800 ms: 'Player B + 10' or 'Player B − 10' was shown for 1000 ms, with the '+' suggesting the other player gained 10 Yuan and the '–' indicating the advisee lost 10 Yuan. The inter-trial interval lasted for 1000 ms. The ERP data of the outcome evaluation stage were time-locked to the outcome for Player B (marked with a red square in the figure). ISI: inter-stimulus interval.

demonstrating that the FRN was more negative for seeing the advisee lose ($M \pm SE = 1.45 \pm 0.23$ µV) than for seeing the advisee win ($M \pm SE = 2.30 \pm 0.30$ µV). There was no main effect of 'prime stimuli', F (1, 45) = 0.24, $P = 0.63$, $\eta_p^2 = 0.005$.

There was also a significant 'feedback from the advisee' × 'outcome for the advisee' interaction in addition to the main effects, F (1, 45) = 63.33, $P < 0.001$, $\eta_p^2 = 0.59$. Importantly, there was a three-way interaction of 'prime stimuli' × 'feedback from the advisee' × 'outcome for the advisee', F (1, 45) = 22.18, $P < 0.001$, $\eta_p^2 = 0.33$. We conducted separate analyses of FRN responses for the money prime condition and control condition. The analysis for the money prime condition yielded a significant 'feedback from the advisee' × 'outcome for the advisee' interaction, F (1, 23) = 101.55, $P < 0.001$, $\eta_p^2 = 0.82$: 'selection accepted–advisee's loss' ($M \pm SE = 0.91 \pm 0.39$ µV) elicited a more negative FRN amplitude than the 'selection

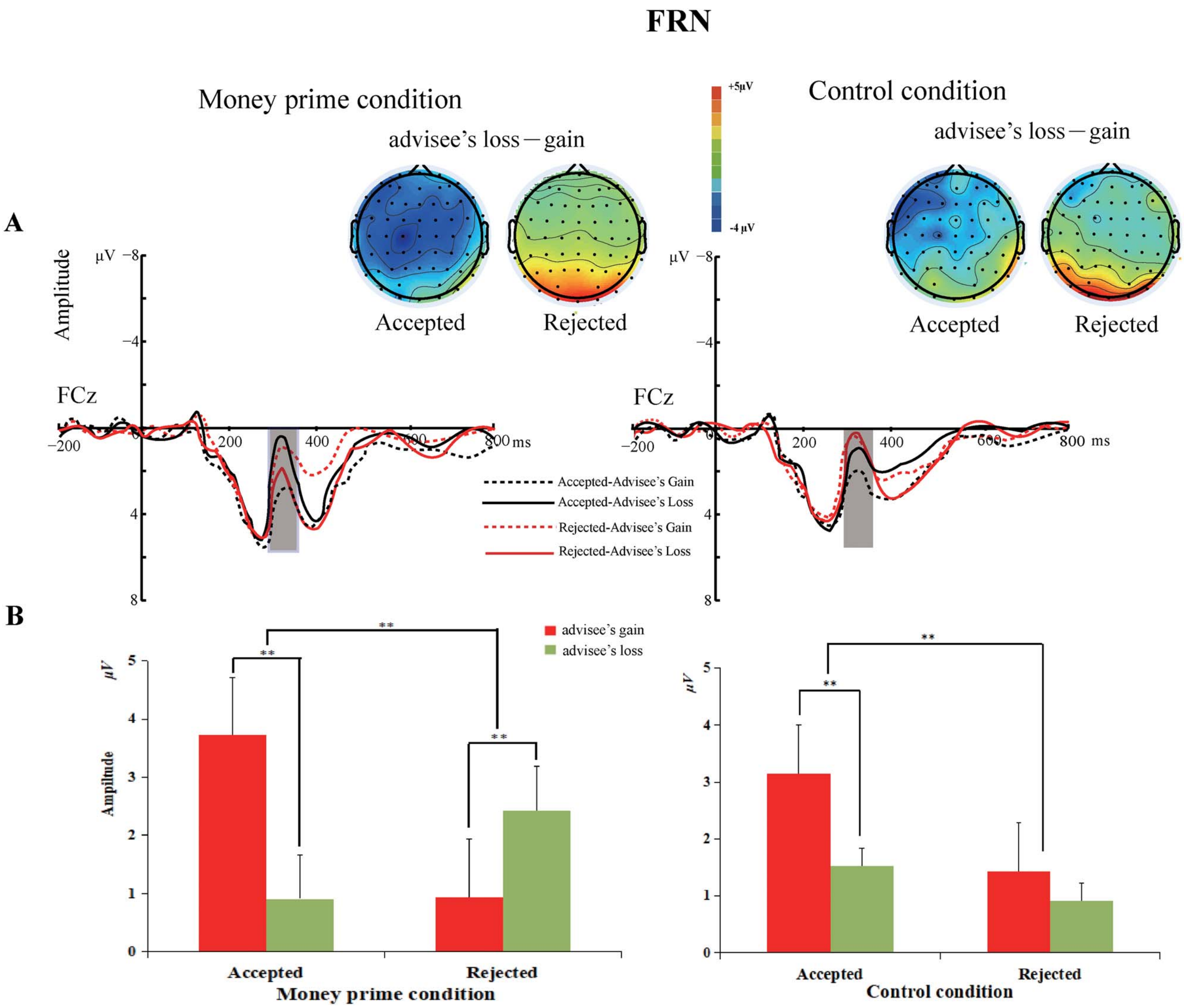

Fig. 2. (A) Grand-averaged ERP waveforms at the FCz. The gray bars highlight the time window of the FRN (280–350 ms); differences in FRN voltage topographies between 'selection accepted–advisee's gain' and 'selection accepted–advisee's loss' and the differences between 'selection rejected–advisee's gain' and 'selection rejected–advisee's loss'. (B) Bar graphs showing mean FRN values of each condition. $^{*}P < 0.05$; $^{**}P < 0.001$. Error bars indicate standard errors of the mean.

accepted–advisee's gain' ($M \pm SE = 3.72 \pm 0.45$ μV), F (1, 23) = 58.57, $P < 0.001$, $\eta_p^2 = 0.66$, whereas the 'selection rejected–advisee's gain' ($M \pm SE = 0.93 \pm 0.41$ μV) elicited a more negative FRN than 'selection rejected–advisee's loss' ($M \pm SE = 2.43 \pm 0.47$ μV), F (1, 23) = 49.10, $P < 0.001$, $\eta_p^2 = 0.50$. The 'feedback from the advisee' × 'outcome for the advisee' interaction in the case of the control condition was also significant, F (1, 22) = 4.29, $P = 0.049$, $\eta_p^2 = 0.23$. There was significant difference between 'selection accepted–advisee's gain' and 'selection accepted–advisee's loss', F (1, 22) = 42.72, $P < 0.001$, $\eta_p^2 = 0.47$, such that 'selection accepted–advisee's loss' ($M \pm SE = 1.53 \pm 0.40$ μV) elicited a more negative FRN amplitude than 'selection accepted–advisee's gain' ($M \pm SE = 3.14 \pm 0.46$ μV). However, the FRN amplitude did not show any difference between 'selection rejected–advisee's gain' and 'selection rejected–advisee's loss', F (1, 22) = 1.28, $P = 0.27$, $\eta_p^2 = 0.03$.

Further, we analyzed the FRN effect (i.e. FRN induced by losses minus FRN induced by gains) for the 'accepted' and 'rejected' trials (for 'accepted' trials, the FRN induced by 'selection accepted–advisee's loss' minus FRN induced by 'selection accepted–advisee's gain'; for 'rejected' trials, the FRN induced by 'selection rejected–advisee's gain' minus FRN induced by 'selection rejected–advisee's loss') in the money prime and control condition. A mixed two-way repeated measures analysis of variance (ANOVA) of 2 (money prime *vs* neutral stimuli prime) × 2 (participant's selection was accepted *vs* rejected) was conducted for the FRN effect. The main effect of 'feedback from the advisee' was significant, F (1, 45) = 13.46, $P = 0.001$, $\eta_p^2 = 0.23$, suggesting that the FRN effect was larger in 'accepted' trials ($M \pm SE = -2.12 \pm 0.27$ μV) compared with which in 'rejected' trials ($M \pm SE = -0.50 \pm 0.30$ μV). Importantly, we found that there was a significant main effect of 'prime stimuli', F (1, 45) = 18.07, $P < 0.001$, $\eta_p^2 = 0.29$, indicating that the FRN effect was stronger in the money prime condition ($M \pm SE = -2.07 \pm 0.23$ μV) relative to the control condition ($M \pm SE = -0.55 \pm 0.25$ μV). No interaction effect was observed.

P3 (350–450 ms). Figure 3A shows grand-averaged ERP waveforms at CPz and topographies of voltage distribution for each condition. The results showed that the main effect of 'prime stimuli' was significant, F (1, 45) = 9.55, $P = 0.003$, $\eta_p^2 = 0.29$,

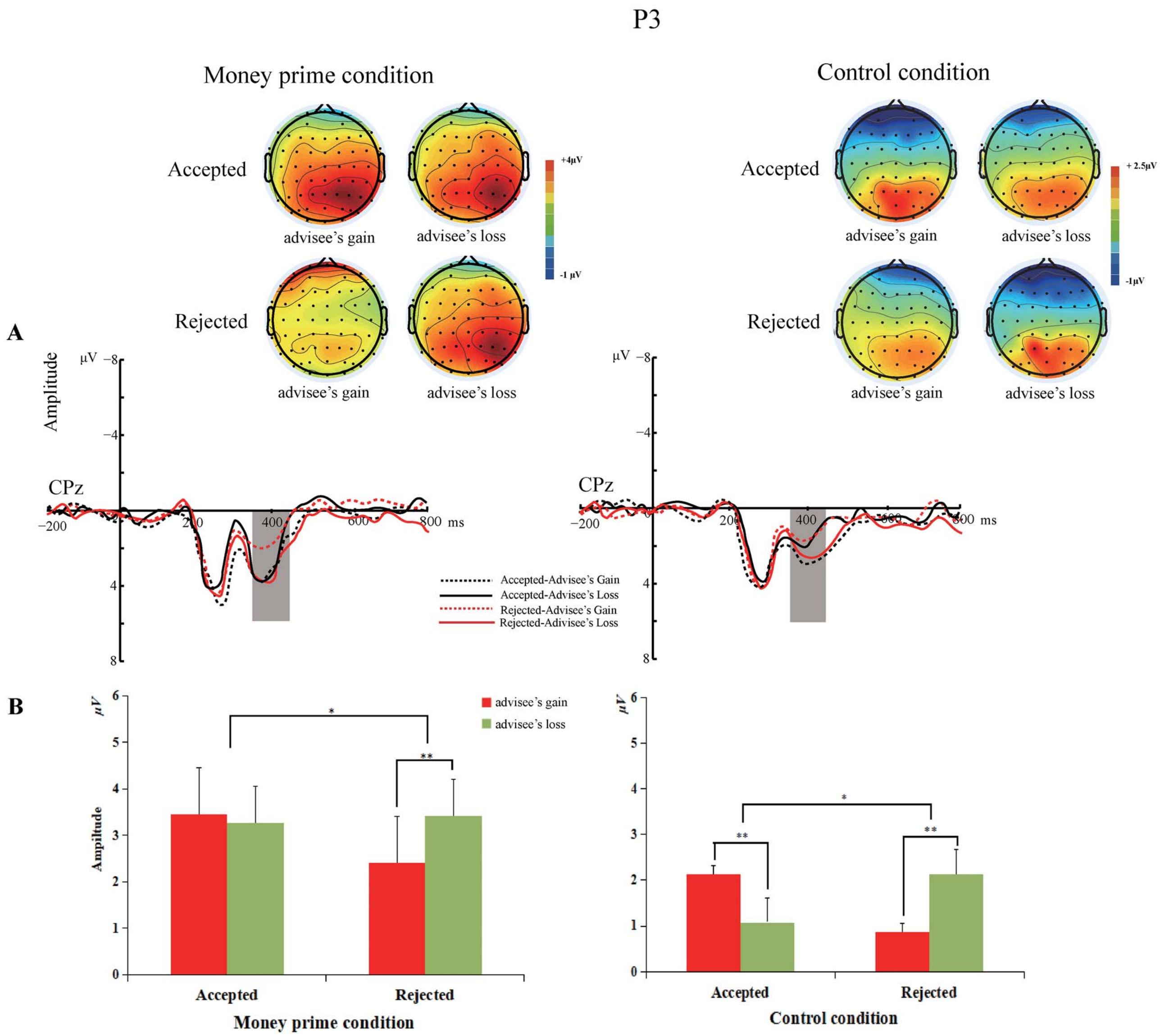

Fig. 3. (A) Grand-averaged ERP waveforms at CPz. The gray bars highlight the time window of P3 (350–450 ms); topographies voltage distribution of P3 for each condition.[1] (B) The bar graphs of mean P3 values for each condition. $^{*}P < 0.05$; $^{**}P < 0.001$.

indicating that the P3 was more positive for participants in the money prime condition ($M \pm SE = 3.13 \pm 0.36$ μV) than in the control condition ($M \pm SE = 1.53 \pm 0.38$ μV). Moreover, there was a significant main effect of 'feedback from the advisee', F (1, 45) = 4.91, $P = 0.032$, $\eta_p^2 = 0.10$, suggesting that the P3 was larger following the participant's choice was accepted ($M \pm SE = 3.48 \pm 0.27$ μV) than following their choice was rejected ($M \pm SE = 2.56 \pm 0.25$ μV). The main effect of 'outcome for the advisee' was not significant, F (1, 45) = 3.62, $P = 0.063$, $\eta_p^2 = 0.08$.

Additionally, we also observed a significant 'feedback from the advisee' × 'outcome for the advisee' interaction, F (1, 45) = 38.86, $P < 0.001$, $\eta_p^2 = 0.49$. Moreover, there was a three-way 'prime stimuli' × 'feedback from the advisee' × 'outcome for the advisee' interaction, F (1, 45) = 4.26, $P = 0.045$, $\eta_p^2 = 0.19$. We also conducted separate analyses of P3 for the money prime condition and control condition. Follow-up analyses in the money prime condition indicated that the 'feedback from the advisee' × 'outcome for the advisee' interaction was significant, F (1, 23) = 5.65, $P = 0.026$, $\eta_p^2 = 0.23$: There was no difference between 'selection accepted–advisee's loss' and 'selection accepted–advisee's gain' conditions, F (1, 23) = 2.67, $P = 0.11$, $\eta_p^2 = 0.07$; but 'selection rejected–advisee's gain' ($M \pm SE = 2.40 \pm 0.41$ μV) elicited a smaller P3 than 'selection rejected–advisee's loss' ($M \pm SE = 3.41 \pm 0.49$ μV), F (1, 23) = 6.66, $P = 0.013$, $\eta_p^2 = 0.32$. The analysis for the control condition also yielded a significant 'feedback from the advisee' × 'outcome for the advisee' interaction, F (1, 22) = 83.89, $P < 0.001$, $\eta_p^2 = 0.79$: 'selection accepted–advisee's gain' ($M \pm SE = 2.13 \pm 0.36$ μV) elicited a larger P3 than 'selection accepted–advisee's loss' ($M \pm SE = 1.08 \pm 0.34$ μV), F (1, 22) = 73.64, $P < 0.001$, $\eta_p^2 = 0.62$;

1 Based on the prior studies (Zhou et al., 2010; Jia et al., 2013; Chen et al., 2017; Hu et al., 2017), for the FRN at the outcome evaluation stage, we adopted the topographies of the voltage difference between 'selection accepted—advisee's loss' and 'selection accepted—advisee's gain' and the difference between 'selection rejected—advisee's loss' and 'selection rejected—advisee's gain' separately.

whereas 'selection rejected–advisee's loss' ($M \pm SE = 2.14 \pm 0.42$ μV) elicited a larger P3 than 'selection rejected–advisee's gain' ($M \pm SE = 0.78 \pm 0.46$ μV), F (1, 22) = 11.46, $P = 0.001$, $\eta_p^2 = 0.42$.

In addition, we also examined the P3 difference for 'accepted' and 'rejected' trials (for 'accepted' trials, the P3 induced by 'selection accepted–advisee's gain' minus P3 induced by 'selection accepted–advisee's loss'; for 'rejected' trials, the P3 induced by 'selection rejected–advisee's loss' minus P3 induced by 'selection rejected–advisee's gain') in the money prime and control condition. The results revealed that there was a significant main effect of 'prime stimuli', F (1, 45) = 4.26, $P = 0.045$, $\eta_p^2 = 0.17$, indicating that the P3 difference was greater in the control condition ($M \pm SE = 1.20 \pm 0.21$ μV) relative to the money prime condition ($M \pm SE = 0.60 \pm 0.23$ μV). No other main or interaction effects emerged.

Discussion

This study adopted the ERP method to examine effects of money priming on neural temporal dynamics when evaluating outcomes involving social reward for the participant. The analyses of self-report data in the market-mode manipulation checks demonstrated that the degrees of willingness to help the other by exerting effort increased significantly along with the increase in the payment in the money prime condition (see Supplementary Material 2.1). Participants in the money prime condition compared to the control condition were more sensitive to the levels of payments when helping others. Past literature suggests that individuals in the market mode are highly sensitive to the magnitude of compensation for their efforts in helping others (Heyman and Ariely, 2004; Li *et al.*, 2018), and our data supported that using monetary (banknote) images for priming effectively induced the market mode. Meanwhile, ERP results showed that the market mode differentially affected the early and late stages of outcome evaluation involving social rewards as indexed by the FRN and P3. In the following discussion, from the participant's point of view, we detailed these effects at the early (i.e. FRN) and later stage (i.e. P3).

The early stage

Compared with 'rejected' trials (i.e. advisee rejecting advisor's advice), 'accepted' trials (i.e. advisee accepting advisor's advice) elicited a more negative early ERP when advice was correct as compared to incorrect. This suggests that errors in one's recommendation may be more attention capturing during early processing when the recommendation had been heeded rather than ignored. In accordance with our predictions, we observed an effect of money priming on the FRN suggesting that the market mode modulated the early automatic stage of outcomes evaluation. Specifically, we found a three-way interaction that suggested that the money prime condition and the control condition showed different patterns as reflected by FRN. In addition, we also observed that the FRN effect was stronger in the money prime condition relative to the control condition. As individuals are highly sensitive to personal rewards in the market mode (Vohs *et al.*, 2008; Gasiorowska *et al.*, 2016; Zaleskiewicz *et al.*, 2017; Li *et al.*, 2018), we accordingly found that participants in the money prime condition were more sensitive to the pairing of advisee's feedback and outcome than the control condition. Specifically, after money priming, participants showed an FRN to their own errors both when they had been accepted and rejected by the other player. By contrast, after control priming, their own errors elicited an FRN only when their recommendation had been accepted. After a rejection, the ERP was equally negative to the game outcome irrespective of advice accuracy. These findings suggest that individuals in the market mode have a higher sensitivity to the social reward at the early stage.

The later stage

There was a significant three-way interaction for the P3, which indicated that the money-primed and the participants in control condition have distinctive patterns of neural responses at the later stage. In line with previous studies, we found that the P3 could be modulated by reward valence (Nick and Sanfey, 2004; Sato *et al.*, 2005; Wang *et al.*, 2017). The positive (rewarding) feedback has been reported to gain preferential access to cognitive resources and induces a greater P3 (Nieuwenhuis *et al.*, 2005; Holroyd *et al.*, 2006). This is what we found for the control group where the P3 was most positive for the situations that led to social reward for the participant, that is, the condition where the advice was accepted and led to advisee's gains or where the advice was rejected and led to advisee' losses. This finding is in line with previous studies suggesting that positive outcomes enhance affective/motivational significance for individuals (Hajcak *et al.*, 2006; Yang *et al.*, 2018). However, in contrast to the early stage (FRN), the market mode did not show a comparable effect in the later stage. Although the P3 was larger when advice was rejected resulting in a loss as compared to a gain for the advisee, P3 amplitudes were equally large for positive and negative outcomes when advice had been accepted.

The absence of a P3 effect in money-primed participants when their advice had been accepted was surprising and inconsistent with our predictions. As null effects are difficult to interpret but the mean difference is in the right direction (rewarding outcome elicited more positive amplitudes, albeit very small), we do not speculate about possible explanations. Meta-analyses regarding the *money prime effect* demonstrated that this effect can be present, absent or biased under different experimental conditions (Caruso *et al.*, 2017; Lodder *et al.*, 2019).Future research will have to determine whether the observed lack of difference between the two conditions is robust in the later P3 response.

It has been suggested that there are two processes in outcome evaluations: an early (automatic) process for social feedback reflected by FRN and a later (controlled) process, which is indexed by P3 (Goyer *et al.*, 2008). Combining the divergent results of FRN and P3, these findings showed that the crossover effect for the FRN in the money prime condition emerged only for the P3 in the control condition. Specifically, after money priming, larger deflections to one's own incorrect advice showed both when advice was accepted and rejected for the FRN but not the P3. By contrast, in the control condition, larger deflections to one's own incorrect advice irrespective of whether advice was heeded showed for the P3 but not for the FRN. Therefore, one can speculate that the market mode facilitates early and potentially more automatic social reward processing but reduces later and potentially more controlled responding.

The current findings are constrained by several limitations. First, these findings indicate that giving advice to the advisee might be one method of enhancing the perceived self-reputation to obtain social reward; but other alternative explanations such as increases in self-esteem are also plausible (Mobbs *et al.*, 2015). Second, the influence of market mode on experienced emotions underlying the processing of social rewards remains unclear; future studies may use scales to measure affect in order to examine the underlying processes. Third, our findings suggest that the market mode has an impact on social rewards processing, yet little is known about the differential effects of market mode on the processing of material and social rewards.

Conclusions

To conclude, the present study adds to a growing body of evidence for modulation of outcome processing by contextual social relevance cues. Our research sheds light on the neural underpinnings of the market mode modulation of social rewards processing via the ERP method. The market mode facilitates early and potentially more automatic social feedback processing, as suggested by the observation that the FRN effect reflecting social reward was stronger in the money prime condition. However, the market mode reduces the social reward effect in later and possibly more controlled responding, as suggested by observation that the social reward effect for the P3 emerged in the control condition, but was only present in the money prime condition when the advice was rejected.

Supplementary data

Supplementary data are available at *SCAN* online.

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Conflict of interest

None declared.

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References

Caruso, E.M., Vohs, K.D., Brittani, B., Adam, W. (2013). Mere exposure to money increases endorsement of free-market systems and social inequality. *Journal of Experimental Psychology. General*, **142**, 301–6.

Caruso, E.M., Shapira, O., Landy, J.F. (2017). Show me the money: a systematic exploration of manipulations, moderators, and mechanisms of priming effects. *Psychological Science*, **28**, 956797617706161.

Chen, Y., Lu, J., Wang, Y., Feng, Z., Yuan, B. (2017). Social distance influences the outcome evaluation of cooperation and conflict: evidence from event-related potentials. *Neuroscience Letters*, **647**, 78–84.

Cialdini, R.B., Borden, R.J., Thorne, A., Walker, M.R., Freeman, S., Sloan, L.R. (1976). Basking in reflected glory: three (football) field studies. *Journal of Personality and Social Psychology*, **34**, 366–75.

Cohen, J., Polich, J. (1997). On the number of trials needed for P300. *International Journal of Psychophysiology*, **25**, 249–55.

Delorme, A., Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, **134**, 9–21.

Duncan-Johnson, C., Donchin, E. (1977). On quantifying surprise: the variation in event-related potentials with subjective probability. *Psychophysiology*, **14**, 456–67.

Ernst, M., Paulus, M.P. (2005). Neurobiology of decision making: a selective review from a neurocognitive and clinical perspective. *Biological Psychiatry*, **58**, 597–604.

Falco, A., Albinet, C., Rattat, A.-C., Paul, I., Fabre, E. (2019). Being the chosen one: social inclusion modulates decisions in the ultimatum game. An ERP study. *Social Cognitive & Affective Neuroscience*, **14**, 141–9.

Faul, F., Erdfelder, E., Lang, A.G., Buchner, A. (2007). G∗power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, **39**, 175–91.

Fiske, A.P. (1992). The four elementary forms of sociality: framework for a unified theory of social relations. *Psychological Review*, **99**, 689–723.

Garret, R., Michael, M.B., Van, Y.N.W. (2015). Money affects theory of mind differently by gender. *PLOS ONE*, e0143973.

Gąsiorowska, A., Hełka, A. (2012). Psychological consequences of money and money attitudes in dictator game. *Polish Psychological Bulletin*, **43**, 20–6.

Gasiorowska, A., Chaplin, L.N., Zaleskiewicz, T., Wygrab, S., Vohs, K.D. (2016). Money cues increase agency and decrease prosociality among children: early signs of market-mode behaviors. *Psychological Science*, **2016**, 331–45.

Gehring, W.J., Willoughby, A.R. (2002). The medial frontal cortex and the rapid processing of monetary gains and losses. *Science*, **295**, 2279–82.

Glazer, J.E., Kelley, N.J., Pornpattananangkul, N., Mittal, V.A., Nusslock, R. (2018). Beyond the FRN: broadening the time-course of EEG and ERP components implicated in reward processing. *International Journal of Psychophysiology*, **132**, 184–202.

Goyer, J.P., Woldorff, M.G., Huettel, S.A. (2008). Rapid electrophysiological brain responses are influenced by both valence and magnitude of monetary rewards. *Journal of Cognitive Neuroscience*, **20**, 2058–69.

Gray, H.M., Ambady, N., Lowenthal, W.T., Deldin, P. (2004). P300 as an index of attention to self-relevant stimuli. *Journal of Experimental Social Psychology*, **40**, 216–24.

Gu, R., Lei, Z., Broster, L., Wu, T., Jiang, Y., Luo, Y. (2011a). Beyond valence and magnitude: a flexible evaluative coding system in the brain. *Neuropsychologia*, **49**, 3891–7.

Gu, R., Wu, T., Jiang, Y., Luo, Y. (2011b). Woulda, coulda, shoulda: the evaluation and the impact of the alternative outcome. *Psychophysiology*, **48**, 1354–60.

Gu, R., Huang, W., Camilleri, J., *et al.* (2019). Love is analogous to money in human brain: coordinate-based and functional connectivity meta-analyses of social and monetary reward anticipation. *Neuroscience & Biobehavioral Reviews*, **100**, 108–28. doi: 10.1016/j.neubiorev.2019.02.017.

Guéguen, N., Jacob, C. (2013). Behavioral consequences of money: when the automated teller machine reduces helping behavior. *The Journal of Socio-Economics*, **47**, 103–4.

Gunia, B. (2017). Deceptive negotiating: the role of the environmental cue. *Academy of Management Perspectives*, **33**, 43–61.

Hajcak, G., Moser, J.S., Holroyd, C.B., Simons, R.F. (2006). The feedback-related negativity reflects the binary evaluation of good versus bad outcomes. *Biological Psychology*, **71**, 148–54.

Hauser, T.U., Iannaccone, R., Stämpfli, P., *et al.* (2014). The feedback-related negativity (FRN) revisited: new insights into the localization, meaning and network organization. *NeuroImage*, **84**, 159–68.

Helm, S., Salminen, R.T. (2010). Basking in reflected glory: using customer reference relationships to build reputation in industrial markets. *Industrial Marketing Management*, **39**, 737–43.

Heyman, J., Ariely, D. (2004). Effort for payment: a tale of two markets. *Psychological Science*, **15**, 787–93.

Holroyd, C.B., Krigolson, O.E. (2010). Reward prediction error signals associated with a modified time estimation task. *Psychophysiology*, **44**, 913–7.

Holroyd, C., Hajcak, B., Greg, L., Jeff, T. (2006). The good, the bad and the neutral: electrophysiological responses to feedback stimuli. *Brain Research*, **1105**, 93–101.

Hong, L., Xiaoguang, Y., Wenyu, Z., Chao, W. (2019). Emotional regulation goals of young adults with depression inclination: an event-related potential study. *Acta Psychologica Sinica*, **51**, 637–47.

Hu, X., Xu, Z., Mai, X. (2017). Social value orientation modulates the processing of outcome evaluation involving others. *Social Cognitive and Affective Neuroscience*, **12**, 1730–9.

Izuma, K. (2012). The social neuroscience of reputation. *Neuroscience Research*, **72**, 283–8.

Izuma, K., Saito, D.N., Sadato, N. (2008). Processing of social and monetary rewards in the human striatum. *Neuron*, **58**, 284–94.

Izuma, K., Saito, D.N., Sadato, N. (2010). The roles of the medial prefrontal cortex and striatum in reputation processing. *Social Neuroscience*, **5**, 133–47.

Jia, S., Zhang, W., Li, P., Feng, T., Li, H. (2013). Attitude toward money modulates outcome processing: an ERP study. *Social Neuroscience*, **8**, 43–51.

Jonas, E., Schulz-Hardt, S., Frey, D. (2005). Giving advice or making decisions in someone else's place: the influence of impression, defense, and accuracy motivation on the search for new information. *Personality and Social Psychology Bulletin*, **31**, 977–90.

Leng, Y., Zhou, X.L. (2010). Modulation of the brain activity in outcome evaluation by interpersonal relationship: an ERP study. *Neuropsychologia*, **48**, 448–55.

Li, J., Zhan, Y., Fan, W., Liu, L., Li, M., Sun, Y., *et al.* (2018). Sociality mental modes modulate the processing of advice-giving: an event-related potentials study. *Frontiers in Psychology*, **9**, 42. doi: 10.3389/fpsyg.2018.00042.

Lodder, P., Ong, H., Grasman, R., Wicherts, J. (2019). A comprehensive meta-analysis of money priming. *Journal of Experimental Psychology: General*, **148**, 688–712. doi: 10.1037/xge0000570.

Luck, S., Gaspelin, N. (2017). How to get statistically significant effects in any ERP experiment (and why you shouldn't). *Psychophysiology*, **54**, 146–57.

Luo, Y.-J., Sun, S.-Y., Mai, X.-Q., Gu, R.-L., Zhang, H.-J. (2011). Outcome Evaluation in Decision Making: ERP Studies. In: Han, S., Pppel, E., editors. *Culture and Neural Frames of Cognition and Communication*, Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 249–85.

Ma, Q., Hu, Y., Pei, G., Xiang, T. (2015). Buffering effect of money priming on negative emotions—an ERP study. *Neuroscience Letters*, **606**, 77–81.

Marco-Pallares, J., Cucurell, D., Mãüte, T.F., Strien, N., Rodriguez-Fornells, A. (2011). On the number of trials needed for a stable feedback-related negativity. *Psychophysiology*, **48**, 852–60.

Mead, N.L., Stuppy, A. (2014). Two Sides of the Same Coin: Money Can Promote and Hinder Interpersonal Processes. In: Bijleveld, E., Aarts, H., editors. *The Psychological Science of Money*, New York, NY: Springer.

Meshi, D., Morawetz, C., Heekeren, H.R. (2013). Nucleus accumbens response to gains in reputation for the self relative to gains for others predicts social media use. *Frontiers in Human Neuroscience*, **7**, 439.

Miltner, W.H.R., Braun, C.H., Coles, M.G.H. (1997). Event-related brain potentials following incorrect feedback in a time-estimation task: evidence for a generic neural system for error detection. *Journal of Cognitive Neuroscience*, **9**, 788–98.

Mobbs, D., Hagan, C.C., Yu, R., Takahashi, H., Feldmanhall, O., Calder, A.J., *et al.* (2015). Reflected glory and failure: the role of the medial prefrontal cortex and ventral striatum in self vs other relevance during advice-giving outcomes. *Social Cognitive and Affective Neuroscience*, **10**, 474–8.

Nick, Y., Sanfey, A.G. (2004). Independent coding of reward magnitude and valence in the human brain. *Journal of Neuroscience*, **24**, 6258–64.

Nieuwenhuis, S., Aston-Jones, G., Cohen, J.D. (2005). Decision making, the P3, and the locus coeruleus-norepinephrine system. *Psychological Bulletin*, **131**, 510.

Olofsson, J., Nordin, S., Sequeira, H., Polich, J. (2008). Affective picture processing: an integrative review of ERP findings. *Biological Psychology*, **77**, 247–65.

Pfabigan, D.M., Alexopoulos, J., Bauer, H., Sailer, U. (2011). Manipulation of feedback expectancy and valence induces negative and positive reward prediction error signals manifest in event-related brain potentials. *Psychophysiology*, **48**, 656–64.

Plöchl, M., Ossandón, J.P., König, P. (2012). Combining EEG and eye tracking: identification, characterization, and correction of eye movement artifacts in electroencephalographic data. *Frontiers in Human Neuroscience*, **6**, 278.

Polich, J. (2007). Updating P300: an integrative theory of P3a and P3b. *Clinical neurophysiology*, **118**, 2128–48. doi: 10.1016/j.clinph.2007.04.019.

Pornpattananangkul, N., Nadig, A., Heidinger, S., Walden, K., Nusslock, R. (2017). Elevated outcome-anticipation and outcome-evaluation ERPs associated with a greater preference for larger-but-delayed rewards. *Cognitive, Affective, & Behavioral Neuroscience*, **17**, 625–41.

Sarial-Abi, G., Vohs, K.D. (2012). The mere presence of money motivates goal achievement. *Advances in Consumer Research*, **40**, 795.

Sato, A., Yasuda, A., Ohira, H., Miyawaki, K., Nishikawa, M., Kumano, H., *et al.* (2005). Effects of value and reward magnitude on feedback negativity and P300. *Neuroreport*, **16**, 407–11.

Simons, R. (2010). The way of our errors: theme and variations. *Psychophysiology*, **47**, 1–14.

Tangney, J.P., Stuewig, J., Mashek, D.J. (2007). Moral emotions and moral behavior. *Annual Review of Psychology*, **58**, 345–72.

Vazire, S. (2016). Editorial. *Social Psychological and Personality Science*, **7**, 3–7.

Vohs, K.D. (2015). Money priming can change people's thoughts, feelings, motivations, and behaviors: an update on 10 years of experiments. *Journal of Experimental Psychology. General*, **144**, e86.

Vohs, K.D., Mead, N.L., Goode, M.R. (2006). The psychological consequences of money. *Science*, **314**, 1154–6.

Vohs, K.D., Mead, N.L., Goode, M.R. (2008). Merely activating the concept of money changes personal and interpersonal behavior. *Current Directions in Psychological Science*, **17**, 208–12.

Wang, Y., Kuhlman, D.M., Roberts, K., Yuan, B., Zhang, Z., Zhang, W., *et al.* (2017). Social value orientation modulates the FRN and P300 in the chicken game. *Biological Psychology*, **127**, 89–98.

Xin, Z., Liu, Y., Yang, Z., Zhang, H. (2016). Effects of minimal social cues on trust in the investment game. *Asian Journal of Social Psychology*, **19**, 235–43.

Yang, D., Li, Z., Yu, M., Ding, C., Yao, S. (2015). Money primes modulate the empathy to others' pain: an ERP study. *Psychological Exploration*, **35**, 140–6.

Yang, Z., Sedikides, C., Gu, R., Luo, Y.L.L., Wang, Y., Cai, H. (2018). Narcissism and risky decisions: a neurophysiological approach. *Social Cognitive and Affective Neuroscience*, **13**, 889–97.

Yeung, N., Holroyd, C.B., Cohen, J.D. (2005). ERP correlates of feedback and reward processing in the presence and absence of response choice. *Cerebral Cortex*, **15**, 535–44.

Zaleskiewicz, T., Gasiorowska, A. (2016). The psychological consequences of money for economic and social relationships. In: Jansson-Boyd, C., Zawisza, M., editors. *The Routledge international handbook of consumer psychology*, New York: Routledge, pp. 312–26.

Zaleskiewicz, T., Gasiorowska, A., Vohs, K.D. (2017). The psychological meaning of money. In: Ranyard, R., editor. *Economic Psychology*, New York: John Wiley and Sons Inc., pp. 105–22.

Zhou, X., Vohs, K.D., Baumeister, R.F. (2009). The symbolic power of money. *Psychological Science*, **20**, 700–6.

Zhou, Z., Yu, R., Zhou, X. (2010). To do or not to do? Action enlarges the FRN and P300 effects in outcome evaluation. *Neuropsychologia*, **48**, 3606–13.

Zhu, R., Wu, H., Xu, Z., Tang, H., Shen, X., Mai, X., *et al.* (2017). Early distinction between shame and guilt processing in an interpersonal context. *Social Neuroscience*, **14**, 53–66.