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A sense of unfairness reduces charitable giving to a third-party: Evidence from behavioral and electrophysiological data

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ABSTRACT

Unfairness commonly impacts human economic decision-making. However, whether inequity aversion impairs pro-social decisions and the corresponding neural processes, is poorly understood. Here, we conducted two experiments to investigate whether human gifting behavior and brain activity are affected by inequity aversion. In experiment 1, participants played as a responder in a joint donation game in which they were asked to decide whether or not to accept a donation proposal made by the proposer. In experiment 2, participants played a donation game similar to experiment 1, but the charity projects were classified as high-deservingness and low-deservingness projects. The results in both of two experiments showed that the participants were more likely to reject an unfair donation proposal and the late positivity potential (LPP)/P300 elicited by fair offers was more positive than moderately unfair and highly unfair offers regardless of charity deservingness. Moreover, after principal component analysis, the differences in P300 amplitude between fair and highly unfair conditions were positively correlated with the acceptance rates in experiment 2. Taken together, our study revealed that late positivity (LPP/P300) reflected the evaluation of fairness of proposals, and could predict subsequent pro-social decisions. This study is the first to demonstrate that inequity aversion reduces pro-social motivation to help innocent third party.

1. Introduction

Fairness is dictated by the basic rules for interpersonal interaction in human society. A growing number of studies have focused on how people's subjective feelings of fairness are generated, as well as the subsequent behavioral decisions based on such feelings (Tricomi and Sullivan-Toole, 2015). Early studies have shown that individual decision-making behavior is not only driven by absolute economic rationality with the goal of benefit maximization, but is also influenced by subjective experiences such as the sense of unfairness (Fehr & Gachter, 2002; Henrich et al., 2006). In a classic experimental paradigm known as the Ultimatum Game (UG), a certain amount of money is given to two players; one player acts as proposer who is asked to allocate the money, the other player acts as a responder who can choose to accept or reject the allocation. If the responder accepts the offer, money is allocated as proposed; otherwise, neither player receives anything (Güth et al., 1982). According to the hypothesis of economic person, the responder will accept all allocation schemes; however, empirical studies of UG have demonstrated that the unfair offers were often rejected by the responder, especially when the offer is less than 20% of the total possible pay-out (Kahneman et al., 1986; Camerer and Thaler, 1995). These studies showed that a sense of unfairness had a large impact on human decision-making behavior and may even lead to "irrational" behavior at the cost of economic benefits.

Many studies investigating a sense of unfairness claim that people may have negative feelings about the unfair scheme they were assigned to, and these emotional responses can drive subsequent decision-making (Pillutla and Murnighan, 1996; Sanfey et al., 2003; Van't Wout et al., 2006; Hewig et al., 2011). When individuals feel a situation is unfair because of others' behaviors, they tend to take actions to punish those responsible, and the offer may be rejected (Güth et al., 1982; Camerer and Thaler, 1995). Moreover, Houser et al. (2012) provided experimental evidence that subjects were more likely to cheat when they reported a coin flip to increase their total gain after receiving either

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nothing or very little money from the investigator, and individuals are more likely to steal money from envelopes when they are treated unfairly (Umphress et al., 2009). However, most of these studies only focused on participants' responses to related offenders (e.g., the proposer); it is unclear whether suffering unfairness impacts pro-social behavior toward others who were not responsible for the offense. In fact, several studies have shown that unfairness could lead to selfish behavior towards innocent third-parties. For example, Zitek et al. (2010) found that compared with participants who recalled a boring experience, those who had recalled an experience as unfair were more inclined to exhibit selfish behavior (e.g., refusing to help the experimenter perform additional tasks). In addition, they also found that participants who lost a game for an unfair reason (e.g., computer failure) allocated themselves more money in the following game than participants who lost the game for a fair reason.

To our knowledge, very few studies have focused on whether unfairness impairs pro-social behaviors such as charitable giving. As a typical pro-social behavior, charitable giving could provide help or benefits to people in need with little or no return (Zhou et al., 2011). Charitable giving promotes social equity and justice, and maintains social harmony and stability. Several possible motivations may drive charitable giving behaviors, including purely altruistic motivation, reputation management (Izuma , 2012), and the "warm-glow" effects; i.e., increased personal satisfaction from serving collective public interests (Andreoni, 1989, 1990; Moll et al., 2006; Harbaugh et al., 2007; Waytz et al., 2012).

Here, we asked whether the sense of unfairness influences people's charitable giving to third-parties by assessing the electrophysiological signals in response to unfair proposals from a second-party and charitable giving behavior toward an unrelated third-party. Event-related potential (ERP) studies have identified several components of the neural processes involved in interpreting and responding to unfair proposals. First, the medial frontal negativity (MFN, or feedback-related negativity, FRN) was found to be more sensitive to unfair offers in studies those adopted UG paradigm (Polezzi et al., 2008; Boksem and De Cremer, 2010; Hewig et al., 2011; Wu et al., 2011a; Alexopoulos et al., 2012; Hu et al., 2014; Ma et al., 2015, 2017; Long et al., 2018). Specifically, the MFN reflects the discrepancy between an expected outcome and the actual outcome; i.e., a larger discrepancy elicits a greater MFN amplitude (Holroyd and Coles, 2002).

In addition to MFN, the late positive components, including P300 and LPP within the 300–600 ms time window following the display of the proposal, are also affected by the fairness of the offer. The P300/LPP appears to reflect later top-down cognitive processing such as motivational affective evaluation and attention allocation for possible outcomes (Boksem and De Cremer, 2010; Massi and Luhmann, 2015, Zheng et al., 2015). Prior research used an adapted UG paradigm showed that P300/LPP was more positive during fair offers than unfair offers (Wu et al., 2011a, b, 2012; Qu et al., 2013; Hu et al., 2014; Ma et al., 2015, 2017), and it could be modulated by various social contexts, such as responsibility level of an outcome, social status, social comparison, social exclusion, initial ownership and social distance (Li et al., 2010; Wu et al., 2011a, b, 2012; Qu et al., 2013; Hu et al., 2014; Yu et al., 2015). For example, fair offers induced a larger late positive component (LPP) than unfair offers, and this effect is influenced by the proposer's social status; the unfair offers from a proposer with high social status induced a greater LPP amplitude compared with offers made by those with low social status (Hu et al., 2014). In a social comparison context, fair reward between self and others also elicits larger LPP than unfair proposals or outcomes (Qiu et al., 2010). Additionally, the P300 component is related to prosocial decision making; larger P300 amplitudes could predict intuitive motivation for and subsequent engagement in pro-social behavior (Carlson et al., 2015).

In the present study, we conducted two experiments to investigate brain responses to unfair proposals and how those unfair proposals influence participants' charitable donation. In order to test the modulation of fairness to giving behaviors, we designed a donation game adapted from UG. In the present study, the proposer was asked to make offers for self and partner to donate a certain amount to a charity instead of splitting the money. If the participant (responder) accepted the offer, both of players would donate the amount of money as the proposer suggested; otherwise, the participant would donate nothing while the proposer would still donate the money as suggested by himself/herself. In the first experiment, we manipulated the fairness of the proposal from a stranger, and the proposals were presented to the participant, depicted by graphical bars showing the relative ratio of the contributions. We hypothesized that the negative feelings of unfairness would impair one's willingness to perform pro-social acts toward others. In the second experiment, we aimed to replicate the results of experiment 1, but with the deservingness of beneficiaries manipulated. Based on previous studies (Guo et al., 2013; Zheng et al., 2017), we hypothesized that participants would donate less money when facing unfair proposals and when deservingness of the beneficiaries was low. Based on the ERP literature reviewed above, we also predicted that fair proposals would elicit reduced MFN and larger P300/LPP than the less fair conditions. The electrophysiological signals related to the processing of proposals might predict subsequent donation behaviors.

2. Experiment 1

2.1. Material and methods

2.1.1. Participants

Twenty-two right-handed volunteers from Shenzhen University participated in this experiment. One participant was excluded due to excessive recording artifacts. The remaining twenty-one participants were aged between 18 and 25 years (Mean = 21.43 years, SD = ± 2.06 years; 7 females). All participants had normal or corrected-to-normal vision, and had no history of brain injury or neurological disorders. The experiment was approved by the Medical Ethical Committee of Shenzhen University. Before the experiment, all subjects provided written informed consent.

2.1.2. Design, materials and procedure

All charitable organizations were selected from the Tencent Foundation and were briefly described by several sentences in Chinese. These sentences contained approximately equal word counts and were displayed in a uniform layout. Before the experiment, participants were informed that the proposer and responder both received ¥50.00 Chinese Yuan for participating and an extra ¥10.00 that could be voluntarily donated from the experimenter.

Participants sat in front of a computer screen at a distance of 80 cm. The experiment consists of 10 blocks. In each block, participants were first presented with a short description of a charitable organization, including an example of the charity's activities, its beneficiaries, name, and main goal. After reading the introduction, they completed 30 trials in this block. In each trial, a proposer proposed a donation (i.e., how much money would be donated to the charitable organization); e.g., proposer donates 5 yuan and responder donates 5 yuan. The participants were told that they would act as the responder in the donation task. The proposals made by anonymous proposers had been collected from previous behavioral studies and were unknown by the responders. There were 8 trials for each of the three offer levels (fair, moderately unfair, highly unfair) and 6 trials with a filler condition. The highly unfair proposals included 1/9, 1/8, 1/7, 1/6; moderately unfair proposals included 4/9, 4/8, 3/7, 3/6; fair proposals included 6/6, 7/7, 8/8, 9/9, where the numerical pairs represent the relative contribution from the proposer and the responder, respectively. The filler proposals were randomly selected from the pool of any other number pairs except those mentioned in the three conditions (Table 1). As shown in Fig. 1, each trial began with a 2000 ms presentation of the identification number of the proposer. A blank screen was subsequently presented for 400–700

Table 1
Offer conditions in Experiment 1. The cells show the possible donation offers that could be proposed. Offers were categorized as fair, moderately unfair, and very unfair. The number pairs indicate the amount to be donated by the responder (participant) and the proposer, respectively. Filler offers were all possible number pairs that were not used in the three fairness categories.

Fair offers	Moderately unfair offers	Highly unfair offers	Filler offers								
9/9	9/4	9/1	1/1	5/5	5/4	9/8	6/4	4/1	9/6	7/2	9/2
8/8	8/4	8/1	2/2	2/1	6/5	3/1	7/5	5/2	5/1	8/3	
7/7	7/3	7/1	3/3	3/2	7/6	4/2	8/6	7/4	6/2	8/2	
6/6	6/3	6/1	4/4	4/3	8/7	5/3	9/7	8/5	8/5	9/3	

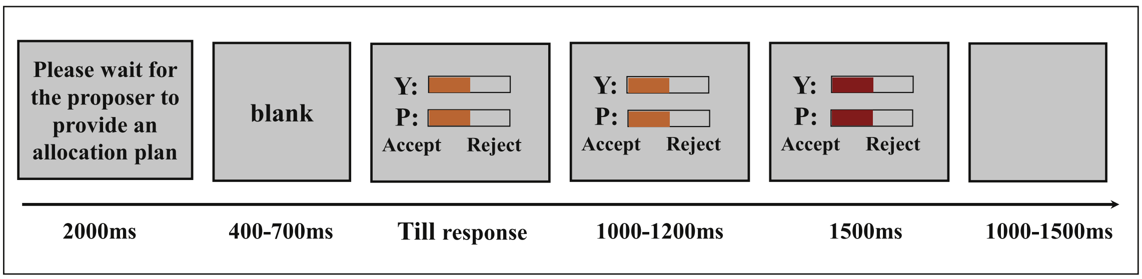

Fig. 1. An illustration of the experimental procedure of a single trial in Experiment 1. The participants first saw the identification number of the proposer prior to the offer presentation. The participants made their choices by pressing "F" or "J" to decide to accept or reject the offer, respectively. After 1000–1200 ms, the final results were displayed in red bars on the screen. Y indicates the amount proposed for the responder to donate; P indicates the amount proposed for the proposer to donate. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

ms, then the proposer's offer was presented on the screen represented by a rectangle; the longer the red rectangle, the more money proposed. The letters "Y" and "P" were used to identify the participant and proposer, respectively. Participants (responders) had sufficient time to decide to either accept or reject the offer by pressing the "f" key or the "j" key, respectively. If a participant accepted the offer, he and the proposer would donate the amount of money the proposer suggested; otherwise, the participant would donate nothing and the proposer would still donate the money he or she suggested. The final results of the total amount donated by the responder and proposer were displayed for 1500 ms. The intertrial interval was 1000–1500 ms. To acclimatize to the task before the formal experiment, participants familiarized themselves with the procedure by practicing 20 trials. At the end of the task, one of the independent trials would be randomly selected and carried out as proposed. Thus, the proposer and responder received 50 yuan plus any money left over from the 10 yuan used to propose donations.

When the participants completed all trials, they were asked to rate the degree of unfairness for each offer using a 7-point Likert-type scale (1 = extremely fair, 7 = extremely unfair).

2.1.3. Electroencephalogram recordings

EEG recordings were acquired (band-pass: 0.01–100 Hz; sampling rate: 1000 Hz) from a 64-electrode scalp cap (Brain Products GmbH, Munich, Germany) according to the 10–20 standard international system. The ground electrode was placed on the medial frontal line between Fz and FPz. The FCz was chosen as an online reference, and the right and left mastoids were digitally converted to averages for use as re-references offline. The vertical electro-oculogram (VEOG) was recorded from an electrode placed below the right eye. All electrode resistances were maintained below 10 kΩ.

2.1.4. Data analysis

A one-way repeated measures analysis of variance (ANOVA) was conducted to compare the acceptance rates and reaction times (RT) for the three fairness conditions: fair, moderately unfair, highly unfair. All post hoc analyses were conducted using the Bonferroni correction.

The electrophysiological signals were analyzed using BrainVision Analyzer 2.0 software (Brain Products GmbH, Munich, Germany). The signal was filtered by a 0.1–20 Hz digital band-pass filter. Independent component analysis (Jung et al., 2001) was used to correct for EOG artifacts. The EEGs were segmented from 200 ms before and 1500 ms after the presentation of the offer. The whole epoch was baseline-corrected afterward by the 200 ms interval before the offer was presented. Epochs with amplitude values over ±80 μV were identified as artifacts and rejected from calculation of the final averages. No more than 5% of trials were excluded for each condition. Finally, the EEG epochs were averaged for the fair, moderately unfair, and highly unfair conditions, separately.

On the basis of prior ERP studies related to fairness (Massi and Luhmann, 2015; Ishikawa et al., 2017), and visual inspection of averaged waveforms and scalp distribution, we analyzed the ERP components of LPP at CPz. The ERP amplitude from the time interval of 1000–1250 ms after presentation of the offer was averaged for the LPP analyses. The LPP amplitudes were compared by one-way repeated measures ANOVA (offer fairness: fair, moderately unfair, highly unfair). The Greenhouse-Geisser correction was applied where appropriate when there were violations of sphericity.

2.2. Result

2.2.1. Behavioral results

Fig. 2A shows the averaged fairness ratings for the three offer conditions. A one-way ANOVA revealed a significant main effect of offer conditions, $F(2, 40) = 74.19, p < 0.001, \eta^2 = 0.79$. The post hoc analysis indicated that the fairness ratings of fair offers (mean ± SE = 1.79 ± 0.21) were significantly higher than moderately unfair (4.24 ± 0.27; $p < 0.001$) and highly unfair offers (5.60 ± 0.35; $p < 0.001$), and the fairness ratings of moderately unfair offers were significantly higher than highly unfair offers ($p < 0.001$). For the RT, as illustrated in Fig. 2B, the results revealed a significant main effect of fairness, $F(2, 40) = 4.54, p < 0.05, \eta^2 = 0.19$. Post hoc analysis found that the RTs for fair offers (1319 ± 87 ms) were significantly shorter than for moderately unfair offers (1550 ± 114 ms; $p < 0.01$) and highly unfair offers (1477 ± 110 ms; $p < 0.01$), but there was no significant RT difference between the moderately unfair and the highly unfair offer conditions ($p = 0.45$). For the acceptance rate, the analysis also revealed a significant main effect of fairness, $F(2, 40) = 17.00, p < 0.001, \eta^2 = 0.46$. The post hoc tests indicated that the acceptance rate of fair offers (0.74 ± 0.07) was

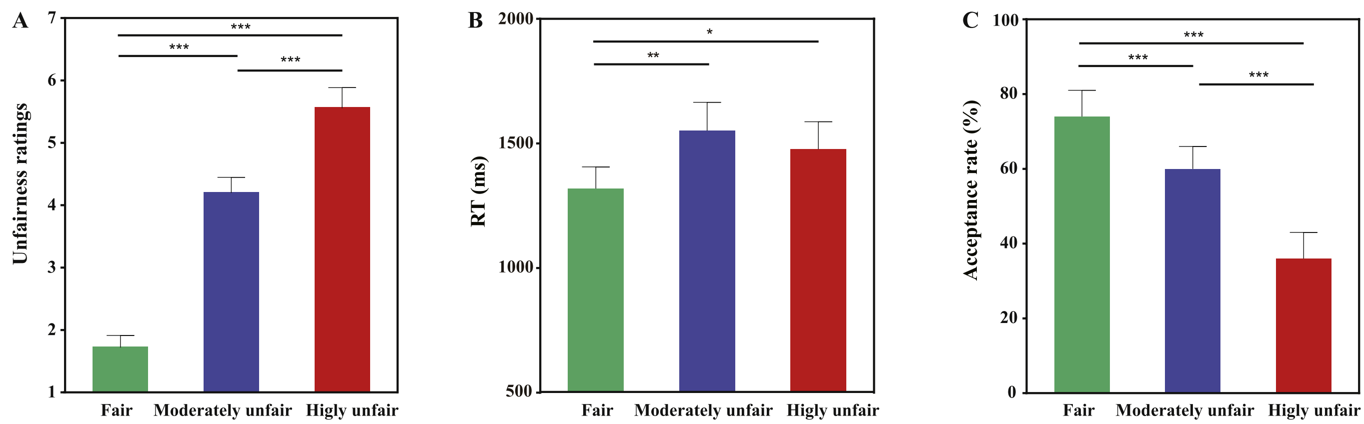

Fig. 2. The behavioral results of Experiment 1. (A) Fairness ratings of the three offer conditions. (B) Reaction time of the three offer conditions. (C)Acceptance rate of the three offer conditions. Error bars represent standard errors of the means. RT = response time. * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$.

significantly higher than for moderately unfair (0.60 ± 0.06; $p < 0.001$) and highly unfair offers (0.36 ± 0.07; $p < 0.001$), and the acceptance rate of moderately unfair offers were significantly greater than for highly unfair offers ($p < 0.001$) (Fig. 2C).

2.2.2. ERP results

Fig. 3 illustrates the grand-averaged ERP waveforms at CPz and the topographies of LPP in each fairness condition over the 1000–1250 ms time interval. The ANOVA revealed a significant effect of offer fairness, $F(2, 40) = 5.45$, $p < 0.01$, $\eta^2 = 0.21$. The post hoc analysis showed a more positive LPP for the fair offers (4.33 ± 0.62 μV) compared to the moderately unfair offers (3.52 ± 0.51 μV; $p < 0.01$) or the highly-unfair offers (3.31 ± 0.60 μV; $p < 0.05$); However, no significant difference was found between the moderately unfair offer and the highly unfair offer condition ($p = 0.51$).

2.2.3. The correlation between ERP amplitudes and behavioral data

For each participant, we calculated the difference between the mean amplitude of LPP responses for fair vs. moderately unfair offers (i.e., fair minus moderately unfair LPP amplitude), and fair vs. highly unfair offers, then calculated the difference of acceptance rate between fair and moderately unfair offer conditions (i.e., fair - minus-moderately unfair) acceptance rate), and between fair and highly unfair offer conditions. Pearson's correlation analysis was performed to measure the relationship between the difference of LPP and the difference of participants' acceptance rate between each pair of fairness conditions. The same analysis was performed for the correlation between LPP amplitude and RT data as well, however, no significant correlation was found (all *ps* > 0.05).

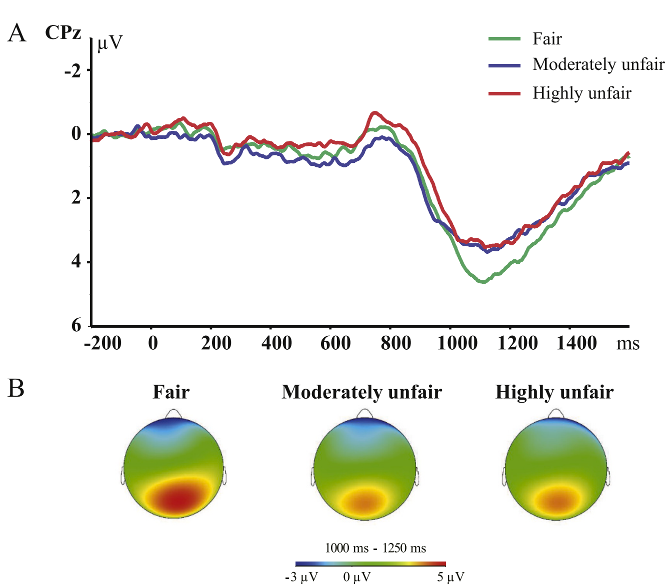

Fig. 3. (A) The grand-average event-related potential (ERP) waveforms at CPz in Experiment 1. (B) The topographies of LPP in the 1000–1250 ms time window in Experiment 1.

2.3. Discussion

Using ERP measurements, experiment 1 employed a donation game adapted from the UG to explore the recipients' perception of fairness during the allocation of charitable donations. Participants reported linearly decreasing fairness feeling from fair offer, moderately unfair offer to highly unfair offer, which confirmed that the present experimental manipulation was valid. Consistent with previous studies (Twenge et al., 2007; Zitek et al., 2010), our data also demonstrated that participants' acceptance rates decreased as the degree of unfairness increased. Moreover, participants made faster decisions in the fair offer condition than in the moderately unfair and highly unfair conditions, suggesting that unfair proposals may induce a cognitive conflict between inequity aversion and pro-social behaviors. Notably, the magnitude of money was tantamount across the three conditions; thus, the reduced acceptance to donate could be caused by negative feelings following unfair proposals.

ERP recording during the proposal phase showed that LPP, a late component related to outcome evaluation, was modulated by fairness—— the mean amplitude of LPP for fair offers was larger than that for the moderately unfair and highly unfair offer conditions. Compared with the unfair conditions, the fair offer has more social reward value in terms of social equality (Tabibnia and Lieberman, 2007; Tabibnia et al., 2008). Therefore, we argue that the LPP-induced reward-related brain signals are associated with positive outcomes that comply with social norms. The fair offers elicited the largest LPP amplitudes at the central-parietal region compared to the other offer conditions in the present experiment, consistent with the ERP findings in previous UG studies (Wu et al., 2011a, b, 2012; Hu et al., 2014). Interestingly, these previous studies have shown that LPPs elicited by highly unfair offers are larger than those induced by moderately unfair offers; however, we found no significant difference between the LPP in these two conditions in our own study. This inconsistent finding may due to the fact that the magnitude of monetary gain for participants and the level of unfairness is co-varied in a typical UG paradigm; less money for participants correlates with a higher sense of unfairness. Thus, the ERP results in previous UG studies may reveal an interaction effect between inequality aversion and arousal caused by low monetary gain (Zhou et al., 2014).

Unfortunately, we did not observe a significant correlation between LPP amplitude and acceptance rate, perhaps due to the relatively small sample size in this experiment 1.

In addition to the internal motivation of a donor, the characteristics of the beneficiaries have also been found to influence charitable donation. For example, people respond more generously to clearly identifiable victims compared to abstract victims (Cryder and Loewenstein, 2010). In an online fundraising context, individuals were more likely to participate in fundraising activities if the recipient's name was the same or similar to their own (Burger et al., 2004). Likewise, that previous study showed that facial attractiveness of women and the reputation of the charity could enhance charitable giving as well (Meijer, 2009; Park et al., 2019). Given that self-reported deservingness was a significant predictor of the magnitude of donations (Hare et al., 2010; Batson, 2011), we also manipulated the deservingness of the charity project (i.e, how much the beneficiaries deserve to be supported (Tusche et al., 2016) in Experiment 2 to investigate whether the main findings of Experiment 1 would still be robust when considering the description and characteristics of a charity project.

Additionally, we also made several adjustments to the way stimuli were presented in Experiment 2. We originally used the length of the red rectangle to represent the amount of money proposed for donation in Experiment 1 in order to visually depict the contrast between the proposed money from proposers and responders. However, this manipulation may cause some problems if participants cared about the exact amount of money they would donate. This concern was evident in long RTs and the latency of the LPP components. Therefore, we replaced the red rectangle by numbers in Experiment 2 to provide more concrete numerical information of the amount of money being proposed for donation. Second, we asked participants to respond in a later phase following the offer presentation to separate stimulus-locked brain activities from response-locked signals. Third, compared with receiving pre-defined offline proposals from previous participants, participants in Experiment 2 were told that the proposal they received was made online by another participant who was participating in this experiment with them. This adjustment was made in order to enhance the ecological validity.

3. Experiment 2

3.1. Material and methods

3.1.1. Participants

Twenty-nine right-handed volunteers from Shenzhen University participated in this experiment. Two participants were excluded due to excessive recoding artifacts; the remaining twenty-seven participants (seven females) were aged between 19 and 25 years (mean = 20.85 years, SD = 1.77 years). All participants had normal or corrected-to-normal vision and had no history of brain injury or neurological disorders. The experiment was approved by the Medical Ethical Committee of Shenzhen University. Before the experiment, all subjects provided written informed consent. We recruited two graduate students (one female) as experimental assistants to act as proposers for the donation task. Considering the influence of different sex pairings on decision-making during social interactions (Kettner and Ceccato, 2014; Sutter et al., 2009), we matched all participants with a proposer of the same sex in the donation game.

3.1.2. Design, materials and procedure

All charitable organizations were evaluated in the same way as in Experiment 1. Sixty charitable organizations were rated for deservingness (from 1 = "not deserving at all"to 7 = "extremely deserving") by 20 volunteers (10 females; mean age = 21.10 years, SD = 1.17 years) prior to the ERP experiment. Ten charitable organizations were selected and categorized into two groups: high-deservingness and low-deservingness (each group had 5 charitable organizations). A paired *t*-test was conducted on the rating of the deservingness of the two categories and the results showed that the deservingness was significantly different between two categories [high deservingness: mean = 5.82 ± 0.67; low deservingness: mean = 4.44 ± 0.97; $t(19) = 18.45$, $p < 0.001$, Cohen's $d = 1.65$].

In this experiment, each participant first met another same-sex participant who was secretly an experimental assistant. Then, participants were told that they would complete a donation task with this stranger in a separate room with a computer connected via local internet. They were informed that and they were randomly assigned to different roles: proposer or responder; though, in reality, all of them were predetermined to be responders in the joint donation task. Similar to Experiment 1, the proposer and responder were informed that they would receive a ¥10.00 endowment to be used for allocation of charitable donations in addition to the ¥50.00 basic compensation provided by the experimenter.

The experiment consists of 10 blocks. In each block, participants were first presented with a short introduction to a charitable organization, including an example of the charity's activities, its beneficiaries, name and main goal. After they had read the introduction, they completed 36 trials. There were 10 trials for each of the three offer levels (fair, moderately unfair, highly unfair) and 6 trials for a filler condition. Based on the ratio of the amount to be donated by the proposer and responder, all the trials were divided into three different offer conditions: fair, moderately unfair and highly unfair conditions as shown by different colors in Fig. 4A. A depiction of a single trial is shown in Fig. 4B. Each trial began with a 2000 ms presentation to indicate a wait for proposer's offer, then a blank screen was subsequently presented for 400–700 ms. Then the proposer's offer of how much money would be donated to the charitable organization was shown to the participant. After another blank screen, a decision cue appeared and the participant (responder) was asked to make a decision to either accept or reject the offer by pressing the '"F″ key or "J" key, respectively, without a time limit. If accepted, he/she and the proposer would donate the amount of money the proposer suggested; otherwise, the responder would donate nothing and the proposer would still donate the money he/she suggested. As soon as the responder made the decision, the final payout for the charitable organization was presented for 1500 ms, then the next trial began. To acclimatize, before the start of the formal experiment, participants familiarized themselves with the procedure by practicing 20 trials.

When the participants completed all trials, they were asked to rate the degree of unfairness for each offer using a 7-point Likert-type scale (1 = extremely fair, 7 = extremely unfair).

cells indicate highly unfair offers; blue cells indicate moderately unfair offers; green cells indicate fair offer. Number pairs in other cells (uncolored) were possible combinations used in filler trials. **(B)** The participants first waited 2000 ms followed by a blank screen prior to the presentation of the offer. The participants made their choices by pressing the corresponding keys to either accept or reject the offer. There was no time limit to make a decision. The screen subsequently displayed the final payouts to the charity. In this example, the proposer suggested both he/she and the responder donate six Yuan each; the offer was accepted and the charity received 12 Yuan.

3.1.3. EEG recordings

The EEG system and recording parameters were the same in Experiment 2 as in Experiment 1.

3.1.4. Data analysis

The EEG signals were analyzed using BrainVision Analyzer 2.0 software (Brain Products GmbH, Munich, Germany). The signal was first filtered through a 0.1–20 Hz digital band-pass filter. Independent component analysis (Jung et al., 2001) was used to correct for EOG artifacts. The EEGs were segmented from 200 ms before the offer presentation to 1000 ms after the presentation of the offer. The whole epoch

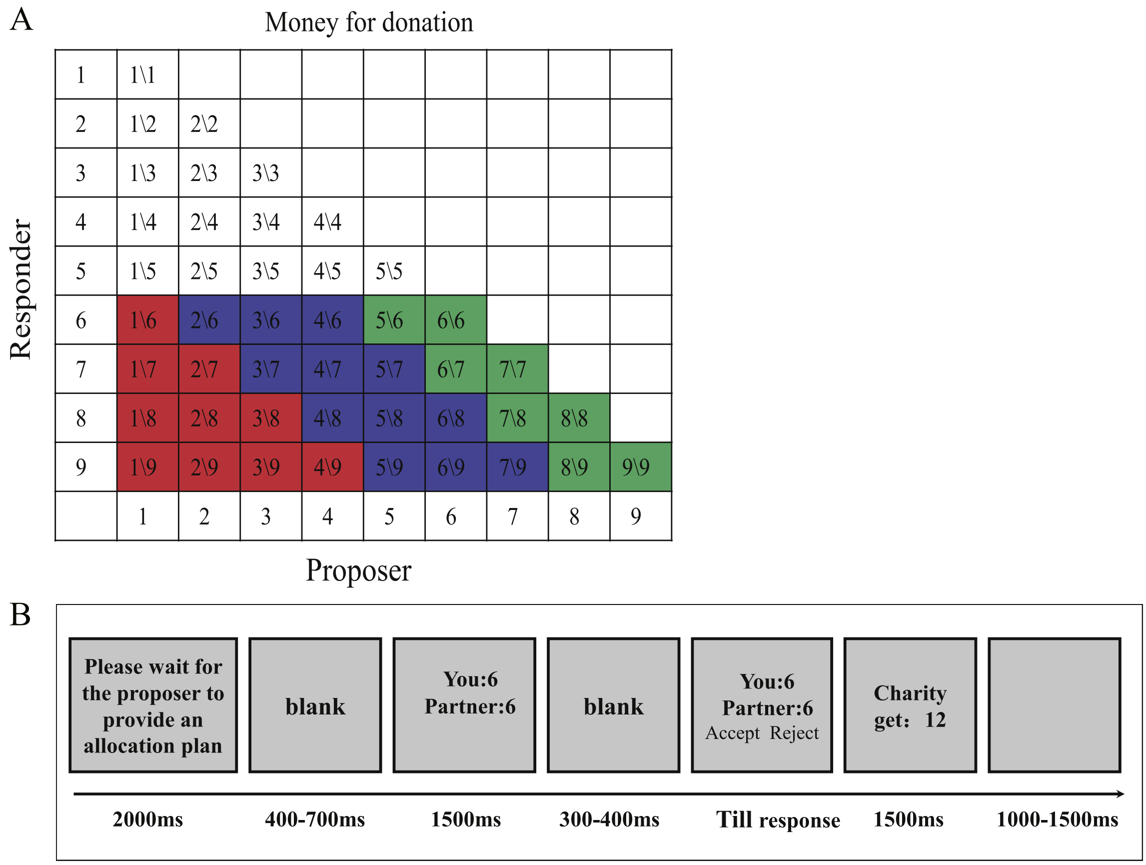

Fig. 4. Offer conditions and an illustration of the experimental procedure in one trial of Experiment 2. (A) The cells show the proposed donation offer based on how much money the proposer (horizontal axis) and the responder (vertical axis) should donate. Red. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

was baseline-corrected afterward by the 200 ms interval before the offer presentation. Epochs with amplitude values over ±80 μV were identified as artifacts and excluded from the final average calculation. No more than 5% of trials were excluded for each condition. Finally, the EEG epochs were separately averaged for deservingness of the charity (high, low) × offer fairness (fair, moderately unfair, highly unfair), yielding six conditions: low deservingness-fair, low deservingness-moderately unfair, low deservingness-highly unfair, high deservingness-fair, high deservingness-moderately unfair and high deservingness-highly unfair. Based on prior ERP studies related to fairness as well as inspection of the waveforms in Experiment 2 (Wu et al., 2011a, b, 2012; Qu et al., 2013; Hu et al., 2014), we focused on the P300 component at CPz. The ERP waveforms in the time interval of 450–650 ms after the presentation of the offer were averaged for analyses. The original P300 amplitude was submitted to a 2 (deservingness: high and low) × 3 (offer fairness: fair, moderately unfair, highly unfair) repeated measures ANOVA. The same ANOVA was also conducted on the acceptance ratios and RTs. The Greenhouse-Geisser correction was applied where appropriate to address violations of sphericity.

Notably, we did not observe an obvious MFN component that is frequently reported (Polezzi et al., 2008; Boksem and De Cremer, 2010; Hewig et al., 2011; Wu et al., 2011a; Alexopoulos et al., 2012; Hu et al., 2014; Ma et al., 2015, 2017; Long et al., 2018). Given that the MFN commonly overlaps with later positive deflections, such as P300, we ran a spatiotemporal principal component analysis (PCA) to parse the ERP waveform into its underlying constituent components (Foti et al., 2009). The spatiotemporal PCA was conducted by using the ERP PCA toolkit (Dien, 2010; Proudfit, 2015). The PCA-P300 amplitude was also analyzed by a 2 (deservingness: high and low) × 3 (offer fairness: fair, moderately unfair, highly unfair) repeated measures ANOVA.

3.2. Results

3.2.1. Behavioral results

Fig. 5A shows the averaged unfairness ratings for the three offer conditions. A one-way ANOVA revealed a significant main effect of offer conditions, $F(2,52) = 90.19$, $p < 0.001$, $\eta^2 = 0.78$. The post hoc analyses indicated that the unfairness ratings of fair offers (2.05 ± 0.20) were significantly lower than moderately unfair (3.92 ± 0.18; $p < 0.001$) and highly unfair offers (5.63 ± 0.21; $p < 0.001$), and the unfairness ratings of moderately unfair offers were significantly lower than highly unfair offers ($p < 0.001$). For the acceptance rate, the two-way ANOVA revealed a significant main effect of offer fairness, $F(2,52) = 55.37$, $p < 0.001$, $\eta^2 = 0.68$. The post hoc analysis indicated that the acceptance rates of fair offers (0.80 ± 0.04) were significantly higher than moderately unfair (0.62 ± 0.06; $p < 0.001$) and highly unfair offers (0.28 ± 0.06; $p < 0.001$), and the acceptance rates of moderately unfair offers were significantly greater than highly unfair offers ($p < 0.001$). There was no significant main effect of deservingness, $F(1, 26) = 2.76$, $p = 0.109$, $\eta^2 = 0.10$, and no significant interaction between deservingness and offer fairness, $F(2, 52) = 0.77$, $p = 0.49$, $\eta^2 = 0.03$ (**Fig. 5B).**

3.2.2. ERP results

3.2.2.1. Original P300. As shown in Fig. 6A and **C,** the ANOVA comparing the P300 revealed a significant main effect of offer fairness, $F(2,52) = 5.93$, $p < 0.01$, $\eta^2 = 0.19$. The post hoc tests revealed a more positive P300 for the fair offers (4.69 ± 0.65 μV) compared with the moderately-unfair offers (3.70 ± 0.65 μV; $p < 0.01$) or the highly-unfair offers (4.07 ± 0.70 μV; $p = 0.08$); No significant difference was found between the P300 amplitude of the two unfair conditions ($p = 0.13$).

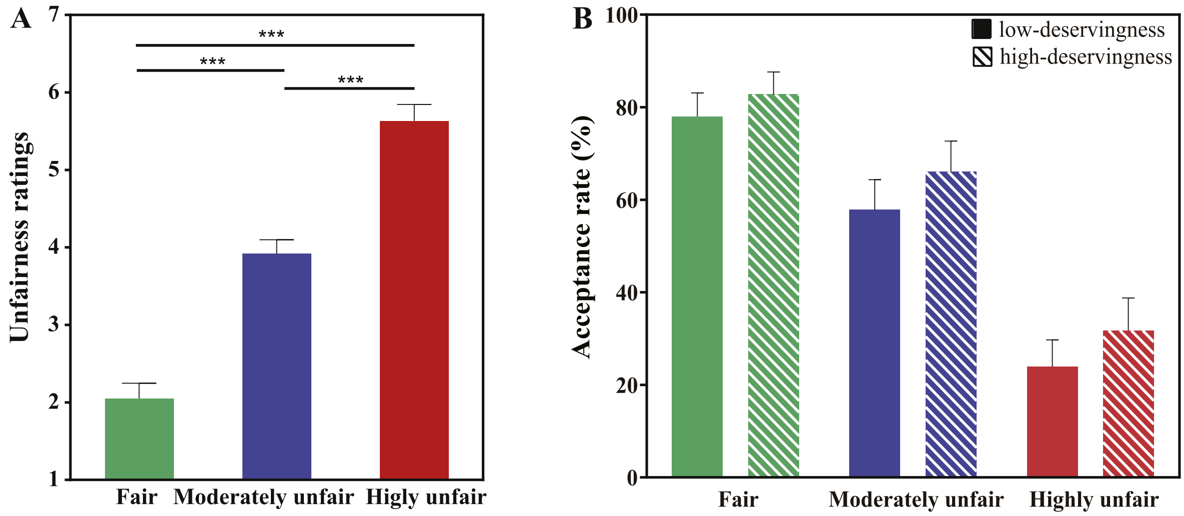

Fig. 5. The behavioral results of Experiment 2. (A) Unfairness ratings for the three offer conditions. (B) Acceptance rates for the six conditions. Hatched bars represent charities classified as having high deservingness; solid bars represent charities classified as having low deservingness. Error bars represent standard errors of the means.

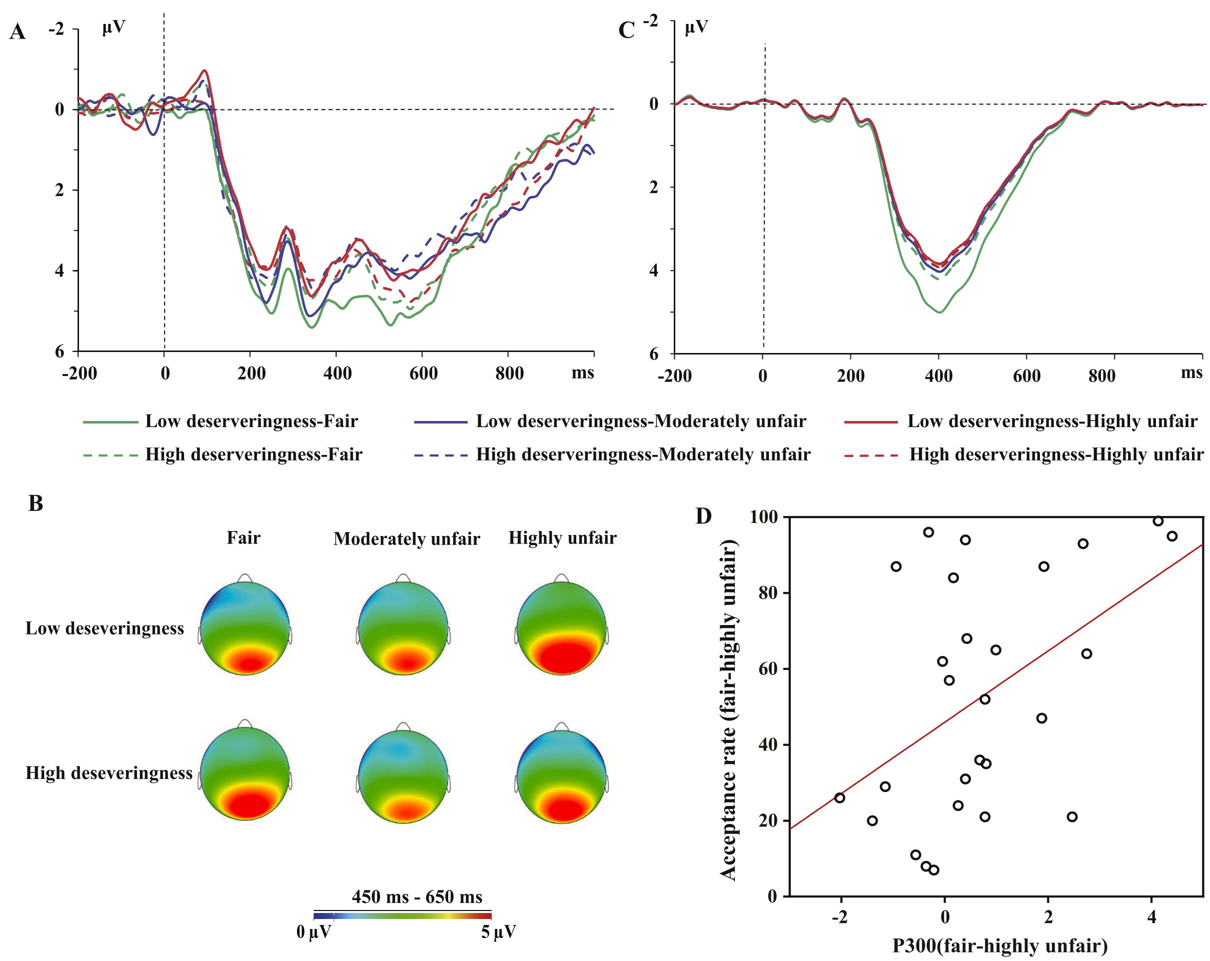

Fig. 6. The ERP results of experiment 2. (A) The ERP grand-average waveforms of P300 for the six combinations of offer fairness and deservingness of the charity, measured at CPz; the time window for measuring P300 was 450–650 ms. (B) Topographic maps for the P300 in the 450–650 ms time window. (C) The PCA-ERP grand-average waveforms of P300 for the six combinations of offer fairness and deservingness of the charity, measured at CPz; the time window for measuring PCA-P300 was 350–450 ms. (D) Correlation between P300 amplitudes and acceptance rates. The horizontal axis is the mean amplitude P300 of (fair-highly unfair) and the longitudinal axis is the acceptance rates of (fair-highly unfair).

There was no main effect of deservingness [$F(1,26) = 0.07$, $p = 0.80$, $\eta^2 = 0.003$] or interaction of deservingness × fairness [$F(1,26) = 2.10$, $p = 0.13$, $\eta^2 = 0.075$].

3.2.2.2. PCA-derived P300. The PCA analysis yielded four spatial and nine temporal factors, which accounted for 95% and 86% of the total variance, respectively. The temporospatial PCA was performed consistently based on previous research (Foti et al., 2009, 2011). Based on the averaged screen plot for all temporal factors, the Temporal Factor 2 and Spatial Factor 2 (TF2/SF2) were selected as the component potentially corresponding to the PCA-P300. As shown in Fig. 6B, the ANOVA revealed a main effect of offer fairness, $F(2,52) = 3.93$, $p < 0.05$, $\eta^2 = 0.13$. The post hoc analysis showed that the fair offers (4.61 ± 0.61 μV) elicited larger P300s compared with the moderately-unfair offers (3.93 ± 0.60 μV; $p < 0.05$) and the highly-unfair offers (3.89 ± 0.59 μV; $p < 0.05$). No significant difference was found between the PCA-P300 amplitudes in the moderately-unfair and highly-unfair conditions ($p = 0.84$). There was no main effect of deservingness [$F(1,26) = 1.23$, $p = 0.28$, $\eta^2 = 0.05$] or an interaction of deservingness × fairness [$F(1,26) = 0.93$, $p = 0.40$, $\eta^2 = 0.03$]. We did not observe any component that had similar temporospatial features associated with MFN/FRN reported by previous studies (Foti et al., 2011; Yin et al., 2018).

3.2.3. The correlation between ERP amplitude and behavioral data

For each participant, we extracted the difference between the mean amplitude of P300 responses for fair vs. moderately unfair offers (i.e. fair-minus-moderately unfair P300 amplitude differences), as well as the difference for fair vs. highly unfair offers. We then calculated the difference in acceptance rates between fair offers and moderately unfair offers (i.e. fair-minus-moderately unfair acceptance rate differences), as well as the difference for fair offers vs. highly unfair offers. Pearson's correlation analysis was performed to assess the relationship between the difference of P300 and the difference of acceptance rates for each offer fairness condition. For the original P300, no significant correlations were found (all *ps* > 0.05). However, For the PCA-derived P300, a significant positive correlation was revealed between the difference of mean amplitude and acceptance rate (fair-highly unfair) ($r = 0.47$, $p = 0.013$). This correlation demonstrated that participants who had smaller P300 amplitudes in highly unfair condition relative to fair condition, accept less highly unfair offer correspondingly (Fig. 6D).

3.3. Discussion

In Experiment 2, we manipulated both deservingness of the charity and fairness of the offers, and the results replicated the main findings of Experiment 1. Participant's feeling of unfairness increased as the offer become more unequal, which indicated that our manipulation for the unfairness was valid. Corresponding to the rating of unfairness, recipients were more prone to accept a fair donation offer, which was consistent with previous studies (Twenge et al., 2007; Zitek et al., 2010). This observation further confirmed the robust effect that a sense of unfairness reduces individuals' pro-social behaviors. In contrast, the deservingness of charitable organizations did not affect the subjects' decisions, which was not consistent with the findings of previous studies (Hare et al., 2010; Batson, 2011). A possible explanation is that the deservingness of charitable organizations is very subjective and varies among individuals. To test this possibility, we actually asked our participants to rate the deservingness of each charitable organization after the formal ERP experiment. The behavioral results showed that participants' ratings of deservingness were significantly different between high deservingness (mean ± SD = 5.80 ± 1.02) and low deservingness (5.08 ± 0.97) conditions ($t(26) = 4.06$, $p < 0.001$, Cohens' $d = 0.72$), suggesting that the manipulation was successful. However, participants' ratings of the deservingness of charitable projects in both pre-determined conditions were relatively higher than the middle point of a 1–7 scale, which may have impaired the ability to detect differences in brain activity.

The current study also showed that the mean amplitude of P300 was larger for fair offers than for moderately unfair and highly unfair offers, which is in accordance with previous studies employing typical UG paradigms (Ma et al., 2015, 2017). The correlation analysis in Experiment 2 suggested that the difference in acceptance rates between fair and highly unfair offers was associated with an increase in the difference of PCA-P300 amplitudes between the two conditions. This correlation suggested that the P300 amplitude elicited by offers could predict subsequent donations after controlling for component overlap. Likewise, previous studies have also shown that larger P300 amplitude is related to pro-social behaviors (Carlson et al., 2015; San Martín et al., 2016). P300 has been commonly linked with reward processing associated with positive vs. negative feedback (Yeung and Sanfey, 2004; Hajcak et al., 2007) or large vs. small rewards (Sato et al., 2005) in economic games. More recent research has found that positive social feedback increases P300 amplitudes as well (Van der Molen et al., 2014; van der Veen et al., 2013). Since fair offers could bring more happiness and enhance brain activity in reward-related regions than unfair offers (Tabibnia and Lieberman, 2007), it is plausible that fair offers convey social rewards that drive more altruistic behaviors.

4. General discussion

In the present study, we employed a modified version of the UG to investigate whether fairness impacted decisions to donate to charitable organizations in two experiments, and we further assessed whether perceived deservingness of the charity affected the donation decisions made in Experiment 2. Specifically, we examined whether LPP or P300 amplitude could predict the motivational salience of an unfair donation offer and the subsequent donation. Behavioral results in both experiments showed that participant acceptance rates for offers proposed by the donor decreased with the unfairness level of the offers, whereas the deservingness of charities did not significantly influence donation behaviors in Experiment 2. At the neural level, the late positive component of the ERP was modulated by offer fairness, showing larger positive deflections (P300/LPP) in fair offers than moderately unfair and highly-unfair offers. Moreover, we found that the PCA-P300 amplitude was correlated with acceptance of the donation offer, suggesting that brain responses to fairness could predict subsequent giving decisions after controlling for component overlap.

Taken together, we found that the higher sense of unfairness leads to a decrease in pro-social behavior toward a third-party who was unrelated to the original unfairness. As mentioned, participants accept more offers and have lower unfairness ratings in the fair condition than unfair conditions, suggesting that they were actually willing to donate a certain amount of money because the total monetary magnitude of the possible offers was equivalent across the three conditions. Therefore, the reduced donations were mainly driven by the unfairness of proposals. The motivation to behave pro-socially and to reject unfair proposals seems to cause increased cognitive processing as evidenced by the long RTs in the highly unfair condition. Various motivations associated with charitable giving have been proposed, including a desire purely to improve the well-being of others, but also to experience an intrinsic reward (warm glow) associated with helping others (Andreoni, 1989; Nunes and Schokkaert, 2003; Moll et al., 2006; Harbaugh et al., 2007; Aknin et al., 2012; Dunn et al., 2014). The present study further indicated that negative feelings associated with inequity aversion impaired some intrinsic motivations for pro-social behaviors, such as the aforementioned warm glow.

This argument was also supported by the electrophysiological data. Specifically, fair offers elicited larger late positive components (P300/LPP) than unfair offers did. Due to the differences in the way stimuli were presented, the LPP in Experiment 1 peaked hundreds of milliseconds later than the P300 in Experiment 2; however, the P300 component has very similar scalp distribution as the LPP. The LPP component was believed to be linked to several psychological processes, including attention resource allocation (Hajcak et al., 2010) and the motivational significance of possible outcomes (Li et al., 2010; Massi and Luhmann, 2015; Ishikawa et al., 2017). Here, we argue that the larger P300/LPP component elicited by the fair offers reflects higher motivational significance than the unfair offers. First, fairness activates reward processing regions in the brain (Tabibnia and Lieberman, 2007; Tabibnia et al., 2008). Second, participants accepted most of the proposers' offers when they were fair; thus, both the proposer and responder could donate more money to a charity by cooperating with each other; these mutual benefits would extend to the innocent third party as well. The correlation between the P300 amplitude and acceptance rate in Experiment 2 further supports the argument that larger late positive activities predict greater motivation to accept charitable giving offers.

More importantly, our study provides a novel insight into social cooperation when the desire to punish an offending second-party hurts an innocent third-party. Robust findings showed that people would punish those who made unfair proposals even at a cost to themselves (e.g., rejecting the proposed money) to maintain social equity norms during resource allocation (Tricomi and Sullivan-Toole, 2015). In the present design, rejection did not have any financial impact on the proposer because the proposer would donate the proposed amount of money anyway, regardless of whether the responder accepted or refuse the offer. In fact, the participant's refusal only reduced the charity's income. Although participants were unable to punish unfair proposers by reducing their money in the present paradigm, they still chose to reject the unfair offers. The possible interpretation is that negative feelings evoked by unfairness impaired pro-social motivation to help others. Previous studies also showed that being treated unfairly or recalling a boring experience leads to selfish behaviors towards a third-party (Zitek et al., 2010; Gray et al., 2014; Wu et al., 2015). Another possibility is that the reduced charitable giving was merely a side-effect of rejecting unfair offers rather than a conscious desire to harm the third-party. Social rejection could lead to a transference of one's psychological distress onto others as physical pain (Eisenberger et al., 2003; Eisenberger and Lieberman, 2004; Eisenberger, 2015). Therefore, participants may intend to punish proposers through social rejection. Future studies are necessary to confirm these possibilities in such complicated norm-compliance contexts.

Although MFN is commonly reported in previous studies employing the UG paradigm (Polezzi et al., 2008; Hu et al., 2014; Ma et al., 2015), we did not find any significant effect during the typical MFN time window in either of the two experiments. These inconsistent findings may be due to a difference in paradigms between our study and previous UG studies. In a classical UG game, a responder and a proposer are asked to divide a certain amount of money, such as \$10. Thus, the total of money split between the responder and proposer is always equal to \$10, which makes the numerical processing relatively easier compared to the way the numbers were presented to participants in Experiment 2. Therefore, individual variations in numerical processing ability may reduce the synchronization of brain response to prediction error processing elicited by a proposed offer in the current context. Another possibility might be that participants did not have a clear expectation before the presentation of the offer because all matching of numbers (from 1 to 10) could be proposed by their partners. Unclear expectation also could reduce the magnitude of the MFN effect based on discrepancies between the expected and actual outcomes (Holroyd and Coles, 2002). These interpretations could also apply to the absence of the MFN effect in Experiment 1 because the graphical depiction of the offers made it even more difficult to think in terms of precise numbers than in Experiment 2. Notably, we also did not observe the temporospatial component associated with MFN/FRN that has been reported by previous PCA studies (Foti et al., 2011; Wang et al., 2017). These results demonstrated that the later positivity component played a more important role than the MFN effect in processing of offers within such a complex social context.

There were some limitations in the present study. First, we only adopted same-sex pairings of participants and proposers in order to shorten the experiments and to control for the possibility of heterosexual attraction (Bhogal et al., 2016; Kettner and Ceccato, 2014; Maestripieri et al., 2017); it is unknown whether opposite-sex pairings would have influenced the participants' behavior. Based on previous studies (Kettner and Ceccato, 2014; Sutter et al., 2009), we predicted that opposite-sex pairings could have increased acceptance rates and related neural activities compared to the same-sex pairings. Second, considering that individuals' baseline levels of generosity and willingness to donate in daily life might vary, it was not possible to control for due to the relatively small sample size in our study. With this concern in mind, we conducted post hoc power analyses using G*Power 3.1 (Faul et al., 2007, 2009) of the significant main effects in our study, including the main effect of fairness on RT, acceptance rate, and LPP amplitude in Experiment 1, and the main effect of fairness on acceptance rate and the original P300 and PCA-P300 amplitudes in Experiment 2. All of the post hoc statistical power calculations were greater than 0.99, except for the correlation between acceptance rate and PCA-P300 amplitude in Experiment 2, which was 0.76. These analyses suggested that the experiments were sufficiently powered, despite the small sample sizes. It would be valuable to measure participants' charitable behaviors in daily life and to assess the role personality plays in behaviors such as generosity in future studies.

5. Conclusion

In two experiments with symbolic and non-symbolic visual representations of monetary donations, we observed that the sense of unfairness modulated pro-social decision making. Higher acceptance rates and larger late positive ERP components (P300/LPP) were induced when participants received fair offers than moderately unfair and highly unfair offers. The correlation between P300 amplitudes and acceptance rate suggests that this late positive deflection works as an electrophysiological motivator for pro-social behavior. This study provided evidence that people reject unfair proposals to enforce social norms, even when such rejections resulted in negative outcomes to themselves or innocent third-parties.

Declarations of competing interest

None.

CRediT authorship contribution statement

Qiang Xu: Conceptualization, Methodology, Writing - original draft. **Shiyao Yang:** Visualization, Investigation, Validation. **Qiuyan Huang:** Methodology, Software, Investigation. **Shi Chen:** Methodology, Software, Investigation. **Peng Li:** Conceptualization, Supervision, Writing - review & editing.

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Appendix A. Supplementary data

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