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Social distance modulates recipient's fairness consideration in the dictator game: An ERP study

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ABSTRACT

Previous research showed that social distance (e.g., being friends or strangers) influences people's fairness consideration and other-regarding behavior. However, it is not entirely clear how social distance influences the recipient's evaluation of (un)fair behavior. In this study, we let people play a dictator game in which they received (un)fair offers from either friends or strangers while their brain potentials were recorded. Results showed that the medial frontal negativity (MFN), a component associated with the processing of expectancy violation, was more negative-going in response to unfair than to fair offers from friends whereas it did not show differential responses to offers from strangers. The P300 was more positive for fair than for unfair offers irrespective of friends or strangers making the offers. These results suggest that violation of social norms can be detected at an early stage of evaluative processing and that this detection can be modulated by social distance.

1. Introduction

Social norms, like fairness and morality, play a large role in societies (Coleman, 1990; Deutsch, 1975). Adhering to social norms or not often implies that people need to make choices between their self-interests and interests of other people. Previous research shows that the application of social norms depends to some degree on situational factors. For example, people's preferences are influenced by the valence of a bargained property (gains vs. losses) (Leliveld et al., 2009; Zhou and Wu, 2011) and by the power of those involved in the transaction (Handgraaf et al., 2008). In this study, we investigate the influence of social distance, or the degree of anonymity between the allocator and the recipient, on the adherence to social norms in economic transactions. More specifically, we study the role of social distance on recipients' fairness consideration of (un)fair economic behavior using the event-related potential (ERP) technique.

1.1. Social distance

The role of social distance in economic decision-making has been studied before, and from these studies we know that social distance influences people's justice concerns (Lind and Tyler, 1988; Mandel, 2006; Parks et al., 1996; Singer, 1998). Personal friendships (i.e., short social distance) make individuals to extend their own justice concerns to their friends, making justice more important in relationship to friends than to strangers. In line with this reasoning, Halpern (1994, 1997) suggested that people use different scripts (i.e., cognitive structures that guide expectancies in a particular situation; Fiske and Taylor, 1991) when being in an economics setting with friends compared to a setting with strangers, resulting in stronger agreement between friendly buyers and sellers. Finally, other research supports these findings by showing that, compared to strangers, friends are more concerned about the sense of fairness (Shapiro, 1975). Thus, "normative pressures towards fairness are salient in the context of friendship" (Mandel, 2006).

In addition, the field of research on economic games also showed that social distance influences people's other-regarding behavior (Bohnet and Frey, 1999; Burnham, 2003; Charness and Gneezy, 2008). Economic games, like the dictator game (DG), are especially useful to disentangle self- and other-regarding behavior. In a typical DG, two players, an allocator and a recipient, are endowed with a sum of money; the allocator decides how to distribute the

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money and the recipient just passively receives the amount given to him (Kahneman et al., 1986). Results consistently showed that as social distance decreases, the allocator becomes more generous in distributing assets to the recipient. Bohnet and Frey (1999), for example, manipulated the social distance between the allocator and the recipient by letting them either look at each other in silence for a couple of seconds or by letting the recipient to identify himself, with a name card, to the allocator or by letting them being completely anonymous to each other. Results showed that the proportion of the distributed money to the recipient decreased over these three manipulations. This finding can be interpreted in terms of the activation level of the fairness norm (Charness and Gneezy, 2008): the more people know each other, the more the fairness norm is activated.

However, it is not clear from these studies how the recipient would react, either explicitly or implicitly, to fair or unfair offers from allocators with different social distances. This lack of knowledge is partly due to the DG paradigm in which the recipient normally receives offers but makes no explicit responses. With the event-related potential (ERP) technique, however, it is possible to study the responses, as it provides a way to measure the implicit responses in the brain to different offers. The purpose of the current study is thus twofold: (1) to examine how the brain responds differentially to fair and unfair offers in DG; and more importantly, (2) to investigate how the social distance between the allocator and the recipient modulates the recipient's brain responses to different offers. We will specifically focus on the MFN (medial-frontal negativity) and the P300 responses to offers. Below we detail out specific hypotheses.

1.2. MFN responses to (un)fair behavior

There have been ERP studies examining brain responses to fair and unfair offers, using the Ultimatum Game (UG; Boksem and De Cremer, 2010; Hewig et al., 2011; Polezzi et al., 2008). This game, originally developed by Güth et al. (1982), is similar to the DG, but has one major difference. The recipient can either accept or reject the allocator's offer. If accepted, the pie is divided as proposed; if rejected, both the allocator and the recipient end empty handed. Using this paradigm, these studies consistently found that when division schemes were presented to recipients, unfair offers elicited enhanced MFN responses than fair offers.

The MFN, also called FRN (feedback-related negativity), is a negative deflection peaking between 200 ms and 350 ms at frontocentral recording sites (Gehring and Willoughby, 2002; Hajcak et al., 2005, 2007; Holroyd and Coles, 2002; Holroyd et al., 2004; Miltner et al., 1997; Nieuwenhuis et al., 2004; van der Helden et al., 2010; Yeung and Sanfey, 2004; Yeung et al., 2005; Yu and Zhou, 2006a,b, 2009). The MFN has been shown to be more pronounced for negative feedback (or offers) associated with unfavorable outcomes, such as incorrect responses or monetary loss, than for positive feedback. It is suggested that the MFN reflects the impact of the midbrain dopamine signals on the anterior cingulated cortex (ACC) (Holroyd and Coles, 2002; Nieuwenhuis et al., 2004). The phasic decreases in dopamine inputs elicited by negative prediction errors (i.e., "the result is worse than expected") give rise to the increased ACC activity that is reflected as larger MFN amplitude, whereas the phasic increases in dopamine signals elicited by positive prediction errors (i.e., "the result is better than expected") give rise to decreased ACC activity that is reflected as smaller MFN amplitudes. Recent studies showed that the prediction error can be defined not only in terms of the valence of outcome but also in terms of whether the outcome fits pre-established, non-valence expectancy (Jia et al., 2007; Oliveira et al., 2007; Qiu et al., 2010; Wu and Zhou, 2009). For example, Wu and Zhou (2009) manipulated orthogonally the reward valence, reward magnitude, and expectancy towards magnitude in a monetary gambling task and found that the MFN effect was sensitive not only to reward valence, but also to expectancy towards reward magnitude, with the violation of expectancy eliciting a more negative-going MFN.

Violations of social expectancy or social norms can also elicit enhanced MFN responses. Using the UG paradigm, Boksem and De Cremer (2010) found that the MFN amplitude was influenced by violations of the equal division rule. Egalitarian distribution of assets constitutes part of social norms in our life (Deutsch, 1975; Messick and Sentis, 1983; Messick, 1993), and violations of these accepted norms increases punishment of those who violated the norms (Fehr and Gächter, 2002; Fehr and Fischbacher, 2004). Boksem and De Cremer showed that MFN amplitude was more pronounced for unfair than for fair offers and this effect was especially true for participants with higher concerns for fairness. The authors suggested that the MFN may reflect a graded response to the degree of social expectancy violation.

Based on these studies, one might predict that, within a DG, unfair offers would also elicit more negative MFN responses than fair offers, reflecting a general violation of social expectancy. This prediction is strengthened by results of a recent study by Hewig and colleagues (2011) who compared recipient's ERP responses, electrodermal responses, and subjective affect rating to offers in UG and DG. They observed similar MFN effects for fair and unfair offers as Boksem and De Cremer (2010) and did not find significant differences between the two games. The authors suggested that similar mechanisms might be engaged in the evaluation of unfairness in the two settings.

More importantly, the present study specifically investigates the moderating role of social distance on recipient's differential MFN responses to fair and unfair offers. Previous studies have shown that social variables such as interpersonal relationship can modulate individuals' brain responses to other persons' performance or monetary outcomes (Fukushima and Hiraki, 2006, 2009; Itagaki and Katayama, 2008; Kang et al., 2010; Leng and Zhou, 2010; Ma et al., 2011; Marco-Pallares et al., 2010; Yu and Zhou, 2006a). We argue that such social variables can also influence the recipient's brain responses to different offers in DG. To manipulate the social distance between the allocator and the recipient, we let the recipient to receive offers from either his/her friends or strangers and recorded his/her ERP responses to the offers. Based on earlier studies on the role of social distance, which suggest that fairness considerations are more salient amongst friends than amongst strangers (Bohnet and Frey, 1999; Halpern, 1994, 1997; Mandel, 2006; Shapiro, 1975), we predicted that this MFN effect would be modulated by the social distance between the allocator and the recipient. As friendship indicates a closer social distance, the recipient might expect the allocator to be more fair or reciprocal (in the long run) than a stranger-allocator. With higher fairness expectancies towards friends, unfair offers provided by friends would consequently lead to stronger perceptions of fairness norm violations by the recipient than unfair offers provided by strangers. This could be detected by the recipient at an early stage of evaluative processing, possibly indexed by MFN.

1.3. P300 responses to (un)fair behavior

Another ERP component, the P300, is the most positive peak in the period of 200–600 ms post-onset of feedback and it typically increases in magnitude from frontal to parietal electrodes. Previous studies employing the oddball paradigm suggested that the P300 is related to higher-order cognitive operations, such as selective attention and resource allocation (Donchin and Coles, 1988). Specifically, unexpected (low probability) stimuli evoked more positive P300 than expected (high probability) stimuli (Courchesne et al., 1977; Duncan-Johnson and Donchin, 1977; Johnson and Donchin,

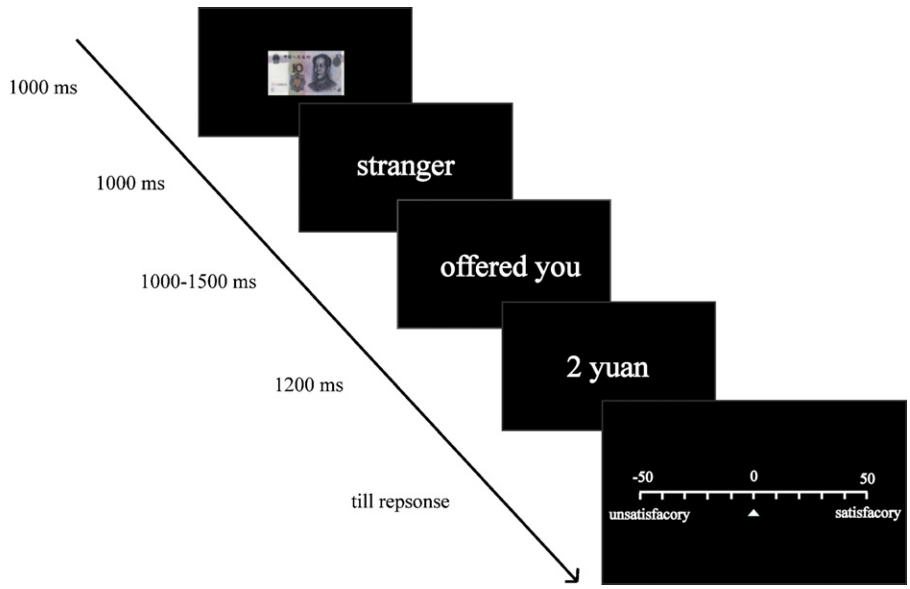

Fig. 1. Sequence of events in a single trial.

1980). The P300 has also been found to be related to various aspects of outcome evaluation. Some studies found that the P300 is sensitive to the magnitude of reward, with a more positive response to a larger than to a smaller reward (Sato et al., 2005; Yeung and Sanfey, 2004). Other studies suggested that the P300 is also sensitive to reward valence, with a more positive amplitude for positive feedback than for negative outcome (Hajcak et al., 2005, 2007; Wu and Zhou, 2009; Yeung et al., 2005).

In the present design and from the recipient's perspective, the magnitude of reward co-varied with the valence of reward: a fair offer was also larger in magnitude than an unfair offer. We therefore hypothesize that, compared to unfair offers, fair offers would elicit enhanced P300 responses. Moreover, a few studies have demonstrated that the P300 can be modulated by social cues, for instance in observing friends vs. strangers getting rewards (Leng and Zhou, 2010; Ma et al., 2011). As the P300 is implicated in processes of attentional allocation (Donchin and Coles, 1988; Gray et al., 2004; Linden, 2005) and/or to high-level motivational/affective evaluation (Nieuwenhuis et al., 2005; Yeung and Sanfey, 2004), these authors suggested that the enhanced P300 in the friend-observation condition might reflect increased involvement of attentional/affective processes. Thus, one might also predict an enhanced P300 for the friend-allocation condition. However, in the present setting, the monetary interests of the EEG participants and the allocators were in conflict, with the amount of reward to the participants being inversely related to the amount of reward to the allocators. This is different from the manipulations in Leng and Zhou (2010) and Ma et al. (2011) in which the interests of the participants and the others were independent from each other. Thus, it was not clear yet how the P300 would be modulated by the manipulation of social distance.

2. Method

2.1. Participants

Twenty-four trios of undergraduate and graduate students (11 female) were recruited through the University intranet. Members of each trio were self-reported good friends (see Section 3.1) and the same sex. The mean age of the main participants undergoing the EEG test was 22.2 years, ranging between 19 and 25 years. They were paid 30 Chinese yuan (about $4.5) as basic payment and were informed that additional monetary rewards would be paid according to the allocators' offers in DG, although in the end all the participants were paid extra 20 yuan on top of the basic payment. Four graduate students (1 pair of females and 1 pair of males), who were strangers to the friend trios, were recruited as confederates. To exclude possible influence of sex on fairness consideration (Andreoni and Petrie, 2008; Solnick and Schweitzer, 1999), each EEG participant was grouped with a pair of same sex friends and another pair of same sex strangers, who played the role of allocators in DG. The purpose of using two friends and two strangers was to reduce reputation building in the repeated-trial game and to make the experimental setup more realistic since the EEG participant would receive both fair and unfair offers from group members.

All the participants were right-handed and had normal or corrected-to-normal vision. They had no history of neurological or psychiatric disorders. Informed consents were obtained from them before the experiment, which was approved by the Academic Affairs Committee of the Department of Psychology, Peking University.

2.2. Design and procedures

The experiment had a 2×2 within-participant factorial design, with the first factor referring to the level of fairness (fair vs. unfair) and the second factor referring to the social distance to the allocator (friend vs. stranger). Fair offers, coming from friends or strangers, could be 4 or 5 yuan (out of 10 yuan) whereas unfair offers could be 1 or 2 yuan. We did not include an condition in which recipients received more allocations than allocators (i.e., unexpected positive offers) because previous behavioral studies have found that, even in circumstances with short social distance between allocators and recipients, the maximum amount of money that allocators provided to recipients was only about 52 percent of the total (Bohnet and Frey, 1999; Burnham, 2003; Charness and Gneezy, 2008).

When a trio of same-sex friends came to the laboratory, each of them, together with a pair of same-sex strangers, was given a card with a number on it. The five persons were told that they would sit in separate rooms to finish a task together through the computer network. One of the friend trios was randomly selected to undergo the EEG test. After the other four participants were led to other rooms, the EEG participant was asked to complete the Chinese version of two questionnaires, the Trust Scale (Rempel and Holmes, 1986) and the Inclusion of Other in the Self Scale (IOS; Aron et al., 1992), both related to their two friends. The Trust Scale measures to what extent a particular partner is trustworthy, with the score ranging between 18 (completely untrustworthy) and 126 (completely trustworthy). The IOS measures, with two circles overlapping to different degrees to represent a 7-point Likert scale, the perceived closeness between a particular partner and the agent.

The EEG participant was told that he/she would play as a recipient in DG and the others would be allocators. The participant was told that in each round of the game one of his/her friends or a stranger would receive 10 yuan endowment and decide how to divide the amount between the allocator and the participant. At the beginning of each round, the participant was categorically informed whether the allocator was a friend or stranger (but the name of the allocator was not given; see Fig. 1). After seeing an offer, he/she would move the mouse and select one integral number between −50 and 50 on a scale to express to what extent he/she was satisfied with the allocator's offer, with −50 indicating "extremely dissatisfied" and 50 indicating "extremely satisfied". The EEG participant was reminded that the allocators made their decisions individually and independently, and his/her rating of each offer would not be sent back to the allocator. The participant was encouraged to express freely his/her feeling towards each offer through the rating.

Each trial began with the presentation of a 10 yuan bill (2.6° × 1.3°) for 1000 ms against a black background (Fig. 1). After 500 ms, the allocator's social identity, either "good friend" or "stranger" in Chinese (white and Song font, size 32), was presented at the center of the screen for 1000 ms. After another 500 ms, the word "offered you" in Chinese (white and Song font, size 32) was presented for either 1000, 1100, 1200, 1300, 1400, or 1500 ms. After a further 500 ms, the amount given to the recipient, in Arabic number plus "yuan" in Chinese (white and Song font, size 32) was presented for 1200 ms. Finally, a blank screen was presented for 500 ms, followed by a rating scale. The participant was asked to indicate how satisfied he/she felt about the offer by moving the cursor with a mouse along the scale. The rating scale remained on the screen until the participant made the response. The inter-trail interval was 1000 ms.

The participant was seated comfortably about 1.5 m in front of a computer screen in a dimly lit and electromagnetically shielded room. The experiment was administered on a Pentium IV computer with a Del 22-in. CRT display, using Presentation software (Neurobehavioral System Inc.) to control the presentation and timing of stimuli. The experiment consisted of 4 blocks of 45 trials each. Each of the four experimental conditions had 40 trials, with 20 trials for each amount of allocation. In addition, another 20 trials with an offer of 3 yuan (out of 10 yuan) were used as fillers. Without the participant's knowledge, all the offers were predetermined by a computer program. The 180 trials were pseudo-randomized with the restriction that no more than 3 consecutive trials were from the same allocator category and no more than 3 consecutive trials were on the same fairness level.

A practice block was administered before the formal test. After the EEG test, the participant was required to indicate, on a 7-point Likert scale, to what extent he/she believed the offers were from his/her friends or strangers, with 1 indicating "do not believe at all" and 7 indicating "truly believe". The participant was debriefed, paid and thanked in the end.

2.3. EEG recording and analysis

EEGs were recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (Brain Products, Munich, Germany) according to the international 10–20 system. The vertical electrooculogram (VEOGs) was recorded supra-orbitally from the right eye. The horizontal EOG (HEOG) was recorded from electrodes placed at the outer cantus of left eye. All EEGs and EOGs were referenced online to an external electrode which was placed on the tip of nose and were re-referenced offline to the mean of the left and right mastoids. Electrode impedance was kept below 10 kΩ for EOG channels and below 5 kΩ for all other electrodes. The bio-signals were amplified with a band pass from 0.016 to 100 Hz and digitized on-line with a sampling frequency of 500 Hz.

EEG epochs of 1000 ms (with a 200-ms pre-stimulus baseline) were extracted offline for ERPs time-locked to the onset of offers from the allocators. Ocular artifacts were corrected with an eye-movement correction algorithm which employs a regression analysis in combination with artifact averaging (Semlitsch et al., 1986). Epochs were baseline-corrected by subtracting from each sample the average activity of that channel during the baseline period. All trials in which EEG voltages exceeded a threshold of ±80 μV during recording were excluded from further analysis. The EEG data were low-pass filtered below 30 Hz.

For statistical analyses, we focused on 12 anterior-frontal electrodes, AF3, AF4, F3, F1, Fz, F2, F4, FC3, FC1, FCz, FC2, FC4, and 15 central-posterior electrodes, C3, C1, Cz, C2, C4, CP3, CP1, CPz, CP2, CP4, P3, P1, Pz, P2, P4. We concentrated on these electrodes because the MFN effect tended to be the largest on these anterior electrodes and the P300 effect tended to the largest on these posterior electrodes in previous studies (Donchin and Coles, 1988; Gehring and Willoughby, 2002; Gray et al., 2004; Holroyd and Coles, 2002). Moreover, we conducted a spatial principle component analysis (PCA), which could identify the spatial distribution of ERP components but disregarding their temporal characteristics (see Dien and Frishkoff, 2005 for a review), and found that the two components could be observed, one on the anterior electrodes and one on the posterior electrodes (data not reported here). Average amplitudes over these electrodes in each region were used in the following analysis, with time windows selected according to the classical definitions concerning the time windows of the MFN and the P300 (Gehring and Willoughby, 2002; Hajcak et al., 2005, 2007) and according to visual inspection of waveforms in the present experiment. The ERP components analyzed included P2 (the mean amplitudes in the time window of 160–240 ms) in the anterior-frontal and central-posterior region, MFN (the mean amplitudes in the time window of 240–340 ms) in the anterior-frontal and central-posterior regions, P300 (the mean amplitudes in time window of 400–550 ms and the peak amplitudes in the time window of 250–600 ms) and the late positivity (the mean amplitudes in the time window of 550–800 ms) in the central-posterior region. Analyses of variance (ANOVAs) were conducted with two within-participant factors: social distance (friend, stranger) and fairness level (unfair, fair). The Greenhouse-Geisser correction for violation of the assumption of sphericity was applied where appropriate.

3. Results

Four EEG participants who stated in the post-experiment questionnaire that they completely disbelieved the setup of the experiment and another three participants with excessive artifacts in EEG recording were excluded from data analysis. The remaining seventeen participants generally believed the setup of the experiment, with the mean score of 4.76 ± 1.03 (with 1 indicating "do not believe at all" and 7 indicating "truly believe") for the questionnaire.

3.1. Manipulation check of social distance

The seventeen EEG participants' self-reports on IOS (ranging from 1 to 7; higher scores indicating more inclusion) showed that these participants had generally close relationship with their friends, although the scores did differ between the closer friends ($M = 5.65$) and the less close friends (4.53), $t(16) = 5.37$, $p < 0.001$. Similarly, the participants generally trusted their friends (score could range between 18 and 126; with higher scores indicating more trust), although the extent of trust did differ between the two friends: more trusted friends scored higher on the Trust Scale (94.65) than less trusted friends (80.29), $t(16) = 6.89$, $p < 0.001$. From the recipient's perspective, these differences could make the fair and unfair offers from friends more realistic. Note that neither the IOS score nor the Trust Scale score significantly correlated with the ERP amplitudes under any conditions.

3.2. Satisfaction rating

An ANOVA on the satisfaction rating (see Fig. 2A), with fairness level (fair vs. unfair offer) and social distance (friend vs. stranger) as two within-subject variables, revealed two main significant effects. The fairness level effect showed that unfair offers were rated more negative ($M = 16.15$) than fair offers (29.10), $F(1,16) = 201.46$, $p < 0.001$. The social distance effect showed that offers from strangers were rated as more positive (9.37) than offers from friends (3.58), $F(1,16) = 5.24$, $p < 0.05$. Importantly, these main effects were qualified by a marginally significant interaction between social distance and fairness level, $F(1,16) = 4.08$, $p = 0.061$. Simple-effect tests showed that whereas the friend's unfair offers were rated more negatively (−20.99) than the stranger's unfair offers (−11.30), $p < 0.01$, there was no such difference between fair offers (28.16 vs. 30.04), $p > 0.1$. These results suggest that the recipient was particularly resentful to the unfairness coming from a friend.

3.3. The P2

A 2 (social distance: friend vs. stranger) × 2 (fairness level: fair vs. unfair offer) × 2 (region: anterior-frontal vs. central posterior) repeated measures ANOVA showed a significant three-way interaction, $F(1,16) = 9.73$, $p < 0.01$. Therefore, we conducted separate analyses for the P2 amplitudes in the anterior-frontal (Figs. 2B and 3A) and central-posterior regions.

At the anterior-frontal region, ANOVA revealed only an interaction of social distance and fairness level, $F(1,16) = 6.52$, $p < 0.05$. Specific contrast analyses indicated that whereas fair offers (4.74 μV) elicited more positive P2 than unfair offers (3.32 μV) in the friend-allocation condition, $F(1,16) = 6.88$, $p < 0.05$, they did not differ in the stranger-allocation condition (3.89 vs. 4.39 μV), $F(1,16) = 1.23$, $p > 0.1$.

At the central-posterior region, we only found a significant main effect of fairness level, $F(1,16) = 10.20$, $p < 0.01$, with stronger P2 following fair offers (4.25 μV) than following unfair offers (3.07 μV). No other effects reached significance.

3.4. The MFN

We conducted a 2 × 2 × 2 ANOVA for the MFN, similar to the analysis for the P2. The three-way interaction between social

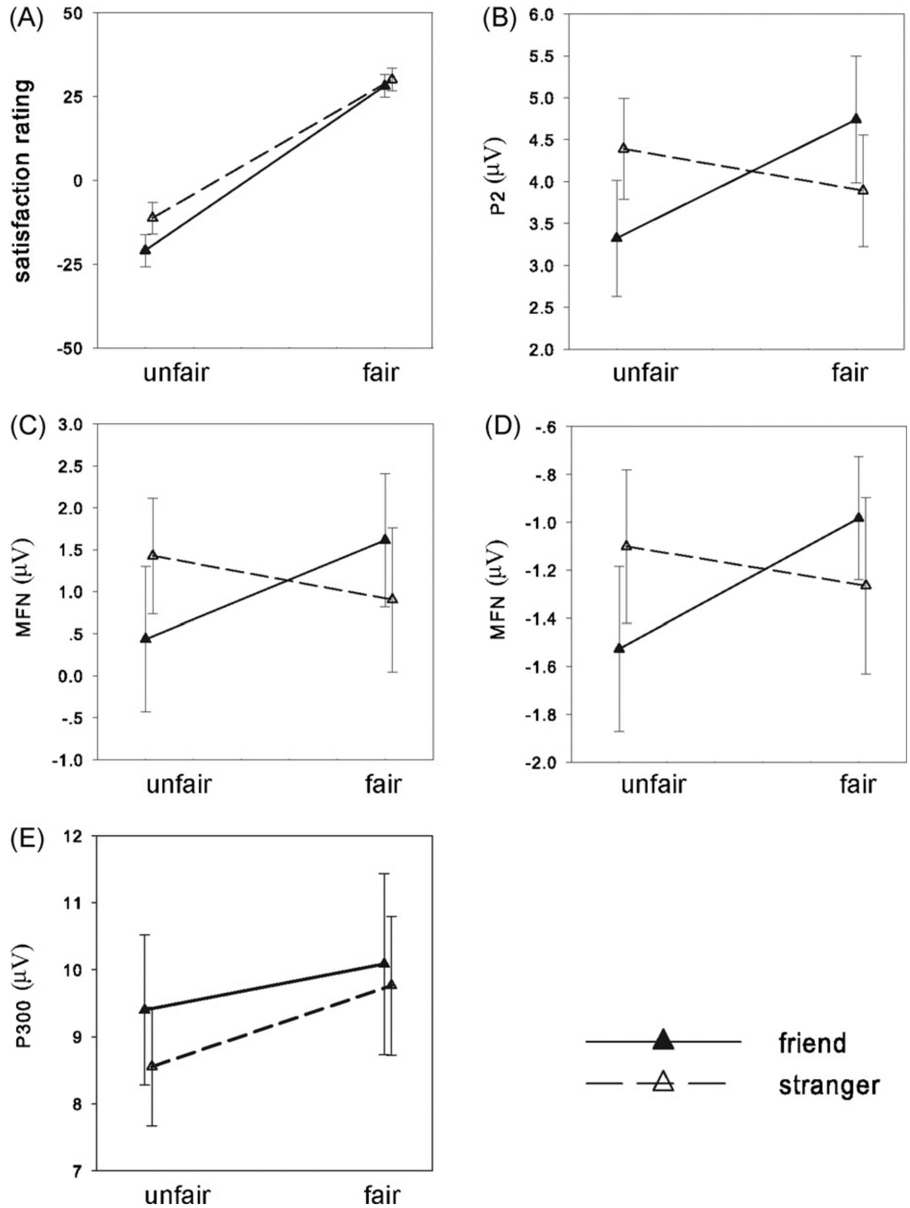

Fig. 2. Behavioral and ERP results. (A) Subjective rating for fair and unfair offers; (B) mean amplitudes (P2) in the 160–240 ms time window for fair and unfair offers at the anterior-frontal region; (C) mean amplitudes (MFN) in the 240–340 ms time window for fair and unfair offers at the anterior-frontal region; (D) mean amplitudes (MFN) in the 240–340 ms time window for fair and unfair offers at the anterior-frontal region after 2–20 Hz bandpass filtering; (E) peak amplitudes in the 250–600 ms time window for fair and unfair offers at the central-posterior region.

distance, fairness level and electrode region was marginally significant, $F(1,16) = 3.50$, $p = 0.08$, suggesting that the MFN effect may have different patterns over the anterior-frontal and central-posterior regions (see also Fig. 3B). We therefore conducted separate analyses for the effect in each region.

In the anterior-frontal region, an ANOVA on MFN measures only revealed an interaction between social distance and fairness level, $F(1,16) = 6.56$, $p < 0.05$ (see Fig. 2C). Specific contrast analyses were conducted within the friend- and stranger-allocation conditions. The difference between fair and unfair offers was significant in the friend-allocation condition, $F(1,16) = 6.46$, $p < 0.05$, with ERP responses more negative-going following unfair offers (0.43 μV) than following fair offers (1.61 μV). In contrast, there was no such difference in the stranger-allocation condition (1.43 vs. 0.90 μV), $F(1,16) = 1.75$, $p > 0.1$.

On the other hand, while ERP responses to fair offers did not differ between the friend- and stranger-allocation conditions (1.61 vs. 0.90 μV), $F(1,16) = 2.83$, $p > 0.1$, ERP responses to unfair offers were more negative-going in the friend-allocation (0.43 μV) than in the stranger-allocation condition (1.43 μV), $F(1,16) = 6.23$, $p < 0.05$, a reminiscent of the pattern in the satisfaction rating.

In the central-posterior region, we found a significant main effect of fairness level, $F(1,16) = 5.87$, $p < 0.05$, with unfair offers (2.94 μV) eliciting more negative-going deflections than fair offers (3.94 μV). However, neither the main effect of social distance nor the interaction between these two factors reached significance, $F(1,16) < 1$ and $F(1,16) = 1.07$, $p > 0.1$, respectively.

It appears that the difference between unfair and fair offers was also present at the central-posterior region (see Fig. 3B), inconsistent with the traditional definition and findings for the MFN. However, this might be due to the influence of the subsequent P300. Given that the P300 is mainly associated with low frequency EEGs, we filtered the EEG data with a 2–20 Hz bandpass (Fig. 3C; see Donkers et al., 2005; Heldmann et al., 2008; Luu et al., 2003 for

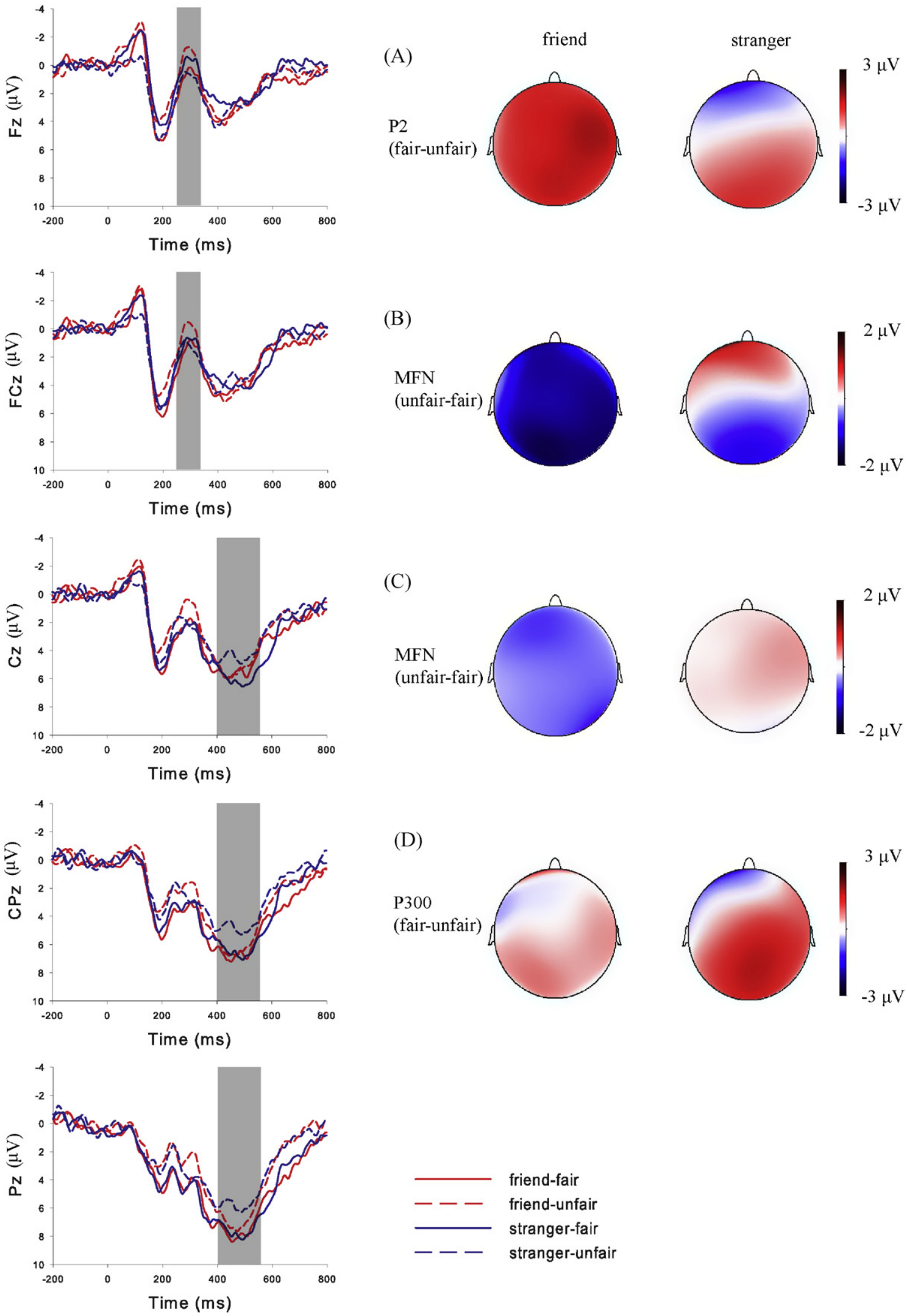

Fig. 3. (Left panel) Grand average event-related potentials at the midline Fz, FCz, Cz, CPz and Pz for different offers. The shaded 240–340 ms time window at Fz and FCz was for the calculation of the mean amplitudes of the MFN. The shaded 400–550 ms time window at Cz, CPz and Pz was for the calculation of the mean amplitudes of the P300. (Right panel) (A) Topographic map for P2 in the 160–240 ms time window; (B) topographic map for MFN in the 240–340 ms time window; (C) topographic map for MFN in the 240–340 ms time window after 2–20 Hz bandpass filtering; (D) topographic map for P300 in the 400–550 ms time window.

similar treatments). In the anterior-frontal region, the mean amplitudes in the 240–340 ms time window were submitted to a 2 (social distance: friend vs. stranger) × 2 (fairness level: fair vs. unfair offer) repeated-measures ANOVA. We found a significant interaction between fairness level and social distance (Figs. 2D and 3C), as in the original analysis, $F(1,16) = 4.22$, $p = 0.057$, with unfair offers eliciting more negative MFN than fair offers in the friend-allocation condition (−1.53 vs. −0.98 μV), $F(1,16) = 6.58$, $p < 0.05$, but not in the stranger-allocation condition (−1.10 vs. −1.27 μV), $F(1,16) < 1$. In the central-posterior region, there was no significant main effect of fairness level, $F(1,16) < 1$, or social distance, $F(1,16) = 1.77$, $p > 0.1$, although the interaction between the two factors was marginally significant, $F(1,16) = 3.28$, $p = 0.09$. The simple-effect test revealed only a trend of unfair offers (−1.21 μV) being more negative-going than fair offers (−0.73 μV) in the friend-allocation condition, $F(1,16) = 3.14$, $p = 0.10$.

3.5. The P300

An ANOVA on the mean amplitudes over the central-posterior electrodes in the 400–550 ms time window, with fairness level (fair vs. unfair offer) and social distance (friend vs. stranger) as two within-subject variables, revealed a significant main effect of fairness level, $F(1,16) = 5.14$, $p < 0.05$. This effect indicated that the P300 responses were larger to fair offers (6.96 μV) than to unfair offers (6.06 μV). The social distance and the interaction between social distance and fairness level were not significant, both $F(1,16) < 1$.

To confirm that there was no interaction between social distance and fairness level on the P300, we entered the peak amplitudes (Fig. 2E) in the 250–600 ms time window into ANOVA. Again, although the main effect of fairness level was significant, $F(1,16) = 5.27$, $p < 0.05$, with fair offers eliciting more positive responses than unfair offers (9.92 vs. 8.97 μV), the main effect of social distance and the interaction between the two factors were not, $F(1,16) = 1.21$, $p > 0.1$, $F(1,16) < 1$, respectively.

It appeared on Fig. 3 (left panel) that there were late positivity effects for fairness level following the peaks of the P300. An ANOVA on the mean amplitudes over the central-posterior electrodes in the 550–800 ms time window found a marginally significant main effect of fairness level, $F(1,16) = 3.86$, $p = 0.067$, with fair offers eliciting more positive responses than unfair offers (2.90 vs. 1.94 μV). Neither the main effect of social distance nor the interaction was significant, both $F(1,16) < 1$. These late positivity potentials (LPPs), identified also in previous studies on evaluative categorization (Cacioppo et al., 1994; Ito et al., 1998) and on outcome evaluation (Leng and Zhou, 2010), showed a pattern almost identical to the pattern for the P300. It is likely that their functions are similar to those of the P300 responses, reflecting a re-appraisal process in which the fairness of different offers are motivationally attended and assessed against the background of different social distance (Leng and Zhou, 2010).

4. Discussion

This study demonstrated that the recipient's consideration of fairness in the dictator game can be modulated by the social distance between the recipient and the allocator. Satisfaction rating result showed that unfair offers from friends were rated as being more unsatisfactory than those from strangers whereas fair offers were rated as being equally satisfactory. A similar pattern was observed in the anterior-frontal MFN, with the ERP responses being more negative-going to unfair offers from friends than from strangers. Moreover, the MFN was more negative-going for unfair than for fair offers in the friend-allocation condition, but this MFN effect disappeared in the stranger-allocation condition. Conversely, the P2 at the anterior-central region was more positive for fair than for unfair offers in the friend-allocation condition, but this effect, again, disappeared in the stranger-allocation condition. Furthermore, the P300 and the late positivity at the central-posterior region were more positive for fair than for unfair offers, irrespective of friends or strangers making the offers.

The differential MFN responses to fair and unfair offers in the friend-allocation condition may reflect the detection of social expectancy violation as egalitarian distribution of assets is an expected social norm (Fehr and Gächter, 2002; Fehr and Fischbacher, 2004; Messick and Sentis, 1983) and this norm is expected to be adhered to more vigorously by our friends in social interaction (Mandel, 2006; Shapiro, 1975). During evolution, the human brain may have developed specific mechanisms to detect ongoing deviations from social norms (Montague and Lohrenz, 2007) and these mechanisms share the same neural correlates as those engaged in predicting errors during non-social reinforcement learning (Harris and Fiske, 2010). The impact of the midbrain dopamine signals on ACC, which generates the MFN, can therefore reflect not only the encoding of prediction errors for monetary reward or performance feedback but also violations of expectancy towards social norms.

A surprising finding in this study was that we did not observe a differential MFN effect for fair and unfair offers in the stranger-allocation condition, inconsistent with previous studies employing UG but using only strangers as allocators (Boksem and De Cremer, 2010; Hewig et al., 2011; Polezzi et al., 2008). We believe that this null effect was due to the introduction of the friend-allocation condition into the experimental setup. Previous studies showed that fairness consideration can be context-dependent, with the same unfair offers leading to different rejection rates in UG when these offers were either presented alone or mixed with fair offers (Falk et al., 2003; Güroğlu et al., 2010). ERP studies on outcome evaluation have also shown that the FRN (or MFN) responses to the same feedback can be context-dependent (Holroyd et al., 2004; Yu and Zhou, 2006b, 2009). For example, when the observer participated in a three-person gambling task with each person betting and getting monetary reward independently, round-by-round in alternation, observing a friend or a stranger getting gain or loss feedback elicited the same FRN effects on the observer (Leng and Zhou, 2010; Ma et al., 2011). However, when the observer did not participate in the game but merely observing the friend and the stranger getting monetary feedback, the FRN effect was larger for the friend-observation condition than for the stranger-observation condition (Kang et al., 2010; Ma et al., 2011). It is likely that having friends making offers in the present setting changed the participants' expectancy towards fairness of offers from friends and from strangers.

Having friends participating in the experiment may automatically activate people's social identity (ingroup vs. outgroup; Tajfel and Turner, 1986) and consequently influence recipient's fairness expectancies regarding friend's and stranger's offers (Bohnet and Frey, 1999; Halpern, 1994, 1997; Mandel, 2006; Shapiro, 1975). Unfair offers from friends thus would constitute strong violations of the increased fairness consideration, causing stronger emotional responses in satisfaction rating and more negative-going MFN responses towards the offers of friends than of strangers. Besides this effect, the increased fairness considerations in the friends-allocation condition may be inversely related to decreased fairness considerations in the strangers-allocation condition. This decreased fairness considerations might have lead to the null effect in the direct and implicit MFN measures, even though the recipient did show differential satisfaction rating after he/she had enough time to explicitly evaluate these offers.

The finding of a main effect of fairness level for the P300, with more positive responses to fair offers than to unfair offers, is consistent with previous studies on the functional significance of P300 in outcome evaluation. A number of studies have shown that the P300 is sensitive to reward valence in gambling tasks, with positive outcomes eliciting stronger P300 than negative outcomes (Hajcak et al., 2005, 2007; Leng and Zhou, 2010; Wu and Zhou, 2009; Yeung et al., 2005). In the present study, fair offers can be considered as implicitly positive in valence whereas unfair offers as implicitly negative. Moreover, fair offers were intrinsically linked with larger rewards in magnitude whereas unfair offers were intrinsically linked with smaller rewards. Previous studies on outcome evaluation have also found that the P300 encodes the magnitude of monetary reward, with more positive responses to larger than to smaller rewards (Sato et al., 2005; Yeung and Sanfey, 2004). We believe that the more positive P300 responses to fair than to unfair offers reflect differential distribution of attentional resources to the two types of offers which had different affective/motional significance (Leng and Zhou, 2010; Nieuwenhuis et al., 2005; Wu and Zhou, 2009; Yeung and Sanfey, 2004).

Note that earlier studies employing the oddball paradigm have shown that unexpected stimuli elicit more positive-going P300 responses (Courchesne et al., 1977; Duncan-Johnson and Donchin, 1977; Johnson and Donchin, 1980). The P300 was also found to be sensitive to unexpected (low probability) outcomes in gambling tasks (e.g., Hajcak et al., 2005, 2007). The increased P300 amplitudes may reflect a general monitoring process that signals the occurrence of unexpected events (de Bruijn et al., 2007) or a context-updating process in which the mental model of the context is actively consolidated or revised (Balconi and Crivelli, 2010; Donchin and Coles, 1988). In the present study, although there could be intrinsic expectancy towards fair offers and violation of the expectancy (i.e., unfair offers) could, in principle, elicit more positive P300 responses, the occurrences of fair and unfair offers were nevertheless equal in probability. Moreover, as suggested by Wu and Zhou (2009), information concerning expectancy violation may have already been coded by the preceding MFN and the neural system does not need to code it again on the P300.

The present study did not find a significant main effect of social distance or interaction between social distance and fairness level on the P300. This seems to be at odds with Leng and Zhou (2010) and Ma et al. (2011) which showed that observing a friend's gambling outcomes elicited more positive P300 responses than observing a stranger's. In these studies, the participant's and the other's monetary interests were independent of each other. However, in the present study, the participant and the others were in dependent relationships playing a fixed-sum game, with the recipient's monetary increase indicating the allocator's interest decrease (Fukushima and Hiraki, 2006; Itagaki and Katayama, 2008). It is possible that the discrepancy in the P300 findings could be attributed to different interdependencies within the current study and these previous studies. In addition, the lack of an interaction between fairness level and social distance on the P300 might indicate that during the late stage of elaborated processing, the neural system could evaluate the fairness of offers in a parallel way, irrespective of whom the participant is playing with.

In the present study, in addition to the MFN and P300 effects for the manipulation of fairness level and/or social distance, we also observed differential effects on the P2. Differences on the P2 in response to negative and positive feedback can be found in some of previous studies (e.g., Gehring and Willoughby, 2002; Kang et al., 2010; Hewig et al., 2011; van der Helden et al., 2010), although these effects were generally not analyzed in detail. In the present study, we found that the pattern of the P2 effect at the anterior-frontal region mirrored that of the MFN effect while the pattern of the P2 effect at the central-posterior region mirrored that of the P3 effect. It is plausible that the patterns of the P2 effect were due to the spillover of the MFN and the P300 effects at these regions, respectively, during the ERP measurement, although this speculation needs further investigation.

The current experiment may have some limitations that need to be addressed in further studies. First, in this experiment we elected to manipulate fairness in only one direction (i.e., unfair offers that gave participants relatively little reward). It is not clear from the present experiment how people would react to positive unfair offers (i.e., unfair offers that reward the recipient more than the allocator). If the MFN is indeed sensitive to social expectancy violation in general, with more negative-going MFN responses to unexpected than to expected feedback, then it is possible that positive unfair offers would also elicit more negative-going MFN responses (Oliveira et al., 2007; Qiu et al., 2010). Indeed in our recent, unpublished study on the effect of initial ownership of bargaining property on individuals' fairness consideration and other-regarding behavior, we did find that both negative and positive unfair offers elicited more negative going ERPs than fair offers in an early, MFN time window.

Secondly, the present study manipulated the social distance between allocators and recipients in a categorical way. Further study may be conducted to investigate how the MFN effect between fair and unfair offers could parametrically vary according to the level of intimacy (Kang et al., 2010) or the difference of social power (Boksem et al., 2009) between individuals.

5. Conclusion

By using a dictator game in which the participants played the role of recipient and received different offers from either friends or strangers, we demonstrated in the current ERP study that interaction with friends may involve increased fairness consideration in monetary distributions and that the medial frontal negativity (MFN) in the anterior-frontal region, a component associated with the processing of expectancy violation, could differentiate between fair and unfair offers provided by friends. The MFN is more negative-going for unfair offers than for fair offers; but this effect disappears when strangers, rather than friends, made the offers, possibly reflecting the influence of context upon fairness consideration. On the other hand, the P300 in the central-posterior region was more positive for fair than for unfair offers, irrespective of friends or strangers making the offers. These results suggest that violation of the accepted social norms, like equality, can be detected at an early stage of evaluative processing, as indexed by the MFN effect in brain potentials; and that this detection could be context-dependent and modulated by social distance.

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