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

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Previous

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,

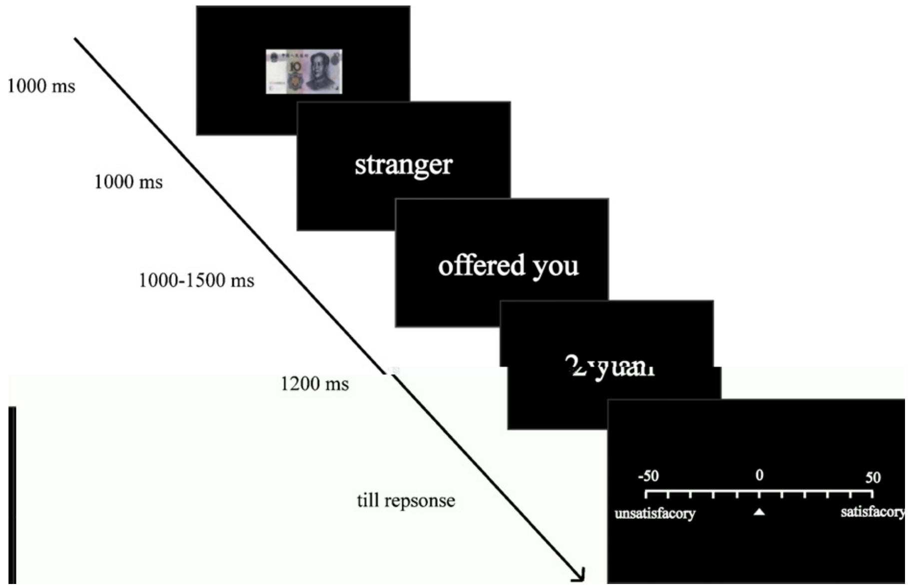

Fig. 1. Sequence of events in a single trial.

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, on80 -F1 2 1 Tf.0002 0 0 -.0002 309.3149 46372869 Tm( )Tj/F1 1 Tf7.9701 0 0 7.9701 136

Each trial began with the presentation of a 10 yuan bill ($2.6^{\circ} \times 1.3^{\circ}$) 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 the in Arabic number plus in (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

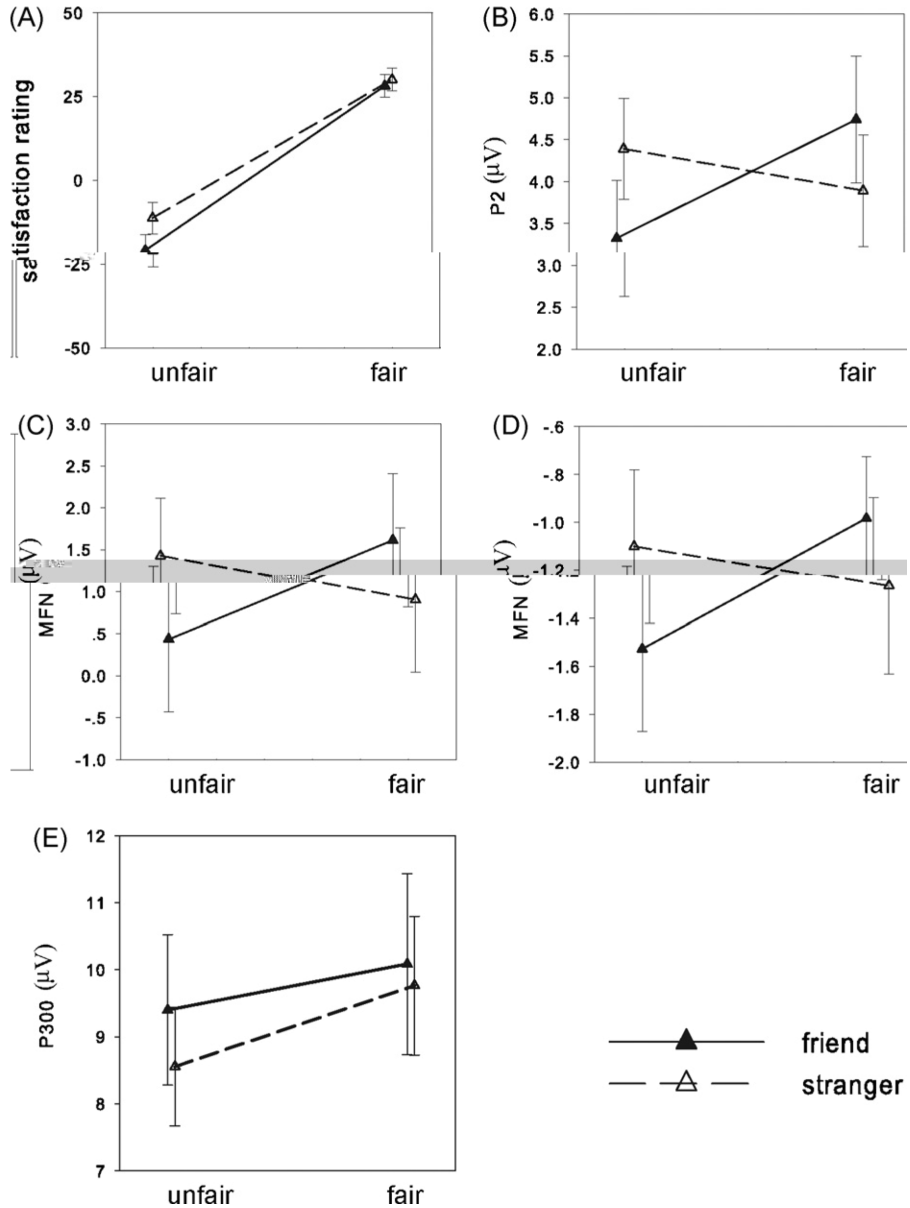

Fig. 2. Behavioral and ERP results. (A) Subjective rating for fair and unfair offers; (B) mean amplitudes (P2) in the 160–240 ms time window for fair and unfair offers at the anterior-frontal region; (C) mean amplitudes (MFN) in the 240–340 ms time window for fair and unfair offers at the anterior-frontal 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

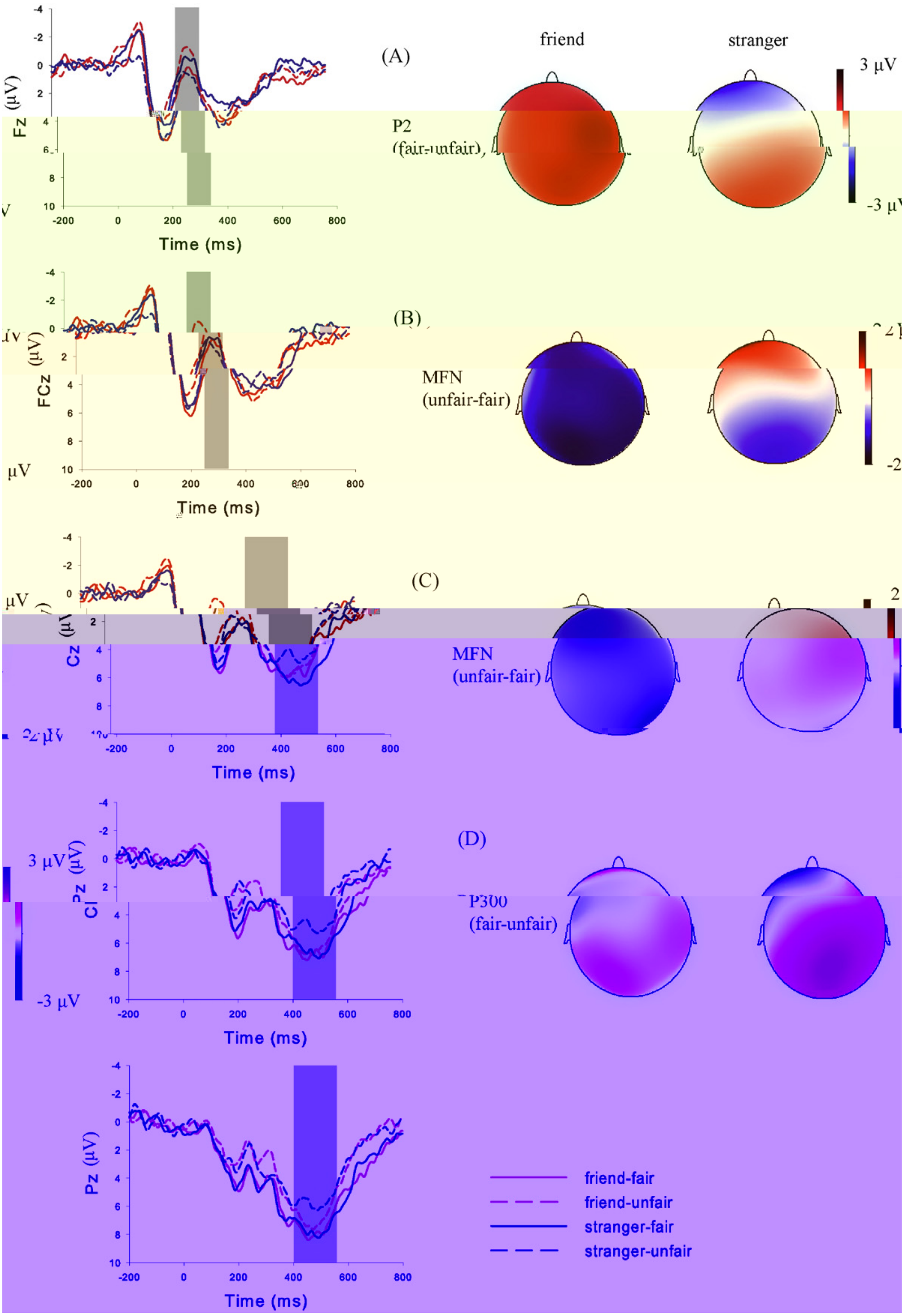

Fig. 3. (Left panel) Grand average event-related potentials at the midline Fz, FCz, Cz, CPz and Pz for different offers. The shaded 240–340 ms time window at Fz and FCz was for the calculation of the mean amplitudes of the MFN. The shaded 400–550 ms time window at Cz, CPz and Pz was for the calculation 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, $F(1,16) = 3.14$, $p = 0.10$.

Tj/F2 1 Tf.0002 0 0 55000299--.0027 516.2697 Tm( )Tj/F1 1 Tf7.9701 0 0 521 T9150-.0027 616.26ga58 Tm(in)Tj/F2 1 Tf.0002 0 0 -79701 50-.0027 516.2697

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 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 offers77.9(wiTf7.9701 0 0 7.9701 425.8603 356.1701 Tr

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