Whether others were treated equally affects neural responses to unfairness in the Ultimatum Game

Li Zheng,[1] Xiuyan Guo,[2,3] Lei Zhu,[4] Jianqi Li,[5] Luguang Chen,[5] and Zoltan Dienes[6]

[1]School of Psychology and Cognitive Science, East China Normal University, North Zhongshan Road 3663, Shanghai, SH 200062, [2]Shanghai Key Laboratory of Magnetic Resonance and School of Psychology and Cognitive Science, East China Normal University, North Zhongshan Road 3663, Shanghai, SH 200062, China, [3]Key Laboratory of Brain Functional Genomics, Ministry of Education, Shanghai Key Laboratory of Brain Functional Genomics, East China Normal University, Shanghai, SH 200062, China, [4]Department of Psychology, Fudan University, Handan Road 220, Shanghai, SH 200433, China, [5]Shanghai Key Laboratory of Magnetic Resonance and Department of Physics, East China Normal University, Shanghai, SH 200062, China, and [6]Sackler Centre for Consciousness Science and School of Psychology, University of Sussex, Brighton BN1 9RH, UK

People expect to be treated equivalently as others in like circumstances. The present study investigated that whether and how equal or unequal treatments of others in like circumstances affected individuals' responses to unfairness through justifying their reference points for fairness considerations. Twenty-five participants were scanned while they were playing an adapted version of the Ultimatum Game as responders. During the experiment, the participant was not only informed of the offer given by her/his proposer but also informed of the division scheme of another proposer–responder pair. It turned out that participants were more likely to accept unequal offers and reported higher fairness ratings when other responders received unequal offers compared with equal offers. Stronger bilateral anterior insula and dorsal anterior cingulate gyrus activities were observed when only participants (but not other responders) received equal offers, whereas greater right dorsolateral prefrontal cortex activity was found when both of them received unequal offers, especially when participants accepted the unequal offers. Taken together, the results demonstrated that whether others in like circumstances were offered equally also plays an important role in responders' fairness-related social decision making.

Keywords: unfairness; reference point; Ultimatum Game; AI; dACC; DLPFC

INTRODUCTION

In social interactions, humans are motivated by fairness considerations. To eliminate inequality they consider unfair, people may reject an unequal distribution even at a cost to themselves. Relevant evidence is provided by studies using the Ultimatum Game (UG) (Sanfey et al., 2003; Tabibnia et al., 2008; Dulebohn et al., 2009; Güroğlu et al., 2010, 2011). During the UG, one player (proposer) proposes how to divide a sum of money. If the other player (responder) accepts the division scheme, both of them get the suggested division of money, and if the responder rejects the division scheme, neither of them receives any. Results showed that the responder accepted all equal offers but was likely to reject unequal offers, especially for offers <20% of the total (Güth et al., 1982; Camerer and Thaler, 1995), indicating the important role of perceived fairness in decision making. Furthermore, responders' judgments of fairness in the UG are not only affected by the proposed income disparity but also by contextual factors, such as the intentions of the proposer (Falk et al., 2003; Sutter, 2007; Güroğlu et al., 2010, 2011), the social distance between the proposer and the responder (Bohnet and Frey, 1999; Wu et al., 2011a) and the loss or gain context (Buchan et al., 2005; Zhou and Wu, 2011; Guo et al., 2013).

Among contextual factors influencing judgments of fairness, people care about others in similar circumstances as themselves (i.e. their peers) (Bewley, 1999; Wu et al., 2011b) and expect to be treated equivalently as them (Bohnet and Zeckhauser, 2004). For example, employees usually do not compare their salary with the income of the employer, but rather with the wages of employees in similar positions (Babcock et al., 1996). The question of how people's fairness considerations depend on the treatment of peers is of fundamental importance, with far-reaching implications ranging from the design of social welfare systems to the optimal provision of incentives in firms. Thus, using functional magnetic resonance imaging (fMRI), the present study aimed to elucidate how individuals' fairness considerations are modulated by equal or unequal treatments of their peers and the underlying neural mechanisms by adopting a modified version of the UG.

Several brain regions involved in fairness considerations have been identified in previous neuroimaging studies using the UG paradigm, including anterior insula (AI), dorsal anterior cingulate cortex (dACC) and dorsolateral prefrontal cortex (DLPFC) (Sanfey et al., 2003; Dulebohn et al., 2009; Güroğlu et al., 2010, 2011; Corradi-Dell'Acqua et al., 2013). Empirical evidences recently suggested that AI and/or dACC were engaged in detecting and responding to norm violations and thus activities of AI and dACC during unfair offers in UG might be associated with behaviors violating social norms (Montague and Lohrenz, 2007; Spitzer et al., 2007; King-Casas et al., 2008; Güroğlu et al., 2010, 2011; Strobel et al., 2011; Civai et al., 2012; Chang and Sanfey, 2013). The engagement of DLPFC in UG has also been related to fairness-related decision making (Sanfey et al., 2003; Güroğlu et al., 2010, 2011). Notably, it has been consistently demonstrated that right DLPFC function was negatively related to acceptance rates of unequal divisions in UG, indicating that right DLPFC may play a key role in fairness-related acceptance behaviors (van't Wout et al., 2005; Knoch et al., 2006, 2008).

To test whether and how equal or unequal treatments given to others in like circumstances affected responders' fairness considerations and its underlying neural basis, we designed an adapted version of the UG. In the adapted UG, two pairs played the UG, while the participants played as responders in one of the pairs

(Figure 1A). In the Unequal-single condition, the offers to the participants were unequal (i.e. ¥5:¥45 or ¥10:¥40), while the offers to the responders in the other pair were equal (i.e. ¥25:¥25). In the Unequal-both condition, the offers to the responders in both pairs were the same unequal offers. In the Equal condition, the offers in both pairs were equal.

We were interested in responders' behavioral and neural responses to unequal offers in the Unequal-single and Unequal-both conditions. Equal split is a default social norm during fairness considerations when there is no salient contextual cue to indicate otherwise (Messick and Schell, 1992; Messick, 1995; Civai *et al.*, 2012). However, when a salient contextual cue has been provided, the reference point for fairness considerations can deviate from an equal split. A recent study showed that past experience could lead people to accept more unequal divisions by shifting the reference point for fairness judgments (Herz and Taubinsky, 2013). Chang and Sanfey (2013) further argued that individuals' context-specific expectations could be used as fairness reference points, and higher expectation violations were associated with increased activity in dACC. In the present study, we directly set an equally treated or unequally treated reference group of responders, which provided a direct contextual cue for the shift of a fairness reference point. When other responders were offered equal splits, the equality norm in fairness judgments would be confirmed. Proposers' norm-violating behaviors in the Unequal-single condition should be more obvious than in the Unequal-both condition, and their unequal offers should trigger stronger perception of unfairness. Thus, we expected greater activations in AI/dACC associated with norm violations in the Unequal-single relative to Unequal-both condition. When other responders received offers below an equal split, the reference points for fairness might be shifted below equality. Unequal offers should be

perceived less unfair, leading to lower acceptance thresholds. Thus, right DLPFC activity related to acceptance behaviors in UG should be observed in the Unequal-both condition relative to the Unequal-single condition.

METHODS

Participants

Twenty-five right-handed volunteers from the university community with normal or corrected-to-normal vision [18 women, mean age = 21.44 ± 3.38 (s.d.) years] participated in this experiment. None of the participants reported a significant abnormal neurological history. All the participants gave informed consent before scanning.

Materials

Seventy-two face pictures were selected from Chinese Facial Affective Picture System (Gong *et al.*, 2011) as materials, which were randomly allocated to three conditions (Unequal-single, Unequal-both and Equal), 24 face pictures in each condition. For each condition, eight faces were selected as the proposers in the participant's pair, eight as the proposers and eight as the responders in the other pair, half of which were women faces. The pictures were counterbalanced across different conditions so as to equalize the emotional valence, arousal and attractiveness.

Procedure

Before scanning, participants were told the rules of the game and that they would play as responders with 24 different proposers, respectively. They were also told that another 24 students also played the same game as responders with another 24 different proposers, and all the offers
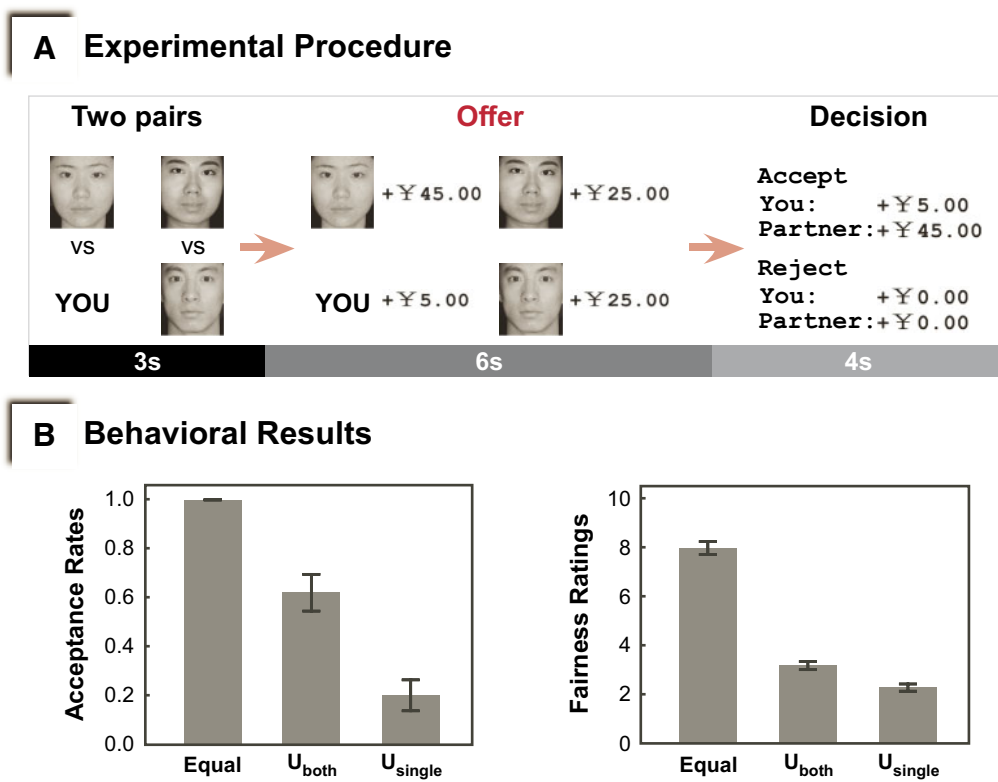

A Experimental Procedure

B Behavioral Results

Fig. 1 (A) Experimental Procedure. Participants were scanned while playing the game for 24 trials, 8 in each condition. Equal offers were given to the participants and the responders in the other pair in the Equal condition. Participants and the other responders received the same unequal offers in the Unequal-both condition, whereas in the Unequal-single condition, only participants were offered unequally. **(B)** Behavioral Results. Lower acceptance rates and fairness ratings were revealed for unequal trials than equal trials. Furthermore, acceptance rates and fairness ratings of Unequal-both trials were significantly higher than that of Unequal-single trials. U_{both} = Unequal-both. U_{single} = Unequal-single. Error bars indicate s.e.m.

about dividing money were collected before the experiment from real people. During each trial, participants would not only view the offer from their proposers but also the offer from one of the other 24 pairs, without receiving feedback on the responder behavior in the other pair. Participants were told that they would judge the fairness of present offer in a context where the responder in the other pair was treated differently, and they should make final decisions according to their own perceived fairness. Participants were also informed that, for both pairs in each trial, responders' decisions would be revealed only to their own proposers and thus their decision would not affect the offer of proposers in the other pair; all the offers and decisions among trials were mutual independent. In addition, participants were told that they would be paid according to their decision (after some kind of transformation to reduce the amount of money involved). They would be paid with the amount of money obtained from a random selection of 10% trials in the game (if the final payment was below 50RMB, they would be paid 50RMB).

Then they completed 24 trials (Figure 1A) in the scanner, 8 in each condition. All the trials were presented randomly and functional images were acquired simultaneously. Each trial began with a 4 s presentation of the faces of two pairs, followed by a 6 s presentation of the offers from two proposers. Equal offers (¥25:¥25) were given to the participants and the responders in the other pair in the Equal condition. In the Unequal-both condition, the offers to the participants were the same as the offers to the responders in the other pair (four trials of ¥5:¥45 and four trials of ¥10:¥40). In the Unequal-single condition, the offers to the participants were unequal (four trials of ¥5:¥45 and four trials of ¥10:¥40), while the offers to the responders in the other pair were always equal (¥25:¥25). After that, a 3 s decision cue appeared and participants were required to decide (accept or reject) within 3 s. Each trial was jittered with interstimulus intervals from 1 to 3 s, during which a black fixation cross was presented.

After scanning, the participants were presented with the same stimuli as inside the scanner and asked to rate how fair they felt for each offer using a nine-point Likert-type scale where 1 indicated extremely unfair and 9 indicated extremely fair.

fMRI image acquisition and analysis

Scanning was carried out on a 3T Siemens scanner at the fMRI Lab (East China Normal University, Shanghai). Functional images were acquired using a gradient echo echo-planar imaging (EPI) sequence (TR = 2200 ms, TE = 30 ms, FOV = 220 mm, matrix size = 64 * 64). Thirty five slices paralleled to the AC–PC line (slice thickness = 3 mm, gap = 0.3 mm) were acquired and covered the whole brain. The first five TRs acquired were discarded to allow for T1 equilibration. Before the functional run, a high-resolution structural image was acquired using a T1-weighted, multiplanar reconstruction sequence (TR = 1900 ms, TE = 3.42 ms, 192 slices, slice thickness = 1 mm, FOV = 256 mm, matrix size = 256 * 256).

Data preprocessing and statistical analyses were performed with Statistical Parametric Mapping (SPM5, Wellcome Department of Cognitive Neurology, London). During data preprocessing, the first five functional images were discarded to allow scanner equilibrium effects. Then all data were realigned spatially to the first image of the first time series. The mean EPI image of each participant was computed and spatially normalized to the Montreal Neurological Institute (MNI) single participant template by using the 'unified segmentation' function in SPM5. The resulting parameters were subsequently applied to the functional images, and all images were thus transformed into standard MNI space (resampled to 2 * 2 * 2 mm³ voxel size). At last, the data were smoothed with an 8 mm full-width half-maximum isotropic Gaussian kernel.

Statistical analyses were performed using the general linear model implemented in SPM5. An event-related design was used at the first-level analysis with three types of events (Equal, Unequal-both and Unequal-single). Events were convolved with a canonical hemodynamic response function and its time derivatives. All the encoding trials were modeled with null duration from the onset time of the offers. Additional regressors of no interest were created for face presentation and decision. Six regressors modeling movement-related variance and one modeling the overall mean were also employed in the design matrix. High pass temporal filtering with a cutoff of 128 s was also applied in the models. For each subject at the first-level analysis, simple main effects for three types of events (Equal, Unequal-both and Unequal-single) were computed by applying the '1 0' contrasts. The three first-level individual contrast images were then analyzed at the second group level using a random-effects model (flexible factorial design in SPM5).

The (Unequal-both + Unequal-single)/2 − Equal contrast was computed to search for brain regions related to unfairness. The reverse contrasts were also computed. Distinct activations between different unequal conditions were calculated by the Unequal-single − Unequal-both and reverse contrasts. To further test how equal or unequal offers to others in similar circumstances affect participants' brain activations associated with unfairness, specific activations identified in the Unequal-single − Unequal-both and reverse contrasts were used to compute regions of interest (ROIs). All the significant voxels in the activated clusters within 6 mm spherical regions centered on the peak or local maximum coordinates were included in each ROI. ROIs were defined in the same way throughout the article.

To identify brain regions associated with acceptance behaviors in the Unequal-both condition, a new model containing only accepted trials in the Unequal-both condition and Equal condition (all trials in the Equal condition were accepted; see Behavioral results) was conducted. Three participants were excluded from this analysis because of lack of accepted trials in the Unequal-both condition. We further searched for brain regions whose BOLD signal change detected from the above contrast varied with the corresponding acceptance rate through a correlation analysis. A voxel-level threshold of $P < 0.001$ (uncorrected) and a spatial extent threshold of $k > 15$ were consistently used throughout the article.

RESULTS

Behavioral results

Paired t-tests revealed lower acceptance rates and fairness ratings for Unequal-both trials than Equal trials (ts > 5.05, Ps < 0.01) (Figure 1B). Furthermore, acceptance rates and fairness ratings of Unequal-both trials were significantly higher than that of Unequal-single trials (ts > 5.10, Ps < 0.01, significant at 5% with sequential Bonferroni correction) (Figure 1B).

fMRI results

Overall brain activities during unequal trials compared with equal trials

Data analyses revealed that bilateral AI (MNI -32 26 2 and 40 20 0) and DLPFC (MNI -40 56 4 and 34 6 56) survived by contrasting unequal trials with equal trials [(Unequal-both + Unequal-single)/2 − Equal], whereas no region was activated in the reverse contrast (Table 1). When Unequal-single trials were compared with Equal trials, greater activities in bilateral AI (MNI -32 26 2 and 32 28 -2), dACC (MNI 14 24 28) and left DLPFC (MNI -44 52 6) were observed. The Unequal-both vs Equal contrast revealed activations in left AI (MNI -30 26 2) and bilateral DLPFC (MNI -40 56 4 and 46 22 44). We further compared the accepted Unequal-both trials with Equal trials. Similar

activations in left AI (MNI -28 26 2) and bilateral DLPFC (MNI -42 54 4 and 40 16 52) were found. Additionally, right AI (MNI 42 22 0) was also activated. The reverse contrasts showed no activated ROI.

Distinct brain activities between different unequal conditions

The Unequal-single–Unequal-both contrast revealed stronger activities in bilateral AI (MNI -34 26 2 and 26 18 -18) and dACC (MNI 8 22 28), whereas a cluster located in right DLPFC (MNI 44 22 44) was observed in the reverse contrast (Table 2, Figure 2). Further ROI analyses based on activations in bilateral AI, dACC and right DLPFC were conducted. Results revealed that bilateral AI and dACC showed greater activities during Unequal-single trials than Unequal-both trials, whereas right DLPFC activity was greater during Unequal-both trials than Unequal-both trials ($ts > 4.22$, $Ps < 0.01$) (Figure 2).

Correlation analyses on acceptance rate

Correlation analyses were performed to determine brain regions whose BOLD signal change detected from the accepted Unequal-both *vs* Equal contrast varied with the corresponding acceptance rate. Significant negative correlations were found in right DLPFC (MNI 30 18 56). We then overlapped activations from correlation analyses with activations from the Unequal-both–Equal contrast. Clusters in right DLPFC overlapped (Figure 3).

Parametric analyses on fairness ratings

Parametric analyses on fairness ratings were also conducted. Bilateral AI (MNI -34 24 4 and 26 22 -14) and DLPFC (MNI -28 14 56 and 32 10 60) showed negative correlations with fairness ratings, indicating higher brain activities in these regions when participants reported lower fairness ratings. No regions showed significant positive correlations with fairness ratings.

DISCUSSION

This study sought to investigate whether and how equal or unequal treatments given to others in like circumstances affected responders' fairness considerations in the UG. At the behavioral level, decreased

Table 1 Overall brain activities during Unequal trials compared with Equal trials

Side	Region	Peak activation			t value	Voxels
		X	Y	Z		
Unequal–Equal						
L	Supplementary motor area	−4	18	48	11.36	51 733
L	AI	−32	26	2	8.38	
R		40	20	0	4.54	
L	DLPFC	−40	56	4	5.07	
R		34	6	56	4.25	
L	Middle temporal gyrus	−52	−18	−10	5.81	433
L		−52	0	−20	3.91	26
R	Superior frontal gyrus	30	66	2	4.73	55
L	Medial temporal pole	−48	10	−30	4.71	76
R	Hippocampus	24	−38	−2	4.41	93
R	Fusiform gyrus	42	−14	−32	4.21	58
R	Superior temporal gyrus	50	−10	−8	4.16	93
R		58	−36	10	3.84	112
L	Superior medial gyrus	−6	56	38	3.71	26
L	Posterior insula	−32	−30	20	3.65	19
Equal–Unequal						
	No regions					

Note: Coordinates (mm) are in MNI space. L = left hemisphere; R = right hemisphere. $P < 0.001$(uncorrected), $k > 15$.

fairness ratings and acceptance rates were found in both unequal conditions relative to the equal condition. More importantly, responders were more likely to accept unequal offers and reported higher fairness ratings in Unequal-both condition relative to Unequal-single condition, indicating that unequal offers were perceived less unfair when their peers received unequal offers compared with when their peers received equal offers. At the neural level, greater right DLPFC activity and lower AI/dACC activities were observed during Unequal-both trials relative to Unequal-single trials. These findings demonstrate that equal or unequal offers given by proposers are not the only determinant of responders' judgments of fairness in UG. Whether their peers are offered equally also plays an important role in their behavioral and neural responses to unfairness.

Unequal offers in UG have been considered as violations of fairness norm (de Quervain et al., 2004; Spitzer et al., 2007; King-Casas et al., 2008; Güroğlu et al., 2010, 2011). Consistent with prior arguments that AI was associated with norm violations (Montague and Lohrenz, 2007; Spitzer et al., 2007; King-Casas et al., 2008; Strobel et al., 2011; Chang and Sanfey, 2013), data analyses showed that greater AI activity was observed during unequal offers relative to equal offers. The role of AI in reacting to norm violations was further supported by the result that more AI activity was found in the Unequal-single condition relative to the Unequal-both condition. Participants reported higher fairness ratings and accepted more often in the Unequal-both condition compared with Unequal-single condition, suggesting that the equal split serving as the social norm during fairness considerations in the standard UG should not be taken for granted as the reference point for fairness judgments when other responders are treated unequally. On the other hand, the equal split is confirmed as the reference point for fairness considerations when other responders are offered equally. Thus, proposers' norm-violating behaviors in the Unequal-single condition would be more obvious, leading to greater AI activities associated with norm violations in the Unequal-single trials relative to the Unequal-both trials. Accompanied by AI activity, dACC also showed significant activation in the Unequal-single condition rather than the Unequal-both condition, indicating the involvement of AI/dACC network in norm violations (Güroğlu et al., 2010, 2011).

Another important brain region involved in fairness considerations is DLPFC. The engagement of DLPFC in decision making is related to top-down executive control of impulses to reject unfair offers (Sanfey et al., 2003) or accept unfair offers (Güroğlu et al., 2010, 2011). In the present study, right DLPFC was activated during the Unequal-both trials relative to the Unequal-single trials. When restricted to accepted trials, the Unequal-both vs Equal contrast also activated right DLPFC, indicating that right DLPFC may relate to acceptance behaviors in the Unequal-both condition. Correlation analyses further revealed that the activations of right DLPFC during the accepted Unequal-both trials showed negative correlation with acceptance rates. The right DLPFC overlapped in the correlation analyses and the Unequal-both–Equal contrast, suggesting individuals with lower acceptance rates had higher right DLPFC activity when their peers were also treated unequally like themselves. This is consistent with converging evidence using repetitive transcranial magnetic stimulation (Knoch et al., 2006) and cathodal transcranial direct current stimulation (Knoch et al., 2008), which revealed that disrupted function of the right DLPFC, but not left DLPFC, increased acceptance rates of unequal offers in UG. Together, our results suggested that right DLPFC might be engaged in executive control of acceptance impulses (Güroğlu et al., 2010, 2011).

Our conclusions come from a design in which the comparison between the participant and another person was made salient. The explicit provision of the comparison may have encouraged participants, consciously or unconsciously, to incorporate the comparison

into decision making more fully. Life also makes comparisons explicit, so the relevance of our conclusions still stands. Nonetheless, future research should investigate the salience of the comparison as a potential moderating variable.

We consider three further interpretations of our results. First, AI and dACC may be more responsive to the Unequal-single rather than the Unequal-both condition because the former is a mismatch condition and the latter a match condition; the mismatch condition may just make the unfairness more salient and hence easier to detect. On this interpretation, individuals should respond to unfairness more quickly in the Unequal-single than Unequal-both condition. Using the same materials and procedure as the fMRI experiment, we asked 23 new participants to press different buttons to indicate whether they were offered an equal amount in each trial. There was no significant difference in reaction time (or accuracy) between the Unequal-single and Unequal-both conditions (reaction time, Unequal-single: $1248 \pm$ s.d. $= 426$ ms vs Unequal-both: 1239 ± 485 ms, $t(22) = 0.22$,

Table 2 Distinct brain activities between different Unequal conditions

Side	Region	Peak activation			t value	Voxels
		X	Y	Z		
Unequal-single—Unequal-both						
R	Rolandic operculum	44	−4	14	8.33	57 552
L	AI	−34	26	2	6.21	
R		26	18	−18	5.27	
R	Anterior cingulate cortex	8	22	28	5.34	
R	Linual gyrus	40	−82	−18	3.66	16
Unequal-both—Unequal-single						
R	DLPFC	44	22	44	4.21	108

Note: Coordinates (mm) are in MNI space. L = left hemisphere; R = right hemisphere. $P < 0.001$ (uncorrected), $k > 15$.
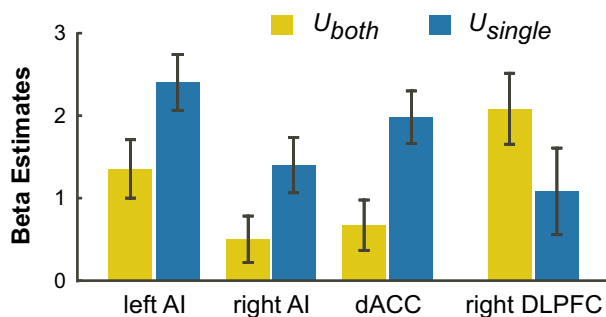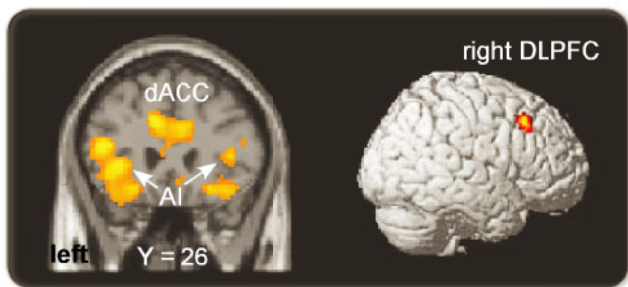

Fig. 2 Distinct brain activities between different unequal conditions. Activities in bilateral AI (MNI -34 26 2 and 26 18 -18) and dACC (MNI 8 22 28) were greater for Unequal-single condition relative to Unequal-both trials, whereas right DLPFC (MNI 44 22 44) activity was stronger during Unequal-both trials than Unequal-single trials. U_{both} = Unequal-both. U_{single} = Unequal-single. Error bars indicate s.e.m. $P < 0.001$ (uncorrected), $k > 15$.
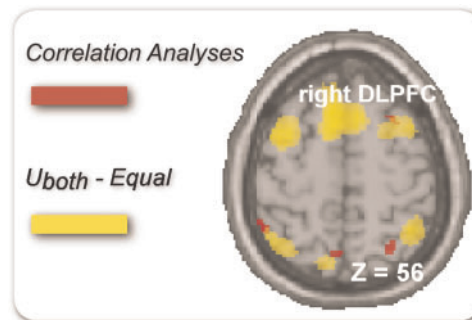
$P = 0.83$). To interpret the non-significant difference, note that Ilic *et al.* (2013) found, for different materials, a match-mismatch difference in reaction time of ∼10% of total reaction time, i.e. for reaction time of around 1240 ms, if there was a match-mismatch difference, a difference of around 124 ms would be reasonable to expect. We found a difference of 9 ms in the wrong direction (standard error = 40 ms, corrected to 42 ms, as per Dienes, 2011). A Bayes factor was calculated, with the predictions of H1 modeled as a half-normal with an s.d. of 124 ms (as per Dienes, 2011, forthcoming), giving B = 0.28. The B indicates the data provide substantial support for the null. That is, the unfairness is not easier to detect per se in the Unequal-single *vs* the Unequal-both condition.

A second interpretation of our results is that the sharing of unfairness is seen as less aversive generally, and our result is a specific case of this more general phenomenon. For example, it may be that if an equal split were given to the participant and an unequal split to the other pair (a condition we did not use), AI and dACC would also be more active than in the Unequal-both condition. This conjecture deserves testing but if found false our hypothesis would still stand. The participants were asked to make decisions for themselves and not for the responder in the other pair; whether the responder in the other pair was treated equally or unequally only provided a contextual cue for the participant's fairness considerations. Participants did not receive any feedback about the responder's behavior in the other pair. Plausibly, participants focused on their own fairness. It has been argued that people do not share others' pain automatically when they are involved in an additional task distracting attention from the pain of others (Gu and Han, 2007). Thus, participants may not share the pain of the responder in the other pair explicitly or automatically when the unfairness occurs only to the other (and not to oneself).

A third interpretation is based on AI being sensitive to others' unfairness when participants are asked to accept or reject unequal divisions for themselves or on the behalf of another person (Civai *et al.*, 2012; Corradi-Dell'Acqua *et al.*, 2013). Thus, one might predict the total amount of AI activation to increase according to the sum of the unfairness for self and other. This theory is falsified by the data; it predicts greater AI activation in the Unequal-both rather than Unequal-single condition. In our paradigm, participants were only asked to play the UG as responders and make decisions for themselves with the co-occurent information on the offer to the responder in the other pair, completely changing the perspective from the task in Civai *et al.* (2012) and Corradi-Dell'Acqua *et al.* (2013).

Recent neuroimaging studies have focused on how to distinguish confounds in the UG to further isolate the variables involved in fairness-related decision-making process. For example, Tabibnia *et al.* (2008) separated the preference for fairness from the desire for material gain. Tricomi *et al.* (2010) further distinguished the aversion to

Fig. 3 Overlap. Clusters in right DLPFC overlapped between correlation analyses and the Unequal-both—Equal contrast. U_{both} = Unequal-both. $P < 0.001$ (uncorrected), $k > 15$.

inequality from social image or reciprocity. Our study contributes to this research program. During the present study, two conditions were manipulated in which participants received the same unequal offers but were provided different information on whether others like them were treated equally, allowing us to probe directly how people's fairness considerations were affected by the comparisons between the referent others and themselves during the same amount of inequality. Different patterns of behavioral and neural responses between the Unequal-single and Unequal-both conditions highlights that people's fairness considerations are dynamic and there is no one-to-one correspondence between unequal and unfair. What people seek may be not absolute equality but relative fairness.

CONCLUSIONS

The present study investigated that whether and how responders' behavioral and neural responses to unfairness in UG were affected by equal or unequal offers to their peers through justifying responders' reference points for fairness considerations. Specifically, participants were more likely to accept unequal offers and reported higher fairness ratings when their peers received unequal offers compared with when their peers received equal offers. More AI/dACC activities were observed when only participants (but not their peers) received equal offers, whereas greater right DLPFC activity was found when both of them received unequal offers, especially when participants accepted the unequal offers. Evidence from correlation analyses further revealed greater DLPFC activity for individuals with lower acceptance rates, indicating right DLPFC might be related to executive control of acceptance impulses. Taken together, the results demonstrated that equal or unequal offers given by proposers are not the only determinants of responders' judgments of fairness in UG, whether others in like circumstances were offered equally also plays an important role in responders' fairness-related social decision-making processes.

Conflict of Interest

None declared.

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