NeuroImage 77 (2013) 246–253

Contents lists available at SciVerse ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

Increased neural responses to unfairness in a loss context

Xiuyan Guo [a], Li Zheng [b], Lei Zhu [c,*], Jianqi Li [d], Qianfeng Wang [d], Zoltan Dienes [e], Zhiliang Yang [b]

[a] 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
[b] School of Psychology and Cognitive Science, East China Normal University, North Zhongshan Road 3663, Shanghai, SH 200062, China
[c] Department of Psychology, Fudan University, Handan Road 220, Shanghai, SH 200433, China
[d] Shanghai Key Laboratory of Magnetic Resonance and Department of Physics, East China Normal University, North Zhongshan Road 3663, Shanghai, SH 200062, China
[e] School of Psychology, University of Sussex, Sussex House, Brighton BN1 9RH, United Kingdom

ARTICLE INFO

Article history:
Accepted 14 March 2013
Available online 3 April 2013

Keywords:
Unfairness
Loss
Gain
fMRI

ABSTRACT

Unfairness plays an important role in economic decision making. This fMRI study sought to investigate how the loss and the gain contexts could modulate behavioral and brain responses to unfairness by focusing on participants' rejection behaviors during an Ultimatum Game paradigm. Participants were scanned while they were playing the Ultimatum Game as responders in both loss and gain contexts, i.e. receiving ¥50 as gains and paying for ¥50 as losses. At the behavioral level, lower fairness ratings and higher rejection rates were revealed for unfair losses than unfair gains. At the neural level, left dorsolateral prefrontal cortex, bilateral anterior insula, anterior cingulate cortex/anterior middle cingulate cortex and bilateral dorsal striatum were associated with rejection (vs. acceptance) in the loss context, but not in the gain context. Together, our data indicated that participants may experience more unfairness in UG and stronger desire to sanction social norm violations in the loss context than in the gain context, inducing more fairness-related neutral activities when rejecting (vs. accepting) unfair losses than unfair gains. These findings shed light on the significance of context (i.e. loss or gain) in fairness-related social decision-making processes.

Introduction

Standard economic theories of human decision-making idealize individuals as perfectly rational cognitive machines aiming to maximize their personal benefits. However, recently, abundant empirical evidence in the field of behavioral economics showed that additional psychological and emotional factors could drive one's decision-making process to deviate from the goal of personal benefit maximization and finally lead to irrational behaviors (Kahneman and Tversky, 1979). A good example is the Ultimatum Game (UG), which has been used widely to illustrate the influence of unfairness on decision-making in behavioral and neuroimaging studies. In this game, two players work together to split a sum of money. One player proposes how to split it and the other one responds (i.e. the proposer and the responder). The responder can accept or reject the offer. Her/his acceptance leads to the suggested division of money, whereas the rejection results in both players receiving nothing. According to standard economic models, in order to maximize personal benefits, responder should accept all the offers. However, an increasing number of UG studies have revealed that responders were likely to reject unfair offers, especially for offers below 20% of the total (e.g., Camerer and Thaler, 1995; Güth et al., 1982), indicating that unfairness had a great impact on human decision-making process.

Irrational rejection behaviors in studies using UG paradigm have been investigated widely in the gain context, i.e. players split a sum of money as their gains (e.g., Corradi-Dell'Acqua et al., in press; Güroğlu et al., 2010, 2011; Sanfey et al., 2003). However, many studies in the field of economics showed that people weighed loss greater than equivalent gain when making a decision and thus human decision-making in the loss context and the gain context diverged in dramatic ways (De Martino et al., 2006; Kahneman and Tversky, 1979; Novemsky and Kahneman, 2005; Tom et al., 2005; Tversky and Kahneman, 1981). A recent behavioral study has tried to explore the potential impact of loss and gain contexts on players' responses in UG (Zhou and Wu, 2011). The set of gain context was the same as typical UG, whereas in the loss context, proposer and responder needed to pay for a sum of money. Responder's acceptance led to the suggested division of payment, and the rejection resulted in both players incurring the whole loss. It was revealed that responders reported lower fairness ratings and rejected more often in the loss context than those in the gain context. Furthermore, Zhou (2010) suggested that the loss vs. gain and unfair vs. fair contrasts showed similar activations in their earlier unpublished fMRI study. However, the neural mechanism underlying rejection of unfair losses and unfair gains in UG was still to be determined.

Neuroimaging studies have identified several fairness-related brain regions involved in UG in the gain context, including anterior insula (AI), anterior cingulate cortex (ACC) extending to anterior middle cingulate cortex (aMCC), striatum, and dorsolateral prefrontal

* Corresponding author. Fax: +86 21 64674201.
E-mail address: judy1981_81@hotmail.com (L. Zhu).

1053-8119/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.neuroimage.2013.03.048

cortex (DLPFC) (Corradi-Dell'Acqua et al., in press; Dulebohn et al., 2009; Güroğlu et al., 2010, 2011; Sanfey et al., 2003). Empirical evidence recently suggested that AI and/or ACC were engaged in detecting and responding to norm violations (Güroğlu et al., 2010, 2011; King-Casas et al., 2008; Montague and Lohrenz, 2007; Spitzer et al., 2007; Strobel et al., 2011). Unfair offers in UG have been considered as violations of social norms, i.e. fairness and cooperation norms (de Quervain et al., 2004; Güroğlu et al., 2010, 2011; King-Casas et al., 2008; Spitzer et al., 2007). AI and ACC/aMCC activities in rejection in UG might be associated with the desire to sanction behaviors violating fairness norm. Another region of interest was striatum which also showed greater activation when comparing unfair offers with fixation (Dulebohn et al., 2009). Striatum activity has been associated with altruistic punishment, i.e. punishing others' behaviors violating social norms at a cost to themselves (de Quervain et al., 2004; Strobel et al., 2011). The involvement of striatum in UG may also reflect the wish to sanction proposers' unfair divisions violating fairness norm. Finally, DLPFC activity has been also observed in decision-making during the UG paradigm. The engagement of DLPFC in UG was interpreted in terms of top–down executive control of impulses to accept unfair offers, supported by greater activation during rejection relative to acceptance (Güroğlu et al., 2010, 2011).

In the present event-related fMRI study, we adopted a variant of the UG developed by Zhou and Wu (2011) in which loss context with different levels of unfairness was firstly employed. Participants were scanned while they were playing UG as responders in both loss and gain contexts (Fig. 1A), i.e. receiving ¥50 as gains and paying for ¥50 as losses. Proposer could propose fair offers or unfair offers. Participants were asked to give responses (rejection or acceptance) to the offers. Within unfair offers, participants' responses could be divided into two kinds: rejection and acceptance (participants never reject fair offers; see behavioral results). Buchan et al. (2005) have initially showed that loss and gain contexts have different impacts on human fairness preference. Zhou and Wu (2011) further found that unfair losses would be perceived as more unfair than unfair gains in subjective rating, leading to higher rejection rates in the loss context than the gain context. Based on Zhou and Wu (2011), we aimed to investigate the brain mechanism underlying the modulation of rejection in UG by context (loss vs. gain). We expected greater activations in brain regions involved in UG (i.e. DLPFC, AI, ACC/aMCC and striatum) for rejection of unfair losses than unfair gains.

Methods

Participants

Twenty-seven right-handed volunteers from the university community with normal or corrected-to-normal vision [10 men and 17 women, mean age = 22.44 ± 3.49 (SD) years] participated in this experiment. Six participants were excluded from further statistic analysis because of lack of rejected trials or accepted trials in at least one condition. Three of them did not reject at all. Two of them did not give rejection responses in the gain context and the last one did not give acceptance responses to unfair offers in the loss context.

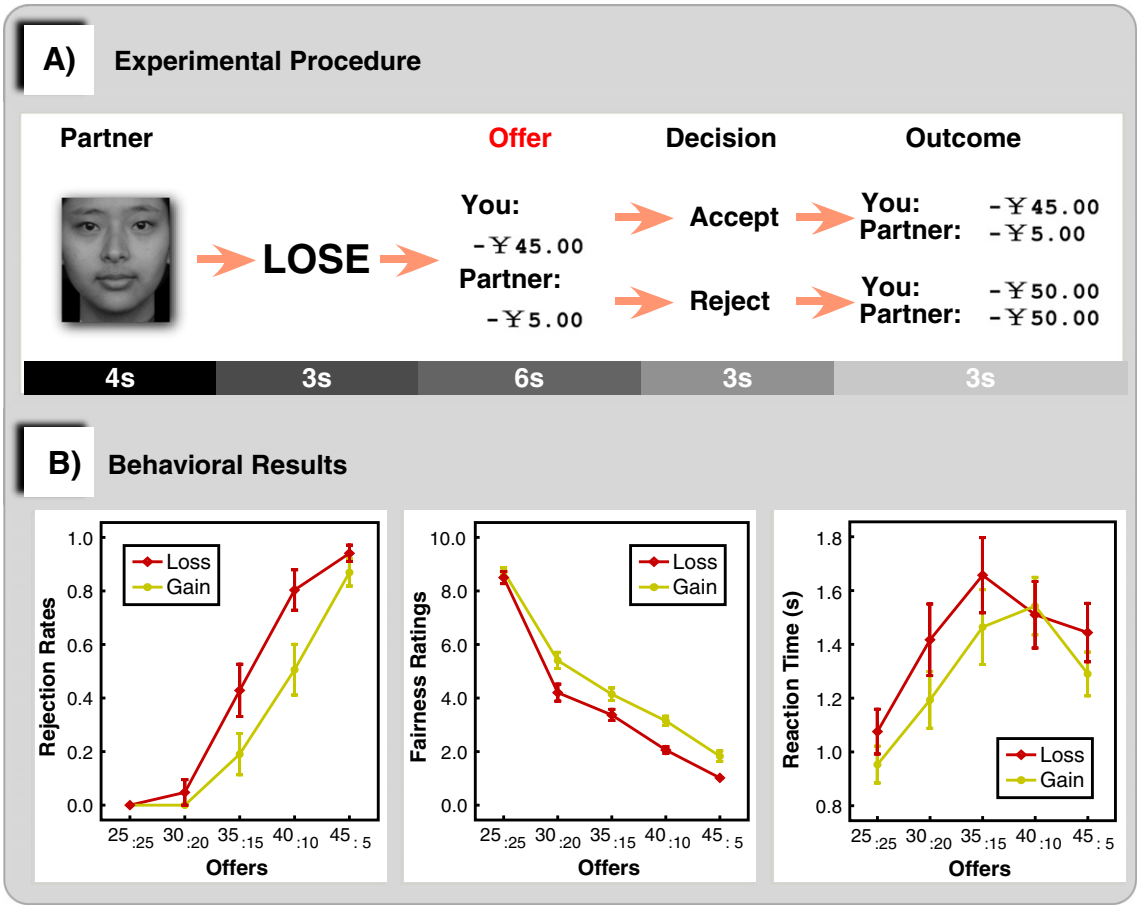

Fig. 1. (A) Experimental procedure. Participants were scanned while playing the game for 64 trials, 32 in each context. Each trial involved splitting a gain or loss of ¥50. Fair offers (25:25) were given in 8 trials of each context, with the remaining 24 unfair trials (4 trials of 30:20, 4 trials of 35:15, 8 trials of 40:10 and 8 trials of 45:5). (B) Behavioral results. Rejection rates, fairness ratings and RTs (s) are plotted as a function of unfairness level in both loss (red rhombuses) and gain (yellow circles) contexts. Error bars indicate s.e.m.