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with and without sanction) and functional MRI, Spitzer *et al.* (2007)

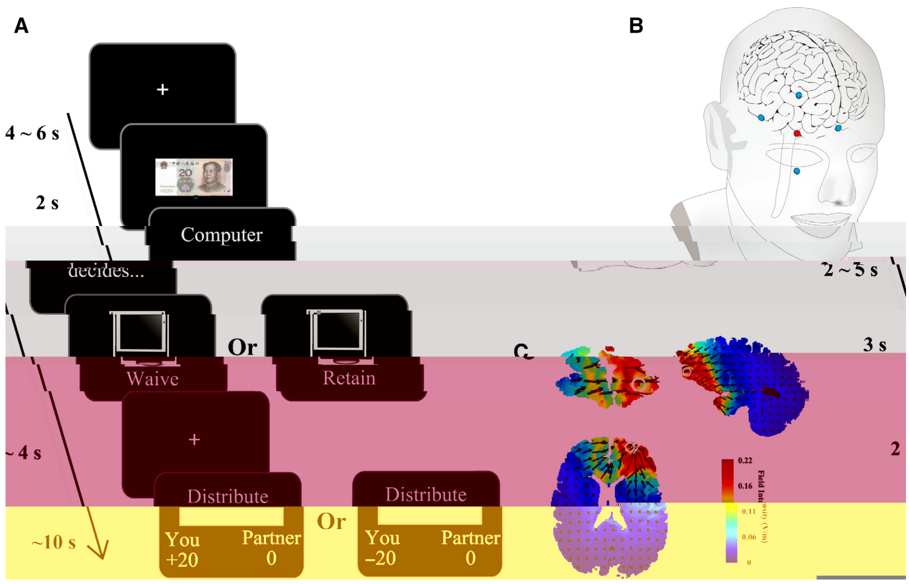
polarity on the target brain area depended on the central electrode. The current distribution under HD-tDCS has been partially validated by empirical data through a MRI-guided finite element model (Datta *et al.*, 2009; Edwards *et al.*, 2013), and recent studies showed that current density of HD-tDCS falls off with increasing cortical depth (Datta *et al.*, 2009). The current intensity was 2.0 mA which created ~0.5 mA/cm^2 peak current density at the central electrode, and ~0.125 mA/cm^2 peak current density at the return electrodes. Stimulation started 8 min before the task, and was delivered during the entire course of the task (~20 min) with an additional 30-s ramp-up at the beginning of stimulation and 30-s ramp-down at the end. The placement of electrodes was the same for the sham and the cathodal stimulation. However, for the sham stimulation, the initial 30 s ramp-up was immediately followed by the 30-s ramp-down, and there was no stimulation for the rest of the session (cf. Gandiga *et al.*, 2006; Douglas *et al.*, 2015). For both the cathodal and sham stimulation conditions, participants felt a little uncomfortable initially, but gradually the feelings associated with stimulation became negligible before the task started, according to our post-experiment interview.

Compared with the conventional bipolar tDCS, HD-tDCS has been shown to have better spatial focality and prolonged effect (Datta *et al.*, 2009; Caparelli-Daquer *et al.*, 2012; Kuo *et al.*, 2013; Shen *et al.*, 2016). Although HD-tDCS is associated with stronger scalp sensations than conventional tDCS, it has been shown to be safe and tolerable with applications of up to 2.0 mA for about 20 min (Minhas *et al.*, 2010; Borckardt *et al.*, 2012; Kuo *et al.*, 2013). It should be noted that the spatial resolution of tDCS is limited compared to transcranial magnetic stimulation (TMS), even in the mode of HD-tDCS (see Fig. 1C for the area estimated to be affected by the tDCS). However, in order to better compare the current findings with the findings from a few previous tDCS studies on similar topics (e.g., Knoch *et al.*, 2008; Ruff *et al.*, 2013; Zhang *et al.*, 2016), we use tDCS to manipulate the activity of the lPFC/lOFC.

Procedure

The experiment had a 2 (stimulation: sham vs. cathodal) by 2 (context: Gain vs. Loss) by 2 (threat: threat-on vs. threat-off) mixed factorial design with stimulation as between-subject factor whereas context and threat as within-subject factors. A modified repeated one-shot Dictator Game was employed (cf. Zhang *et al.*, 2016), in which the participants allocated either a profit or a loss of 20 Chinese *yuan* (about U.S. $ 3.5) between themselves and a randomly paired co-player randomly chosen from three confederates. In each round, before the participant made the allocation, the computer randomly decided to retain or waive the punishment threat (4 *yuan*). If the threat was retained and the amount allocated to the paired co-player was lower (higher) than what the latter had expected in the gain (loss) context, the participant would be penalized by 4 *yuan*, although no feedback was given concerning how much the co-player expected and whether the participants were in fact punished. Voluntary compliance was defined as the amount allocated when no threat was imposed, whereas compliance under sanction threat was defined as the amount allocated when sanction threat was retained. Moreover, threat-induced strategic compliance was defined as the difference in allocation amount between the threat retained and the threat waived conditions.

Upon arrival at the laboratory, the participant and three same-sex strangers (confederates of the experimenter) went through a randomization procedure (i.e., drawing lots) to determine their role in the game. We told the participant that one lot had a letter ‘A’ on it, while the other three had ‘B’. The one who drew the unique lot would be assigned the role of allocator, while the others would be assigned the role of receiver. Unbeknownst to the participant, all the four lots had an “A” on it to ensure that the participant be assigned the role of allocator. The participant believed that he/she would play each round through internet with a randomly paired receiver who was in another room. We told the participant that on each round the paired receiver would indicate the minimum share he/she expected



F . 1. (A) Procedure and task sequence. The participant allocated 20-*yuan* profit (about $ 3.5) or 20-*yuan* loss between him/herself and a randomly paired partner in each round. The computer randomly decided to retain or waive the punishment threat (4 *yuan*) before the participant made the allocation. (B) Schematic illustration of the HD-tDCS electrodes placement: Right OFC was localized at FP2 in the 10/20 EEG system (red circle). (C) Electric field simulation was performed with the HD-explorer software (SoterixMedical, New York, USA); simulated field intensity was indicated by the color bar. Arrow direction indicated current flow direction and arrow length indicated current flow intensity.

from the allocator. If the amount the allocator (i.e., the participant) allocated to the receiver was less than that minimum amount, a sanction may or may not be imposed on the allocator, depending on a prior decision by the computer (see below). To avoid learning effect, no feedback of earning/loss or sanction was provided. The participant was also told that a gain round and a loss round would be randomly chosen and realized after the experiment; this was to motivate the participant to treat each round equally and independently.

Each round began with the presentation of a white fixation cross against a black background, lasting for 4000 to 6000 ms with a step of 400 ms (Fig. 1). Then a cue of the total allocation amount (a picture of 20 *yuan* bill) was presented for 2000 ms, followed by a sentence indicating that punishment threat would be randomly decided by the computer for this trial. This sentence remained on the screen for 2000–5000 ms (with a step of 400 ms). Then the decision (Waive vs. Retain) together with a picture of computer were presented on the screen for 3000 ms. Specifically, 'Waive' means the computer decides that no sanction will be imposed on the current round, so the participant can allocate as she wishes without worrying about sanction. 'Retain' means the computer decides to keep the sanction threat on the current trial. In that case, if the participant's allocation was less than the minimum expectation given by the receiver, the participant would receive a sanction (although he/she did not know whether he/she was actually sanctioned in a given trial). Finally, after a 2000-to-4000-ms fixation, a distribution screen was presented. The participant was required to make the allocation within 10 s by pressing two buttons to adjust the allocation amount with a step of 2 *yuan* and a third button to confirm the allocation. The allocation was directed to the receiver so that in the gain context the positive points allocated to the receiver would be added to the receiver's account, while in the loss context, the negative points allocated to the receiver would be deducted from the partner's account. Button press was counterbalanced across participants. The initial amount on the side of the participant was either 0 or 20 *yuan* (0 or −20 *yuan* in the loss context) and was counterbalanced across conditions.

The allocation task consisted of a gain block and a loss block, each of which had 32 trials. Overall the task lasted about 20 min. Block sequence was counterbalanced across participants. A regression analysis showed that the sequence did not have any significant influence on participants' allocation decision. Therefore, in our data analysis we collapsed this factor. Each of the four experimental conditions (context × threat) has 16 trials. Presentation order of Waive and Retain conditions was pseudo-randomized and different sequences were created for different participants. To make sure that the participants actually believe our experimental setup, we included in the post-experiment questionnaire a number of questions assessing the participants' thoughts and attitudes about the experiment. These questions are 'To what extent you care about your payoff in the game' (1, not at all; 5, very much), 'To what extent you think you are interacting with a real human partner' (1, not at all; 5, very much), 'Do you have any questions, comments, and concerns about this experiment' (open-ended question). If a participant chose 1 for any of the first two questions or expressed suspicion about the experiment in the third question, we excluded him/her from data analysis.

Participants were randomly assigned to the inhibitory group (i.e., cathodal stimulation) or the control group (i.e., sham stimulation). Before the main task, the participants were familiarized with the task with a practice block of 8 trials. They performed the task while receiving cathodal or sham stimulation. To test whether fairness perception was affected by tDCS, participants indicated, before and after the tDCS stimulation, which of the ten different allocation schemes (from 0 to 20 *yuan* in steps of 2) to the receiver was fair.

Results

To achieve a similar measure of the degree of compliance in both the gain and the loss domains, we computed the distance between the participant's allocation and the least compliance situation in each context. Let us suppose that the participant's allocation in a given trial is x. In the gain context, the degree of compliance, according to our definition, is $x–0 = x$, which is straightforward. In the loss context, it is $x– (−20) = 20+ x$. For example, if the allocation is −16 for the partner and −4 for the participant, then the degree of compliance to fairness norm is 20+ (−16) = 4. Thus, in indicating that lPFC/lOFC may not play a direct role in mediating norm compliance in the loss-sharing situation.

rejection rates in the loss context than in the gain context, suggesting that they were more willing to suffer personal cost to punish norm violators in the loss context. Using functional MRI, Wu *et al.* (2014) further demonstrate that rejecting unfair offers in the loss domain activate the dorsal striatum, an indication of rewarding and satisfactory experience (see also De Quervain *et al.*, 2004; Crockett *et al.*, 2013). It is thus clear from these studies that people have higher demand for fairness in the loss-sharing context. It is possible that in the current study, the participants were (implicitly or explicitly) aware of the higher demand of norm compliance in the loss domain and behaved accordingly.

Alternatively, although allocating less gain and allocating more loss to the co-player equally deviate from fairness norm, these two types of behaviors may induce different feelings, as incurring loss is more easily appraised as a kind of harm and thus is more likely to elicit the feeling of guilt (cf. Van Beest *et al.*, 2005). Harm aversion and such requirement is abolished in the loss context, probably because other motivations (e.g., enhanced fairness demand or harm/guilt aversion) become prominent in loss domain.

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Con ic of in e o

The authors declare no conflict of interest.

A ho con ib io o

YY, HY, YZ, and XZ contributed to the design of the study and wrote the paper; YY and ZS collected the data; YY and HY analyzed the data.

Da a acce ibili

The article's supporting data can be accessed through the journal's Figshare page.

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