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RESEARCH ARTICLE

Modulation of financial deprivation on deception and its neural correlates

Peng Sun[1] · Xiaoli Ling[2] · Li Zheng[3,6] · Jia Chen[1] · Lin Li[1] · Zhiyuan Liu[4] · Xuemei Cheng[4] · Xiuyan Guo[5,6]

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Abstract Deception is a universal phenomenon in human society and plays an important role in everyday life. Previous studies have revealed that people might have an internalized moral norm of keeping honest and the deceptive behavior was reliably correlated with activation in executive brain regions of prefrontal cortices to over-ride intuitive honest responses. Using functional magnetic resonance imaging, this study sought to investigate how financial position modulated the neural responses during deceptive decision. Twenty-one participants were scanned when they played a series of adapted Dictator Game with different partners after a ball-guess game. Specifically, participants gained or lost money in the ball-guess game, and had opportunities to get more financial gains through cheating in the following adapted Dictator Game. Behavioral results indicated that participants did not cheat to the full extent; instead they were more likely to lie after losing money compared with gaining money. At the neural level, weaker activities in the dorsolateral prefrontal cortices were observed when participants lied after losing money than gaining money. Together, our data indicated that, people really had an internalized norm of keeping honest, but it would be lenient when people feel financial deprivation. And suppressing the truthful response originating from moral norm of keeping honest was associated with increased level of activation in the dorsolateral prefrontal cortices, but this association became weaker when people were under financial deprivation.

Keywords Deception · Financial deprivation · Moral norm · fMRI

Peng Sun and Xiaoli Ling contributed equally to this work.

✉ Lin Li
lilin@psy.ecnu.edu.cn

1 School of Psychology and Cognitive Science, East China Normal University, North Zhongshan Road 3663, Shanghai 200062, SH, China

2 School of Psychology, Shandong Normal University, Jinan, China

3 School of Psychology and Cognitive Science and Shanghai Key Laboratory of Magnetic Resonance, East China Normal University, Shanghai, China

4 Shanghai Key Laboratory of Magnetic Resonance and Department of Physics, East China Normal University, Shanghai, China

5 Shanghai Key Laboratory of Magnetic Resonance and School of Psychology and Cognitive Science, East China Normal University, Shanghai, China

6 Key Laboratory of Brain Functional Genomics, Ministry of Education, Shanghai Key Laboratory of Brain Functional Genomics, East China Normal University, Shanghai, China

Introduction

Deception is a universal phenomenon in human society and plays an important role in everyday life. Most people had thought of cheating, or carried out cheating behavior in their lives. A generally accepted definition of deception described it as a psychological process by which one intentionally attempted to convince another person to acknowledge what a liar knew as unreal to be true, typically motivated by potential benefit or loss-avoidance of the liar (Abe 2009). According to traditional economic theory, for pursuing the maximum personal benefit, people would lie to the full extent if deception would increase their expected utility (Becker 1968). Contrary to this assumption, however, abundant empirical evidences indicated that humans were often willing to sacrifice their own economic payoffs for keeping honest (Gneezy 2005; Grolleau et al. 2016; Sutter

2009; Urs and Franziska 2008). Therefore, some researchers speculated that people might have an internalized moral norm of keeping honest and they are intuitively honest and dislike lying or cheating (Gibson et al. 2013; Gneezy 2005; Mazar et al. 2008). Support for the intuitive and automatic nature of honest behavior was also provided by findings from neuroimaging studies. With a large variety of experimental protocols, previous studies consistently exhibited a reliable correlation between deception and activation in executive brain regions of prefrontal cortices, whereas honest responding usually has not been shown associated with any areas of greater activation compared to deception (Abe 2009; Christ et al. 2009; Ganis et al. 2003; Gombos 2006; Langleben et al. 2002; Lee et al. 2002; Spence et al. 2001, 2004, 2008). These results supported the notion that deceptive behavior required additional regulatory processes to over-ride intuitive honest responses (Spence et al. 2001, 2004).

Recently, with the insight that people have an internalized norm of keeping honest was widely accepted, more and more attentions have focused on studying the determinants that induced lying behavior,such as money priming, power position and fairness perception (Gino and Mogilner 2014; Houser et al. 2012; Koning et al. 2011). A latest and interesting finding was that people were more likely to lie when they experienced financial deprivation, a psychological state in which people felt financially inferior because they perceived a deficit in their financial position (Sharma et al. 2014). In Sharma's study, participants firstly played a gambling game, in which financial deprivation was triggered by losing money. Then, a task where participants had opportunities to get more financial gains through cheating was completed. Sharma's experimental results showed that participants behaved more dishonestly after they lost money in gambling game. Based on these results, Sharma speculated that people's moral norm of keeping honest seems more lenient when they experienced financial deprivation.

In this paper, we were particularly interested in further exploring the neural mechanism underlying the modulation effect of financial deprivation on moral norm of keeping honest. Previous neuroimaging studies have suggested that the involvement of prefrontal cortices in deceptive behavior might be related to inhibiting intuitive honest responses (Baumgartner et al. 2009; Greene and Paxton 2009; Sip et al. 2010; Spence et al. 2004). Thus, if people' moral norm of keeping honest was more lenient when experiencing financial deprivation, the involvement of prefrontal cortices in deceptive behavior would also decreased. In the current study, we used functional magnetic resonance imaging (fMRI) to examine this assumption. Additionally, in order to test the generalizability of Sharma's findings, the current research took use of a task different from what Sharma had used (Sharma et al. 2014). We employed an adapted Dictator Game which was generally used in previous deception researches to measure participants' deception behaviors (Kagel et al. 1996; Koning et al. 2011; van Dijk et al. 2008). In the classic Dictator Game, two players worked together to split a sum of money. One player proposed how to split it and the other one had to accept it passively. We adopted similar procedure in the current study with some important adaptions. Specifically, our participants would play as responder in the Dictator Game dividing 60 tokens, and they were told that tokens had different exchange value for responder and proposer (the worth of a token was 2 yuan for responder but only 1 yuan for proposer), whereas this info was unknown to proposer. Prior to the proposers' decision of allocation, participants needed to decide informing partner the truth or deceiving him. Besides, in order to induce experience of financial deprivation, participants were asked to complete a ball-guess game before every Dictator game, in which a losing instead of winning outcome triggered deprivation. Based on previous findings and our assumption, we hypothesized that participants would be more likely to deceive the proposer after losing money in the ball-guess game. And, weaker activities in the prefrontal cortices would be observed when participants lied after losing money than gaining money.

Methods

Participants

Twenty-one right-handed volunteers participated in this experiment (8 female, M = 24.05 years, SD = 2.65). All of them had normal or corrected-to-normal vision and no abnormal neurological history. This experiment was approved by the Ethics Committee of the East China Normal University and all participants gave written informed consent before scanning. Four participants were excluded from further statistical analyses. Two of them were exclude due to lack of lying trials (one did not lie at all and the other one did not lie in non-deprived condition) and another two had to be excluded due to excessive head movements (>3 mm).

Materials

78 face pictures were selected from Chinese Facial Affective Picture System (Gong et al. 2011) with consent for publication, and randomly allocated to different financial position (deprived vs. no-deprived). The emotional valence, arousal and attractiveness of pictures were counterbalanced across different conditions.

Procedure

Before scanning, participants were told the rules of the games and that they would play with 78 different strange partners. They were also informed that, for practical reasons, not all 78 game partners could actually be present in the fMRI laboratory, but that partners' offers about splitting 60 tokens were collected before the experiment. In addition, participants were told that both he/she and the partner in each trial would be paid partly according to the money they got during the experiment. Participants would be given a basic payment for their participation (50 RMB) plus the amount of money obtained from a random selection of 3 trials in the games.

The participants then completed 78 trials (Fig. 1) in the scanner. These trials consisted of 6 different subtypes: there were 39 trials in each financial position (deprived or no-deprived), which equally distributed across three types of offers (50:10, 40:20, and 30:30), resulting in 13 trials in each treatment (a specific combination of financial position and type of offer). All trials were presented in a random order. Each trial began with a fixation cross presented for 1250–4750 ms. During the next 3.5-s epoch, participants were asked to guess which box contained a ball. In a trial of ball-guess game, participants would win a fixed amount of money (¥20) if they selected right box, or lose the same amount of money (¥20) if they selected wrong box. The outcomes of the ball-guess game were determined in advance (losing money in half trials and winning money in the other half trials). Once the participants selected a box, the two boxes would open and a red frame would appear outside the selected box. After that, the outcome of the guess (+¥20 or −¥20) would be presented for 2 s, followed by inter-stimulus intervals jittered from 500 to 1500 ms. Then, participants need to choose between telling proposers the truth (one token was worth 2 yuan for them) or the lie (one token was worth 1 yuan for them). This choice should be made within 8 s. After the decision, a feedback with sentence "You are lying" or "You are honest" would be presented, followed by inter-stimulus intervals jittered from 500 to 1500 ms. Finally, the photo of proposer and the distribution of the Dictator Game would be presented for 3 s.

fMRI image acquisition and analysis

Scanning was carried out on a 3T Siemens scanner at the Functional MRI Lab (East China Normal University, Shanghai). For functional images, 36 slices were acquired using a gradient echo echo-planar imaging (EPI) sequence (TR = 2200 ms, TE = 30 ms, FOV = 220 mm, matrix size = 64 × 64, slice thickness = 3 mm, gap = 0.3 mm). Before the functional run, a high-resolution structural image was acquired using a T1-weighted, multiplanar reconstruction (MPR) sequence (TR = 1900 ms, TE = 3.42 ms, 192 slices, slice thickness = 1 mm, FOV = 256 mm, matrix size = 256 × 256).

Data pre-processing and statistical analyses were performed with Statistical Parametric Mapping (SPM8, Wellcome Department of Cognitive Neurology, London). The functional images were corrected for the delay in slice acquisition and were realigned to the first image to correct for interscan head movements. The individual T1-weighted, 3D structural image was co-registered to the mean EPI image generated after realignment. The co-registered structural image was then segmented into gray matter (GM), white matter (WM) and cerebrospinal fluid (CSF) using a unified segmentation algorithm. The functional images after slice timing and realignment procedures were spatially normalized to the Montreal Neurological Institute (MNI) space (resampled at $2 \times 2 \times 2$ mm^3) using the normalization parameters estimated during unified segmentation and then spatially smoothed with a Gaussian kernel of 8 mm full-width half-maximum (FWHM).

A general linear model (GLM) was defined for each participant that examined the neural response to the period in which participants decide cheating or not. More specially, at the first level, four types of events were defined according to financial position (deprived vs. no-deprived) and participants' decision (lying vs. honest). They were convolved a canonical hemodynamic response function (HRF) and its time derivatives. All the encoding trials were modeled from the onset time of the decision phase and the duration was the reaction time. Additional regressors of no interest were created for boxes presentation, feedback of ball-guessing, outcome of ball-guessing, feedback of decision, and allocation of tokens. Six regressors

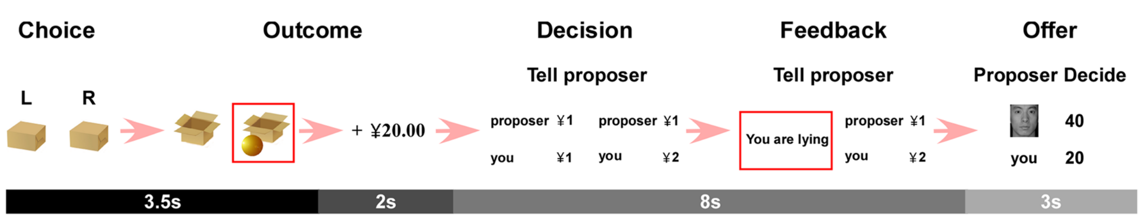

Fig. 1 Experimental procedure

modeling movement-related variance and one modeling the overall mean were also employed in the design matrix. A general linear model analysis created four contrast images for each participant summarizing differences of interest. The four first level contrast images from each participant were then analyzed at the second level employing a random-effects model (flexible factorial design in SPM8). The financial position × decision interactions defined by $(\text{lying–honest})_{\text{not deprived}} - (\text{lying–honest})_{\text{deprived}}$ were computed to explore how financial position affect neural response of deception. Activations were identified as significant only if they passed the threshold of $p < 0.05$ family-wise error (FWE) corrected for multiple comparisons at the cluster-level with an underlying voxel-level of $p < 0.001$ (uncorrected).

Results

Behavioral data

We calculated the rates of lying in financial deprived and no-deprived condition, respectively (Table 1). A paired t test found that the rate of lying in the financial deprived condition was significantly higher than that in the no-deprived condition [t (16) = 6.73, $p < 0.001$]. A two (financial position: deprived vs. no-deprived) × 2 (decision: lying vs. honest) repeated-measure ANOVA on the reaction time of decision (Table 2) showed no significant main effects [financial position: $F(1,16) = 0.40$, $p = 0.54$; decision: $F(1,16) = 1.88$, $p = 0.19$] and no interaction effects [$F(1,16) = 1.80$, $p = 0.20$].

Table 1 Means and standard deviations of rate of lying in different financial positions

Condition	Lying rates
Financial no-deprived	0.23 ± 0.16
Financial deprived	0.65 ± 0.19

Table 2 Means and standard deviations of reaction time of different decision

	Financial no-deprived	Financial deprived
Lying	1585.58 ± 602.92	1374.66 ± 548.06
Honest	1216.92 ± 401.32	1404.73 ± 800.44

fMRI results

Main effects

A (lying–honest) contrast of decision stage was conducted to search for the lying-related regions and revealed regions including bilateral posterior cingulate cortex and bilateral precuneus (Table 3). The reverse contrast did not reveal any significant activation.

Interactions

Interaction between financial position and participants' decision was computed by the $(\text{lying–honest})_{\text{not deprived}}-(\text{lying–honest})_{\text{deprived}}$. Results showed that the dorsolateral prefrontal cortex (MNI 50 24 28) was activated (Fig. 2), whereas no region was activated in the reverse contrast.

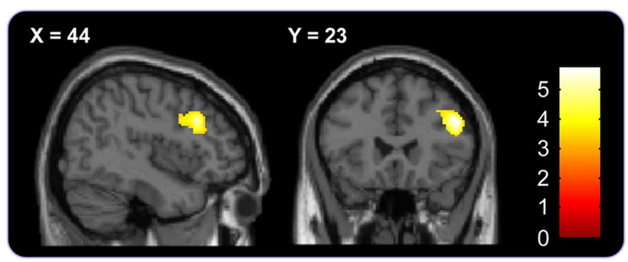

Fig. 2 Brain activities in interaction between financial position and participants' decision ($p < 0.001$, uncorrected)

Table 3 Regions showing main effects of decision

Brain region	Side	Coordinates			t value	Voxels
		X	Y	Z		
Posterior cingulate cortex	R	8	−38	32	5.27	645
Posterior cingulate cortex	L	−6	−36	30	4.32	
Precuneus	L	−10	−54	22	3.98	
Precuneus	R	8	−48	38	3.75	

Coordinates (mm) are in MNI space. All reported clusters are cluster-level family-wise error (FWE) corrected for multiple comparisons at $p < 0.05$ with an underlying voxel-level of $p < 0.001$ (uncorrected)

L left hemisphere, *R* hemisphere

Discussion

The main purpose of the present study was to explore the neural mechanism underlying the modulation effect of financial deprivation on moral norm of keeping honest. Consistent with previous studies, the behavioral data showed that participants did not cheat to the full extent; instead they were more likely to lie after losing money compared with gaining money. Parallel with this, at the neural level, the whole brain analysis revealed weaker activation in the dorsolateral prefrontal cortices when participants lying after losing money than gaining money.

In line with Sharma's experimental results (Sharma et al. 2014), we also found participants behave more dishonestly after they were losing money. In addition, our findings were also consistent with the evidence from a recent series of studies (Panasiti et al. 2011, 2014, 2016), in which the authors employed a novel paradigm in the form of an interactive game where participants can choose whether to lie to another person in situations of loss or gain. They also found, in the case of loss, participants were more likely to lie to reverse the outcome in their favor. Together these results provided a support for Sharma's notion that people's moral norm of keeping honest seems more lenient when they experienced financial deprivation. This notion also corresponded to previous findings that morality was not stable and unethical behavior was easy to trigger, even mere exposure to money(Gino and Pierce 2009a, b; Kouchaki et al. 2013).

Spence et al. (2001) initialed the pioneering research exploring neural substantial of deception. Since then, a growing body of works have taken to using neuroimaging techniques to study deception, and have suggested the important role of the lateral prefrontal cortex in deception (Abe et al. 2006; Ganis et al. 2003; Kozel et al. 2005; Langleben et al. 2002, 2005; Lee et al. 2002; Mohamed et al. 2006; Nunez et al. 2005; Phan et al. 2005). Previous studies have identified the significant role of the lateral prefrontal cortex in cognitive control, response selection and inhibition (Chikazoe et al. 2007; Christ et al. 2009; MacDonald et al. 2000; Nobuhito 2011; Rowe et al. 2000). Thus, from a cognitive standpoint, some researchers thought the involvement of dorsolateral prefrontal cortex in deception might be associated with suppressing a truthful response which originating from moral norm of keeping honest (Abe et al. 2007; Baumgartner et al. 2009; Greene and Paxton 2009; Xu and Ma 2015; Zhong 2011). Consistent with this view, a recent study also revealed that cortical thickness of the dorsolateral prefrontal cortex was negatively related to prosocial behavior, suggesting its involvement of controlling intuitive drive for prosociality (Yamagishi et al. 2016). Therefore, combined with the neuroimaging evidence linking the dorsolateral prefrontal cortex to suppress intuitive response, the weaker activation in the dorsolateral prefrontal cortex when participants lying under financial deprived condition might suggest people's intuitive drive for honest become weaker when they were monetary deprived, which may also explain why participants behaved more dishonestly after losing money. However, as Greene and Paxton (2009) suggested, there existed two competing hypotheses about the pattern of neural activity associated with honest decisions. The ''grace'' hypothesis argued that honesty resulted from the absence of temptation and is determined by the presence of automatic processes while the ''will'' hypothesis suggested that honesty resulted from the active resistance to temptation. Our findings were more likely consistent with the ''grace'' hypothesis, but it is worth noting that support for ''will'' hypothesis is also provided by recent findings that honesty required more time and damage to dorsolateral prefrontal cortex decreased the effect of honesty concerns on behavior in economic games (Dogan et al. 2016; Shalvi et al. 2012; Zhu et al. 2014). About this debate, we thought some modulatory factors should be taken into consideration. For example, recent experimental evidence showed that "grace'' hypothesis was valid for people with a high moral identity, while the ''will'' hypothesis was accurate for individuals with a low moral identity (Xu and Ma 2015). Additionally, in our study, no significant results about reaction time of decision were revealed. But according to the greater involvement of dorsolateral prefrontal cortex when lying after a win in the ball-guess game, lying after gaining money should take more time than lying after losing money. As for this, we also thought it possibly could be attributed to individual differences such as moral identity, which caused high variance of reaction time of decision.

The precuneus and the posterior cingulate gyrus activities were also found when identifying activations associated with lying decision. Notably, these regions are located in the cortical midline structure, which is closely linked to the default-mode network. Previous studies have revealed that the default-mode network played an important role in the moral decision-making and self-referential processing (Harrison et al. 2008; Northoff et al. 2006; Reniers et al. 2012). Thus, it is plausible that compared to deciding to be honest, lying decision required more self-referential processing.

In conclusion, the current study further illustrated how financial deprivation affected people's deceptive behavior and its related neural responses. Results showed that, at the behavioral level, participants behaved more dishonestly after experiencing financial deprivation. At the neural level, lying-related activations in the dorsolateral prefrontal cortex became weaker in financial deprived condition. Together, our data might indicate that, people really had an internalized norm of keeping honest, but it would be lenient in some circumstances such as financial deprivation, which was manifested as decreased involvement of the dorsolateral prefrontal cortex in deception decision.

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Compliance with ethical standards

Ethical approval This experiment was approved by the Ethics Committee of the East China Normal University and has been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all individual participants included in the study.

Conflict of interest The authors declare that no competing interests exist.

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