Brain and Cognition 102 (2016) 13–25

Contents lists available at ScienceDirect

Brain and Cognition

journal homepage: www.elsevier.com/locate/b&c

Let the man choose what to do: Neural correlates of spontaneous lying and truth-telling

Lijun Yin [a,b,*], Martin Reuter [a,c,d], Bernd Weber [a,b,e]

[a] Center for Economics and Neuroscience, University of Bonn, Nachtigallenweg 86, 53127 Bonn, Germany
[b] Department of Epileptology, University Hospital Bonn, Sigmund-Freud-Str. 25, 53127 Bonn, Germany
[c] Department of Psychology, University of Bonn, Kaiser-Karl-Ring 9, 53111 Bonn, Germany
[d] Laboratory of Neurogenetics, University of Bonn, Kaiser-Karl-Ring 9, 53111 Bonn, Germany
[e] Life & Brain Center, Department of NeuroCognition, University of Bonn, Sigmund-Freud-Str. 25, 53127 Bonn, Germany

ARTICLE INFO

Article history:
Received 24 March 2015
Revised 18 November 2015
Accepted 19 November 2015

Keywords:
Deception
fMRI
Truth-telling

ABSTRACT

Many previous functional magnetic resonance imaging (fMRI) studies on deception used a paradigm of "instructed lies", which is different than other, more spontaneous forms of lying behavior. The present study aimed to investigate the neural processes underlying spontaneous and instructed lying and truth-telling, and to investigate the different mechanisms involved. This study used a modified *sic bo* gambling game with real payoffs in order to induce lying. In the spontaneous sessions, the participants themselves decided whether or not to lie, whereas in the instructed sessions they were explicitly told to respond either honestly or dishonestly. In the spontaneous lying (vs. truth-telling) condition, the subgenual anterior cingulate cortex (sACC) showed significantly higher activity, whereas the right dorsolateral prefrontal cortex (DLPFC), ventrolateral prefrontal cortex (VLPFC) and inferior parietal lobule (IPL) were more strongly activated when participants spontaneously told the truth (vs. lied). Our results suggest that the extra cognitive control required for suppressing the self-interest motives in spontaneous truth-telling is associated with higher activity in the fronto-parietal network, while the process of negative emotion in spontaneous lying induced greater involvement of the sACC. Although similar to spontaneous deception, instructed deception engenders greater involvement of the right inferior frontal gyrus (IFG), left supplementary motor area (SMA), anterior cingulate cortex (ACC), IPL and superior frontal gyrus (SFG) compared to baseline, instructed decisions did not elicit similar activation patterns in the regions of sACC, DLPFC, VLPFC and IPL which were sensitive to either spontaneous truth-telling or lying.

1. Introduction

Over the past few decades, progress in functional magnetic resonance imaging (fMRI) has resulted in an increasing number of neuroscientific studies focusing on the investigation of the neural correlates of deception. A paradigm referred to as "instructed lies" (Farah, Hutchinson, Phelps, & Wagner, 2014; Greely & Illes, 2007; Schauer, 2010; Sip, Roepstorff, McGregor, & Frith, 2008; Wright, Berry, & Bird, 2013) was used in many previous neuroimaging studies. In a typical paradigm setting, participants were instructed to lie about specific statements at certain points in time, such as possession of an item (Langleben et al., 2002; Luan Phan et al., 2005), personal information or experience (Abe et al., 2006; Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003; Ganis, Morris, & Kosslyn, 2009; Ganis, Rosenfeld, Meixner, Kievit, & Schendan, 2011; Nunez, Casey, Egner, Hare, & Hirsch, 2005), knowledge of a mock crime (Kozel, Johnson, et al., 2009; Kozel, Laken, et al., 2009; Mohamed et al., 2006), valence of pictures (Lee, Lee, Raine, Chan, & Manzoni, 2010), or memories (Abe, Suzuki, Mori, Itoh, & Fujii, 2007; Abe et al., 2008; Bhatt et al., 2009; Ito et al., 2011). However, the weaknesses of the experiments make them less suitable for studying deception (Greely & Illes, 2007; Sip et al., 2008). In these instructed experiments, "liars" were not as motivated to deceive as they would be in most real world situations where deception is more impulsive and context dependent (Ganis & Keenan, 2009; Sip et al., 2008). The motivation for achieving pleasant and avoiding unpleasant states guides human behavior and decisions (Daw, O'Doherty, Dayan, Seymour, & Dolan, 2006; Linke et al., 2010). The mental processes involved when making dishonest decisions which are motivated by extrinsic motivation (e.g. money), such as cognitive control (Greene & Paxton, 2009; Zhu et al., 2014) and emotion (Ekman, 1985,

* Corresponding author at: Center for Economics and Neuroscience, University of Bonn, Nachtigallenweg 86, 53127 Bonn, Germany.
E-mail address: yin.lijun@uni-bonn.de (L. Yin).

http://dx.doi.org/10.1016/j.bandc.2015.11.007
0278-2626/

1989), might differ from instructed "deception". In particular, the complex executive functions associated with deception might not be fully investigated in the absence of voluntary intention/motivation (Sip et al., 2008). Additionally, the neural correlates of self-motivated truth-telling could not be fully investigated in the instructed paradigm. In many previous deception studies, lying was thought to be more cognitively demanding, whereas a truthful response was treated as a default behavior (Spence et al., 2004). This assumption was supported by functional neuroimaging studies showing that attempted lying was linked to the activation of executive brain regions, while truthful behavior rarely elicited higher activity (Christ, Van Essen, Watson, Brubaker, & McDermott, 2009; Farah et al., 2014). However, truth-telling might be also cognitively demanding if successful deception comes with considerable benefits. The limited findings on the specific neural activity during truth-telling might be due to a lack of strong motivation toward lying in the previous instructed experiments.

In recent years, many researchers have started investigating the neural mechanism of lying in a more natural way: by tempting participants to lie in return for monetary rewards (Abe & Greene, 2014; Baumgartner, Fischbacher, Feierabend, Lutz, & Fehr, 2009; Baumgartner, Gianotti, & Knoch, 2013; Bhatt, Lohrenz, Camerer, & Montague, 2010; Greene & Paxton, 2009; Sip et al., 2010, 2012; Sun, Chan, Hu, Wang, & Lee, 2015; Volz, Vogeley, Tittgemeyer, von Cramon, & Sutter, 2015) or shortening the experiment duration (Ding, Gao, Fu, & Lee, 2013). In most of these experiments, participants formed deceptive intents all by themselves and decided when to lie. Formulating a false statement based on one's own initiative is lying in a more spontaneous way (Cooper & Peterson, 1980). However, the findings from these studies are mixed. The brain regions, such as the DLPFC and BA 10, were activated not only in the lying condition (Baumgartner et al., 2009; Sip et al., 2010), but also in the truth-telling condition (Abe & Greene, 2014; Greene & Paxton, 2009; Zhu et al., 2014). One possibility for these conflicting findings, especially in the DLPFC, might be due to the different engagement of control processes (Zhu et al., 2014) in different experimental designs. Additionally, in some of these experiments, individual lies were not clearly identified (Abe & Greene, 2014; Greene & Paxton, 2009) and an honest response in the control condition was unconditional and less spontaneous (Sip et al., 2010).

Although there are many instructed lying studies and a few spontaneous lying studies, no study has yet been conducted which directly compares these two settings and allows for deeper insight. A recent meta-analysis investigating the social-cognitive processes involved with deception (Lisofsky, Kazzer, Heekeren, & Prehn, 2014) revealed an increased activation in the bilateral IPL for volitional (versus instructed) deception. In the included volitional studies, the participant was given the opportunity to deceive and no explicit instructions were included. However, participants were required to follow some rules while making the decision, such as achieving an approximate balance between truthful and deceptive responses (Spence, Kaylor-Hughes, Farrow, & Wilkinson, 2008) or imagining that successful feigning would lead to monetary gain (Browndyke et al., 2008; Lee et al., 2002, 2009; McPherson, McMahon, Wilson, & Copland, 2011). Similar to the typical instructed paradigms, the natural motivation to lie was, for the most part, lacking. When taking into account the increasing number of neuroimaging studies on spontaneous lying and sustained studies on instructed lying (Cui et al., 2014; Lee, Leung, Lee, Raine, & Chan, 2013; Sun, Lee, & Chan, 2015; Yang et al., 2014), it is necessary and important to investigate the underlying differences between these two types of paradigms at the neural level.

In our experiment, we investigated the neural correlates of spontaneous lying and truth-telling (i.e. an honest or dishonest decision based on one's own initiative), and also investigated the different neural patterns underlying spontaneous and instructed decisions. We adopted a modified *sic bo* gambling game (Eadington, 1999) in which participants bet on the outcome of three dice rolls and then reported the betting results in both spontaneous and instructed ways. The advantage of using the *sic bo* game is that it simulates a true gambling game which is motivated by cognitive and emotional factors (Clark, 2010) and increases the participants' involvement with the experiment. The experiment is comprised of two sessions in which the participants can either freely make decisions themselves or they were instructed to make decisions. If the prediction is wrong in the spontaneous session, then a dishonest response would lead to a higher payoff and, inversely, an honest response would lead to a lower payoff. If the prediction is correct, an honest response would then lead to a higher payoff. We sought to investigate three types of decision-making: lying and truth-telling in a situation in which lying leads to higher payoff, as well as truth-telling in a situation in which truth-telling leads to higher payoff. Among these, honest decision-making in cases where truth-telling leads to a higher payoff might be a prepotent response as with the honest responses in the previous instructed studies. We expected spontaneous lying and truth-telling conditions to elicit higher activity in the prefrontal cortex (especially the DLPFC) for two reasons. First, the consistent findings in instructed deception studies indicated that deception activated multiple prefrontal regions (including the DLPFC) (Abe et al., 2006, 2007; Ganis et al., 2009; Langleben et al., 2002, 2005; Lee et al., 2002, 2005, 2010; Luan Phan et al., 2005; Nunez et al., 2005; Sun, Lee, et al., 2015). Second, previous studies using the spontaneous paradigm found that honest/dishonest decision-making was associated with higher activity in the DLPFC. In the current design, honest and dishonest responses can be distinguished, which is different from the previous spontaneous experiments of Greene et al. (Abe & Greene, 2014; Greene & Paxton, 2009). The context used in our experiment was similar to that of previous spontaneous studies from Greene et al. (i.e. dishonest responses about predictions of coin flips or dice outcome lead to a higher monetary payoff). The similar control process of actively deciding whether or not to lie might lead to a higher involvement of the DLPFC and associated regions. Also, studies of pathological liars showed increased white matter volume in the prefrontal cortex (Yang et al., 2005, 2007). Therefore, the prefrontal region is one of the regions of interest which might be associated with (dis)honest decision-making. In addition to the prefrontal regions, deception is commonly associated with strong emotional experiences such as guilt or fear (Ekman, 1985, 1989). Emotional arousal and regulation might thus also be involved to a higher degree when telling a lie. We hence expected to observe differences, at both the behavioral and neural levels, between spontaneous decisions in the emotional domain. Furthermore, we wanted to investigate whether the neural processes involved were different if the motivation to lie varied (i.e. were either externally instructed or intrinsically motivated). We introduced the instructed session in which instructions for correctly or incorrectly reporting the betting results were shown beforehand and participants responded by following the instructions. Because participants could choose freely in the spontaneous paradigm and due to the potentially different mental processes underlying their choices, we proposed that the neural network involved for spontaneous deception and truth-telling might display different patterns from instructed decisions.

2. Materials and methods

2.1. Participants

Fifty-four male participants (19–36 years; $M = 26.1$; $SD = 3.8$) were enrolled. Of these participants, data from twelve were