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The cognitive mechanisms underlying deception: An event-related potential study

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ABSTRACT

The cognitive view on deception proposes that lying comes with a cognitive cost. This view is supported by the finding that lying typically takes longer than truth telling. Event-related potentials (ERPs) provide a means to unravel the cognitive processes underlying this cost. Using a mock-crime design, the current study ($n = 20$) investigated the effects of deception on the Contingent Negative Variation (CNV), the Lateralized Readiness Potential (LRP), the Correct Response Negativity (CRN), and the stimulus-locked N200 and P300 components. In line with previous research, lying resulted in more errors, longer reaction times (RTs) and longer RT standard deviations compared to truthful responses. A marginally significant effect suggested a stronger CNV for the anticipation of lying compared to the anticipation of truth telling. There were no significant deception effects on the stimulus- and the response-locked LRPs. Unexpectedly, we found a significantly larger CRN for truth telling compared to lying. Additional analyses revealed an enhanced N200 and a decreased P300 for lying compared to truth telling. Our results support the cognitive load hypothesis for lying, yet are mixed regarding the response conflict hypothesis. Results are discussed with regard to the specific characteristics of our design and their theoretical and applied implications.

1. Introduction

For a long time, researchers and practitioners have relied on the assumption that deception is accompanied by heightened emotional arousal. Yet, the robustness and specificity of the link between deception and arousal have been criticized (Lykken, 1998; National Research Council, 2003; Vrij et al., 2006, 2011). Therefore, in the last decade, there has been renewed interest in a cognitive approach to deception. The central idea is that lying is cognitively more demanding than truth telling (DePaulo et al., 2003; Vrij et al., 2006; Zuckerman et al., 1981). More specifically, it has been reasoned that the formulation of a credible lie requires that the truth is kept active in working memory. The activated truth response then conflicts with the to-be-given lie response, requiring response monitoring and inhibition processes (Christ et al., 2009; Seymour and Schumacher, 2009; Spence et al., 2001; Verschuere and De Houwer, 2011; Walczyk et al., 2003). Finally, task switching enables changing between truthful and deceptive responses. So far, several lines of research support this cognitive view of deception (Christ et al., 2009; Vrij et al., 2011).

Event-related potentials (ERPs) provide an attractive means to study the cognitive processes involved in deception more closely. Of specific relevance in this context are studies using the Contingent Negative Variation (CNV; Brunia et al., 2012; Walter et al., 1964). The CNV is a slow negative-going brain potential, evolving after a cue and before an imperative stimulus. It is thought to reflect processes of anticipation and response preparation. Using different paradigms and stimuli, three deception studies found an enhanced CNV for lying compared to truth telling (Dong and Wu, 2010; Fang et al., 2003; Sun et al., 2011). In the study by Fang et al. (2003), participants were instructed to deceptively deny knowledge of familiar target faces, and to truthfully admit knowledge of other familiar faces and deny knowledge of unknown faces. In the study by Sun et al. (2011), participants chose for their own financial gain whether to truthfully or deceptively evaluate banknotes as genuine. Dong and Wu (2010) instructed participants to truthfully or deceptively indicate the attractiveness of faces. In line with the cognitive theory of deception, authors of all three studies interpreted these CNV deception effects as indication for a higher effortful involvement and higher cognitive load for lying compared to truth telling. It should, however, be noticed that in the three studies, the CNV was measured after participants had already been given all stimulus information necessary to prepare their correct deceptive responses. As a consequence, the CNV in these studies did not purely measure the

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anticipation of lying and truth telling, but this anticipation was already combined with stimulus processing and (motor) preparation of the correct response.

Another component that has attracted attention in the context of lying is the Correct Response Negativity (CRN; Vidal et al., 2000, 2003). The CRN is closely related to the error-related negativity (ERN), a negative ERP component at fronto-central electrodes along the midline, peaking 0–100 ms after an incorrect response (Falkenstein et al., 1991; Gehring et al., 1993). Although initially attributed to error-detection (e.g., Coles et al., 2001), the discovery of a similar – albeit smaller – negative peak after correct responses challenged this view and led to the proposal that both components serve a more general conflict-monitoring function (Botvinick et al., 2001). Within deception research, it has been found that deceptive compared to truthful responding elicited a stronger CRN (also referred to as Medio-Frontal Negativity), which had been attributed to stronger response-monitoring demands for deceptive responses (Dong et al., 2010; Johnson et al., 2004, 2005, 2008; Kireev et al., 2008). Johnson et al. (2004, 2005) employed an old/new word paradigm, in which participants had to sometimes correctly and sometimes incorrectly indicate recognition of old words. Johnson et al. (2008) instructed participants to lie about their attitudes towards well-known persons. Dong et al. (2010) instructed participants to make honest or deceptive evaluations of the attractiveness of face stimuli. However, although those studies found and replicated the effect with different paradigms and stimuli, none of the four studies created a more realistic deception situation in which participants were actually motivated to lie successfully. The only study that used an incentive for successful lying was a study by Kireev et al. (2008), in which participants responded truthfully or deceitfully (i.e., to indicate the directions of arrows with button presses either correctly or incorrectly) with the purpose to win money by 'deceiving' a computer. Yet, the sample size of their study was relatively small ($n = 13$; Simmons et al., 2011), and – as in the CNV study of Sun et al. (2011) – participants could freely choose between truth telling and lying, which made it impossible to differentiate between intentional lies and behavioral errors.

The aim of the present study was to replicate effects of previous studies, yet with a paradigm that enables maximal experimental control. More specifically, we used a Sheffield Lie Test (Spence et al., 2001; based on the Differentiation of Deception paradigm by Furedy et al., 1988). Unlike in many other deception paradigms (e.g., CQT; Reid, 1947), the experimental and control conditions here only differ in the crucial variable: Deception. Originally combined with recordings of the autonomic nervous system, the paradigm has more recently also been used to measure neural and behavioral effects of deceptive responding (Spence et al., 2001). In the Sheffield Lie Test, participants are presented with stimuli, as for instance simple yes/no questions, and instructed to lie or tell the truth depending upon a color cue. By lying and telling the truth on the same set of questions, each stimulus forms its own control. In line with the view that lying is cognitively more demanding than truth telling, behavioral studies using this paradigm have consistently shown that lying is more error-prone than truth telling and associated with longer and more variable response latencies (Debey et al., 2012; Farrow et al., 2010; Fullam et al., 2009; Hu et al., 2012; Van Bockstaele et al., 2012; Verschuere et al., 2011). In our version of the Sheffield Lie Test, participants gave speeded yes/no responses to mock-crime and control questions using left and right button presses. A question was presented (e.g., "Did you steal a …") for 2000 ms, followed by a truth (T) or lie (L) cue. The cue was replaced after 1500 ms by a keyword (e.g., "cd-rom?"), allowing participants to respond. This setup allowed us to measure the CNV during the pure anticipation of lying and truth telling, without the interference of processing of the crucial stimuli or (motor) preparation of the correct response.

The setup of the current study also allowed us to measure the CRN after deceptive and truthful responses. It also allowed us to investigate another ERP component that has not been investigated in the context of deception before: the Lateralized Readiness Potential (LRP; for a review see Smulders and Miller, 2012). The LRP is a negative potential over the primary motor cortex (M1), contralateral to the responding hand that starts before the response is emitted. It reflects the time at which one hand is activated over the other in the preparation of a unimanual overt response. Crucially, this allows tracking covert response-competition processes before the overt motor response has occurred. In many 'conflict' paradigms (e.g. Gratton et al., 1988), initial activation of the incorrect response was shown to precede later correct response activation. Whereas the stimulus-locked LRP indicates the duration of processes occurring before the start of the correct response-activation, including stimulus-processing and response competition, the response-locked LRP interval indicates the duration of processes that occur after activation of the correct response. Based on the idea that during lying, the truth is initially activated and conflicts with the lie, we expected the stimulus-locked LRP to reveal an initial activation of the (incorrect) truthful response during lying.

Following up on the suggestion of a reviewer, we further extended our analyses and included two additional components: the N200 and the P300. The N200 is a negative-going component that occurs around 200–350 ms post-stimulus and is found primarily over anterior scalp sites. It has been hypothesized to be involved in executive cognitive control, and more specifically in conflict detection (Folstein and Van Petten, 2008; Van Veen and Carter, 2002). The P300 component (Sutton et al., 1965) occurs around 300–800 ms post-stimulus and is found mostly over posterior scalp sites. It has been mostly studied in oddball paradigms, in which it is thought to reflect increased attention towards rare, novel or salient stimuli (Polich, 2012). It has also been shown to be influenced by cognitive load (Isreal et al., 1980a,b; Kramer et al., 1985; Wickens et al., 1983). A previous study of Hu et al. (2011) used a slightly different variant of the Sheffield Lie Test, in which participants indicated recognition of self- and other-related information equally often truthfully and deceptively. The authors observed an increased fronto-central N200, and a decreased fronto-central P300 for lying compared to truth telling, which they interpreted as indication that compared to truth telling, lying comes with increased response conflict and enhanced cognitive load, respectively (see also Johnson et al., 2003, 2005; Wu et al., 2009). In our extra analyses, we examined whether these results replicate in our data.

In sum, in the current study, we aimed at replicating and extending previous ERP deception results with a deception paradigm that guarantees maximal experimental control. In order to create a situation that mimics forensic contexts, we used a mock-crime procedure in which participants performed one mock-crime and planned another mock-crime (i.e., criminal intention). The latter was implemented to contribute to an emerging research line that investigates whether classical deception findings can be extended from deception about already performed acts (e.g., crimes) to deception about merely planned ones (e.g., Clemens et al., 2011; Granhag and Knieps, 2011; Meijer et al., 2010; Meixner and Rosenfeld, 2011; Noordraven and Verschuere, 2013). To increase motivation, participants were promised an extra financial reward for hiding their true acts. Based on previous research and the cognitive processes that were proposed to underlie deception, we expected the following: (1) a more negative CNV after lie cues compared to truth cues, (2) an initial deflection of the stimulus-locked LRP in the direction of the incorrect truth response in lie trials and no such deflection in truth trials, (3) a stronger CRN after lie responses compared to truth responses, and (4) an increased N200 and a decreased P300 for lying compared to truth telling.

2. Method

2.1. Participants

Twenty students (15 female) from Maastricht University participated for a monetary reward (30€). All participants were right-handed, free of neurological disorders, and reported normal or corrected-to-