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Abstract

The Correct Response Negativity (CRN) is an event related potential (ERP) component that is affected by the act of deception. However, there have been inconsistent findings on the effect of deception on the CRN. Suchotzki, Crombez, Smulders, Meijer, & Verschuere (2015) suggested that the design of the paradigm used to elicit the deceptive response is what controls the size of the CRN. Specifically, that motivation to deceive changes the size of deception relative to telling the truth. This study attempted to follow up on suggestions made by Suchotzki et al. (2015) to investigate if extraneous motivation to lie does indeed invert the ratio of CRN in lie compared to truth responses in a deception experiment by manipulating the motivation to lie. This study used a modification of the image-based guilty knowledge test (GKT) paradigm used in Langleben et al. (2002). The first hypothesis of this experiment was that a larger CRN during deception relative to truth-telling will be observed when participants are not motivated to lie, while a larger CRN during truth-telling relative to deception will be observed when participants are motivated to lie. The hypothesis was not supported; there was no observed difference in CRN responses when participants were motivated to lie. The second hypothesis of this experiment was that the P300 component would be larger when participants were motivated to lie, as compared to when they were instructed to lie. Results indicated that P300 was significantly higher in the lie conditions than in the truth conditions; however, there was no difference in amplitude as a function of whether they were in the informed or motivated lie condition.

1. Introduction

Research has shown that the act of deception utilizes more cognitive resources than truth-

telling. This means that deception generates a different set of amplitudes for event related

potentials (ERPs) than telling the truth. One of these such ERPs is the correct response negativity

(CRN; Vidal, Hasbroucq, Grapperon, & Bonnet, 2000; Vidal, Burle, Bonnet, Grapperon, &

Hasbroucq, 2003) a negative ERP component related to conflict-monitoring and the error-related

negativity (ERN). The ERN is a negative ERP component at fronto-central electrodes along the

midline, peaking 0–100 ms potential that accompanies errors in speeded performance (Gehring,

Liu, Orr, & Carp, 2012). The CRN is similar, occurring at the same time as the ERN but

appearing smaller. Because the CRN has also been observed to occur even on correct trials when

no error has been made, it is proposed to serve a conflict monitoring function. In a study by

Suchotzki, Crombez, Smulders, Meijer, & Verschuere (2015), which was designed to replicate

previous findings on deception ERP components, one of which is the CRN, it was suggested that

a larger CRN will be elicited by lie responses than by truth responses, because of the conflict that

arises when a true response is not given. However, findings on this have been inconsistent.

Johnson, Barnhart, and Zhu (2004, 2005) and Johnson, Henkell, Simon, & Zhu, (2008) found

that the CRN was stronger for lying versus truth responses, while Dong et al. (2010) found the

opposite, namely a stronger CRN for a truth response compared with the CRN for lying. Kireev,

Pakhomov, & Medvedev, (2008) also found that the CRN was stronger for truth responses

relative to deceptive responses after the consumption of alcohol. Suchotzki et al. (2015)

predicted that there would be a stronger CRN after lie responses than after truth responses.

However, the results were the opposite: a stronger CRN for truth responses compared with lie

responses. Suchotzki et al. (2015) suggest that this is because of paradigm design characteristics, with some studies that simply instruct participants to give deceptive response while other studies motivate participants to give deceptive responses with a reward for successfully lying. This motivation causes CRN ratio to invert, as "correct" responses become the ones that lead to reward, even though this requires giving a response that is incongruent with the truth. Suchotzki et al. (2015) posit that this hypothesis should be tested in future studies by manipulating the motivation to lie.

The goal of this study was to confirm this hypothesis on the effect of motivation on the CRN. Suchotzki et al. (2015) used the paradigm known as the Sheffield Lie Test, which has participants pretend to steal an item from another room and cues about which responses to give in a guilty knowledge test (GKT) that followed the act of stealing. Because the Sheffield Lie Test is very complex, the present study used a simpler design which allowed for the manipulation of motivation to deceive, using a modified version of the paradigm used in Langleben, D. D., Schroeder, L., Maldjian, J. A., Gur, R. C., McDonald, S., Ragland, J. D., …Childress, A. R. (2002), which is based on the image-based GKT used by Furedy and Ben-Shakhar (1991). The present study used the same conditions and the stimuli of playing cards as utilized by Langleben et al. (2002), but used the same timing of stimulus presentation as used by Suchotzki et al. (2015). It also included two new irrelevant control question types, in which the participants answered truthfully to questions unrelated to the deception task. These questions allowed for the testing of the hypothesis that the motivation will only invert the CRN ratio on truth responses relevant to the task where deception is being used, but not on other truth responses. This study involved two conditions: an instructed lie condition where the participant is simply told to give

lie responses at certain times because it is required for the experiment, and a motivated lie condition where the participants are motivated to lie in order to receive a reward. The use of these two conditions is the main experimental manipulation of the experiment. Based on the study by Suchotzki et al. (2015) the expected results of this experiment are that there will be a stronger CRN for deception relative to truth-telling in the instructed lie condition, while there will be a stronger CRN for truth-telling relative to deception in the motivated lie condition. This is because the correct response in the motivated lie condition is to answer dishonestly. It was also hypothesized that in the instructed lie condition, the CRN of the irrelevant control questions will match the CRN of the relevant truth responses. However, in the motivated lie condition the CRN of the relevant truth responses will be stronger relative to the CRN of the irrelevant control responses.

In addition to examining the CRN component, the P300 component will also be analyzed, as it has been implicated in deception. The P300 component is a potential that occurs around 300–800 ms post-stimulus and reflects attention to rare, novel or salient stimuli (Sutton, Braren, Zubin, & John, 1965; Polich, 2012). The P300 is also thought to be affected by cognitive load (Isreal, Chesney, Wickens, & Donchin, 1980; Isreal, Wickens, Chesney, & Donchin; 1980; Kramer, Wickens, & Donchin, 1985; Wickens, Kramer, Vanasse, & Donchin, 1983). While this would make it appear that the P300 is always reduced by deception, the P300 reacts differently to deception depending on the characteristics of the paradigm used to study deception. In oddball designs, when the target stimulus is different than the majority of the stimuli being presented, the P300 amplitude is found to be increased. In a study where participants lied on only 10% of trials, Verschuere, Rosenfeld, Winograd, Labkovsky, and Wiersema, (2009) found a higher P300 for

deception than truth- telling. Using a non-oddball design where participants chose whether or not

to lie about the position of a knife in a computer task, Pfister et al. (2014) found that the P300

was attenuated by deception. The Suchotzki et al. (2015) study also found a stronger P300 for

deception compared with truth-telling. These results seem to show that the cognitive load of

deception sometimes reduced the P300, but is possibly "overridden" by the novelty of a stimulus

during oddball-design tasks. None of these studies manipulated motivation, so it is unknown how

this factor will affect the P300. The hypothesis concerning the P300 is that this component will

differ between the instructed and motivated lie conditions.

2. Method

This experiment used a modified version of the GKT paradigm used in Langleben et al.

(2002), with the stimuli and conditions being from the Langleben et al. (2002) GKT and the

timing coming from Suchotzki et al. (2015) paradigm. There are two conditions in the

experiment: the instructed lie condition and the motivated lie condition.

2.1 Participants

Twenty-four participants took part in the study. They were recruited through the East

Tennessee State University SONA study website and by personal contact with the main

investigator. All subjects signed an informed consent approved by the East Tennessee State

University Institutional Review Board. Twenty-one of these participants gave demographic

information on the informed consent document. Out of these participants, the mean age was

21.41 (standard deviation: 5.14), 11 were female and 10 and were male, 18 were right-handed
and three were left-handed.

2.2 Design & Procedure

When participants entered the lab, written informed consent was first obtained. The
capping procedure was then explained, and the capping procedure began. After the capping
procedure was complete, and all impedance reduced to a sufficient level, the participants were
read a paragraph explaining the task and the purpose of the study. Participants were told that
there are two parts to the experiment. In the instructed lie condition, the condition performed
first, the participants were told that the goal of the experiment is to investigate the brainwaves
associated with incorrect responses, and this would be done by giving incorrect answers about
the identity of a playing card while pictures of playing cards are displayed to the participant on a
computer screen. They were instructed to answer incorrectly or "dishonestly" when the card they
were given was displayed on screen, and answering correctly or "truthfully" when pictures of
other cards were displayed. After participants completed the first condition, the motivated lie
condition was performed. To begin this condition participants were told that the true goal of this
experiment was to test the efficiency of a computer program that uses brainwaves to detect lies,
and that the goal of the first session was to calibrate what their brainwaves look like during lying
and truth telling. They were told that in the second condition the instructions were the same as in
the first condition, but they would now choose one of three envelopes that contains a playing
card, and this would be the playing card they would be lying about to the computer. They were
also instructed to conceal the identity of this card from the experimenter. They were told that the

computer was using their brainwaves to discern the identity of the card they were now holding.

They were also told that if they were able to trick the computer by lying well, they will receive

an extra $5. However, performance on the GKT was not really relevant; it was really not being

defined or observed on-line and after being debriefed, all participants received $5. The goal of

this reward was to manipulate motivation to lie. In actuality, the computer was not reading

brainwaves, it was just administering the GKT and recording participants' ERPs and keyboard

responses, and all the envelopes contained the same card. After participants completed the

motivated lie condition, they completed a brief survey designed to assess the level of motivation

they had to perform the task in each condition, and then they were debriefed as to the true

purpose of the experiment. Permission to use the data from the study was obtained orally from

each participant, and they were given $5.

2.3 Instructed Lie Condition

In the Instructed Lie condition, participants were given a 5 of Clubs card, and told to

answer incorrectly or "dishonestly" to questions about this card. The GKT test was administered

on a computer using the E-Prime stimulus presentation program. Responses to the GKT were

entered using the keyboard, with the 'm' key used to indicate 'yes' and the 'z' key used to

indicate 'no'. Data was recorded using G.recorder. The GKT consisted of the following six

types of trials: Relevant Truth Affirmative, Relevant Truth Negative, Irrelevant Control

Affirmative, Irrelevant Control Negative, Lie Affirmative, and Lie Negative. The relevant truth

affirmative trial was accompanied by the statement "I do not have this card" and a picture of a

random card the participant does not have (the "non-target card") was shown. The participant

was to respond "yes" to this statement. The relevant truth negative trial was accompanied by the question "Is this your card?" and a picture of a random card the participant does not have (the "non-target card") was shown. The participant was to respond "no" to this question. The irrelevant control affirmative trial was accompanied by the question "Is this card red?" and a picture of a red card was shown. The participant was to respond "yes" to this question. The irrelevant control negative trial was accompanied by the question "Is this card red?" and a picture of a black card (though not the 5 of Clubs) was shown. The participant was to respond "no" to this question. The lie affirmative trial was accompanied by the statement "I do not have this card" and a picture of the 5 of Clubs (the "target" card) was shown. The participant was to responds "yes" to this statement. The lie negative trial was accompanied by the question "Is this your card?" and a picture of a 5 of Clubs was shown. The participant was to respond "no" to this question. This use of six different types of questions in trials pairs each of the questions with both types of answers (affirmative or yes and negative or no). This was used to reduce habituation and give the appearance of randomness in the experiment. The use of irrelevant control questions that are always answered truthfully allows for the examination of the CRN ratio when the answer is unrelated to the goal that deception is being used to obtain. Trials began with presentation of a fixation cross for 1000 ms, followed by presentation of the question for 2000 ms. The stimulus (picture of the card) is then presented for 2000 ms and during this time the participant was allowed to respond. If the participant responded, then the stimulus disappeared for the remaining of the 2000 ms. If the participant did not enter a response before the end of 2000 ms, then the feedback "Too Late Please Enter Your Responses More Quickly" was displayed on screen for 700 ms. Words were presented in the center of the 44 x 27.5cm (17.32 x 10.83in) screen in 18 point Courier New font on a white background. Stimuli (the

pictures) were 13.5 x 16.5cm (5.31 x 6.5in). Each trial type was presented 25 times in a random

order, for a total of 150 trials.

2.4 The Motivated Lie Condition

The motivated lie condition was similar to the instructed lie condition. To begin this

condition of the experiment, participants were told to choose one of three envelopes that

contained a playing card, and secretly open the envelope and memorize what playing card it

contained. In reality, all three envelopes contain a 4 of diamonds playing card. In the motivated

condition, this 4 of diamonds card was the target card instead of the 5 of clubs. The GKT

consisted of the following six types of trials: Relevant Truth Affirmative, Relevant Truth

Negative, Irrelevant Control Affirmative, Irrelevant Control Negative, Lie Affirmative, and Lie

Negative. The relevant truth affirmative trial was accompanied by the statement "I do not have

this card" and a picture of a random card the participant does not have (the "non-target card")

was shown. The participant was to respond "yes" to this statement. The relevant truth negative

trial was accompanied by the question "Is this your card?" and a picture of a random card the

participant does not have (the "non-target card") was shown. The participant was to respond

"no" to this question. The irrelevant control affirmative trial was accompanied by the question

"Is this card red?" and a picture of a red card (though not the 4 of Diamonds) was shown. The

participant was to respond "yes" to this question. The irrelevant control negative trial was

accompanied by the question "Is this card red?" and a picture of a black card was shown. The

participant was to respond "no" to this question. The lie affirmative trial was accompanied by the

statement "I do not have this card" and a picture of the 4 of Diamonds (the "target" card) was

shown. The participant was to respond "yes" to this statement. The lie negative trial was

accompanied by the question "Is this your card?" and a picture of a 4 of Diamonds was shown.

The participant was to respond "no" to this question. The timing and presentation of the stimuli

and trials were the same as in the instructed condition described in section 2.3.

During both conditions, participants were told that they should only give a deceptive

response when the card they were given is displayed, and to verbally indicate if they make any

errors in their responses. Each condition lasted approximately 14 minutes.

2.5 Survey

After the participants completed both conditions of the experiment, a survey was

administered to assess how motivated the participants were to complete the task in each

condition. The survey consisted of two questions: "How motivated were you to hide the identity

of your card during the first phase of the experiment?" and "How motivated were you to hide the

identity of your card during the second phase of the experiment?" Answers were given on a 10-

point Likert-type scale ranging from 0 (Not At All) to 9 (Extremely).

2.6 Data Acquisition and Reduction

A 32-channel EEG cap was used to record data. The recordings were referenced to the

right mastoid, and grounded to the left mastoid. The EEG was amplified with two Guger

Technologies g.USBamp amplifiers, digitized at a rate of 256 Hz, high-pass filtered at 0.05 Hz,

and low-pass filtered at 30 Hz. Data was recorded using G.recorder. Effort was made to reduce electrode impendence to 40 kU or below, but due to time constraints some values were higher. Reaction time was collected as a behavioral indicator. Reaction time was defined as the amount of time (in ms) between the onset of a stimulus and the keypress response. Only correct responses were analyzed. In order to reduce the amount of data to be analyzed, only the data from the negative response trials (i.e. the trials with questions that the correct response was "no") were analyzed. These trials were selected because the questions they consisted of were the most relevant and easy for the participant to respond correctly to. Henceforth, all references to the control, lie, and truth questions refer to the control negative, lie negative, and truth negative question type trials, respectively.

Out of the 24 participants who were recruited for the study, three were removed before completion of the study, two of them due to experimenter error and one due to complaints of a headache. Out of these 21 participants, a further five were excluded from data analysis; two due to mistakes during the task, one due to inability to follow the instructions of the experiment, and two due to poor data quality.

2.7 Data Analysis

To compare waveforms, ERPs from all participants were averaged by condition. The P300 component was analyzed at electrode Pz with a 2x3 repeated measures ANOVA with the two factors being Condition (instructed lie vs. motivated lie) and Question Type (control, lie, and

truth). The CRN component was inspected at electrode Fz using the same procedure. The

analyses were conducted separately for the amplitude data and the latency data.

3. Results

3.1 Survey Data

On the survey data from the 16 participants whose data was analyzed the mean answer to

the first question ("How motivated were you to hide the identity of your card during the first

phase of the experiment?") was 5.44 (standard deviation: 2.71) and the mean answer to the

second question ("How motivated were you to hide the identity of your card during the second

phase of the experiment?") was 8.13 (standard deviation: 1.41). A paired samples T-test

performed on this data revealed that the difference between the answers to these questions was

statistically significant at the 2-tailed .005 level, with the participants indicating they were more

motivated to hide the identity of the card during the motivated condition, $t(15) = 3.257$, $P = .005$.

3.2 Reaction Time Data

				95% Confidence Interval	
Condition	Question	Mean RT	Standard Error	Lower Bound	Upper Bound
Instructed	Control	717.00	36.60	638.99	795.00
	Lie	736.82	49.29	631.77	841.87
	Truth	756.94	49.30	651.87	862.02
Motivated	Control	669.09	43.54	576.28	761.91
	Lie	577.13	54.25	461.51	692.76
	Truth	650.51	62.31	517.69	783.318

Table 1: Mean reaction time for all conditions and question types. RT = reaction time

Reaction time data is presented in Table 1. A 2 x 3 repeated measures ANOVA analysis

was performed and indicated that there was a significant effect of motivation on reaction time,

with participants in the motivated condition responding to question significantly faster ($F(1,15) =$

7.390, $P = .016$). The analysis also indicated there was a marginally significant effect of question

type on reaction time, with participants responding faster to the lie questions than the truth

questions at a level approaching significance ($F(1,15) = 4.480$, $P = .051$). Comparisons between

control and lie questions and control and truth questions were not significant. A significant

Motivation x Question type effect on reaction time was found ($F(1,15) = 10.703$, $P= .005$).

Reaction times were significantly faster in the motivated lie condition than in the instructed

control condition ($t(15)= 3.497$, $P = .003$), the instructed lie condition ($t(15) = 4.027$, $P = .001$),

the instructed truth condition, ($t(15)= 3.627$, $P = .002$), the motivated control condition ($t (15)=$

2.459, $P =.027$), and the motivated truth condition ($t(15)= -2.453$, $P =.027$). None of the other

conditions and question type comparisons were significant.
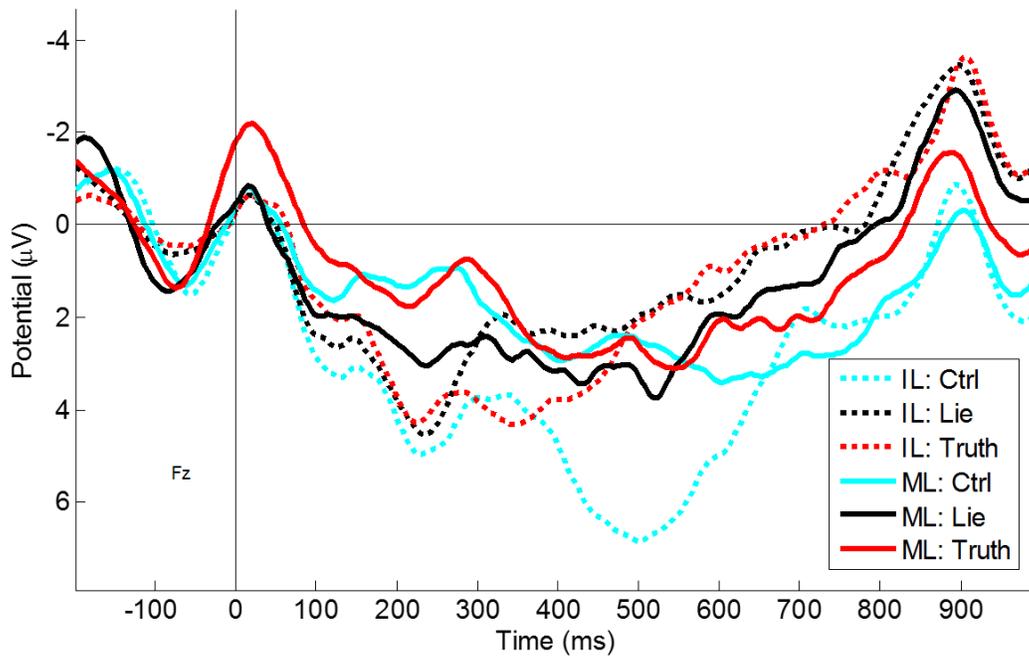
3.3 ERP Data

3.3.1 CRN

Figure 1: Grand Mean CRN waveforms at Fz for both conditions and the six analyzed question

types.

Visual inspection of the grand average waveforms of the CRN revealed a negative peak

around 20 ms after correct responses (Fig. 1). This peak was highest in the motivated relevant

truth condition, and virtually the same in the other five conditions and question types. However,

visual inspection of individual waveforms failed to reveal an identifiable CRN in many of these

waveforms. Thus, statistical analyses could not be performed.
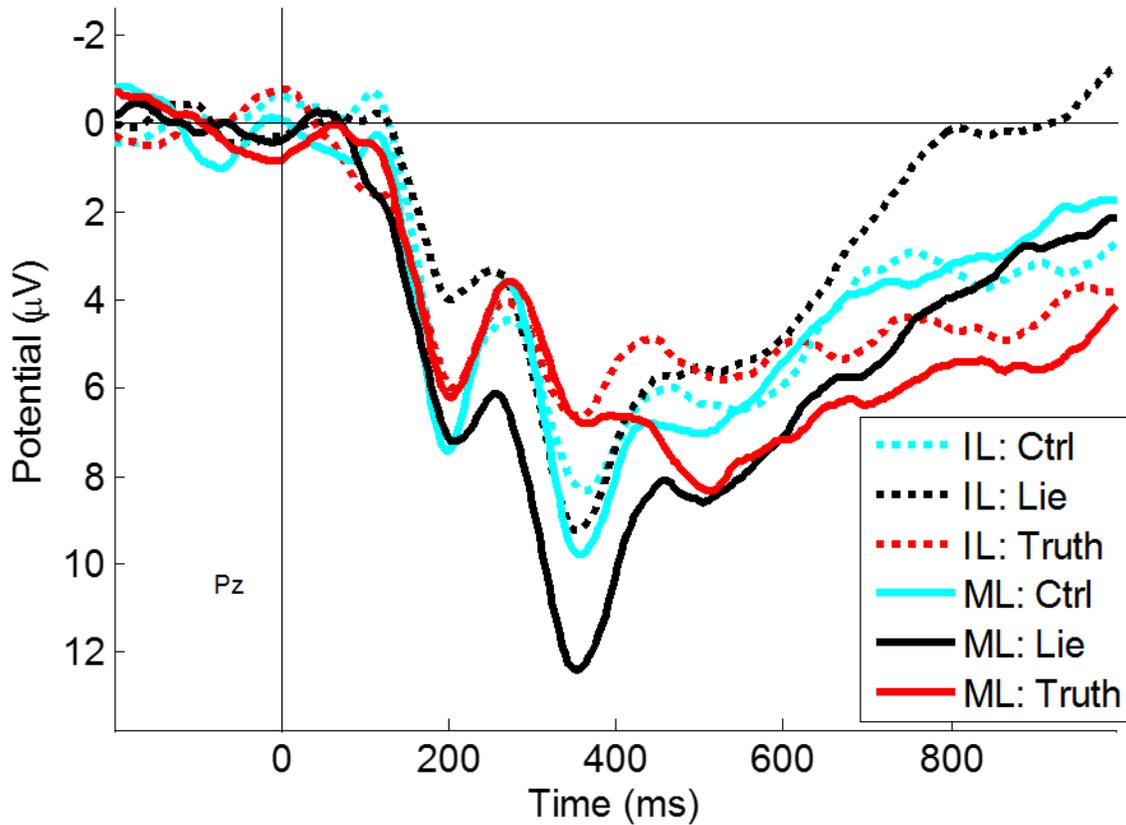
3.3.2 P300

Figure 2*: Grand Mean P300 waveforms at Pz for both conditions and the six analyzed question types.*

Condition	Question	Mean P300 Amplitude	Standard Deviation
Instructed	Control	10.19	3.54
	Lie	10.74	3.56
	Truth	9.51	3.94
Motivated	Control	11.81	6.18
	Lie	13.49	5.53
	Truth	9.30	4.67

Table 2: Mean P300 amplitudes at Pz for both conditions and the six analyzed question types.

Condition	Question	Mean P300 Latency	Standard Deviation
Instructed	Control	352.06	112.36
	Lie	354.93	80.17
	Truth	341.52	103.19
Motivated	Control	378.13	107.90
	Lie	378.82	89.90
	Truth	378.04	120.11

Table 3: Mean P300 latencies at Pz for both conditions and the six analyzed question types.

Visual inspection of the grand average waveforms of the P300 revealed a positive peak around 380 ms after stimulus presentation (Fig. 2). This peak was highest in the motivated lie condition. Mean P300 amplitude data is presented in Table 2. A 2 x 3 repeated measures ANOVA indicated that there was not a significant effect of motivation on the amplitude of the P300, $F(1,15) = 3.176$, $P= .095$. The analysis indicated there was a significant effect of question type on the amplitude of the P300, with the P300 significantly higher in the lie questions than the truth questions ($F(1,15) = 5.381$, $P= .035$). Comparisons between control and lie questions and control and truth questions were not significant. A significant Motivation x Question type effect on P300 amplitude was not found, ($F(1,15) = 1.917$, $P = .186$). Mean P300 latency data is presented in Table 3. A 2 x 3 repeated measures ANOVA analysis indicated that there was a significant effect of motivation on the P300 latency, with the P300 in the motivated condition coming significantly later ($F(1,15) = 5.797$, $P = .029$). There was not a significant effect of question on the P300 latency, ($F(1,15) = .259$, $P = .618$). In addition, a Motivation x Question type interaction was not observed ($F(1,15) = .186$, $P = .672$).

4. Discussion

The survey data indicate that the design of this study effectively manipulated motivation, as participants indicated they were more motivated to complete the task in the motivated lie condition. The faster reaction times seen in the motivated condition is further evidence that the manipulation of motivation was successful.

The lack of a significant effect of motivation on the amplitude and latency of the P300 may indicate that the participants did not view the act as deceptive, and the design of this study failed to create actions that felt like real world deception. The increased P300 amplitude after deception responses is in line with the results of other studies that used an oddball-type stimuli as the lie target stimulus (e.g., Pfister et al. 2014; Suchotzki et al. 2015; Verschuere, et al. 2009). This increase in amplitude most likely resulted from participants' increased attention toward the target lie stimulus.

This study was unsuccessful in evoking the CRN ERP and replicating Suchotzki et al. (2015). While it did appear from grand waveforms that CRN after truth-telling responses in the motivated condition had higher amplitude relative to lie responses in the motivated condition, as well as the overall highest amplitude (which is congruent with the hypothesis), it was not found in the individual waveforms of many participants, and thus could not be statistically analyzed. Failure to find this potential may be due to the design of the task, which failed to evoke it. It also may have been that our filtering techniques in data analysis, which differed from those of Suchotzki et al. (2015), failed to discern it in data analysis. It also may be that because the CRN is a small potential, more participants were needed to find it.

This study did have some limitations. A major limitation of this study is that due to the design, the conditions were always performed in same order, with instructed lie condition always first and the motivated lie condition always second. This could have confounded the reaction time data: it could be that participants responded faster in the motivated condition due to increased motivation and attention toward the task, or due to the fact that participants completed this condition second and thus had more practice with the task. Thus, the difference in reaction times between the instructed lie and motivated lie conditions could be due to either the effect of the manipulation of motivation, or practice on the first instructed condition that carries over to the second motivated condition. Nonetheless, it is more likely that the faster reaction times are due to the motivation in the second condition, as the survey data indicated that participants were more motivated in the motivated lie condition. However, future studies that use this experimental design should vary the order that the two conditions are completed to control for this possibility.

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