The Influence of Explicit Emotional Information on the Inhibition Process of Deceptive Response: Evidence from ERP

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Abstract: Deceptive response may be influenced by the individual's internal emotional experience and external emotional information. Deception can bring nervous, fearful or even emotional experiences to the deceiver. The emotional experience can also affect deceptive behavior. Based on previous studies, this paper used facial expressions as a stimulus material, combined with explicit tasks, to study the impact of emotional information on the inhibition process of deceptive responses. The experiment adopted the emotional Stroop paradigm, used event-related potential to discuss the neural mechanism of the influence of explicit emotional information on deception. In the explicit task, it was found that high intensity triggered greater P300 amplitudes, high-intensity negative emotions triggered greater LPC amplitudes, and deceptive responses triggered greater N200, P300 and LPC amplitudes. These results show that in the explicit tasks, the impact of emotional information on fraudulent responses runs through the three stages of executive function. This is, inhibition stage, conflict and reaction monitoring stage and implementation stage. This study also found that negative emotion information had greater influence on deceptive response in explicit tasks.

Keywords: Deceptive response, Emotional information, N200, P300, LPC

Introduction

Hyman (1989) believes that deception refers to an individual's incorrect belief, which is generated when it intentionally manipulated others through verbal or nonverbal behavior. Clifford (2000) believes that deception is an intentional intention, and that some kinds of success or unsuccess intention to create a certain knowledge of incorrect belief in the absence of any warning. Abe (2009) believes that deception is a psychological process. It will inhibit the correct information and try to mislead the other person to believe that incorrect information is correct when the person understands the facts. It highlights the non-forewarning and intentional characteristics of deception, it means deception is not only an incorrect attribute, but also an intentional behavior.

In real life, deception is often caused by the complex social situation and the interpersonal interaction, and it also involves a considerable number of repeated executions. Sip et al. (2008) believes that information management, impression management, risk management and reputation management are interrelated to deception in the process of deception. Dong Shanshan et al. (2013) constructed a psycho physiological model of deception through previous theories and studies. The model involves various psychophysiological processes of deception, which are divided into three modules: cognition, emotion and peripheral physiological responses.

In this model, the cognitive module includes four parts: episodic memory reconstruction, risk decision, executive function and theory of mind. The episodic memory reconstruction means that the experienced by the individual is characterized in the brain, and the individual can extract the representation when it is confronted with the related or similar situation. The risk decision means that the cheater weighs the pros and cons of all aspects before cheating and evaluates the benefits and the consequences of deception. The executive function refers to the cheater suppresses the impulse of honest response, monitors the conflict between deceptive and honest response and finally makes deception in the process of cheating. The theory of psychology means that the cheater needs to pay attention to the response of the deceived, guesses his intention and constantly adjust his own words and needs to ensure the smooth progress of the deceptive response.

Emotion and cognition are the basic of deception, and there is an inseparable link between them. The individual cognitive process can regulate the current emotional state to a certain extent, and emotional responses can further affect the individual's cognitive behavior. Frank and Svetieva (2012) believe that the interaction of cognitive and emotional interactions in lie recognition needs to be fully considered, and that cognitive and emotional clues should be sought to identify lies. However, Vrij and Granhag (2012) believe that emotional clues be ignored in lie recognition. They tend to regard deception as a cognitive process and think that when individuals cheat, they can use the characteristics of higher cognitive load and further increase the individual's cognitive load by skillfully designing questions. With the increase of cognitive load, individuals may have corresponding behaviors. These behaviors may be clues to deceptive cognition. The autonomic nervous system is closely related to emotion. In emotional states, people usually have obvious self-reactions. In the process of cheating, there will be tension, anxiety and other emotions. These emotions will activate the autonomic nervous system to cause changes in peripheral physiological responses.

In the previous studies of deception, there are three main experimental paradigms: the deliberate error response paradigm, the pretense memory damage paradigm and the spontaneous deception paradigm in social situations. The purpose is to let the subjects make a wrong response in the recognition stage of learning recognition. The main materials used in this study are words, pictures, personal information and related experiences. When the material is new stimulation, the subjects need to learn and recognize, then when the material is old stimulation, the subjects only need to recognize. In the study of deliberately error, the differences in brain activation induced by individual intentional error (deceptive response) and honest response were mainly discussed, and then the degree of brain activation associated with deceptive response and the ERP components induced by deceptive response were more accurate. Pretending memory damage is a kind of disease, which is a kind of exaggerated or even disguised behavior of a certain physiological or psychological disease, it is a kind of deliberately wrong (T.W.C. Lee et al., 2002). The two important components of deception in this paradigm are spontaneous and deceptive in social situations (Vrij, 2004). Deception in real life is not only a process of error response, but also involves a lot of complex social situations, trade-offs and interpersonal relationships. Of course, there are many psychological processes, such as emotion, attention, memory and decision when making trade-offs (Kireev et al.,2012).

Deceiver must monitor and control his response in the process of deception. The studies found that in the Stroop task, it is necessary to inhibit the automatic processing of word semantics and to name the color of the word, inducing the activation of the dorsolateral prefrontal cortex, the lower frontal cortex and the back of the dorsal cingulate (Adam et al., 2014; Blasi et al., 2006). In these two studies, the subjects need continuous monitoring to prevent discomfort, thus we can know the inhibition process of the dominant response.

The study of emotional mechanism is divided into two categories. One is the direct induced emotion, and the emotion itself is the goal of cognitive task, and the interaction mechanism of emotion as unrelated to the main task, but it can perceive and experience the disturbing background information and examine the implicit or subliminal effect of emotion. A subliminal study shows that potential positive emotional faces activate bilateral cingulate and amygdala, while negative emotions mainly activate the left anterior cingulate (Killgore & Yurgelun-Todd, 2004). Shafritz et al. (2006) examined the neural mechanism of emotional information affecting response inhibition and found that the medial frontal lobe and the insula were the main brain areas involved in emotional face tasks.

In explicit emotional tasks, Sharma et al. (2001) used emotional Stroop task to investigate the effect of emotional information on cognitive control. The results showed that negative words would interfere with color naming, while the emotional Stroop effect of positive words was not significant. Hare et al. (2005) found that subjects responded more quickly to happy stimuli. Altarriba (2007) used bilingual subjects in the study. It was found that the negative Stroop effect was observed in two languages. In the study of Xin Yong, Li Hong and Yuan Jiajin (2010), the subjects were asked to respond differently to standard stimuli and deviation stimuli, and the effects of emotional stimuli on individual behavior control were investigated. The bias stimulus was composed of three emotional images, positive, negative and neutral. It was found that the response time was the longest under negative bias. Martin et al. (1991) found that both positive and negative vocabularies produce the same degree of emotional Stroop interference.

Based on these studies, this paper will use explicit task experiments, and the explicit experimental tasks need to be tested to judge the emotion of the stimulus picture, at this time sex is unrelated task. Each experiment included honest and deceptive response to compare the impact of emotional information on deceptive responses. In this paper, we use the event related potential on deceptive response. Than research is different from before, this software can not only generate 3D face images of various emotional intensity and types, but also make the arousal of emotional information vary accurate.

Method

Participants

The participants were 24 college students recruited from Henan University (11 boys; 13girls; age range 18-24). 3 subjects were removed from the brain wave instability. All subjects were right-handed, with normal visual acuity or corrected visual acuity, colorless, blind and weak color. No history of brain injury, no family history of abnormal brain heredity, and no similar experiments have been done before. All subjects signed the subject’s informed consent. And a certain reward was given after the experiment was completed.

Stimuli

The experimental materials are 20 images of 3D faces generated by Facegen Modeller 3.4.1 software. Then we used software to regulate the emotional types and intensity of faces accorded to the generated original face pictures. Emotional types include anger and happy, and emotional intensity include 40% and 100%.

Design and Procedure

The experiment used 2(emotional type: anger, happy) ×2(emotional intensity: 40%, 100%) ×2(reaction type: honest reaction, deception reaction) in the experimental design. The emotional Stroop paradigm was used to examine the effects of positive and negative emotion information on deceptive responses in explicit tasks under 40% and 100% emotional intensity.

The experiment programed by E-Prime 2.0 and presented experimental materials and collected the behavioral date. EEG equipment is a Brain Cap 32 lead Ag/AgCl EEG recording analysis system produced by the German Bain Products company. The electrode cap adopts the international 10-20 expansion system and records the horizontal and vertical eyes. The computer used to collect ERP data and behavioral data was purchased by a laboratory administrator from a regular company, a 14.7-inch LCD display, and a keyboard connected to a computer. The key "D" and "K" which are used on the keyboard are manually processed and labeled with "positive" and "negative" labels. The subjects were asked to conduct experiments in a quiet, light and dark moderate, temperature and humidity sound insulation environment. The subjects looked at the computer screen and the distance between the display screen and the subjects was about 100cm.

The experiment was divided into honest and deceptive response. In the honest response, the subjects need to respond to the emotional type of the emotional face. The subjects need to react to the button "positive" if there is a positive picture(happy) and the negative picture(angry) reacts to the label "negative" button. In the deceptive response, subjects need to react to the emotional face. The subject responds to the "negative" button with the label, and the negative picture reacts to the label "positive" button. Each block includes two stages of practice and formal experiment. First, the subjects are presented and explained, until the subjects fully understand the experimental task and enter the exercise stage. If the subjects are already familiar with the experimental process after the practice finished, they could enter the formal experiment stage. Or else continue to learn the process until they are familiar with the process. The experimental process was first presented to the subjects "+" on the 500ms, followed by a stimulus picture, then the trial was used to judge the picture, and finally the 300ms-500ms was presented randomly. The time of stimulating picture is 2000ms. They skip over if the subjects do not respond, and there is a rest between block. The first 12 subjects made an honest response firstly, the deceptive response was done first in the last 12 subjects. The experimental flow chart and other figures are shown in Appendix.

Data Acquisition

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 resistance between each electrode point and scalp was reduced to less than 10kΩ in each experiment. The signal is collected by the sampling frequency of 500Hz. EEG data were filtered offline at frequencies of 0.01-30Hz, and the offline analysis duration was from 200ms baseline before stimulation to 1000ms after stimulation. Manual removal of the artifact of ±100μV, automatic correction of Electromyography.

Results

SPSS21.0 was used to analyze the RT and the mean amplitude of N100, N200, P200, P300 and LPC, and the *p* value was corrected by Greehouse-Geisser.

Behavioral Results

The 2 (emotional type: anger, happy) ×2 (emotional intensity: 40%, 100%) ×2 (response type: honest, deceptive) repeated measures analysis of variance (ANOVA) in this experiment. We found there was a significant main effect of emotional type, $F(1, 20)=8.774$, $p=0.009$, $\eta^2=0.340$, and a significant main effect of emotional intensity $F(1, 20)=98.423$, $p=0.000$, $\eta^2=0.853$, and a significant main effect of response type $F(1, 20)=8.055$, $p=0.011$, $\eta^2=0.322$. There was a significant interaction between emotional type and emotional intensity $F(1, 20)=14.778$, $p=0.001$, $\eta^2=0.465$. For emotional type, we found significant main effects of 40% intensity ($F=7.930$, $p=0.012$) and 100% intensity ($F=6.720$, $p=0.019$). For emotional intensity, we found a significant main effect of anger ($F=11.180$, $p=0.004$), there was no significant main effect of happy ($F=3.180$, $p=0.092$).
3.2. ERP results

According to the previous research (Paul et al., 2013; Shafir et al., 2015; Suchotzki et al., 2015) and the purpose of the study, C3, C4, Fz, Cz, and FCz are selected as reference electrodes, and the average amplitude of N1, P2, N2 and LPC was 5 (electrode: C3, C4, Fz, C, FCz) ×2 (emotional type: anger, happy) ×2 (emotional intensity: 40%, 100%) ×2 (response type: honest, deception) repeated measures analysis of variance (ANOVA). This paper focuses on the components and characteristics of event-related potentials triggered by emotional information under explicit honesty and deception tasks.
3.2.1 100-130ms time window (N100)

N100 (100-130ms) results. We found there was a significant main effect of electrode, $F(4, 80)=45.105$, $p=0.000$, $\eta^2=0.693$, and a significant main effect of emotional intensity, $F(1, 20)=5.616$, $p=0.028$, $\eta^2=0.219$. There was a significant interaction of electrode, emotional intensity and response type, $F(4, 80)=3.591$, $p=0.005$, $\eta^2=0.152$. For electrode, we found every condition was significant.

160-210ms time window (P200)

P200 (160-210ms) results. We found there was a significant main effect of electrode, $F(4, 80)=3.825$, $p=0.003$, $\eta^2=0.161$, and a significant main effect of response type, $F(4, 80)=2.282$, $p=0.052$, $\eta^2=0.102$. There was a significant interaction between electrode and emotional intensity, $F(4, 80)=2.452$, $p=0.039$, $\eta^2=0.109$. For electrode, we found every condition was significant. For emotional intensity, we found significant main effects of C4(F=143.930, p=0.000), Fz(F=99.870, p=0.000), Cz(F=56.260, p=0.000) and FCz(F=159.880, p=0.000).

3.2.3 200-270ms time window (N200)

N200 (200-270ms) results. We found there was a significant main effect of electrode, $F(4, 80)$=35.075, p=0.000, η^2=0.637, and a significant main effect of emotional intensity, $F(1, 20)$=20.544, p=0.000, η^2=0.507, and a significant main effect of response type, $F(1, 20)$=11.636, p=0.003, η^2=0.368. There was a marginal interaction between emotional type and emotional intensity, $F(1, 20)$=3.818, p=0.065, η^2=0.160, and a significant interaction between electrode and response type, $F(4, 80)$=9.298, p=0.000, η^2=0.317, and a significant interaction of electrode, emotional intensity and response type, $F(4, 80)$=2.595, p=0.030, η^2=0.115. For electrode, we found every condition was significant. For response type, we found significant main effects of C3(F=4.850, p=0.039), Cz(F=5.320, p=0.032) and FCz(F=3.760, p=0.067) under 100% emotional intensity, and significant main effects of C3(F=13.640, p=0.001), C4(F=5.760, p=0.026), Fz(F=17.740, p=0.000), Cz(F=19.750, p=0.000) and FCz(F=19.230, p=0.000) under 40% emotional intensity.

3.2.4 260-400ms time window (P300)

P300 (260-400ms) results. We found there was a significant main effect of electrode, $F(4, 80)$=22.008, p=0.000, η^2=0.524, and a significant main effect of emotional intensity, $F(1, 20)$=20.757, p=0.000, η^2=0.509, and a significant main effect of response type, $F(1, 20)$=10.545, p=0.004, η^2=0.345. There was a significant interaction between electrode and emotional intensity, $F(4, 80)$=3.902, p=0.003, η^2=0.163, and a significant interaction between electrode and response type, $F(4, 80)$=6.644, p=0.000, η^2=0.249, and a significant interaction of electrode, emotional intensity and response type, $F(4, 80)$=2.379, p=0.044, η^2=0.106. For electrode, we found every condition was significant. For response type, we found significant main effects of C3(F=5.260, p=0.033), C4(F=3.920, p=0.062), Cz(F=7.050, p=0.015) and FCz(F=3.680, p=0.069) under 100% emotional intensity, and significant main effects of C3(F=11.670, p=0.003), C4(F=7.120, p=0.015), Fz(F=15.380, p=0.001), Cz(F=25.430, p=0.000) and FCz(F=23.190, p=0.000) under 40% emotional intensity.

3.2.5 450-550ms time window (LPC)

LPC (450-550ms) results. We found there was a significant main effect of electrode, $F(4, 80)$=3.366, p=0.007, η^2=0.144, and a significant main effect of emotional type, $F(1, 20)$=7.433, p=0.013, η^2=0.271, and a significant main effect of emotional intensity, $F(1, 20)$=5.392, p=0.031, η^2=0.212. There was a significant interaction between electrode and emotional intensity, $F(4, 80)$=4.624, p=0.001, η^2=0.188, and a significant interaction of electrode, emotional intensity and response type, $F(4, 80)$=2.766, p=0.022, η^2=0.121. For electrode, we found every condition was significant. For response type, we found a significant main effect of C3(F=7.840, p=0.011) under 40% emotional intensity. For emotional intensity, we found significant main effects of C3(F=11.420, p=0.003), C4(F=9.360, p=0.006), Fz(F=6.180, p=0.022) and Cz(F=4.030, p=0.058) under deceptive response.

Discussion

Based on comparative analysis between honest and deceptive response, it was found that lower intensity emotion only caused larger N200 amplitude on C3 and Cz, higher intensity caused greater P300 amplitude on FCz and Fz, and higher intensity of negative emotion at C3 and C4 caused greater LPC amplitude. Pessoa (2012) studies the effect of the stop signal paradigm on the response inhibition of high and low threatening emotional stimuli. The results show that the high hypochondriac signal causes a greater skin response, and the emotional type has no difference in promoting response inhibition. That is the intensity of emotion plays an important role in the process of response inhibition. The influence of emotional intensity on the inhibition of deceptive response is significant in this study, which is consistent with the results of Pessoa. Sussman et al. (2016) found that LPC evoked by negative and neutral stimuli increased. The results of Brudner et al. (2017) found that negative emotions could cause later positive wave amplitude. Negative cue stimulation may allocate attention resources for upcoming events, then enhancing emotional awareness and weaken their executive function. Albert et al. (2010) believes that negative emotions can reduce individual's emotional awareness and weaken their executive function. Suchotzki et al. (2015) found that the P300 amplitude of honest response was less than deception reaction. In this study, the P300 amplitude of deceptive response was greater than honest response and supported the results of the study of Suchotzki. Deceptive response can trigger greater N200 amplitude in explicit tasks, which is consistent with the results of Ji Shumei et al. (2012).

In this study, three typical ERP components, N200, P300, and LPC, were involved in affective information affecting deceptive response. According to the model of Dong Shanshan et al. (2013), the core component of the individual's deceptive response is the executive function, and the executive function refers to the cheater in the process of deception, to suppress the impulse of the honest response, to monitor the conflict between the deceptive and honest response, and finally make a deceptive response. N200 waves were induced in the impulsive suppression phase of the deception reaction. In the early study of N200, Puce et al. (1999) used the intracranial ERP to obtain the face specific component N200. Therefore, they used a three-stage paired test to verify that the results found that N200 was not related to the learning and recognition of the face. McCarthy et al. (1999) found that N200 was associated with structural analysis of facial features, but not with gender, age and race. The experimental results show that the amplitude of N200 induced by deception is greater than the N200 amplitude induced by honest response. N200 is not only related to the analysis of the results of the face characteristics, but also may be related to the inhibition of the real information phase of the deceptive response.

In the study of facial recognition, eyes, nose, mouth, eyebrow, mandible and cheek are often used as internal features, and the parts of the hair, neck, and ears are called external features. It has been found that N100, P160, and N240 components are produced regardless of the external characteristics. The amplitude of P160 with external characteristics is small, while that of N240 is large. No matter whether or without external characteristics, N170 is not appear. N170 may not only be related to the structural features of the face, but also the inner facial characterization of the brain. In previous studies, if the research object of the researcher is Westerners, the facial representation in the Western brain is a westerner face. If the researcher's research object is the Orientals, the facial representation in the Oriental brain is the Orientals face, and the different facial representation may be the main reason of the emergence of N170. The experiment used by the subjects as the ordinary college students as the Oriental, the experimental material is generated by Facegen Modeller 3.4.1, is the face of Southeast Asia. The face representation in the subjects' brains was Oriental. Perhaps the formal difference in facial representation led to the absence of N170 in this experiment.

One view is that P300 represents the end of the perceptual task, P300 represents the inhibition of stimulating the processing. When the desired stimulation is made to some conscious processing, the related parietal or medial temporal lobe is activated to produce a negative potential. Once this processing ends, these parts are suppressed, then the P300 produced. Another hypothesis widely supported by psychophysiology is that Donchin et al. (1979, 1981), according to their experimental results, suggests that the latency of P300 reflects the time required for the evaluation or classification of stimuli, and the P300 amplitude reflects the renewal of the representation in working memory. The main reason is that there is more than one endogenous P300, P300 is not a simple component, but related to a variety of cognitive processing. The interests of the stimulants and the subjects and the subjects' emotions were all reflected on the P300. For example, the ERP of several suspects was measured after the theft of an item, and different items were presents on the screen. The P300 of the thieves was abnormal when the stolen objects appeared. According to these characteristics, P300 has become a typical component. In the results of this study, both implicit and explicit tasks have obvious P300 components. The positive emotion in the implicit task leads to a greater P300 amplitude, which leads to a greater P300 amplitude. In Suchotzki et al. (2015), the P300 amplitude of deceptive response was larger than that of honest response, which was consistent with the results of this study. In explicit tasks, the high intensity emotion can cause larger P300 amplitude, and the deceptive response can lead to greater P300 amplitude. Therefore, we can get P300 not only to reflect the emotion, but also the important component of deception and lie detection, and it is mainly related to the conflict of executive function and the monitoring phase of the response.

LPC increases especially in attention position and stimulus characteristics, indicating that the target selection of attention position and stimulus characteristics occurs during this period. Sussman et al. (2016) found that the LPC amplitude induced by negative and neutral stimuli increased. The results of Brudner et al. (2017) found that negative emotions could trigger a larger LPC amplitude. Negative emotions can induce relatively large LPC amplitude. In the explicit tasks, negative emotions elicit significant LPC amplitudes, and deceptive responses elicit greater LPC amplitudes than honest responses. This is consistent with the findings of Sussman and Brudner et al. Negative emotion can induce greater LPC amplitude, and LPC is an important component of the study of deceptive response, which is mainly related to the executive function of the execution of lying response stage.

The emotional Stroop paradigm was used to study the effect of different emotional information on deception in this experiment. Although it was also valuable and meaningful, there were still some shortcomings and limitations. In the selection of experimental materials, the negative emotion of this experiment only selected anger as the representative. Negative emotion also includes sadness, fear and so on. It is inevitable to use anger to represent all negative emotions. In the selection of experimental paradigm, it is incomplete to use the emotional Stroop paradigm. In the selection of experimental subjects, the subjects were selected without systematic selection, but were selected at Henan University randomly. After all, college students only represented a part of the group, so the results were not necessarily applicable to other groups. The early components of the experiment were not well controlled, leading to unstable baseline results in ERP.

There are many studies on deceptive response and many achievements have been made, but the study on the mechanism of deceptive response by specific emotional information still needs our efforts. Future research can be further explored in the following aspects. In terms of emotional information selection, standardized emotional videos can be used to arouse the emotion of the subjects. In the experimental technique, the event related potential was studied in this experiment. Although the ERP technology has a high resolution in the time process, it is not enough to explore the specific neural mechanism, so fMRI technology can be used to explore the neural mechanism of the influence of emotion on deception. In the future study, the subjects of different age groups can be selected to further understand whether there are cultural differences, individual personality differences and other developmental studies on the influence of emotional information on deception.

Conclusion

The high intensity of P300 wave is caused by the high intensity in the explicit task, the high intensity negative emotional leads to the larger LPC amplitude, and the deceptive response leads to the greater amplitude of N200, the amplitude of P300 and the amplitude of LPC. Combining the physiological and psychological models of deceptive response, the influence of emotional information on deceptive response runs through the three stages of executive function, which are the stage of inhibition of real information, the stage of conflict and response monitoring and the stage of executing deceptive response. Moreover, negative emotion information has greater influence on deceptive response in explicit tasks.

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Appendix. Figures

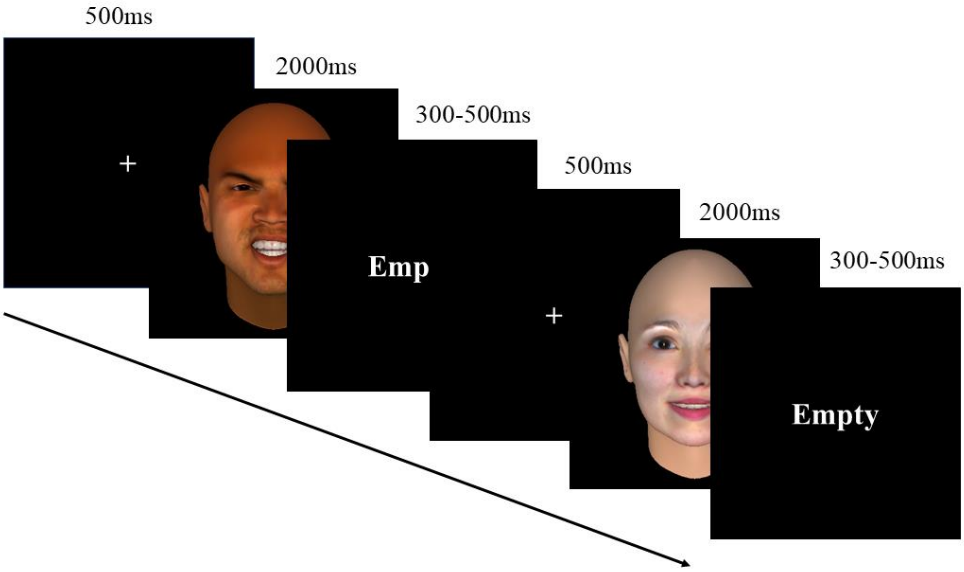

Figure 1 The Experimental Flow Chart

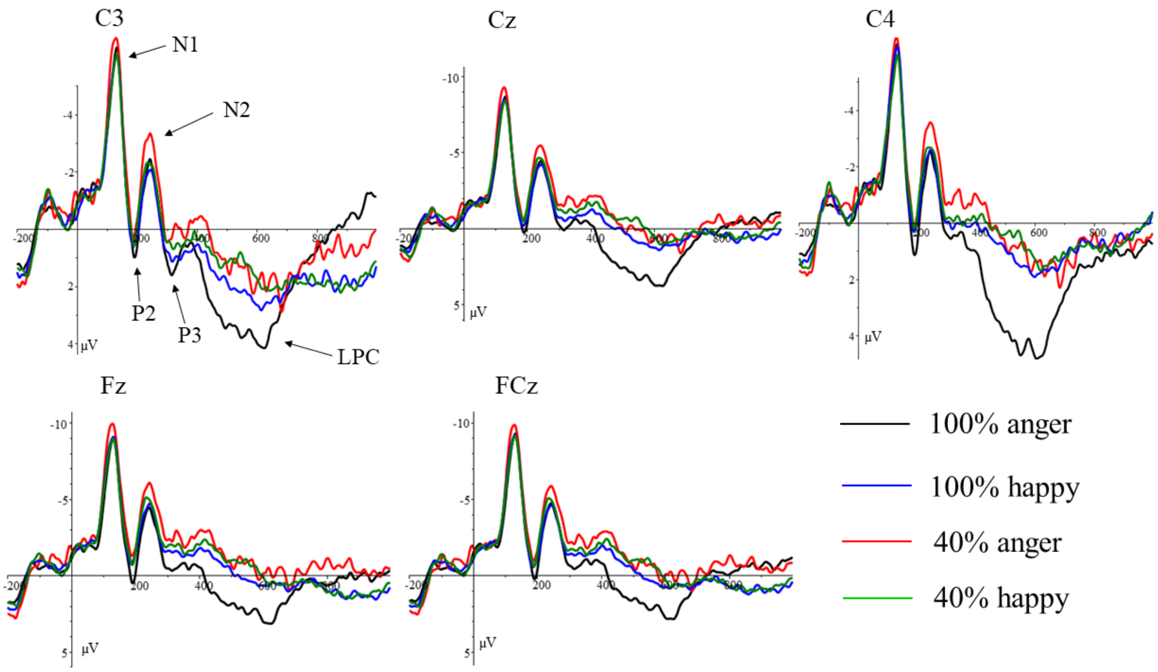

Figure 2. The Waveforms of Average Wave Amplitude under Different Conditions in Honest Response

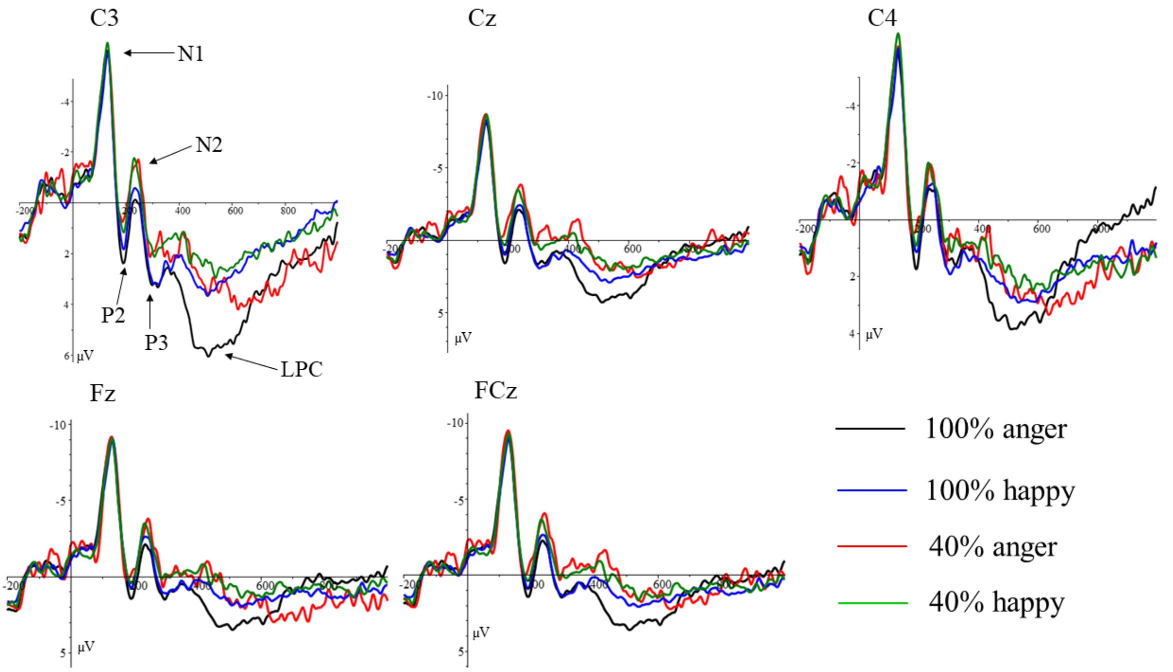

Figure 3. The Waveforms of Average Wave Amplitude under Different Conditions in Deceptive Response

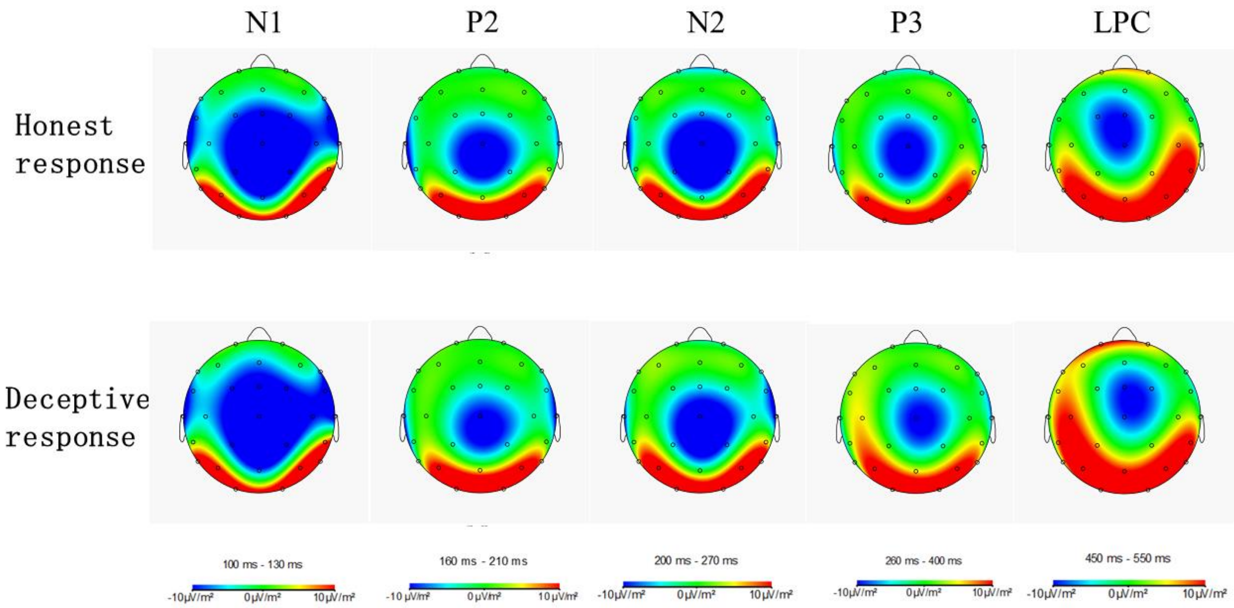

Figure 4. Differential Wave Topographic Map of Average Wave Amplitude under Different Conditions

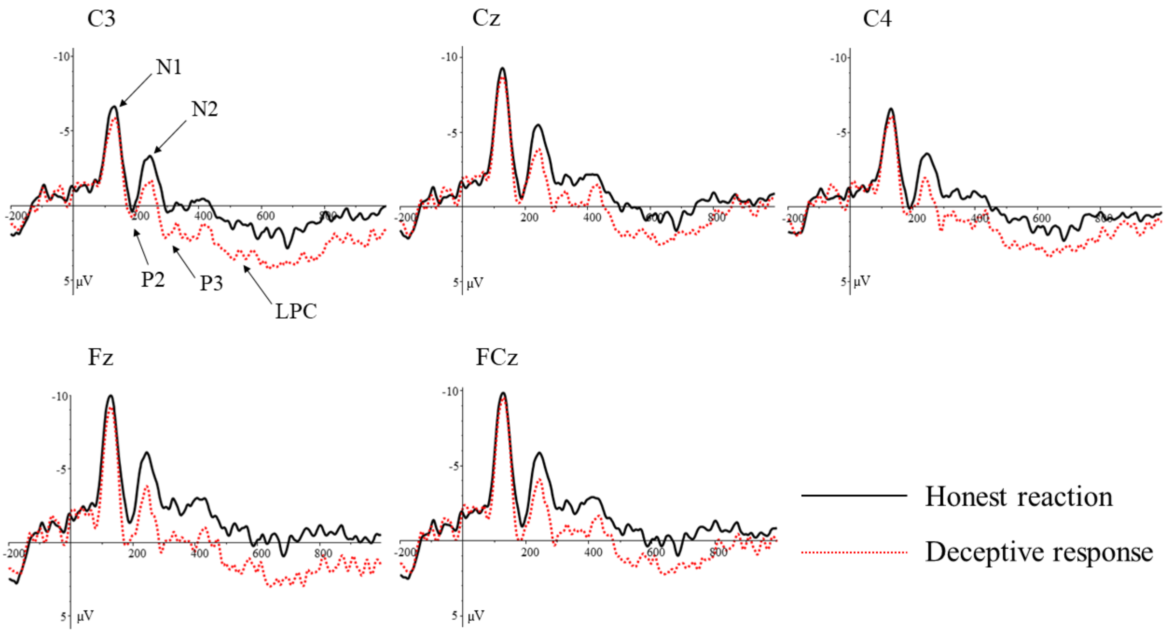

Figure 5. The Waveforms of the Average Amplitude of 40% Intensity Anger Conditions

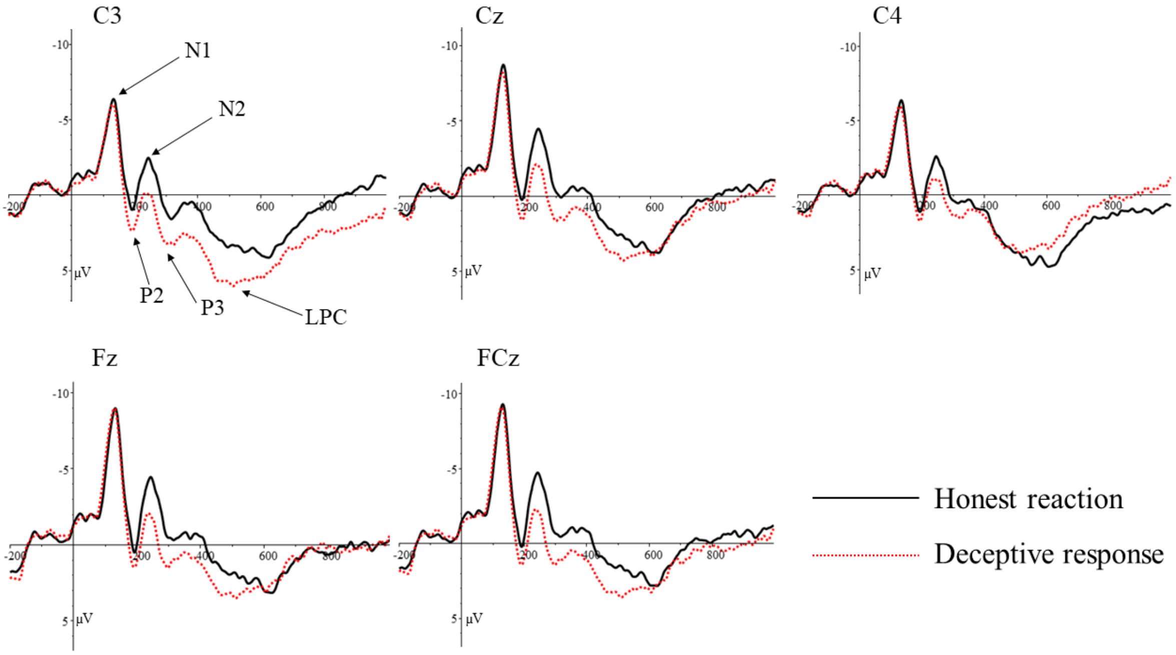

Figure 6. The Waveforms of the Average Amplitude of 100% Intensity Anger Conditions

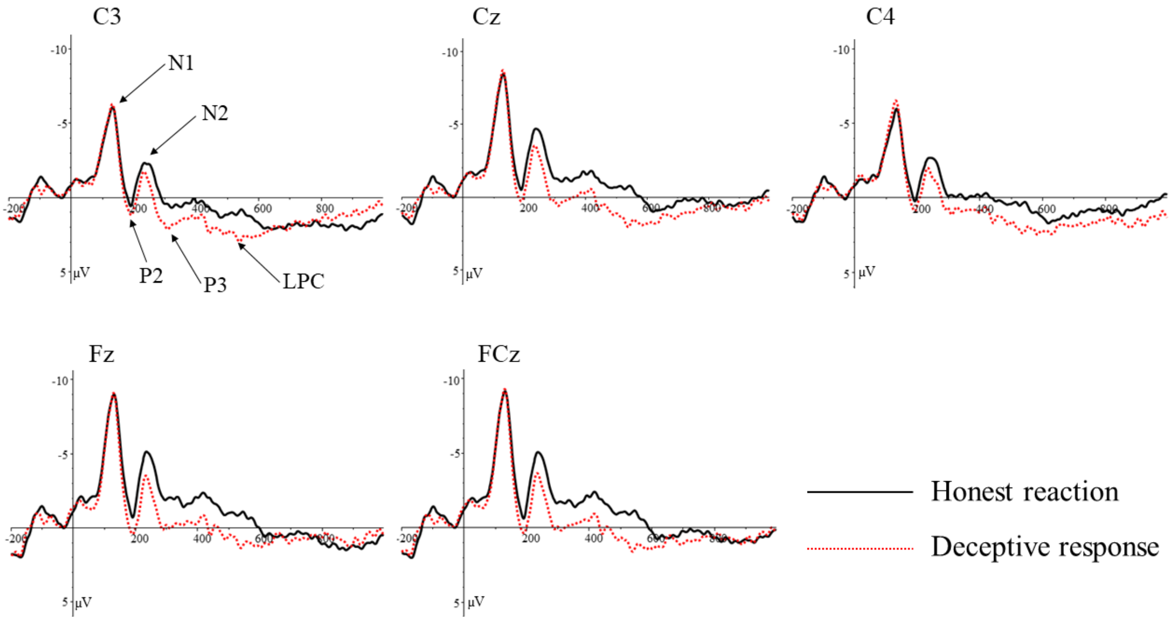

Figure 7. The Waveforms of the Average Amplitude of 40% Intensity Happy Conditions

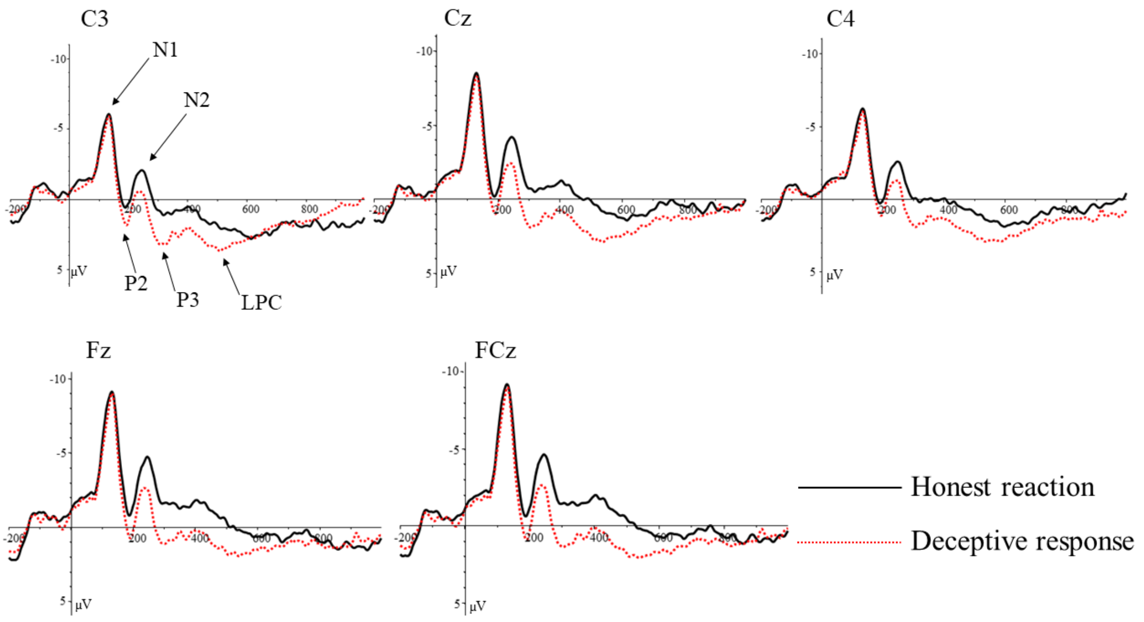

Figure 8. The Waveforms of the Average Amplitude of 100% Intensity Happy Conditions

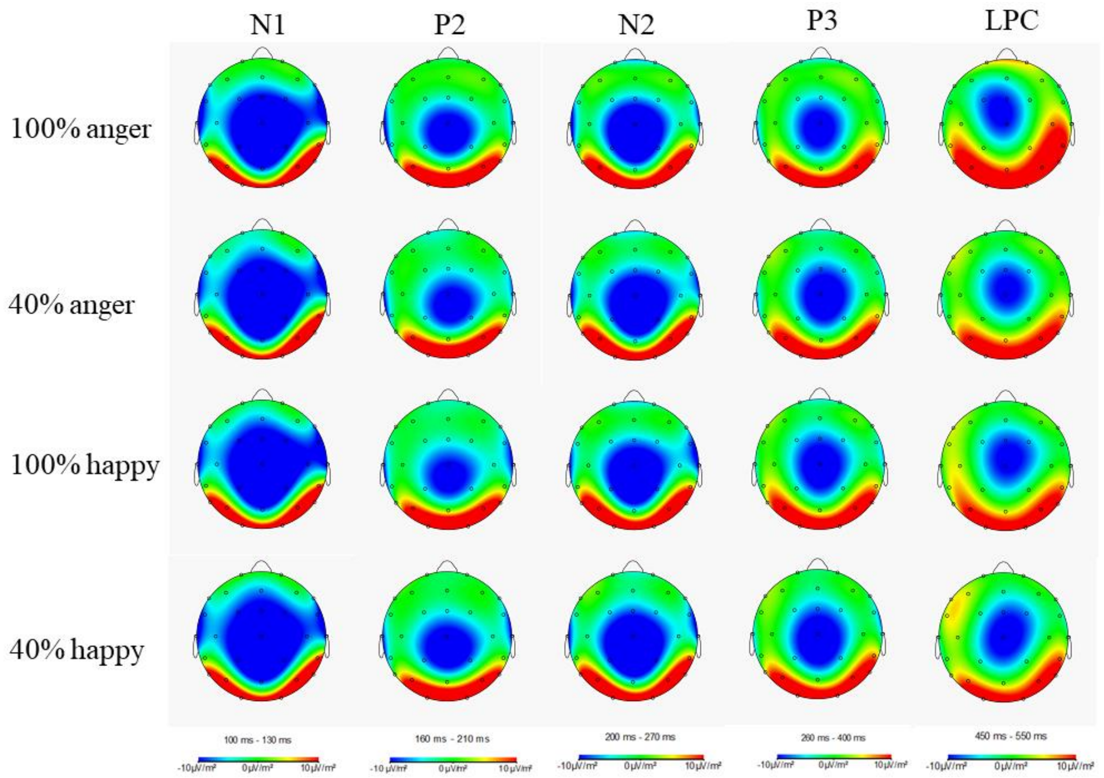

Figure 9. Differential Wave Topographic Map of Average Wave Amplitude under Honest and Deceptive Response