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Reference cues of lie-detection questions on physiological potentials response

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Abstract
Objective: Compare two different reference cues: prompts and fixation points, grope for their event-related potential features of reaction time under three different picture stimuli types: strange picture stimuli, familiar picture stimuli and self-related picture stimuli.
Methods: Tested are 35 school students. The experiment chooses commix experimental design of 3*2*2. Record kinds of brain waves the testes fulfilled separately and deal with them classified and spliced. Results: No matter the cue clew is prompts or fixation points, deceive reaction has a longer reaction time and lower veracity compared with honesty reaction. In the 400ms~550ms time zone, the amplitude of prompts is smaller than the amplitude of Fixation points.
Conclusion: The amplitude of prompts is smaller than the amplitude of fixation points and deceive is smaller than honesty.

Keywords: lie-detection, reference cues, event-related potential

1. Introduction

With the development of cognitive neuroscience research, researchers use event-related potentials (ERP) technology that reflects the processing of individual information to detect relevant crime information in the brain of the subject [1]. By collecting the information of EEG physiological changes of specific events in the process of individual information processing, the cognitive memory of certain information points of the event can be detected, so as to judge whether there is information related to the case in the brain [2].The relevant research analysis focuses on the specific component of P300 (late positive component). The research design follows the classical Oddball experimental paradigm and the Go/No-Go experimental paradigm by controlling different types of stimuli (eg, case related stimulus and case unrelated stimulus) to induce ERP components, through comparative analysis to understand the response of participants to stimuli with different psychological significance [3, 4]. In the choice of experimental materials, because the picture stimulation can most intuitively stimulate the physiological and psychological reaction of the subjects at the relevant point of the case, the preferred stimulus material is picture stimulation [5]. Relevant ERP studies have consistently found that there are differences in both deceptive and honest responses in the course of the reaction and the degree of activation in the cerebral cortex [6, 7].

However, there are still some shortcomings in the past research: First, the traditional rendering stimulation process, often in order to achieve smooth baseline test map etc used to render fixation point (+), and then presents the stimulation unit, and in accordance with the order until the end of the test methods to orchestrate stimulation sequence, rather than focus on stimulus appeared before the importance of strengthening honest conditions [5]. However, in the actual application process, similar to the problem of multi-channel physiological tester test, "will you be honest to answer the question?" neutral problems of this nature, can not only play the same as the pure fixation focused subjects of the role of attention, more important is that it can deceive reaction to implement the guilty to increase psychological pressure, increase the content of cognitive processing, thus more difficult to cheat behavior, are to be measured is easy to appear in front of the stimulate cell fixation point expectation effect, extend the subjects to stimulate cell information processing time, affect the accuracy of the test results[8].Second, most of the relevant studies focused on the changes in brain areas activated by the deception response versus the honesty response. One study suggested that P300 may be reduced when a person has to concentrate on lying. One possible explanation is that human attention has a limited capacity for information processing and cannot perform other tasks once assigned to certain tasks [9]. The brain resources used for the main task are allocated to perform the deception response, so the P300 amplitude is reduced [10]. But it is often assumed that if a suspect tries to deceive in order to conceal real information, more psychological resources will be needed and the brain wave amplitude or area will change. In the test, the more the suspect wanted to control his brain waves, the more abnormal his brain waves would be, because the thought of "wanting to control" itself would generate distinctive brain waves [11]. Therefore, adding a task of strengthening honesty before presenting the relevant information of the case can increase the psychological pressure of the tested person, and make the test index and test graph more dissimilar. This provides a basis for judging whether specific individuals have hidden information about crimes for fraudulent purposes in the future, and provides a possibility for the use of event-related potential assessment in criminal investigation to investigate the situation of people involved in crimes [12].

Therefore, the article hypothesized that in the research and application of deception response, the expansion of the cue (prompts and fixation points) can improve the accuracy of the test. Before the emergence of the stimulus unit, a new suggestive clue was added: the purpose of strengthening honesty is to segment the stimulus, and the normative role of the guide language forces the subject to answer the prompts honestly, increasing the difficulty of the case participants in deceiving. Previous ERP studies on Stroop effect have shown that there are differences in ERP components and consistency under the condition of inconsistency between the content of prompt and the content of stimulus [13]. In this experiment, when two different cues of fixation point and prompt appeared in front of the stimulus picture, the induced ERP components and waveform amplitude were different. This will not only improve the accuracy of the detection, but also help to add new elements to the EEG lie detection database, and provide theoretical basis for the practical application of ERP lie detection.

2. Method

2.1 The participants

The subjects were 35 college students, 19 males and 16 females, with an average age of 21.7 years, SD=1.27. They volunteered to participate in the ERP experiment. All subjects were physically and mentally healthy, had no history of brain injury, had normal vision or corrected vision, and were right-handed.1 group of non-conformance was excluded without analysis. Finally, there were 34 groups of valid subjects, including 19 males and 15 females.

2.2 Experimental Materials

Mainly use pictures as experimental materials. Stimulus pictures fall into three categories: strange pictures, familiar pictures, and self-related pictures. The whole stimulation sequence is divided into two groups: honest response group and deceptive reaction group. Each group contained 6 types of stimuli. Each type of stimulus contained 8 familiar images, 1 unfamiliar image and 1 self-related image. There were a total of 60 stimulus images in the 6 types of stimuli. Add a fixation point (+) and a prompt (your honest answer) to each picture, and each group will form a total of 360 stimuli. Finally, the processed image is cross-bound with two prompts, and the 360 stimulus image sequences are completely randomized.

The experiment used a mixed experiment design of 3 (stimulus type) × 2 (reaction mode) × 2 (prompt clue). The types of stimuli include strange pictures, familiar pictures, and self-related pictures; the response methods include honest response and deceptive response; prompt cues include prompting words and fixation points. In the arrangement of the stimulus sequence, the GO/NOGO paradigm is adopted, and the total amount of the three types of stimulus, namely, unfamiliar stimulus, familiar stimulus and self-related stimulus, is equal, thus offsetting the interference of the probability of the stimulus's presentation.

2.3 Experimental Procedure

Before the experiment, the subjects should be explained about the purpose, duration and harmlessness of the experiment, which may have a negative impact on the experiment. After the instrument is connected, the subjects should do exercises first, and the formal experiment can be started after they understand the requirements of the experiment and can be skilled in operation.

Experiment, using computer rendering image, to form a black background, horizontal Angle is 0.84 ° ~ 4.72 °, the vertical Angle is 0.52 ° ~ 3.40 °.The stimulus is presented as follows: first, the cue cue is presented in the center of the screen: fixation point "+" or the prompt "you answer honestly", followed by the picture stimulus, in which the fixation point is presented for 1500ms and the prompt for 2500ms.The function of cues is to prompt the subjects to focus on the coming stimulus picture and get ready to respond according to the instruction. Subsequently, the subjects were asked to make a judgment of "seen/not seen" as soon as possible, and to make a corresponding mouse button reaction according to the "whether" position in the image.

After the experiment, in a timely manner will be recorded EEG data and behavior data marking the preserved in case of loss, offline analysis is the EEG data are the basic steps of preliminary treatment, the merge behavior data, remove Eye-electric, electrical section, baseline correction, removal of artifact, after superposition average, according to the relationship between the distribution and scalp electrode, on the basis of previous work has chosen a few representative electrode, calculation of ERP data amplitude and latent period, its entry in the SPSS statistical software for statistical analysis, statistical analysis for different tip clues. According to the observation of the total average graph and relevant research literature, the time history of the difference in the experimental graph was comprehensively analyzed, and each time period was combined to better illustrate the experimental effect.

3. Results

3.1 ERP Comparison of Fixation points and Prompt Cues in Honesty and Deception Response under Unfamiliar Picture Stimulation

The incubation period and amplitude of ERP components induced by two different cues of prompting words and fixation points were shown in table 1 and 2 when the two responses of honesty and deception were implemented under the stimulus of unfamiliar pictures.

Table 1: Comparison of latency (ms) and amplitude (μV) of 400ms~550ms waves induced by two kinds of cues under honest - strange stimulus condition

Electrode	Fixation points（Z）	Prompts（T）	Difference（T-Z）
	Incubation period Amplitude	Incubation period Amplitude	Incubation period Amplitude
F3	502 -4.58	512 -4.30	10 0.28
F4	500 -4.98	482 -3.76	-18 1.22
C3	521 -3.21	521 -3.11	0 0.1
C4	577 -2.33	522 -1.51	-55 0.82
FC3	502 -4.75	515 -4.54	13 0.21
FC4	496 -3.82	480 -3.31	-16 0.51

Note: * difference = result of prompts-result of fixation points

Table 2: comparison of latency (ms) and amplitude (μV) of 400ms~550ms waves induced by two kinds of cue under the condition of spoofing and unfamiliar stimulus

Electrode	Fixation points（Z）	Prompts（T）	Difference（T-Z）
	Incubation period Amplitude	Incubation period Amplitude	Incubation period Amplitude
F3	496 -4.88	521 -4.62	25 0.26
F4	487 -6.54	509 -6.40	22 0.14
C3	489 -2.54	514 -2.35	25 0.19
C4	561 -2.65	527 -2.43	-34 0.22
FC3	491 -4.85	518 -4.51	27 0.34
FC4	482 -4.97	522 -4.92	40 0.05

Note: * difference =result of prompts-result of fixation points

As can be seen from Table 1 and Table 2, in terms of the incubation period, the incubation period of the prompt language under honest reaction is generally short, while the incubation period of the prompt language under cheating reaction is generally long. The T-test results of independent samples show no significant difference.The amplitude change can be analyzed from two aspects: (1) from different cues, the changes of honest response and cheating response are consistent:The amplitude of the prompts is generally smaller than that of the fixation point, that is, it is more skewed than that of the fixation points.For the dependent variable of the amplitude of the unfamiliar stimulus, the two-factor anova showed that the main effect of fixation points and the prompt was significantly different on the electrode (F3, F4, FC3, FC4, C3 and C4). The values of F（1，52）were:12.238,P=.001;26.376,P =.000;20.560,P =.000;15.744,P =.000;8.526,P =.005;22.954,P =.000.The analysis shows that the amplitude of the prompts is less than the amplitude of the fixation point in the 400ms~550ms time interval and the difference is significant. (2) From the point of view of the electrode, the amplitude of the two electrodes of C3 and C4 is small, whether it is under honest conditions or deceptive conditions.

The corresponding ERP feature maps are shown in Fig.1 and Fig.2.

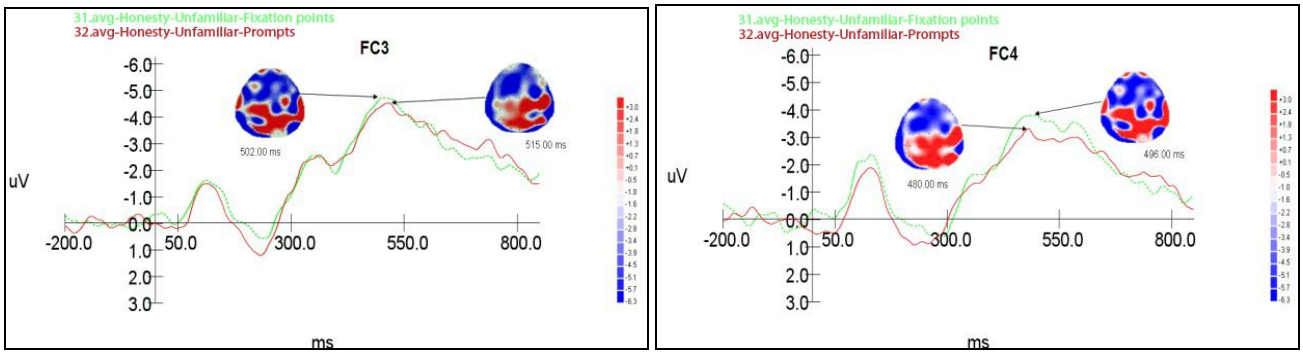

Fig 1: ERP waveform induced by fixation points and prompts under the condition of honest - unfamiliar pictures

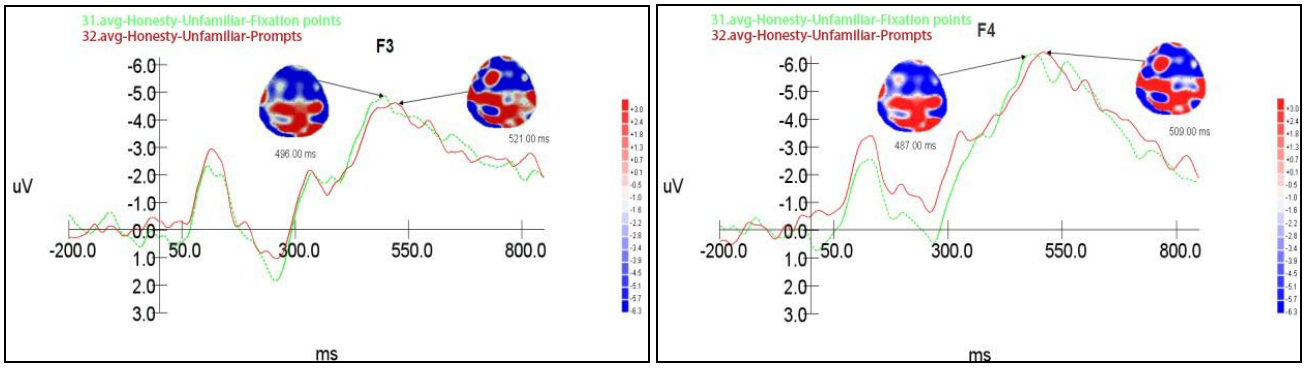

Fig 2: ERP waveform induced by fixation points and prompts under the condition of spoofing - unfamiliar images

As shown in Fig.1 and Fig.2, there was no significant difference between the two cues in terms of the latency period between 400ms and 550ms, but the amplitude of the prompt was generally smaller than that of the fixation point. This is consistent with the analysis in Tables 3.4 and 5.6.

3.2 ERP Comparison of Fixation points and Prompt Cues in Honesty and Deception Response under Familiar Picture Stimulation

The incubation period and amplitude of ERP components induced by two different cues of prompting words and

fixation points were shown in table 3 and 4 when the two responses of honesty and deception were implemented under the stimulus of familiar pictures.

Table 3: comparison of latency (ms) and amplitude (μV) of the 400ms~550ms waves induced by the two cue cues under the condition of honesty – familiarity

Electrode	Fixation points（Z）		Prompts（T）		Difference（T-Z）	
	Incubation period	Amplitude	Incubation period	Amplitude	Incubation period	Amplitude
F3	577	-4.44	512	-3.15	-65	1.29
F4	591	-4.61	509	-3.78	-82	0.83
C3	514	-3.28	548	-2.91	34	0.37
C4	564	-1.64	548	-1.44	-16	0.20
FC3	521	-4.90	502	-3.85	-19	1.05
FC4	564	-3.91	512	-3.65	-52	0.26

Note: * difference =result of prompts-result of fixation points

Table 4: comparison of latency (ms) and amplitude (μV) of 400ms~550ms waves induced by the two cue cues under the condition of deception -- familiar stimulus

Electrode	Fixation points（Z）		Prompts（T）		Difference（T-Z）	
	Incubation period	Amplitude	Incubation period	Amplitude	Incubation period	Amplitude
F3	512	-4.43	494	-2.62	-18	1.81
F4	515	-4.60	494	-3.70	-21	0.9
C3	507	-2.33	502	-1.92	-5	0.41
C4	591	-2.02	604	-1.84	13	0.18
FC3	507	-4.71	491	-3.81	-16	0.90
FC4	512	-4.14	494	-4.28	-18	-0.14

Note: * difference =result of prompts-result of fixation points

As can be seen from Table 3 and 4, in terms of the incubation period, the incubation period of prompts under the honest and cheating reaction conditions is generally short, and the statistical test results show that there is no significant difference between the two. The variation of the amplitude :(1) according to different cues, the amplitude of the prompt is smaller than that of the fixation point under both honest and deceptive response conditions. The variation of the amplitude: (1) From the different cue cues, the volatility of the cues is smaller than the fixation point volatility regardless of the honest or deceptive response conditions. For the dependent variable of familiar stimulus, two-factor anova showed that the main effect of fixation point and prompt language was different on the electrode (F3, F4, FC3, FC4, C3 and C4), and the difference was significant, the F（1，52） values of are respectively: 55.868, P=.000; 12.020,P =.001;71.777,P=.000;6.994,P =.011;11.976, P =.001;9.699, P =.003. The analysis shows that the amplitude of the prompts is less than the amplitude of the fixation point in the 400ms~550ms time interval and the difference is significant. (2) From the point of view of the electrode, the amplitude of the two electrodes of C3 and C4 is small, whether it is under honest conditions or deceptive conditions.

The ERP function diagram is shown in Fig.3 and Fig 4.

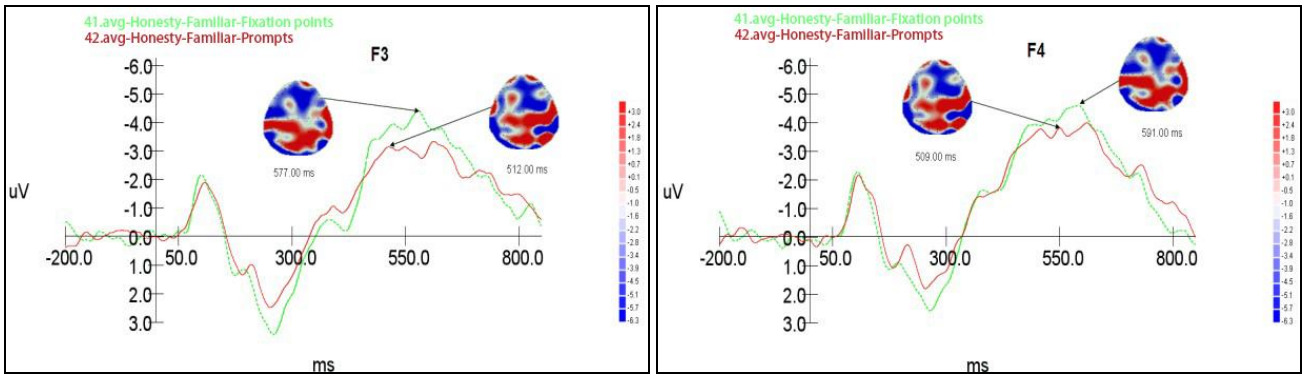

Fig 3: Honest - familiar with ERP waveform induced by fixation point and prompt under picture condition

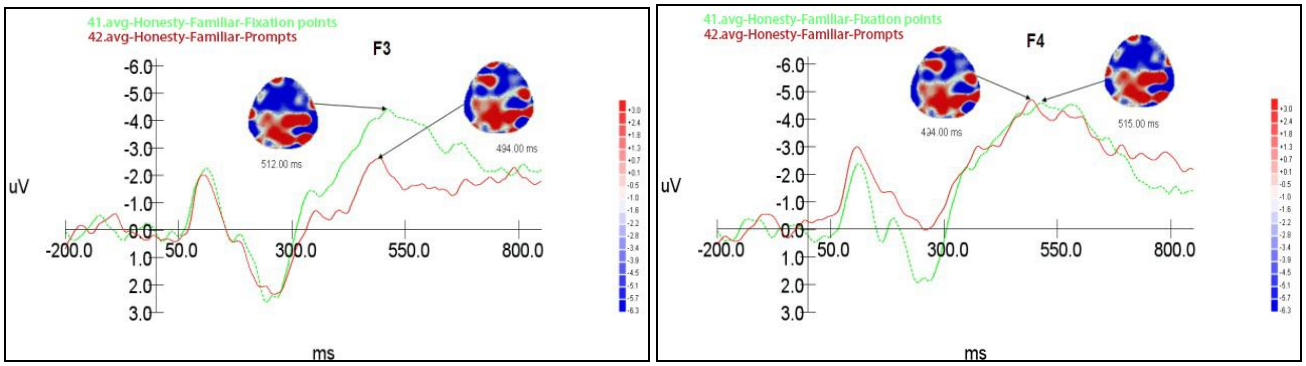

Fig 4: Deception - familiar with picture conditions, fixation points and prompts evoked ERP waveform

As can be seen from Fig.3 and Fig.4, from the incubation period of 400ms~550ms waves, the prompt is slightly shorter than the fixation point, but there is no significant difference between them. The amplitude of the cue is smaller than that of the fixation point.

3.3 ERP Comparison of Fixation points and Prompt Cues in Honesty and Deception Response under Self-related Picture Stimulation

The incubation period and amplitude of ERP components induced by two different cues of prompting words and fixation points were shown in table 3 and 4 when the two responses of honesty and deception were implemented under the stimulus of Self-related Picture.

Table 5: Comparison of latency (ms) and amplitude (μV) of 400ms~550ms waves induced by two kinds of cues under the condition of honest - self - correlation stimulus

Electrode	Fixation points（Z）		Prompts（T）		Difference（T-Z）	
	Incubation period	Amplitude	Incubation period	Amplitude	Incubation period	Amplitude
F3	564	-4.08	539	-2.97	-25	1.11
F4	584	-5.29	539	-3.69	-45	1.60
C3	539	-3.53	530	-2.59	-9	0.94
C4	576	-2.91	522	-1.27	-54	1.64
FC3	577	-4.58	541	-3.74	-36	0.84
FC4	579	-4.73	539	-3.09	-40	1.64

Note: * difference =result of prompts-result of fixation points

Table 6: Comparison of latency (ms) and amplitude (V) of 400ms~550ms waves induced by the two cue cues under the condition of cheating-autocorrelation stimulation

Electrode	Fixation points（Z）		Prompts（T）		Difference（T-Z）	
	Incubation period	Amplitude	Incubation period	Amplitude	Incubation period	Amplitude
F3	487	-4.28	485	-2.60	-2	1.68
F4	532	-4.89	494	-4.23	-38	0.66
C3	489	-2.40	482	-1.85	-7	0.55
C4	561	-2.37	535	-1.96	-26	0.41
FC3	487	-4.33	482	-3.27	-5	1.06
FC4	534	-4.45	537	-3.63	3	0.82

Note: * difference =result of prompts-result of fixation points

As can be seen from Table 5 and 6, in terms of the incubation period, the incubation period of prompt language in the honest and cheating response is relatively short, and the statistical test results show that there is no significant difference between the two. 1) From the different cue cues, the volatility of the prompt is smaller than the fixation amplitude, whether it is an honest response or a deceptive response. For the dependent variable of familiar stimulus, two-factor anova showed that the main effect of fixation point and prompt language was different on the electrode (F3, F4, FC3, FC4, C3 and C4), and the difference was significant. The values of F (1,52) are respectively: 55.868, P=.000; 12.020, P=.001;71.777, P=.000;6.994, P =.011; 11.976,P =.001;9.699, P =.003.As in the two cases above, the amplitude of the cue is smaller than that of the fixation point and the difference is significant.2) from the perspective of the electrode, no matter under the condition of honesty or deception, the amplitude of C3 and C4 electrode points is small.

The corresponding ERP characteristic maps are shown in Fig.5 and Fig.6.

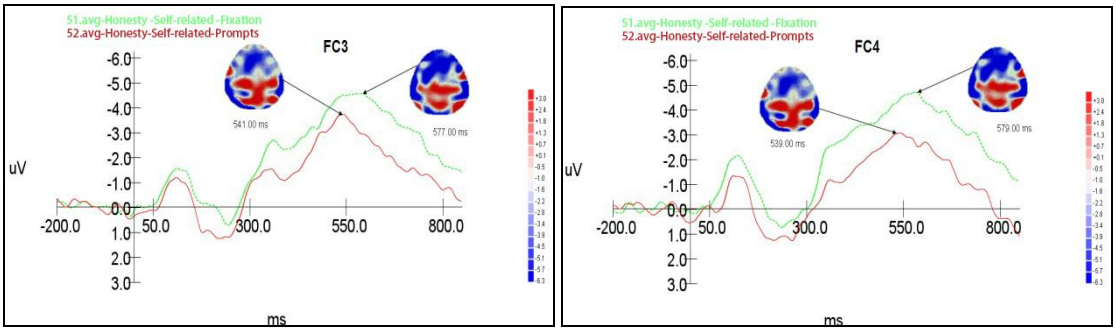

Fig 5: ERP waveform induced by fixation point and prompt under the condition of honesty - self - correlation picture

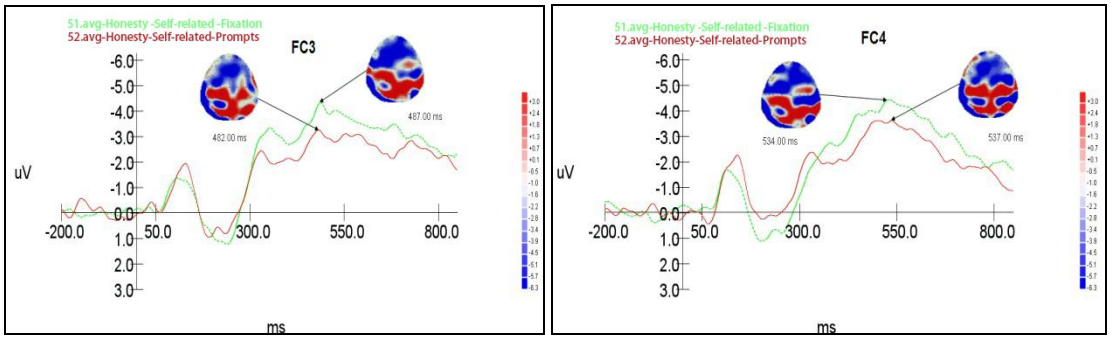

Fig 6: ERP waveform induced by fixation point and prompt under the condition of self-related pictures

The results in Fig.5 and Fig.6 are the same as those in the two cases above, that is, when comparing the incubation period of 400ms~550ms waves, the prompt is slightly shorter than that of the fixation point in general, but there is no significant difference, and the amplitude of the prompt is smaller than that of the fixation point in general.

Based on the experimental results in three different cases, it can be found that different electrode points have different characteristics and differences when describing different reactions under specific conditions, and the amplitude of the prompt in the reaction time window from 400ms to 550ms is generally smaller than that of the fixation point.

Conclusion

The aim of this study was to investigate how different cue cues would affect the response time and changes in brain potential of the subjects under the same response pattern and the same type of stimulus.

Within the time range of 400ms~550ms after the stimulus is presented, the fixation point amplitude is larger than the prompt volatility under both honest and deceptive conditions. The execution control process plays an important role in the deceptive response of the participants to the contradiction of objective facts. Because this process can resolve the conflict between various reaction tendencies, suppress the potential honest reaction tendency, select and execute cheating reaction. Ray Johnson *et al*.'s research shows that individuals need to invest more psychological resources in completing strategic monitoring tasks than the response monitoring process in the stimulus chain involved in the consistency deception reaction process. The task is more difficult and requires more [5]. When the subject spoofed the stimulating picture that he did not know, the prompt and the subsequent picture stimuli showed a difference in cognitive psychology selection, the prompt required honest answer, and the picture stimuli required negative answer [14]. This cognitive psychological conflict also leads to the excessive distribution of cognitive resources, which is reflected in the map is that the cues are less cues when the prompts are used as prompt clues [15].

In essence, the executive control process of cheating response has a general purpose, which aims to minimize the influence of honest reaction tendency. The results of behavioral data and ERP data of ensuring the successful implementation of the deceptive response. Ray Johnson *et al*., both indicate that the deceptive response should be completed in different tasks. Individuals first suppress the tendency of honest reaction and then perform the deceptive reaction. This process requires more attention resources, involving other psychological processes. The deceptive response process involves multiple tasks with a relatively honest response process. In the case of multiple tasks, the execution control process also coordinates and flexibly allocates cognitive resources [16]. When the hint clues and the stimulus pictures are sequentially presented, the subjects will make more efforts to overcome the inner reaction conflicts. This process will occupy a large amount of psychological cognitive resources, which is reflected in the ERP. On the map, the amplitude of the prompt is smaller than the amplitude of the fixation point. It is further verified that the results of Gevins *et al*. are the same as those of strange and familiar picture stimuli. The response of self-relevant image stimuli under the prompts and fixation points also shows that the volatility of the cues is smaller than the fixation amplitude [17]. This explains to a large extent that no matter which level of familiarity the picture stimulus responds to, the use of prompts as a clue can increase the difficulty of the respondents to a greater extent, taking up more psychological cognitive resources [18].

In summary, under the deception condition, for three different familiarity picture stimuli, the ERP volatility induced by the Prompts as the cueing cues is smaller than

the ERP volatility induced by the gazing point as the cueing cues. With the prompting as a clue, when the subject is deceiving, it will be more difficult to suppress the potential honest response tendency and select and execute the deceptive reaction process, and consume more psychological cognitive resources, reflected in the ERP map. The average amplitude of the ERP induced by the prompt is reduced. It can be considered that ERP experiments with prompts as hints can more effectively identify suspects. Test the results of the study.

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