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A Research on Goal-Guiding Method of Initiative Individuals in Safety Production Management Based on ERPs Experiment

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Abstract: At present, human factor is considered as the most important reason of safety production. In this research, we study the targeting guidance of initiative individuals in the process of safety production management. Aiming at initiative individual, it takes personality types in psychological category as reference, supported by Cognitive Neuroscience Theory. We took the "prime-probe" experimental paradigm to present stimulation pictures in order to make the participants to respond. In the paradigm, the priming stimuli were safety production signs and the targeting stimuli were different goal-directed words. In Experiment 1, the participants were asked to respond to the words guiding positive goals or negative goals as soon as possible, in order to confirm whether the method can guide them to strictly obey the safety production sign, "Yes" or "No". In Experiment 2, the participants were asked to confirm if the goal-guiding words are explicit or obscure and whether the words can make them observe the signs strictly, "Yes" or "No". We use ERPs to measure the EEG (electroencephalogram) factor P300 and N270 of the participants. The analysis of the experiments shows that in safety production management, initiative individuals prefer positive guiding goals because the positive stimuli induce higher P300 than the negative stimuli. They are inclined to explicit goal guidance by showing stronger endogenous conflict between obscure guidance and initiative individuals that induces more significant N270. The finding shows that positive and explicit goal guidance will cause better effect in safety production management.

Keywords: ERPs experiment, initiative individuals, goal-guiding, safety production management, safety behavior

1 Introduction

With the failure rate of mechanical system decreases continually, human factor has become a main cause leading to accidents. Many causes of safety problems are attributed to the companies prefer shot-term benefit to safety interest, the safety facilities are not standardized and the relevant laws are not distempered, etc. Researching people's behaviors is conductive to solving the safety production problems much better. People's behaviors will be influenced by psychological factors, physiological factors and environment factors. A person's psychological and behaviors are interdependent and influence each other. The explicit behaviors are dominated by implicit psychological activities, and the implicit physiological activities get development through the explicit behaviors. From the perspective of the relationship between the psychological activities and behaviors, this study explored the mechanisms of Goal-Guiding Method of Initiative Individuals in Safety Production Management.

Because personality characteristics are formed in social environment, and it is not easy to change, safety production management is believed to be an effective way to take relevant managing methods on employees with different personalities. Positive personality is a stable tendency influencing surroundings when an individual taking initiative behavior [1]. And the influence is interactive that individuals and the environment impact each other. Environment influences the behavior decision of individuals and individuals can change the environment through their behavior. Positive individuals are restricted less than negative individuals by the environment [2]. The former are more intended to accept and effect the environment [2]. The research shows that personality can significantly influence people's behavior that workers with different personalities experienced different incidents [3-4]. Jones et al indicated in previous researches that "safety controlling genes" could influence people's perception, namely people with internal "safety controlling genes" believed they could change the surroundings and they are more intended to take necessary safety preventive measures; however, people with external "safety controlling genes" are vulnerable to environmental repression and generally they would not take enough preventive measures [5]. Personality and worker's accident are closely relevant in

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the researches of relation between five personality dimensions and work accident [6].

A goal can lead people's attention and effort to relevant things and abandon irrelevant things; the function exists in cognition and behavior as well. As driving force, a goal can stimulate worker's behavior. Goal setting theory regards "goal" as a kind of stimulation [7]. A goal can induce people to transfer their demands into motivation, so that people make efforts towards the right direction and correct their deviation into the targeting track to achieve their goals [8]. In terms of cross culture, task, individual and context, individuals were found that they tended to choose specific and challenging goals under highly acceptable circumstance and with timely feedback [8]. Highly self-respect individuals are inclined to choose highly challenging goals [9]. Internal-controlled individuals believe that the level of effort has positive correlation with the difficulty of the goals [10]. Researches show that the influence of goals placed on human behavior performs in four aspects: goal guidance enables workers to lay their attention on the direction of their goals rather than non-targeting directions; the level of goal setting has positive ratio with their efforts; goals influence the persistence of behavior; goals can influence individual behavior by virtue of media such as awakening, discovering, targeting task and strategy [11]. Like demanding and motivation, goals place regulating function on human behavior, guiding people's behavior decision. Behavior is an interactive result of internal demanding and external environment, however, goals not only corrects direction but also provide guidance for people. A goal is psychologically called incentives that can stimulate motivation. Next, motivation generates behavior. The process in which the goal is achieved is called inspiration process. In the field of safety production management, managers are able to stimulate their workers' motivation, arouse their initiative and guide their safety production behavior by effective management means, distinguishing goals guiding individual to realize the targeting safety production management. Based on the classification of safety production management measures, the patterns can be divided into directing-type mode regulating and guiding workers by positive factors, constraining-type mode punishing and monitoring them by negative factors and regulating-type safety production mode regulating them by neutral factors. In the directing-type safety production management, people are regarded as the most important resource and object [12].

People's unsafe behavior is mainly related to information processing [13]. Reason believes that people's unsafe behavior can be explained from behavior level, relation level and concept level. From concept level, he got 3 basic unsafe behaviors; miss, negligence and fault [14]. Therefore, through classification, Reason provided a universal pattern system (GEMS Generic Error-Modeling System) that explained the underlying reason of people's unsafe behavior by linking different types of unsafe behavior and different phases of their cognitive activities [14]. When researching individual characteristic and sensibility of rewards and punishment, Gray indicated that extroverts were highly connected with sensibility of rewards and punishment, namely they are more sensible to positive goal-guiding [15]. Most of the researches and application of cognitive neuron experiment used explicit target currency as stimulus. However, practically, workers also have obscure goals. The obscure goals can be used also as stimulus of cognitive neuron experiments so as to guide workers' behavior. In real work, non-monetary guiding is another effective method, although most experiments use money as positive or negative guiding stimulus. Van den Berg et al（2011） monitored brain wave of the participants in monetary guided safety behavior to judge the sensibility difference of different people under positive and negative direction guidance [16]. Their result shows that the participants with high scores (positive individuals) are more sensible to their gains [16]. Roth Kopf and Billing ton indicated that in their research, specific learning objectives always enabled students to concentrate on goal-related content rather than those irrelevant [17]. If an organization wants to realize safety production management, it should set different goals based on their workers' different needs and guide their direction through the goals as well as correct their unsafe behavior.

In safety production management activities, people's reaction is a decision process going through receiving information, information processing and reaction and execution [18]. The information processing of Cognitive Psychology has four stages: noticing, understanding, evaluation and motivation. Initiative individual is goal guided and active. They are good at receiving and changing situational factor. Compared with non-active individuals, analyzing process of noticing resources of this kind of individuals are more significant. Their behavior reaction mechanism is different. P300 is a forward EEG component whose wave amplitude is around 300ms after its main components receiving target stimulation. It is the most important component of Evoked Potential (EP), reflecting participants' cognitive function such as attention, detection, perception, information processing, reaction capability, evaluation, classification and memory etc [19]. The amplitude of P300 reflects the amount of the participants' attentive resource allocated into the external stimuli. The higher the amplitude is, the more attentive the participant is to the external stimuli. The higher the stimulus intensity was and the longer the interval was, the greater the amplitude of P300 was [20-21]. However, little change happens in latency period [20-21]. Wu Yan and Luo Yuejia (2011) stated in the research of result evaluation of altruistic punishment that the P300 amplitude of initiative individual was higher than non-initiative individual when they saw other people being awarded [22]. It means that high-initiative individual has greater anticipation for awards. High-initiative individual shows negative behavior when there is no award or the rewarding

mechanism is unfair [22]. N270 is a kind of negative brain wave whose latency is 270ms, reflecting information conflict recognition of the brain. It presents the conflict processing function of wave matching and it reflects the understanding and evaluation process of cognition. In prime-probe experimental paradigm, when the prime stimulus and target stimulus does not match, namely the target stimulus does not fit the internal information, the N270 EEG component will be induced [23]. As a negative EEG component to match conflict processing waves, it lays emphasis on the matching and judgment to conflict so as to reflect people's understanding and evaluation process of their cognition. In goal-guiding mechanism of safety production management, we need to verify the matching of goal-guiding object and guiding method, and matching status of goal-guiding intensity and the object so that the N270 EEG component becomes important to verify this matching relation. In addition, the N270 negative wave is difficult to be influenced by stimulus probability, but fixed time interval should be ensured. Therefore, whatever the types of stimulus materials and the correlation of work task are, the N270 will be still induced and the latency periods have less difference.

In conclusion, because people's safety behavior reflects the decision of information receiving and information processing, goal-guiding deviation reflects people's attention preference and goal-guiding method reflects people's subjective evaluation process, we designed the attention preference experiment of goal-guiding direction and the ERPs experiment of goal-guiding method signal. It reveals the generation mechanism of high-initiative individual's safety production behavior. Studied the theories and practices before, the experimental hypotheses of this paper are provided:

Hypothesis H1: The preference values of initiative individuals are different, showing different P300. The positive goal-guiding stimuli generate higher P300 waves than negative goal-guiding stimuli.

Hypothesis H2: The difference of initiative individuals' subjective evaluation to goal-guiding method stimuli, showing different N270. The N270 wave amplitude values of explicit goal-guiding stimuli and obscure goal-guiding stimuli are significantly different.

2 Methodology

Because the brain wave in ERPs is not influenced by sex and education background, we use undergraduates to replace workers as participants. They are representative as well [24]. Based on related literatures, we needed to use BIS-BAS scale questionnaire to screen the subjects and select initiative individuals to be the participants of our experiments [24]. Eventually in 36 students we choose these 18 persons as participants who are all students come from Harbin engineering university. All the 18 students (10 male) are healthy person aged between 19 and 25. All participants did not use any sedative or psychoactive substances within 24 hours before the experiment. They had normal eyesight or normal corrected vision, and no color blindness and no mental or psychological illness. Each participant voluntarily signed informed consent form. The data tested are all valid. The participants were paid after the experiment.

The whole experiment was in a room with favorable light and good sound isolation. The participants were asked to sit comfortable about 1m away from the screen and press button according to the signs appearing on the screen [25]. The stimulus materials were presented as pictures or words with 200×150 pixels and 2.58° × 2.4° visual angle. According to the 64 channel Ag/Cl electrode cap of the International 10-20 System, we collected the participants'' consecutive EEG data. During the experiment, the resistance between electrode and skin were under 5 $k\Omega$ all the time. The EEG data was collected by DC collection with 0.1-100Hz tape pass-filter frequency and 500Hz sampling frequency. In addition, we used nasal tip as reference electrode and placed a horizontal electrooculogram (EOG) electrode 1cm from on the outside part of each eyes, vertical EOG electrodes on the upside and down side of the left eye and an electrode at the mastoid process behind the left and right ear. The experimental stimuli were presented by E-prime software and simultaneously EEG and behavior data, including reaction time and button-pressing values were recorded by the Scan4.5 software. After the recording, we conducted integration and disposal, integrating the behavior data recorded by the E-prime software into the EEG data recorded by Scan4.5 so that the final EEG data includes behavior data.

The Experiment 1 was mainly designed to verify the hypothesis H1, namely an attention preference experiment for goal-guiding direction signal of safety production management.

Noticing is the first phase that cerebral neurons information processes external stimulus signals. Only if the external stimulus signal is noticed, people would start the next phase of explanation and evaluation and then go to the phase 3 "reaction and execution". The more the external stimulus signal catches people's attention, the more people will present relevant observing behavior. Therefore, the Experiment 1 uses "prime-probe" paradigm to testify the H1. Because the directional guidance can guide people's behavior towards a given goal, the attentive resources of individuals are distributed to goal-related objects in order to realize the goal-related performance. In safety production management, individuals pursue different goals and their cognition is different. When facing the same task, given positive and negative goal guidance respectively, namely given rewarding or punishing stimulus guidance, their distribution of attentive resources will be different as well as their cognitive behavior performance. The stimulus materials of Experiment 1 were in the form of

pictures or words, specifically: prime stimulus (S11) was safety production signs, target stimulus (S12) were words of positive and negative goal-guiding direction words (rewarding and punishing words) [26]. Primarily, we presented safety production signs (1.7cm width×1.0 height) in the middle of the computer screens. The words were black and time of durance was 2000ms. Then, the screen showed goal stimuli representing different goal-guiding direction words with black color and white background. The time of durance was 500ms. And the participants had 1500ms to carry out a button-pressing task that asked the participants to react to the stimuli of positive and negative goal-guiding direction words rapidly, in order to verify if the method could guide them to strictly observe the safety production instructions， if “Yes” press 1, “No” press 2, as in Fig.1.

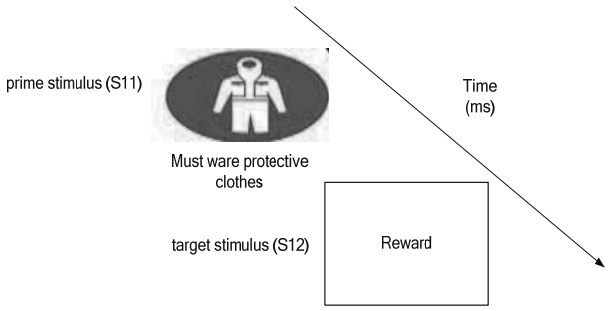

Fig.1 Experiment 1 procedure diagram.

The Experiment 2 was mainly designed to verify the hypothesis H2, namely a signal experiment for goal-guiding method of safety production management.

The information processing of the brain neuron to external stimuli enters the second phase “understanding and evaluation” after the first stage “attention”. Because people have different individual cognitive features, the difference of internal information decided different criteria of their understanding and reaction. The experiment focuses on exploring high-initiative individual’s subjective evaluation to different goal-guiding methods and explaining the problem. It can be divided into explicit goal and obscure goal. Explicit goal refers to measurable and quantifiable goals and obscure goal refers to immeasurable and unquantifiable goals [27]. In safety production management, goal-guiding method stimuli can be divided into explicit goal guidance and obscure goal guidance based on the experiment object in order to verify the individuals’ understanding and evaluation to different goal-guiding methods.

The stimulus materials of Experiment 2 were in the form of pictures or words, specifically: prime stimulus (S21) was safety production signs, target stimulus (S22) were words of clear (such as: Reward one hundred) and obscure (such as: Reward a certain amount) goal-guiding direction words [28-30]. Primarily, we presented safety production signs (1.7cm width×1.0 height) in the middle of the computer screens. The words were black and time of durance was 2000ms. Then, the screen showed goal stimuli representing different goal-guiding method words with black color and white background. The time of durance was 500ms. And the participants had 1500ms to carry out a button-pressing task that asked the participants to react to the stimuli of clear and obscure goal-guiding method words rapidly, in order to verify if the method could guide them to strictly observe the safety production instructions， if “Yes” press 1, “No” press 2, as in Fig.2.

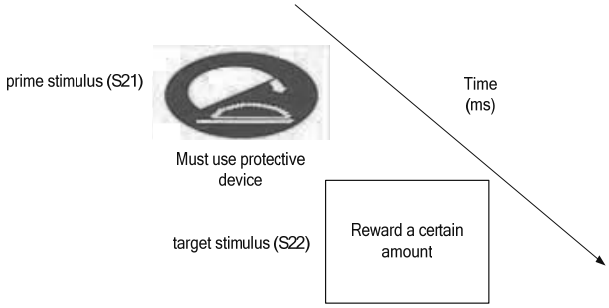

Fig.2 Experiment 2 procedure diagram.

3 Result

In the experiment, we used Scan4.5 software to record EEG data. After the experiment, we output the EEG data to conduct offline disposition. We mainly used repeated measurement of variance to dispose and analyze the button-pressing accuracy of the participants’ different reaction and their reaction time values.

Specific computer data processing includes computer data browsing and removal of floating or unclear data because some EEG data may be not accurate due to the movement of participants’ heads (Reject block). Eliminate the EEG wave may fluctuate after eye blinking (Ocular artifact reduction). The analysis time-histories were 100ms before and 400ms after stimulation (Epoch file). The brain wave 100 ms before was taken as the baseline value to rectify the EEG baseline (Baseline correct). The amplitude was chosen at ±100μV (Artifact rejection) to get the stimulus type of the experiment and the average overlay EEG segments of reaction type (average). The filtering parameter was set as 20Hz zero phase distortion low-pass filters (Filter).

The behavior data of Experiment 1 shows that the participants’ mean reaction time to positive goal guidance is less than the mean reaction time to negative goal guidance（827.25ms<835.34ms）. The goodness of fit between positive goal-guiding words and reacting value is bigger than the goodness of fit between negative goal-guiding words and reacting value, namely the accuracy of button pressing of positive goal-guiding method（89.37%>85.67%）. When capturing P300 component, we got the maximum amplitude of time

windows between 200ms-400ms. The nine electrode sites（C3，CZ，C4，CP3，CPZ，CP4，P3，PZ，P4）in the central top distributed as Fig.3. We used SPSS17.0 statistical analysis software to conduct repeated 2（positive goal guidance/negative goal-guiding words）×9（electrode sites） measured variance analysis on the maximum amplitude of P300 EEG component. Results show F(1，17)=3.024，P=0.046 < 0.05. We chose the EEG oscillogram of 3 relatively significant electrode sites, as shown in Fig.4, Fig.5 and Fig.6.

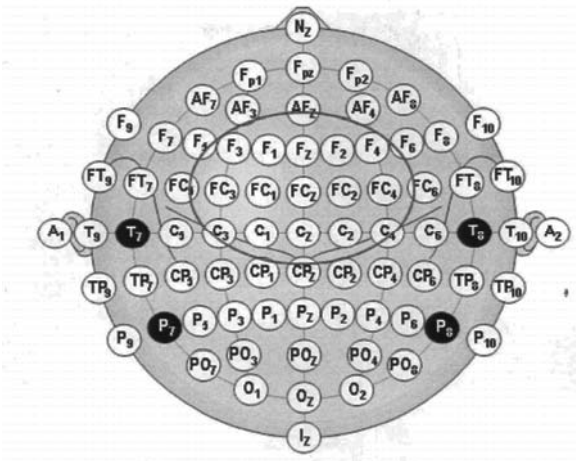

Fig.3 Brain electrode distribution picture

When capturing N270 component, we got the maximum amplitude of time windows between 240ms-330ms. The six electrode sites（F3、FZ、F4、FC3、FCZ、FC4）in the central top distributed as Figure 3. We used SPSS17.0 statistical analysis software to conduct repeated 2（clear goal guidance/obscure goal-guiding words）×6（electrode sites） measured variance analysis on the maximum amplitude of N270 EEG component. Results show F(1，17)=2.244，P=0.037 < 0.05. We chose the EEG oscillogram of 3 relatively significant electrode sites, as shown in Fig.7, Fig.8 and Fig.9.

4 Conclusion

The Experiment 1, namely the attention experiment of goal-guiding direction signals of safety production management, researches the attentive problem of high-initiative individual to guiding direction. The behavior data result shows that the mean reaction time of high-initiative individual to positive goal-guiding words is shorter than that of negative goal-guiding words. It means that positive goal-guiding direction can catch more attention of high-initiative individuals. The higher accuracy of positive-guidance button pressing indicates that positive guidance is more effective to the management of high-initiative individual. The P300 amplitude reflects that the attentive resources are allocated into more important stimuli and the magnification of wave amplitude manifests that the participants put more attentive resources to the stimuli. The EEG data shows that positive goal-guidance is paid more attention by high-initiative individuals and they put into more attentive resources. Therefore, the Hypothesis H1 has been validated by tests: The preference values of initiative individuals are different, showing different P300. The positive goal-guiding stimuli generate higher P300 waves than negative goal-guiding stimuli.

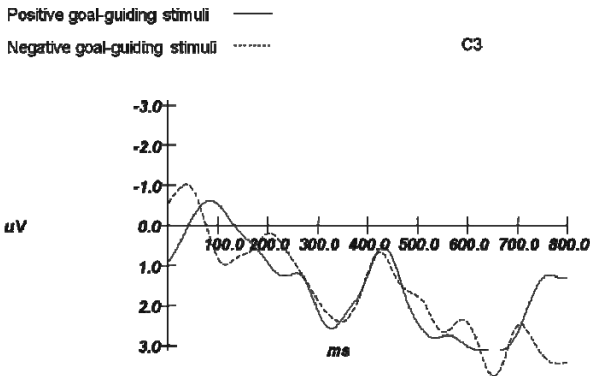

Fig.4 Electrode oscillogram of C3

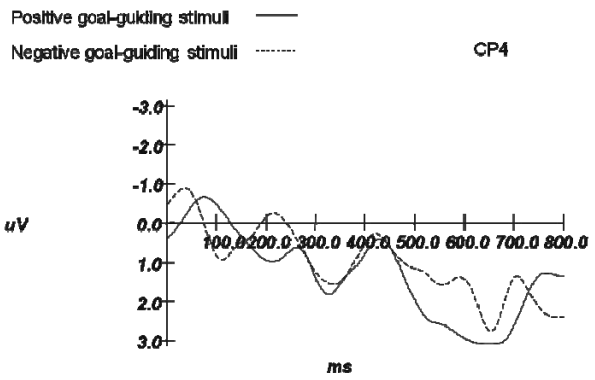

Fig.5 Electrode oscillogram of CP4

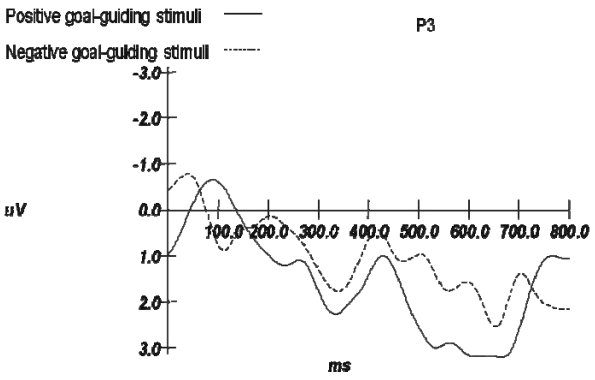

Fig.6 Electrode oscillogram of P3

The Experiment 2, namely the ERPs experiment of goal-guiding method of safety production management, researches the subjective evaluation and explanation problem of different goal-guiding method through stimulating different goal-guiding method to

high-initiative individuals. The EEG data shows that obscure guiding stimuli induced more significant N270. Compared to explicit goal-guiding stimuli, the conflict between obscure goal-guiding stimuli and internal information of high-initiative individual is higher. Consequently, it illustrates the cognitive results induced by explicit goal-guiding stimuli are more comply with the subjective evaluation and explanation of initiative individuals. Therefore, the Hypothesis H2 has been validated by tests: The difference of initiative individuals' subjective evaluation to goal-guiding method stimuli, showing different N270. The N270 wave amplitude values of explicit goal-guiding stimuli and obscure goal-guiding stimuli are significantly different.

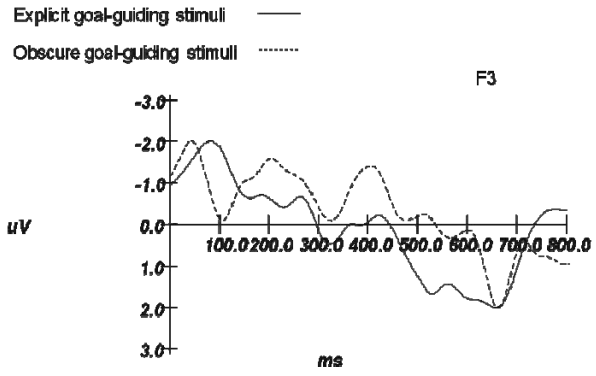

Fig.7 Electrode oscillogram of F3

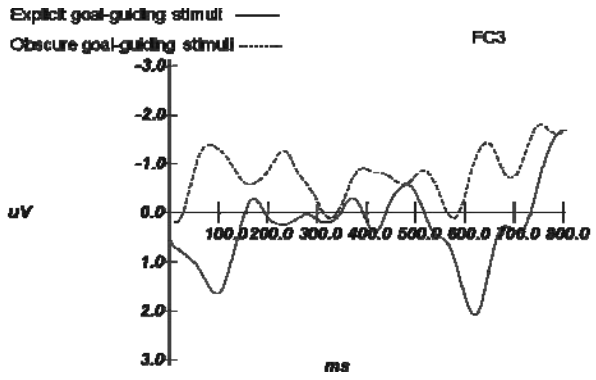

Fig.8 Electrode oscillogram of FC3

Through data analysis of the two experiments, the hypotheses are verified. At first, the preference values of initiative individuals are different, showing different P300. The positive goal-guiding stimuli generate higher P300 waves than negative goal-guiding stimuli; The second, The difference of initiative individuals' subjective evaluation to goal-guiding method stimuli, showing different N270. The N270 wave amplitude values of explicit goal-guiding stimuli and obscure goal-guiding stimuli are significantly different.

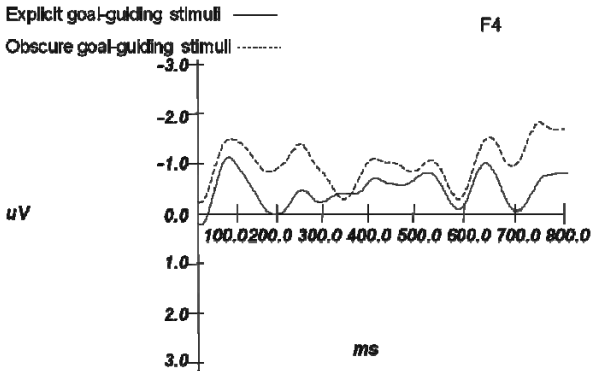

Fig.9 Electrode oscillogram of F4

Therefore, the cognitive neuron experiment reveals the cognitive characters of attentive preference and subjective evaluation of goal-guiding signals in the goal-guiding mechanism of safety production management. It explains the production mechanism of safety production behavior of initiative individual's safety production behavior so that the research hypotheses are verified. From the discussion of results, we can see that enterprises should conduct management in a guiding way by starting from considering the workers' type of initiative and complying with their cognitive principles so as to mobilize more initiative to standardize their own safety behavior. With technological improvement and input of advanced production equipments, more and more enterprises realize the simplex safety management can not satisfy diversified demanding of management. Targeted safety production management to different individuals has been a focusing tendency of future development. The enterprises must primarily consider the nature of the workers and let them feel they are valued and respected, if you want them to realize their important roles in the work and exert their initiative cognition.

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