Research of decisional behavior on miners' emergency response based on ERPs

Li Hongxia[1, a], Fan Yongbin[1, b] and Shi Lin[1]

[1]School of management, Xi'an University of Science and Technology, Xi'an 710054, China

[a]email: 406144519@qq.com, [b]email:416139865@qq.com

Keywords: ERPs, emergency, decision, EEG

Abstract. This study using the event related potential (ERP) experiment means, researches the coal mine production emergency scenario miners in emergency response electrical experiments, and designs experiment of miners' emergency information decision response. According to possible accidents and disasters in the coal mine emergency scenario, researches miners' risk perception and reaction process of emergency decision-making in sudden emergencies. Study shows that the different emergency information warning degree leads to different negative emotions degree. Negative emotions generate decision-making related electrical N2 negative elements, besides the higher warning degree, the greater amplitude. Results show that when the underground coal mine workers expose in emergencies, with the stimulus of the emergency information there is the emergency decision-making reaction which is associated with the conflict of decision level.

Introduction

According to the coal mine accident investigation and statistics, more than 80% of China's coal mine accidents are closely related to the miners' unsafe behavior. People's unsafe behavior reflects the level of individual emergency capability. To some extent, the level of emergency treatment with the coal mine emergency decides the degree of the damage to this emergency.

Many scholars have studied the level of individual emergency response by microcosmic physiological index. The scientific measure index of psychological and physiological indexes can reflect the level of emergency capability of commanding staff[1]. Further combined with computer technology, L.Yang[2] through the study found that the technology of internet can improve individual level of environmental perception to improve emergency operation capabilities. In order to evaluate actual emergency response capability of individual emergency, Lawson[3] established the emergency stimulation scene which the method is according the measure of emergency response and based on the ergonomics to predict individual emergency response capability.

This study uses the event related with potential technology (ERP).The physiological index data of relevant brain electric wave is measured by experiment to quantitatively measure the reaction mechanism of underground employees in emergency situations, and to analyze the miners' emergency mechanism under coal mine production emergency. Exploring and analyzing to the relationship between the physiological parameters of the miners' emergency response and the mental activity of emergency decision-making and behavior to judge the microscopic characteristics in the behind of the miners' behavior.

At present, ERP technology become an effective technique for the study of risk decision and advanced human brain function, which has the characteristics of the millisecond time resolution.

Multiple meanings and characteristics of brain nerve processing are represented by the same ERPs composition, which shows differences according to the experimental background. N2 is frequently used among numerous ERP negative components, whose crest is usually present 200ms-350ms after the stimulus.

Through some auditory and visual experiments, we found that the N2 component Induced was different with the different level of target stimulation, and the N2 latency and the location of the cortex would be changed with the change of target stimulus[4]. In the whole process of conscious processing, the larger negative stimulus will induce the larger amplitude of N2 compared to the

low-level[5].

In a word, this study attempts to provide a direct and scientific index for the brain electrophysiology of the decision making process and mechanism of emergency response in a sudden event, which is based on the time resolution of the event related potential. In particular, the ERP component, which is relatively sensitive to the conflict, is used to monitor the conflict level of the behavior decision making, and then help us to find the relationship between the decision conflict and the behavioral response based on it.

Experiment material and text methods

Experiment samples methods

16 students from the Xi'an University of Science And Technology participated in this experiment. The experimental subjects were male with the relevant professional learning experience or internship experience, and the average age was 24.67 years. Considering the coal mine as the research background, the miner as the research object, the selected subjects are all male. Subjects were all right handed, and had normal vision or corrected visual acuity.

Experimental materials

In this experiment, the stimulating materials are presented in the form of pictures of warning words of safety of coal mine. All the pictures of stimulating materials are unifiedly processed by the professional picture software Visio Microsoft 2007, remain the same parameters of picture quality, length-width ratio, contrast ratio, the background of display is black. The contents of the stimulating materials used 50 pounds of white Arial font, the stimulating materials were randomly presented. The presented sequence of experimental stimulus used software E-prime2.0.

Table1 verbal types of experimental stimulus

Emergency warning level	Category of safety sign	Content
High emergency warning level	Prohibition	Carry fireworks、Drunk into the well、Operation of open fire、Picking by tramcar、Climbing pull cable
	Warning	Gas gathering、Roof falling underground、Rib spalling、Fire、Water permeable
Low emergency warning level	Instruction	Without a lamp
	Prompt	Exit

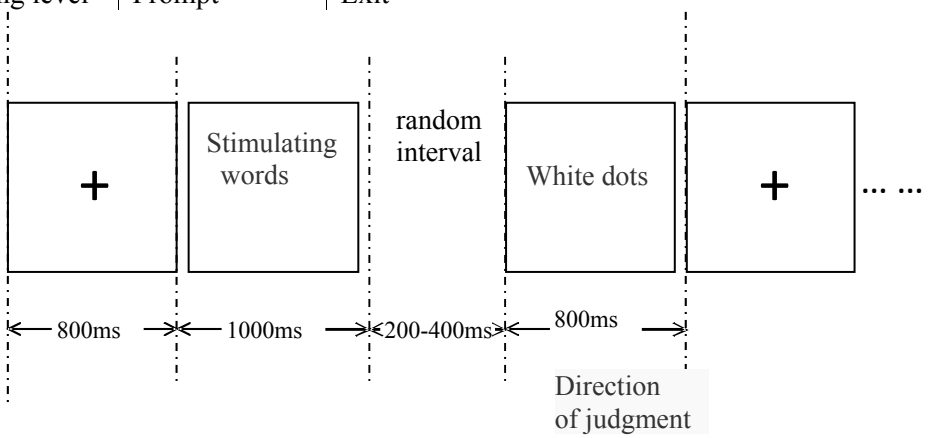

Figure 1 Single trial experimental paradigm of decision response experiment

Experimental design

The whole experiment consists of two parts, which are exercise experiment and formal experiment. At the beginning of the experiment, experimental instruction appeared, after being read seriously by subjects, we start the experiment. After the experiment, there will be a formal experimental jump interface. If the subjects have not yet understood the exercise experiment, continue to practice, if the subjects have understood the content of the experiment, then choose to

carry out a formal experiment. The experimental paradigm is shown in Figure 1, formal experiments are divided into 3 blocks, each block has 36 trials. All the experimental contents are presented by E-prime2.0 software.

Experiment Process

This experiment should be experimented in single testing. Experimenters need introduce tests the directions about the experiment and instrument before we conduct this experiment on them. Only if the tests understand the experiment process and sign the Informed Consent of Safety Management Experiment in Laboratory. The experimenter put the 64 Conducted Cap, on test. And the test is waiting for the finish of experiment preparation. Experimenter post the reference electrode well and inject the conductive paste into the test cap in order to get every electrode resistance down to less than 5K Omega.

Being in the formal experiment, the test should sit in a low-light situation and a suitable laboratory interval. The body should be apart from the screen in about 95cm. The test should finish this task and electroenephalogragh record synchronously the test EEG data. Before we formally start this experiment, we should do some practices first and when test understands the whole process, we start out the experiment. According to test's condition, test can decide to have a rest for 5 minutes after every testing stage. When finishing the experiment, the experimenter should remove the conducted cap and external electrode on the test.

Experiment Analysis and Record

The experiment record and analysis combines behavioral data and EEG data. On the behavioral data, we use E-prime 2.0 to automatically record the test's reaction time of adaptive choice and selection results. On the EEG data, we use NeurOne EEG/ERP-System EEG Data Recorder to record test's brain wave activity reacting to response and decision of the direction after the appearance of emergency information. We should eliminate the electric supply electromagnetic interference to insurance the accuracy of the data records.

Experimental results

Behavioral data results

To the participants in the experiment of information to determine whether it is right to determine the participants in the course of the experiment. In accordance with the decisions were created by each participant analysis. Overall measurement of the accuracy、High emergency warning information accuracy and the Low emergency warning degree accuracy are in more than 90%.The high emergency warning information decision-making accuracy is 96.73% and the low emergency warning information decision-making accuracy is 99.84%.

Decision response behavior data import SPSS17.0, try to be the average reaction time of emergency decision-making in paired T test, get the following results in table 2.

Table 2 When emergency alarm information decision response matching T test

Paired sample statistics				
	Mean	N	standard deviation	The mean standard error
High emergency warning degree	639.91	459	244.800	11.426
Low emergency warning degree	665.70	459	269.477	12.578

Paired sample test				
	Difference in pairs			
	t	df	Sig. (bilateral)	
High emergency warning degree - Low emergency warning degree	-1.622	458	.006	

Results can be seen in the above table，Individual reaction time for downhole emergency

situation's decision will be affected by the emergency information warning degree. Emergency warning the stimulation of high degree of decision making in significantly (Mean=639.91ms, standard deviation=244.8) less than the average response emergency warning high degree of stimulus(Mean=665.70ms, standard deviation=269.477), t=-1.622, p=0.006<0.05, the reaction shows that emergency decision-making has significant difference. When the individual is in the process of the signal information of different emergency level, the response time of decision making is different. In other words, the High degree of emergency information than the low degree of emergency need more processing time.

The Data Result of ERPs

N2 composition is a negative composition, which is mainly appeared between 200 ~ 400 ms ,the time when it appeared will change with specific experiment of different .There is huge distribution scope and it is distributed generally over the top of the forehead, the forehead and the central area of the forehead. We selected the nine Electrode Points as the position of analysis, likeFcz,Fc4,Fc,3Fz,F3,F4,Cz,C3andC4,because of through the study of the brain electrical activity mapping and combine with previous related theories,can draw a conclusion that obvious part of the N2 composition in the top of the forehead, the forehead and the central area of the forehead.

After certain analyse the Electrode Points, According to the waveform of Electrode Points target, can reveal the time intervals of N2 composition.Then,N2 wave can from each Electrode Points target..In an experiment, the ordinate located in Waveform diagram which above the horizontal axis is negative, otherwise is Positive values, because of the N2 is a negative ERP components. Therefore, Image results showing that the "wave" of N2 to the minimum actually. Taking Electrode Points C3and FCZ for example, shows the N2 composition when subjects make decisions in High degree of emergency warning and low emergency warning level , As shown in figure 2, figure 3:

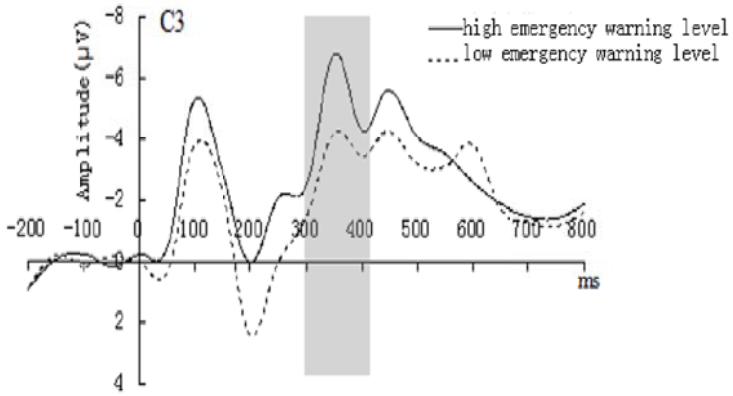

Figure 2 C3 electrode composition N2 waveform figure according to the emergency warning degree classification

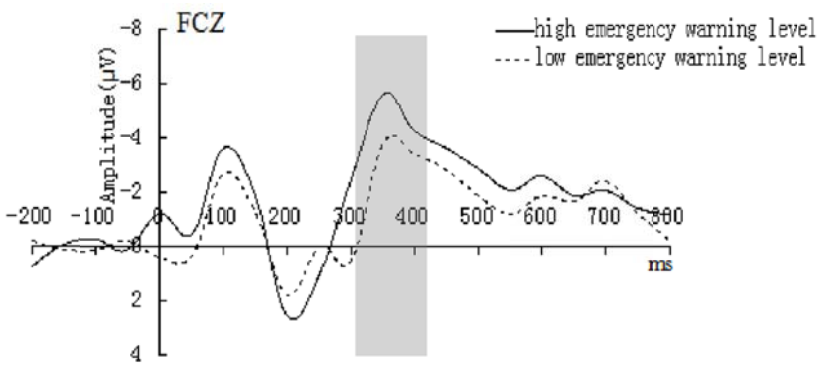

Figure 3 FCZ electrode composition N2 waveform figure according to the emergency warning degree classification

Interception of the N2 component in the period after the emergency stimulus, take time window average amplitude in 200 ~ 400 ms. It can be seen from the figure 3 roughly, the N2 amplitude

when subjects making decisions under the high degree of emergency alert is greater than the N2 amplitude when subjects making decisions under the low degree of emergency alert. In order to inspect that the N2 amplitude whether has the significant difference in statistics, the repetitive measurement and analysis of variance at which the emergency information warning degree and electrodes for influencing factors were performed for subjects. Thereinto, Emergency information warning degree of two values for "high emergency warning degree" and "low emergency warning degree",and Classification for the emergency warning degree of information prompt, The value of electrode point is Fcz、Fc4、Fc3、Fz、F3、F4、Cz、C3 and C4. The amplitude of N2 2（Emergency warning degree：high/low）×9（Electrode position）by repeted measurement and analysis of variance（ANOVA）. It turned out that the main effect of emergency alert degree is remarkable [F（1，22）=11.543.p=0.016<0.05]. This means that the N2 composition that accompany when subjects in the experimental scenario of high emergency warning and low emergency warning degrees making decisions is a significant difference. In order to further compare the difference, our experiment continue to extract the N2 wave that the subjects making behavior under the different levels emergency warning to compare for Matching test. The results in the following table 3:

Table 3 N2 wave matching test results of The subjects under the different levels of emergency warning decisions

Condition	Average	Standard deviation	Paired T test results	
			T-value	P-value
High emergency warning degrees	-0.896	0.743	1.526	0.003
Low emergency warning degrees	-2.658	0.732		

From the paired T test results can be obtained that the N2 composition that the subjects in high emergency warning and low emergency warning degrees making decisions is a significant difference, And it shows that the high peak value of low emergency warning degrees is greater than high emergency warning degrees. However, the bigger the wave crest value, the smaller the actual amplitude,because of the negative characteristic of N2. It concluded that the N2 amplitude, when the subjects in the coal mine emergency scenario, generated by the decision under the high degree of emergency warning message is greater than it under the low degree of emergency warning message.

Analysis And Discussion

Behavior Data Discussion

For high emergency warning information, testees make the correct decision rate for 96.73% and the accuracy rate of low emergency warning information was 99.84%, which indicated that if the level of emergency information warning was different, the testees make a different decision. The T test is carried out in the emergency response information, and the results show that it has a significant difference in the response to the different emergency warning level of coal mine emergency information.Compared to the low degree of emergency warning information, high emergency warning information need more processing time. With the fact that the uncertainty of emergency response, the miners will produce negative emotions. Such emotions make it easier for miners to make wrong decisions.

EEG Data Discussion

The results show that the N2 component of the brain appears obvious between 200-250ms. According to different emergency warning level classification results show that the N2 amplitude and response are significantly affected by the degree of emergency warning, resulting in different degrees of negative emotions, so as to affect the decision making. Further analysis revealed that the N2 amplitude of the high emergency warning level is greater than that of the low level of emergency warning when the same subjects receive the emergency information .

In a word, we can find out that when facing different emergency situations, miners' decisions

and behavior results are related to their body-perception, thought process and the conflict of decision reaction level, which impact the correct emergency decision.

Conclusion

According to event-related potentials experimental techniques, this paper draws the following conclusions: First of all, when underground coal mine workers encountered unexpected events and take emergency decisions, it will cause a policy-relevant electric N2 EEG. Secondly, different levels of emergency warning information lead to different amplitude size of N2 component. Thirdly, during the discussion and analyze we found that the pressure of the event and negative emotion caused by it when we handle the problem will influent the emergency decision behavior. The result shows that the miners' decision process of emergency information is impressionable to the irrational decision under the time pressure. Emergency information will cause different degrees of negative emotion to every individual due to the degrees of emergency warning and it influents individual's emergency decision process.

Acknowledgement

The work was supported by Soft Science Project of Shaanxi Provincial Department of Science and Technology(2011KRM41,2015KRM011,2015R043); National Natural Science Foundation of China(71271169, 71273208); Xi'an University of Science and Technology (2013SY01, 2014SX07,15BY46). Project of Shaanxi Provincial Department of Education (13JZ029, 14JK1445, 14JZ026, 15JZ036); The Doctoral Program Foundation (20126121110004, 20116121110002).

Reference

[1] Deng Lihong, Meng Enhong, Liu Weiwei. Emergency response capability metrics Based on the command staff galvanic skin, heart rate and β wave [J]. CSSJ 2012,11:170-176.

[2] L.Yang. How the internet of things technology enhances emergency response operations[J]. Technological Forecasting and Social Change,2012,16.

[3] Lawson,G.Validating a low cost approach for predicting human responses to emergency situations[J]. Applied Ergonomics,2013,1(44):27-34.

[4] Potts,G.F.An ERP index of task relevance evaluation of visual stimuli [J]. Brain and Cognition, 2004,56(1):5-13

[5] Yuan,J.J.,Zhang,Q.L.,Chen,A.T.,etal.Are we sensitive to valence Differences in emotionally negative stimuli Electrophysiological evidence from An ERP study [J]. Neuropsychologia, 2007,45(12): 2764-2771