Correlation between Risk Perception and Decision Making in Coal Mine Based on ERP Testing Technology

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ABSTRACT

Safety production in coal mine is often faced with great pressure. Security risks often lead to severe life and property loss, which greatly influence economic development and social stability. Risk perception is created on the basis of objective risk. Based on the ERP Technology, the paper regards risks in the coal mine as objective risks and tests the risk perception and risk-based decisions of the subjects. The results show that the main effect of the risk levels is significant, and the interaction of the risk level and the electrode point is not significant. High-risk scenario will lead to more negative emotions and greater fluctuations. Under high-risk conditions, the response time of consistent decisions is shorter than that of inconsistent ones. By analyzing the accuracy rate of the reaction, it is found that the accuracy rate in high-risk scenario is higher than that of the low-risk one. Compared with behavioral test, ERP testing is a more sensitive and effective test method in risk perception process.

Key Words: Security Risk in Coal Mines, Risk Perception, ERP Testing Technology, Risk-based Decision Making
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Introduction

In recent years, the state has paid great attention to the coal enterprises, adopting a series of measures to improve the safety of production. Although the overall environment has been improved steadily, the security risk still exists and is confronted with severe situation (Ford *et al.*, 2011). The underground environment of the coal mine is special, in which an accident will bring a series of chain reactions (Sari *et al.*, 2009; Hulse, 2015). At present, China's coal industry is in the mid-term stage of rapid industrialization transformation, and the safety of coal mining is facing great pressure (Sherval *et al.*, 2014). It has been found that most of the coal mine accidents in our country occurred in safe areas under normal production conditions, that is to say, under the influence of very small probability of risk events, the so-called "safe area" is converted to "dangerous area". Illegal operations, however, plays a major part in causing those accidents (Chassot *et al.*, 2014; Nepomuceno *et al.*, 2012).

In coal mines, potential risks are everywhere, therefore, how to effectively recognize and understand the risks and deal with them with reasonable responses so as to reduce or avoid losses and injuries is of the utmost important (Yang *et al.*, 2011). Risk perception, as an important intermediary among risk information, risk responses and risk-based decisions, is influenced by individual choice and real factors (Connor *et al.,* 2016). When people are confronted with high-level risks in coal mines, they are more likely to be panic and anxious and tend to choose strategies and measures with lower risks (Ash, 2011; Maddirala *et al.*, 2016). How to judge people's risk perception level has become an important subject of researchers.

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When people think that the objective risk is smaller than the perception, they may believe the risk has reached a higher level. However, when the objective risk is greater than the people's perception, people will overlook the existence of the risk, which will lead to the expansion of the potential risk (Cinar *et al.*, 2013). Risk perception and decision-making depend on individuals. The popularity of neuroscience research has begun to be applied to the study of people's cognition and decision-making (Shi *et al.*, 2018; Wang *et al.*, 2016). Based on ERP testing technology, taking the risk of underground coal mine as an objective risk, this paper studies the risk perception and risk-based decision-making ability of the subjects.

Individual psychological characteristics and behavioral decisions of coal mine staff under unexpected incidents

Individual risk perception and psychological mechanism in coal mine emergencies

Coal mine emergencies seriously threaten the safety of production, people's life and property, with characteristics including- sudden, complex, destructive and interlocking (Schaik *et al.*, 2017). Risk dimension influence the risk perception of the coal miners. When both the value of the unknown risk dimension and the fear for risk are high, people's risk perception is more acute (Ferdik *et al.*, 2016). People always have relatively weak risk perception for observable, understood and old-type risks. Figure 1 is the influencing factors and the result of individual risk perception. It can be found that the individual's awareness and cognitive bias to the risk of emergencies will cause psychological and behavioral changes. Event factors, social factors, personal factors and personal relations will affect the individual's understanding and cognitive bias to the risk of emergencies. The cause of the event, the scope of the impact, the degree of the loss, the duration and the degree of familiarity all have different impacts on individuals. These factors are the law of understanding the risk perception under the unexpected events in coal mines. By consciously taking advantage of those influencing factors, and discovering the weak links and elements influencing individual perception of unexpected events, emergency response capability, decision-making ability and self-help ability can then be improved. According to the research of decision-making science, it is very difficult for decision-makers to make correct decisions on the basis of risk perception due to the uncertainty of the incidents in the coal mine. Compared with the conventional decision-making process, people's behavior decision under unexpected events has the characteristics of pressing time, scarcity of information, insufficient knowledge, lack of rational judgment, different decision-making procedure, uncertainty of decision consequence, etc. (Volpentesta *et al.*, 2011).

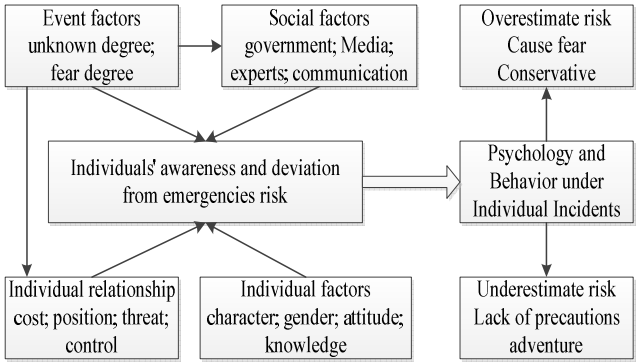


Figure 1. Influencing factors and results of personal risk perception

Analysis on miners' decision-making behavior in emergencies

Human behavior and mistakes play an important part in leading to coal mine safety accidents (Eloi *et al.*, 2018). In general, decision often depends on the group's decision-making ability in incidents occur in coal mines. Decision-making ability, the scale of the group, information communication among group members, structure and type of the group will affect decision-making ability of the group. The decision-making ability of a group is reflected in the ability of individual decision-making ability. Figure 2 is the decision-making behavior analysis of coal miners. The decision-making behaviors can be divided into unintentional behaviors and intentional behaviors, in which, the intentional decision-making behaviors include decision behaviors based on mimicry, decentralized responsibility, and information dissemination.

(1) Decision-making behavior based on mimicry refers to risk information with vague objective risks and is lack of valuable risk information. Coal miners make their own behavioral decisions based on other members' actions and behavioral decisions.

(2) Behavioral decisions based on the decentralization of responsibility belong to negative behaviors. Decision-making behavior may be changed due to others' intervention.

Miners may also intervene in other people's decision-making behaviors, and thus lead to malicious behavior.

(3) Group behavior based on information dissemination refers to the decision behavior produced by personal information as well as by observing the behaviors of others. In this case, the decision-making behavior may affect other members' decisions or guide the others to make the same decision.

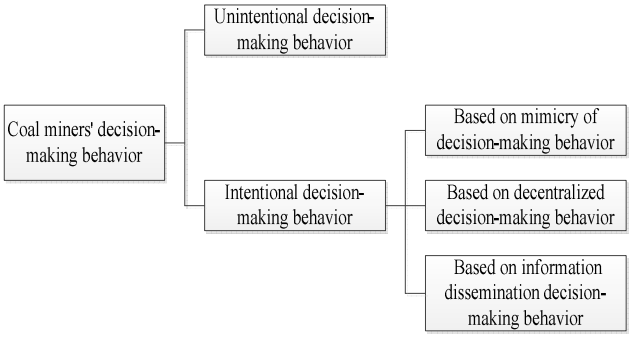


Figure 2. Analysis on the decision-making behavior of coal mine employees

Research on neural mechanism of risk perception in coal mine based on ERP experiment

Experimental method

This paper takes advantage of people's risk perception differences of different risk levels in real scenarios. Before the experiment, assumptions are made about behavioral data and ERP data, that is, the response time of the high risk scene is shorter than that of the low risk scene, and the high risk scene induces greater P200 amplitude and LPP amplitude. 30 college students are recruited with payment. All the subjects are right-handed. The experiment selects the pictures of the incidents occurred in coal mines as stimulation materials, which are divided into high-risk pictures and low-risk ones. All the pictures are processed in a unified way, so that the matched pictures have similar color and brightness. Neurone EEG/ERP related potential system is used in test equipment. The system consists of the Neurone Model Black amplifier and ERP electrode cap (Ag/AgCl64 Neurone electrode cap). The sampling frequency is 1000Hz, and the EEG data is amplified by the Neuroscan Synamp2 Amplifier system so that the quality of the data collected is guaranteed. After the experiment, the data of the subjects were merged, filtered, cleaned, and corrected by baseline.

Research results

Before the experiment, the risk level of the pictures is assessed. The results show that the pre classified pictures are effective. According to the behavioral data of the subjects, the response time of the high-risk pictures was 746.03ms while that of the low-risk pictures was 717.86ms, which shows that the response of the high-risk pictures was greater than that of the low-risk ones, which was contrary to the hypothesis. There was no significant difference in response time difference between the two kinds of images. Fig. 3 is the P200 waveform diagram of electrode points Fz and FCz, and the electrode points Fz and FCz come from the center line. By repeated measurements of variance analysis of the components of P200 of Fz and FCz, the statistical results showed that the main effect of the risk degree was significant, and the P200 amplitude caused by the high-risk picture was significantly larger than that of the low-risk picture; the main effect of Fz and FCz was significant, and the interaction of the risk level and the electrode point was not significant. Figure 4 is the LPP waveform of three electrode points Fz, Cz and Pz. According to repeated measurement of variance analysis of the components of LPP, the main effect of the risk level is significant, and the amplitude of LPP caused by high-risk pictures was significantly greater than that of the low-risk ones; the main effect of the electrode point is also significant, but the interaction of the risk level and the electrode point is not significant.

The experimental analysis shows that the reaction time is inconsistent with the research hypothesis, while P200 and LPP are consistent with the research hypothesis. The reaction time of the security risk perception process can be used to determine the difficulty of risk assessment to a certain extent, but for the risk of underground coal mine, the cognitive requirements for evaluating whether there is a risk and whether it is safe or not are the same. The reaction time, however, is different from the ERP test. The risk scene stimulates people's risk perception and is motivation related. In addition, high-risk scenes will cause more negative emotions and lead to greater amplitude fluctuation. ERP testing is a more sensitive and effective test method in the process of risk perception.

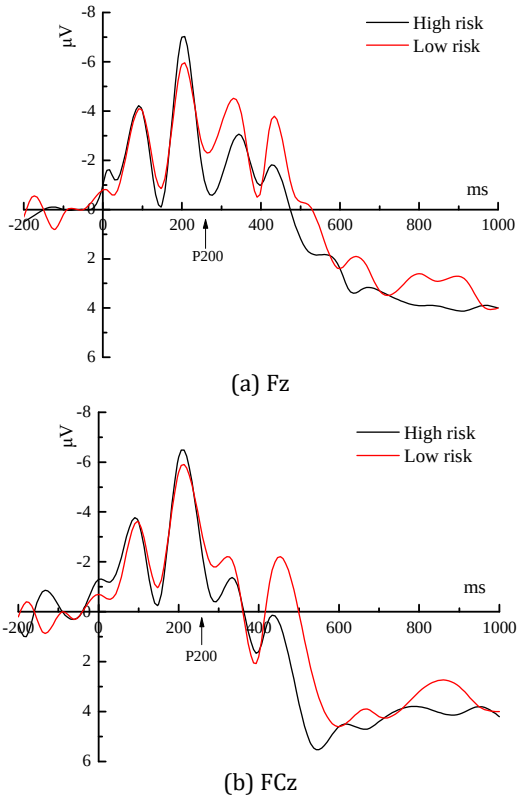
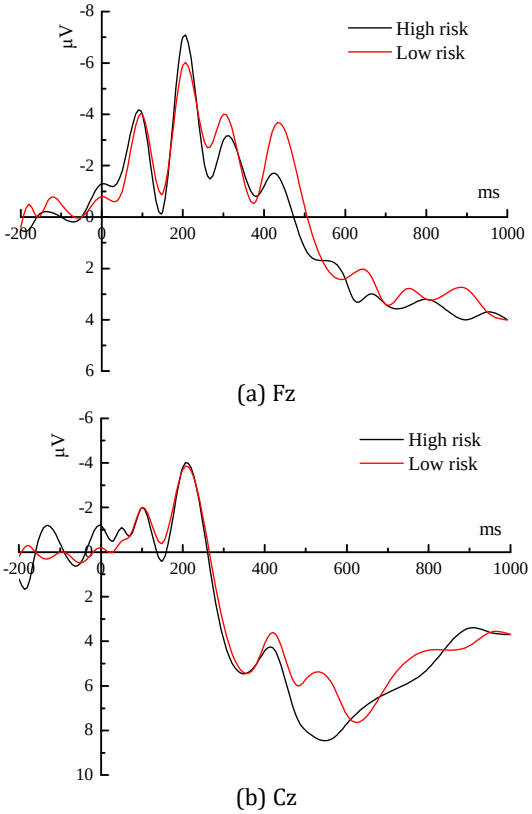


Figure 3. P200 waveform plots for Fz and FCz electrode points



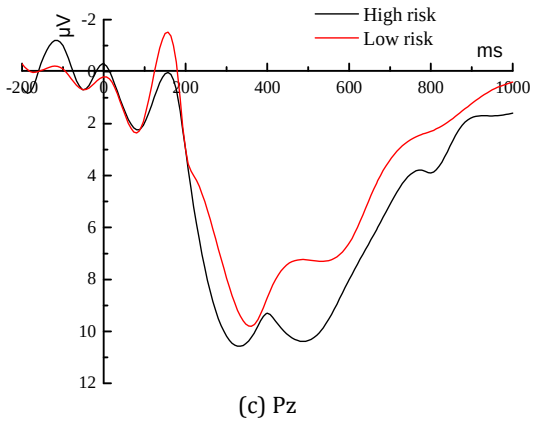


Figure 4. LPP Waveforms for Fz, Cz, and Pz Electrodes

Neural mechanism of risk information in coal mine based on ERP experiment

Experimental method

In this section, the consistency of the neural mechanisms and related decisions of image risk perception is studied. People have different risk perceptions of different risk levels and thus make different decisions. Based on ERP testing technology, we explore the moderating effect of decision consistency on risk perception and evaluation process. In this experiment, 22 college students were recruited, all of which were from mining majors. Risk pictures in the coal mines are selected as stimulate materials in this test, which were divided into high-risk group and low-risk group according to the risk level.

In addition to providing risk pictures, feasible decisions are also provided. Decisions may correspond to the risk or not. Therefore, there will be four situations: high risk - consistency; high risk - inconsistency; low risk - consistency and low risk - inconsistency. During the experiment, the stimuli were displayed on the screen, and decision information was then appeared at the center of the screen, and the participants responded to the consistency of the risk level and the decision. Testing methods, acquisition and processing methods are exactly the same as those in the section 3.1.

Research results

Table 1 shows the reaction in four situations. According to variance analysis with repeated measurements, the inconsistency of decision-making had significant main effect while the main effect of risk level was not significant, but the inconsistency of decision and the risk level showed significant interaction effect. Under high-risk conditions, the response time of decision

consistency is shorter than that of inconsistent decisions. By analyzing the accuracy of the response data, the accuracy rate of high-risk scenario is higher than that of the low-risk scenario.

Figure 5 is the electroencephalogram of four electrode points Fz, FCz, Cz and CPz. According to repeated measurement of variance analysis of the components of P1, four electrode points, the main effect of the decision inconsistency is not significant while the main effect of the risk is significant. The amplitude of P1 induced by high risk is greater than that in low risk situation. The simple effect shows that when the decision is consistent, the average risk-induced amplitude is greater. The contras of the amplitudes in different situations are shown in Table 2. By analyzing the amplitude of the LPP component of four electrode points, the main effect of the decision inconsistency is significant. The LPP amplitude of the decision-inconsistent scenario is smaller than that of the decision-consistent situation, and the main effect of the risk level is not significant, which is opposite to the P1 component. According to the ERP waveform, high-risk pictures cause greater P1 component and P200 amplitude compared to low-risk pictures. Decision inconsistency will affect the process of risk and safety stimulation, which is reflected in the difference of LPP amplitudes. Risk perception depends on intuition and experience, but it shows two stages.

Table1. Reaction time for different situations

Situation	Mean value /ms	Standard error	95% confidence interval	
			Lower limit	Upper limit
High risk - consistent	724.514	25.437	668.738	780.30
High risk - inconsistent	737.504	25.247	682.118	792.879
Low risk - consistent	683.12	25.124	628.002	738.238
Low risk - inconsistent	650.75	18.409	609.780	691.729

Table 2. P1 component comparison results for different situations

Situation	Mean value	Standard error	95% confidence interval		Significant level
			Lower limit	Upper limit	
High risk – consistent	-1.887	0.461	-2.876	-1.007	0.479
High risk –inconsistent	-1.608	0.445	-2.555	-0.740	
Low risk – consistent	-2.420	0.470	-3.427	-1.412	0.001
Low risk –inconsistent	-1.081	0.434	-2.016	-0.146	

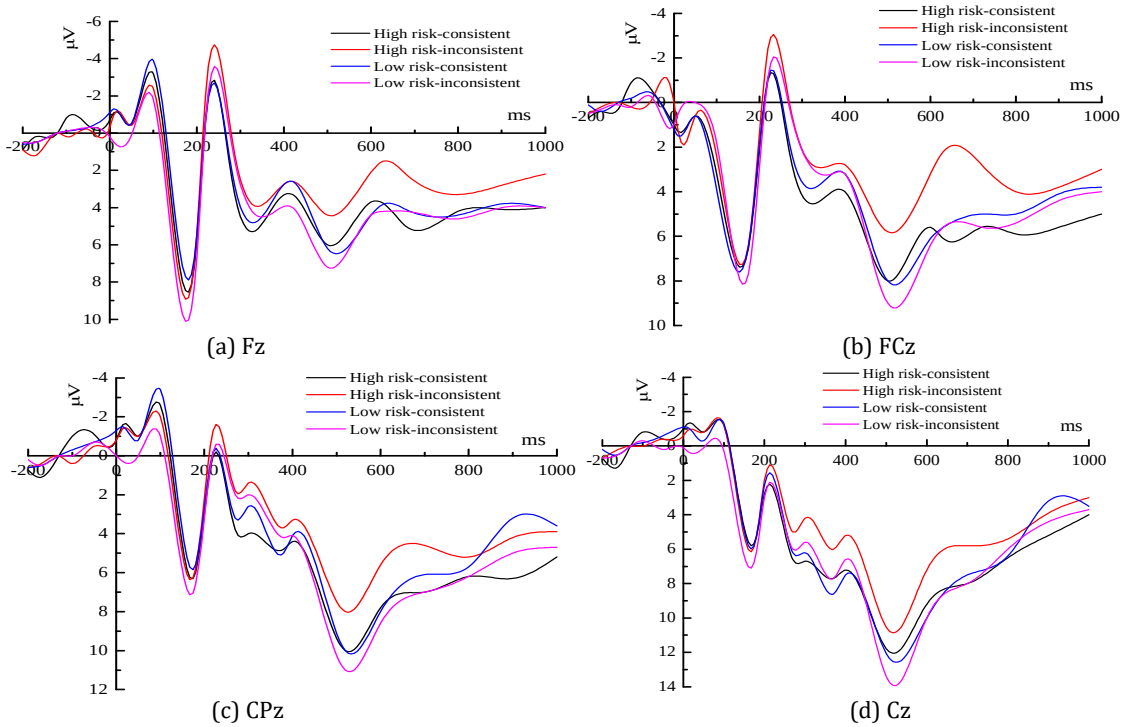


Figure 5. Electroencephalograms of four electrode points Fz, FCz, Cz, and CPz

Conclusions

Based on the ERP testing technology, the risk perception and risk decision ability of the subjects are studied with the risk of coal mine as the objective risk. Conclusions are as follows:

(1) High-risk scenarios can cause more negative emotions and larger amplitude fluctuations, in which the response time is different from that of the ERP test. Risk scenarios stimulate people's risk perception and motivation relevance.

(2) Under high-risk conditions, the response time of decision consistency is smaller than that of inconsistency. By analyzing the accuracy of the response data, it is found that the accuracy rate is higher than that of the low-risk scenario.

(3) High-risk pictures cause greater amplitudes of P1 and P200 than those of low-risk pictures. Decision inconsistency affects the process of risk and safety stimulation, which is reflected in the difference in the amplitude of LPP. Risk perception depends on intuition and experience, but it shows two-stage characteristics.

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