The Relationship between Geological Disaster Risk Perception and Behavior Characteristics Based on Electroencephalogram Testing Technology

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ABSTRACT

Geological disasters will bring about great harm, often causing serious personal and property losses to the public. The existing researches point out that the behavior characteristics of individuals in the face of geological disasters can exert a significant influence on the implementation effect of disaster reduction policies. Under this background, this paper establishes a binary model of "risk perception type—behavior decision characteristic" by using geological disaster risk perception measurement scale and Electroencephalogram (EEG) testing technology, and studies the behavior characteristics of different groups in the face of geological disasters through this model. The research results show that compared to others, women and subjects going through geological disasters have a higher level of risk perception in the face of geological disasters, and they also show a greater degree of concern for disaster information, indicating that women and those experiencing geological disasters can respond more effectively to geological disasters. From the perspective of policy suggestion, policy makers should take groups with low risk perception as the focus of publicity of disaster prevention and reduction policies so as to enhance the effectiveness of policies.

Key Words: Geological Disasters, Risk Perception, EEG Testing Technology, Behavior Decision

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Introduction

Geological disasters refer to disastrous events because of various geological movements (Santos, 2012), including earthquakes, landslides, tsunamis and typhoons. The leading cause of geological disasters lies in the geological movement which can be seen as a change in the natural environment. However, geological disasters have shown the characteristics closely related to human activities in recent centuries, often resulting from the interaction between human beings and the natural ecological environment. From the perspective of geographical distribution, China is a typical area where geological disasters occur frequently. In recent decades, all kinds of geological disasters have occurred in China from time to time, causing huge personal, economic and property losses to the masses.

In the face of geological disasters, the public is both the main body to bear the disaster and the executive body of the disaster prevention and reduction policies. Their behavior characteristics (such as negative or positive,

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prepared or unprepared) have determined the implementation effect of disaster prevention and reduction policies to a large extent. According to the research, behavior characteristics of the public in the face of geological disasters largely depend on the risk perception of geological disasters (Rundmo, 2000). However, the risk perception belongs to the category of subjective judgment, which not only leads to differences between individual's risk perception and the real risk situation, but also causes differences in the risk perception of the same geological disasters between individuals, leading to different behavior characteristics (Pidgeon, 2012). Therefore, it is of great practical significance to study the risk perception of the public in the face of geological disasters, especially the risk perception differences and behavior results of different groups for the rational formulation and effective guidance of disaster prevention and reduction measures.

Theoretical Analysis of Risk Decision and Geological Disaster Behavior

In the face of risk, individuals need to collect relevant information and judge the degree of the risk first, which is the determination of risk perception (Cannistraro and Cannistraro, 2016; Rehwinkel, 2016; Zhi and Min, 2015; Simard and Marchand, 1994). Then individuals will take different actions based on risk perception. This process is called the risk decision-making process. Just because risk perception varies with each individual, the risk decision process of individuals is quite different (Bettman and Park, 1980; Raju and Mangold, 1995).

Many scholars' researches have shown that emotions, physical states and other indicators will react under risk conditions and influence subsequent actions (Johnson 2005; Saadé, 2007). Furthermore, human beings' physical indicators will change first in the face of external risk or risk information. These changes include tachycardia and muscular tension, which may stimulate brain activity and produce emotional responses, dominating and influencing information processing and behavior decision-making process in the next step (Hughes, 1995). After recognizing the basic principles of the body's perception of risk and coping behavior, scholars have proposed a dual system theory of risk perception. The theory holds that there are two parallel and interactive systems in the face of risk, namely analysis system and subjective risk perception system. The subjective risk perception systems play a very important role in risk judgment and behavior decision (Tanfer 1986; George 1997; Peacock *et al*., 2005; Hough *et al*., 2006). The risk perception and decision-making process held by the theory are shown in figure 1.

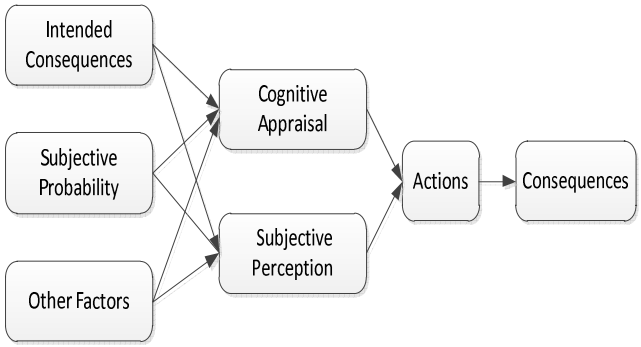


Figure 1. Risk Decision Process

Based on the above theoretical basis, this paper proposes a method of risk perception and EEG testing to study the public's risk perception and behavior characteristics in the face of geological disasters.

Design of Risk Perception Measurement Scale

The measurement of risk perception is mainly expressed by the product of risk uncertainty and risk loss outcomes (Pidgeon, 1998). In the specific operation process, questionnaires or direct inquiry are used to investigate the subjects' feelings about the uncertainty and the possible losses caused by a certain risk (Cohen, 1999). This paper follows the above method to measure the risk perception of subjects on geological disasters.

Therefore, first, this paper extracts risk perception dimensions for miners based on reality of coal mining enterprises through literature review and from the risk perception research in the construction, transportation, and consumption fields. Then the miners' risk perception dimensions are determined through the interview. And we use the Likert five-level scale to make measurement scale to measure the risk severity of each dimension and the possibility of risk. By using Peterand Tarpey's (1975) measurement research on risk perception, the following formula is put forward to calculate the level of risk perception of miners.

$$OP_{RJ} = P_{Lj} \times I_{Lj} \quad (1)$$

where, OP_{RJ} is level of risk perception, PL_J is the possibility of the loss caused by risk, IL_J is the severity of the loss caused by risk.

In the process of designing the specific scale, we have adopted the interview way to interview the experts of geological disaster, related emergency departments and medical and rescue personnel, and finally compiled the following risk perception scale (table 1).

Table 1. Risk Perception Scale

Dimensions	Contents
Financial risk	Geological disasters can cause my economic loss.
	Geological disasters can affect my income for a period of time
Social risk	Geological disasters can lead to social disorder.
Psychological risk	Geological disasters are frightening.
	Geological disasters will affect me for a long time
Physical risk	Geological disasters can endanger my life.
	Geological disasters can lead to my disability.

After designing the initial risk perception scale, we have randomly selected the reliability and validity of testing scale of 300 subjects and analyzed the results by SPSS 17.0 software. The results show that the reliability and validity indexes of the above scale are good, which can fully reflect the various aspects of geological disaster risk perception.

Relationship between Geological Disaster Risk Perception and Behavior

This part mainly includes three aspects: First, risk perception types of subjects are classified based on the above risk perception scale. Second, EEG testing technology is used to monitor brain activities subjects of different types of risk perception. Third, different behavior characteristics (gender, education, past experience) of subjects are analyzed in the face of geological disasters.

Type testing of subjects' risk perception

This paper selects 300 subjects from Sichuan Province where there are many geological disasters. According to preliminary statistics, among the 300 subjects, there are 141 males and 159 females; 112 have bachelor degree or above and 188 have degree lower than bachelor degree; 121 experienced geological disasters (including earthquakes, landslides, floods, etc.) and 179 have no geological disaster experience.

We use the geological disaster risk perception scale set above to test all subjects, finding that 98 of the subjects have high risk perception (scale scores 70-100), 79 have medium risk perception (scale scores 40-70), and 123 have low risk perception. The research in the later part of this paper will focus on 221 subjects with high risk perception and low risk perception.

Difference in brain activities of subjects with different risk perception types

(1) Experimental apparatus

The apparatus required for this experiment includes: 10 electroencephalographs which can monitor the changes in the α-band and β-band of EEG. α-band and β-band can represent the main changes in brain activities of subjects after receiving external stimuli, including fluctuation range and fluctuation time; electrode cap; electrode; 75% alcohol; degreasing cotton; 10% saline.

Figure 2. ERP Experiments.

(2) Experiment process

Before the formal experiment is conducted, the researcher explained to each subject about the purpose of the experiment and the basic procedure of the experiment in detail, and introduced the basic knowledge and principle of EEG so that subjects could correctly understand the EEG experiment to eliminate the panic mood.

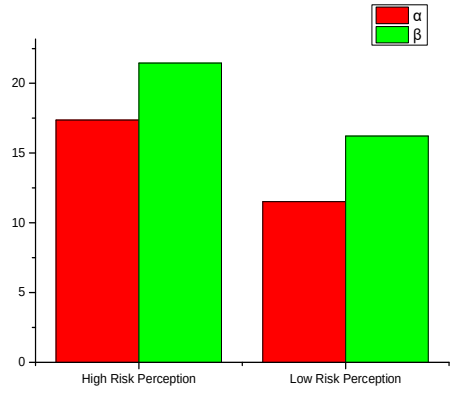
In the preparation before the experiment, the electrode cap of the subject was comfortable and the electrode was installed by using the standard installation method of International Electroencephalography Institute and the international system electrode placement method. During the entire testing process, the subjects sat on the chairs, closed their eyes lightly, placed their hands on legs, kept their eyes closed, and didn't move their eyeballs. Subjects shall keep

awake during the test. The light in the room should not be strong.

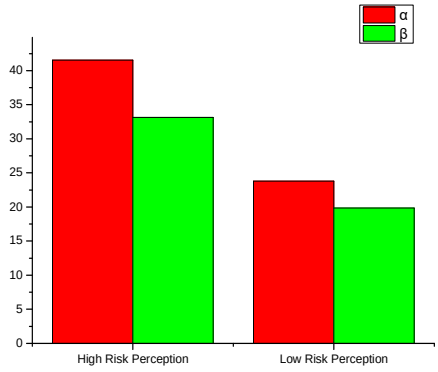
In the experiment, EEG of one minute was recorded during a quiet mood. Then the subjects saw geological disaster warning information and geological disaster scene pictures, and EEG of two minutes was recorded. At the end of the experiment, the experimental records were saved. Then we disconnected the amplifier and the electrode cap, removed the electrode cap. The electrode of experimental apparatus was cleaned and dried.

(3) Data processing and analysis

SPSS17.0 statistical software was used to conduct analysis and processing of experimental data and the data values were expressed as mean plus or minus standard deviation. The differences of EEG characteristics between different risk perception types in fluctuation range and duration are as follows.



(a) Voltage Fluctuation



(b) Duration(s)

Figure 3. The Difference between High & Low Risk Perception

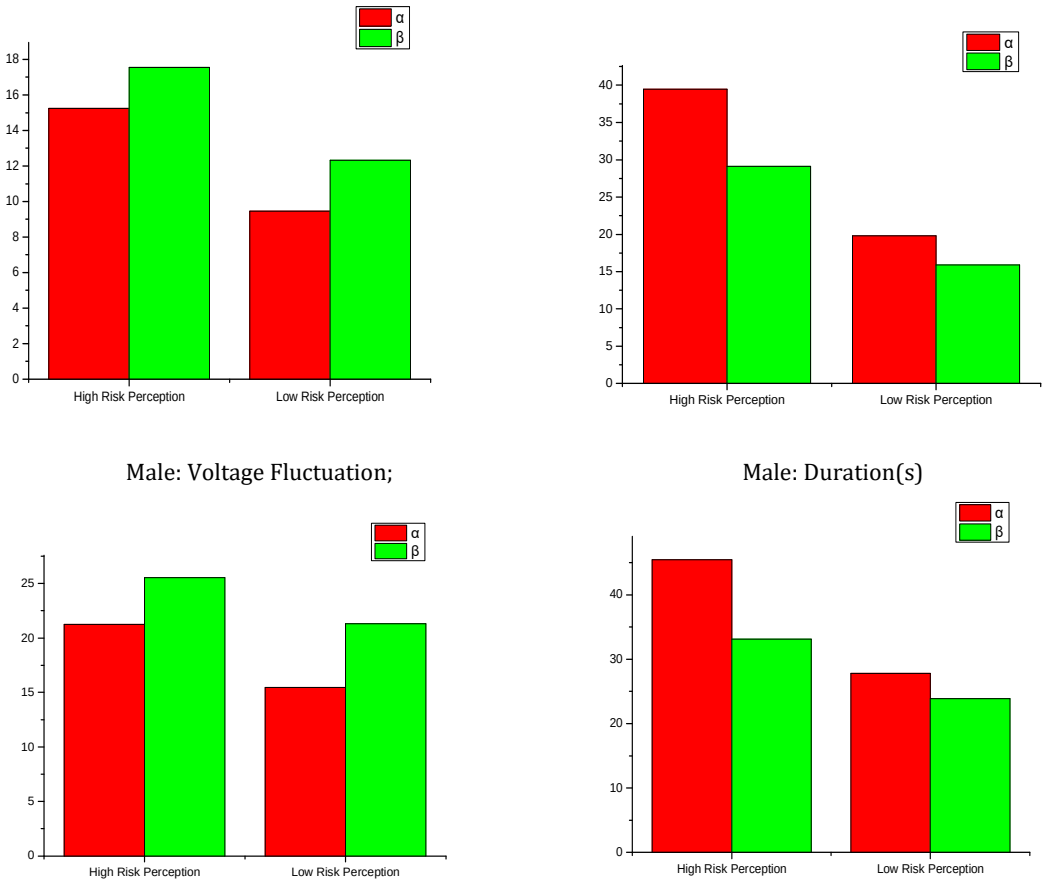
Table 2. The Difference between High & Low Risk Perception

	High Risk Perception	Low Risk Perception	p-Value
Voltage Fluctuation	17.36±2.14	11.52±1.67	0.01
	21.46±1.79	16.21±2.21	0.00
Duration(s)	41.55±3.65	23.79±4.11	0.02
	33.17±2.99	19.86±2.87	0.04

As shown in Table 2, subjects with high risk perception are significantly higher in both fluctuation range and duration of brainwaves than those with low risk perception ($P<0.05$). According to the data, the mean fluctuation range value in the α-band of subjects with high risk perception is 17.36, which is significantly higher than that of the low risk perception type of subjects (11.52); the mean fluctuation range value in the *β*-band of subjects with high risk perception is 21.46, which is significantly higher than that of the low risk perception type of subjects (16.21); the mean duration value in the α-band of subjects with high risk perception is 41.55 s, which is significantly higher than that of the low risk perception type of subjects (23.79 s); the mean duration value in the *β*-band of subjects with high risk perception is 33.17 s, which is significantly higher than that of the low risk perception type of subjects (19.86 s). The above data shows that subjects with high risk perception show a higher degree of concern in the face of geological disaster warning information and geological disaster pictures (manifested as large fluctuation range of brain waves) and longer concern time (manifested as longer duration of brain waves). In contrast, in the face of geological disaster warning information and geological disaster pictures, subjects with low risk perception show a lower degree of concern and shorter time (figure 3).

Influence of gender, education, past experience on behavior characteristics

The previous experiment demonstrates that subjects with high risk perception have a higher degree of concern for geological disaster information, but doesn't exactly point out which different context causes the above differences. This is the research focus of this part.



Male: Voltage Fluctuation; Male: Duration(s)

Female: Voltage Fluctuation; Female: Duration(s)

Figure 4. The Difference between Male & Female

(1) Influence of gender factors on risk perception

In this paper, 221 subjects were divided according to their ages to study their risk perception types and brain wave characteristics. The specific situation is shown in the following table 3.

Table 3. The Difference between Male & Female

	Index		High Risk Perception	Low Risk Perception	p-Value
Male	Voltage Fluctuation	α	15.24±2.55	9.46±0.99	0.00
		β	17.55±0.79	12.31±1.25	0.00
	Duration(s)	α	39.47±2.45	19.81±4.11	0.00
		β	29.15±1.99	15.87±1.88	0.01
Female	Voltage Fluctuation	α	21.24±1.67	15.46±1.21	0.02
		β	25.55±1.81	21.31±1.35	0.00
	Duration(s)	α	45.47±2.41	27.81±3.78	0.03
		β	33.15±0.99	23.87±2.88	0.01

The testing data in Table 3 shows the difference in brain wave among subjects of different genders. We first analyze data of males: in male subjects, brain wave fluctuation range of subjects with high risk perception was significantly higher (α-band 15.24 and *β*-band 17.55) than those of low risk perception type (α-band 15.24 9.46 and *β*-band 12.31). The duration of brain wave fluctuation in subjects with high risk perception type (α-band 39.47 and *β*-band 29.15) was significantly higher than those with low risk perception type (α-band 19.81 and *β*-band 15.87). Data of female subjects also showed similar characteristics to that of male subjects, that is, women with high risk perception type had significantly higher fluctuation range and duration of brain wave than women with low risk perception type. The above experimental result is consistent with the result in 4.2, which can be verified with each other.

The paper further compares data of male subjects to data of female subjects, finding that on average, fluctuation range and duration of brain wave of female subjects both with high risk perception and low risk perception are significantly greater than those of male subjects ($P < 0.05$), indicating that women have a higher degree of concern for geological disaster information and their reaction is more intense.

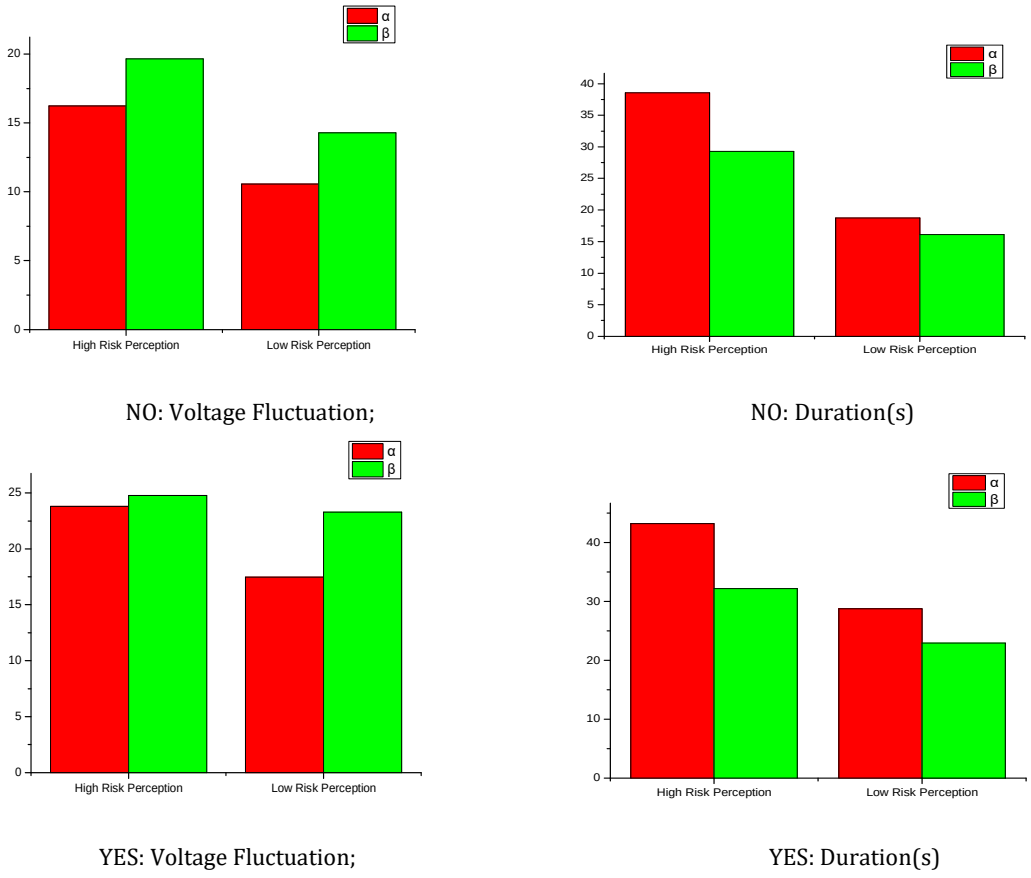


Figure 5. The Difference between Non-Previous Experience & Previous Experience

(2) Influence of geological disaster experience on risk perception

In this paper, 221 subjects are studied their risk perception types and brain wave characteristics according to whether they experienced geological disasters. The specific situation is shown in the following table 4.

Table 4. The Difference between Non-Previous Experience & Previous Experience

	Index		High Risk Perception	Low Risk Perception	P-VALUE
NO	Voltage Fluctuation	α	16.24±1.77	10.57±0.34	0.01
		β	19.65±0.89	14.28±1.47	0.00
	Duration(s)	α	38.59±1.86	18.77±3.11	0.02
		β	29.28±2.11	16.11±2.11	0.00
YES	Voltage Fluctuation	α	23.81±1.89	17.49±1.23	0.01
		β	24.77±2.12	23.28±0.78	0.00
	Duration(s)	α	43.25±1.99	28.77±2.23	0.00
		β	32.17±0.87	22.91±2.12	0.05

The testing data in Table 4 shows the influence of the previous geological disaster experience on the subjects' brain wave test. We first analyze data of subjects who didn't experience geological disasters: subjects with high risk perception have significantly higher fluctuation range of brain wave (α-band 16.24 and β-band 19.65) than those with low risk perception type (α-band 10.57 and β-band 14.28) The duration of brain wave fluctuation (α-band 38.59, and β-band 29.28) of subjects with high risk perception is significantly higher than that of subjects with low risk perception (α-band 18.77 and β-band 16.11). Data of subjects who have experienced geological disasters also show similar characteristics, that is, fluctuation range and duration of brain wave of subjects with high risk perception are significantly higher than those with low risk perception. The paper further compares the data of subjects experiencing geological disasters and those with no experience of geological disasters, finding that on average, fluctuation range and duration of brain wave of subjects with experiencing geological disasters both with high risk perception and low risk perception are significantly greater than those of subjects with no experience of geological disasters ($P<0.05$), indicating that subjects who experienced geological disasters in the earlier period have a higher degree of concern and their reactions are more intense (figure 5).

Conclusions

In the face of geological disasters, the public is the direct implementer of disaster prevention and reduction policies. Therefore, it is of great practical significance to improve the public's ability to deal with geological disasters. This study shows that the level of risk perception and individual characteristics have a significant influence on the behavior characteristics of the public in the face of geological disasters. Targeted prevention and reduction measures should be formulated for the public with different levels of risk perception and different characteristics. The specific research conclusions are as follows:

(1) EEG testing of subjects with different risk perception types shows that subjects with high risk perception show greater concern for geological disaster information, indicating that they are able to respond to geological disasters earlier and more effectively so as to reduce the extent of damage.

(2) From the perspective of group classification, women and groups with geological disaster experience belong to the high risk perception type. Men and groups without geological disaster experience belong to the low risk perception type.

(3) In formulating and publicizing measures for disaster prevention and reduction, the government should pay more attention to low-risk-perception groups and increase their perception level of geological disaster risk so as to enhance the effectiveness of overall disaster prevention and reduction measures.

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