Cognitive Mechanism of Economic Management Risk Based on EEG Analysis

Ruiwei Duan

ABSTRACT

In the face of complex and changeable economic situation, the perception of potential risks in economic operation is directly related to the attitude and decision-making of managers to follow-up risks. Neuromanagement is a frontier interdisciplinary subject which is developed from decision-making neuroscience and management science, and has been applied in economic management. Based on the methods of literature research, cognitive neuroscience experiment, induction and summary, this paper attempts to use cognitive electroencephalogram (EEG) analysis technology to analyze the cognitive mechanism of management risk through subjects' cognitive differences in natural scenes with different risk levels. The experimental results show that from the perspective of behavior science there is no difference in assessment between high risk and low risk in the process of economic management risk perception, but EEG signal analysis shows that P200 and LPP induced by high risk scenarios are larger than low risk scenarios, which indicates that EEG signal analysis can be used as an effective measure of economic management risk perception and is helpful for managers to avoid risk and make correct decision..

Key Words: Risk Perception, Economic Management, Experiment of Cognitive Neuroscience, Analysis of EEG Signals

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Introduction

The risk perception of economic management is the manager's feeling and perception of all kinds of objective risks such as economic environment and economic information in the course of economic operation. The risks mentioned here include the objective risks and the risks that can be realized (Burns *et al*., 2012). The risk perception of managers can directly influence the economic risk behavior, which is related to the risk organization attitude, risk response and decision-making to all subsequent economic activities. Especially in recent years, the economic situation at home and abroad is complicated and changeable. Once the risk situation is wrongly perceived, a serious economic loss may occur. Therefore, the risk perception of economic management has always been the key content in the field of economic management.

At present, the researches on risk perception are mainly based on the two aspects of behavioral science and cognitive neuroscience. Behavioral science divides the study of risk perception into two levels: individual and group (Cannistraro and Cannistraro, 2016; Ferruzzi *et al*., 2017; Renn and Swaton, 1984; Rehwinkel, 2016; Tirmizi and Tirmizi, 2017).

At the level of individual research, we study individual perception of risk itself and risk warning information (audio, text, picture, etc.) from the perspective of psychology. Fischhoff, Slovic and Lichtenstein developed psychological measurement paradigm of risks. Douglas and Wildavsky studied group risk perception from the perspective of cultural and social background

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(Okrent, 1998), but all of the above researches neglected the characteristics of time stress in the process of risk perception, coping and decision-making. Based on the research of behavioral science, the cognitive neuroscience studies the problem of risk perception of people in production and life from the aspect of cerebral nerve with brain imaging and EEG technology (event-related potential and EEG) (Sjoberg, 2000), with important achievements. It provides some references for the research of this paper, but there are fewer research achievements on risk perception and risk cognitive adjustment variables in the field of economic management.

Based on the above analysis, this paper takes behavioral science and cognitive neuroscience as the theoretical basis and combines the commonly used EEG signal analysis techniques (ERPs) in cognitive neuroscience experiments to study the brain nerve mechanism of people's perception of risks in economic management activities. The experimental data are analyzed in detail from the aspects of behavioral science and cognitive neuroscience. The experimental results can help people to understand the cognitive problems of economic management risk, to prevent and avoid potential risks in economic management activities, and to assist managers in making correct risk response decisions and reducing economic losses.

Related Theoretical Basis

Risk perception of economic management

(1) Risk perception of economic management

Economic management risk (Bontempo *et al.*, 1997) refers to the event that exists objectively and may lead to adverse consequences. It is the result of the joint action of risk situation, possibility and consequence. With uncertainty, it may be affected by various factors such as economy, society, culture and institution.

The essence of the cognitive process of the risk by the economic manager is the processing of various risk situations and information in the economic environment (Mensen and Khatami, 2013). Figure 1 shows the information processing model proposed by Wickens. When the manager receives the economic information related to the outside world, he or she perceives and understands the information with the experience and memory in the past, makes corresponding response plans and decisions through analysis, and finally implements them in economic management activities (Filatova *et al.*, 2011). Of course, if there is a deviation in the perception of the risk in the early stage, the wrong decision will be made, which will lead to the bad economic consequences in the implementation stage. Because the process fully considers the psychological factors of people and describes the process of managers' perception of economic management risk in detail, it is generally accepted by people.

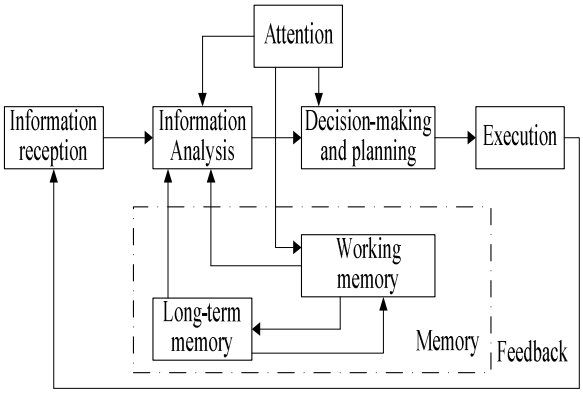

Figure 1. Wickens's information processing model

(2) Two-stage model of risk perception

With the constant development of neuroscience, some researchers use EEG (event-related potential) to study the neural mechanism of risk perception by making subjects judge the risk degree of risk words. It is found that P200 and LPP in EEG are closely related to risk information processing (Billeke *et al.*, 2013), where P200 is related to attention, mainly focusing on the information processing of early risk stimulation, appearing about 200ms after stimulation, while LPP reflects the activation and subjective evaluation of motivation system, appearing about 300-700ms after stimulation, which belongs to the fine processing in late stage. Then some researchers put forward the two-stage model of risk perception (Tamura *et al.*, 2009), one is the early stage of perception and detection, and the other is the stage of risk degree evaluation. As shown in Figure 2, when people encounter the risk information carrier, they will quickly pay attention to the risk and find out the risk. Then they will conduct risk perception - understanding, evaluating, and judging the risk information based on own experience. This process takes a longer time and occurs later.

Figure 2. Risk perception two-stage model

Risk perception related techniques

Event-related potentials, functional nuclear magnetic resonance (fMRI) and electroencephalogram (EEG) are commonly used experimental techniques in cognitive neuroscience (Finkel, 2008). These techniques have advantages and disadvantages and can be used in different fields according to their own characteristics. Among them, the event-related potentials (EPRs) with high temporal resolution can be used to record and reflect the related EPRs component of the cognitive process and can use amplitude intensity and high temporal resolution to reveal cognitive processes (Paul Slovic *et al.*, 2004). Therefore, it is an important research tool in the field of neuromanagement and neuroeconomics. The common EPRs (Gonzalo-Fonrodona and Porras, 2015) in neuromanagement include N1, N2, ERN and P200, among which the EPRs related to the risk perception of economic management studied in this paper are mainly P200 and LPP.

Behavioral study of risk perception

In the field of behavioral science, early researchers conducted a great deal of theoretical and empirical researches on risk perception, among which psychological measurement paradigm and risk cultural theory (Brown and Braver, 2008) are universally recognized. Among them, the psychological measurement paradigm is the most influential research tool in the field of risk perception, emphasizing the influence of individual's intuitive judgment and subjective experience on risk perception (Traczyk *et al.*, 2015), while the cultural theory of risk believes that risk perception depends on the social structure and culture of people's life (including belief and value). But most of the studies are relatively unexplanatory (Tom Schonberg *et al.*, 2011). The contemporary researches on risk perception in behavioral science has turned to disciplinary integration and hermeneutic risk perception.

Neural Mechanism of Environmental Risk Perception in Economic Management

Purpose and method of the experiment

In order to study the neural processing process and mechanism of risk perception in complex economic management environment, and whether there are differences in risk perception under different levels of economic management risk environment, this paper selects college students as subjects by using EEG signal analysis technique commonly used in cognitive neuroscience field, and applies pressure to the subjects economic management (reaction time) to simulate the situation characteristics of real economic management risk.

In the experiment, the ERPs method is mainly used, and the subjects are provided the scene pictures of a pilot fighter in a pair form, and the risk level is adjusted by changing the flight angle, obstacles, etc. (Adolphs, 2003). As shown in Figure 3, 40 pictures selected according to the different risks are divided into two groups: high-risk and low-risk. The subjects are allowed to quickly judge the risk degree of fighter in the picture scene by pressing keys (high and low key reaction), and scored (ranging from 1 representing very low to 5 representing very high). The neural mechanisms of environmental risk cognition in economic management are analyzed from the aspects of behavioral science and cognitive neuroscience by collecting ERPs in EEG signals of subjects (Porbadnigk *et al.*, 2015)

Experimental process and data acquisition

In a professional ERPs laboratory with sound insulation and light isolation, the subjects wear electrode caps to collect EEG data, and computer data were amplified by Neuroscan Synamp2 Amplifier system. In the experiment, in order to make the subjects focus their attention, the screen will appear 800-1200ms different "+," and then there will be 500ms empty screen. When the subjects see the fighter's flight situation picture, they should respond to press the key for the risk level as soon as possible (1500ms), and the data will be invalid if the time is exceeded. The

experiment is divided into 2 rounds, 80 times in total. In the course of the experiment, relevant measures are adopted to ensure the quality of the data collected by the computer. After the experiment, the original EGG data collected by the experiment are analyzed offline to obtain the total average ERP data of each case.

Figure 3. Example of different risk scenarios experiment picture

Results and analysis of the experiment

(1) Results and analysis of behavioral data studies

From the results shown in Figure 4, the average response time of high-risk situation is longer than that of low-risk situation, and almost 90% of the key-pressing response of high-risk and low-risk situation pictures is consistent with that in the pre-classification, which shows that the pre-classification of pictures is effective.

But paired t test (t(16)=1.963, p=0.066) had no significant difference in reality, indicating that there was no difference in response time between subjects in high-risk and low risk situations, and this result is also the same as previous research results.

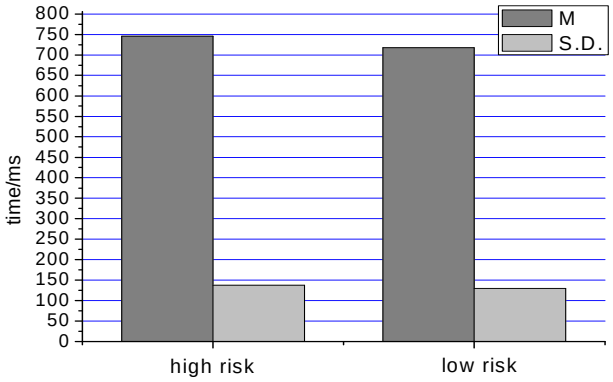

Figure 4. Average response time of different risk level key-pressing

(2) Results and analysis of EEG data

Through the experimental observation, we concluded that two key EPRs components were related to the mechanism of risk perception and they are P200 and LPP, which appear around 260ms and 450ms after stimulation, and both are positive waves.

1) P200 component

P200 is mainly distributed in the forehead area, so 6 electrode points are selected in the forehead area and the central forehead area, and two representative electrode points of FZ and FCZ are used for 2 × 6 repeated measurement variance analysis. Figure 5 shows the waveform of FZ and FCZ. Finally, the average amplitude of P200 in 250-280ms is selected for statistical analysis. The amplitude of high risk pictures (-0.37uv) is greater than that of low risk pictures (-1.81uv). The other significant results are shown in Table 1.

According to the experimental results, the amplitude of P200 component induced in the high-risk scenario is larger than that in the low risk scenario, and the subjects pay more attention to the high risk, which indicates that P200 component could pay attention to and deal with the early risk.

Table 1. P200 the degree of risk and the significant point of the electrode

Significant degree	F	P	η^2
The main effect of the degree of risk is significant	F(1,16)5.713	0.028	0.262
The main effect of the electrode is significant	F(5,80)4.002	0.015	0.261
The degree of risk and electrode interaction is not significant	F(5,80)1.757	0.160	0.098

Table 2. LPP risk level and electrode point significant situation

Significant degree	F	P	η^2
The main effect of the degree of risk is significant	F(1,16)13.832	0.002	0.463
The main effect of the electrode is significant	F(8,128)17.801	0.000	0.526
The degree of risk and electrode interaction is not significant	F(8,128)0.846	0.472	0.049

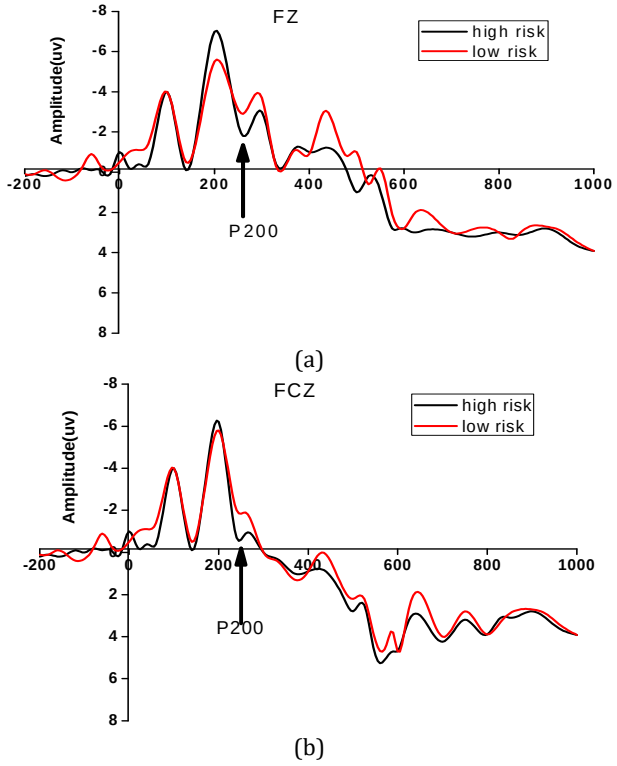

Figure 5. P200 waveforms of FZ and FCZ points

2) LPP component

LPP is distributed in the whole brain, 9 electrode points are selected in forehead and central parietal area, and two representative electrode points (FZ and CZ) are used to conduct 2×9 repeated measurement variance analysis. Figure 6 shows FZ and CZ waveforms. Finally, the average amplitude of LPP in 430-650 ms is selected for statistical analysis. The amplitude of high risk pictures (6.12uv) is greater than that of low risk pictures (4,63uv). The other significant results are shown in Table 2.

The analysis of the experimental results shows that the amplitude of LPP component induced by whole brain in high risk scenario is larger than that in low risk scenario, indicating that the high risk scenarios with stronger motivation can activate the motivation system and evaluate the subjective process of risk process, and LPP component can handle the late and more complicated information.

At the same time, the experiment shows that the subjects could recognize and evaluate the hidden risk information in the picture of risk scene, and the time period of subjects when P200 and LPP components are occurring is analyzed to confirm that the risk perception of economic management depends on the intuitive processing.

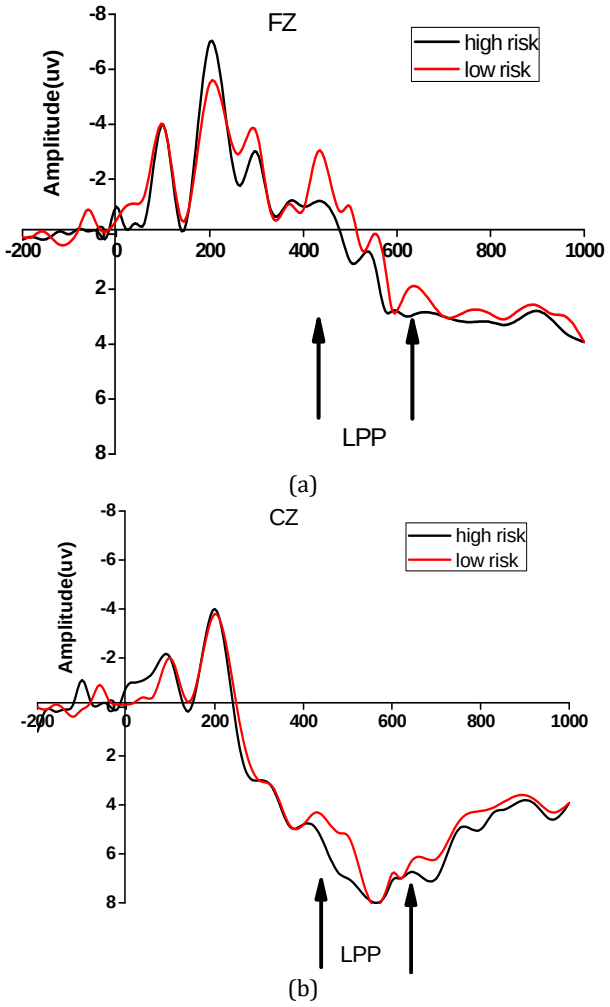

Figure 6. FZ and CZ point LPP waveforms

Conclusions

Based on the theory of behavioral science and cognitive neuroscience, this paper studies the neural mechanism of risk cognition in economic management by means of EEG signal analysis (ERPs) in cognitive neuroscience experiments after reviewing and summarizing the references at home and abroad, and draws the following main conclusions:

(1) The analytic results of behavioral data show that people can effectively distinguish

between high-risk and low-risk scenes, and there is no significant difference in time, but EEG data shows that high-risk and low-risk scenes can induce different P200 and LPP components.

(2) Compared with low-risk scenarios, high-risk scenarios can induce larger P200 and LPP amplitudes, indicating that P200 and LPP amplitudes are related to subjective evaluation and scoring of risk events.

(3) P200 component reflects the perception and detection of risk at the early stage, which is related to risk attention, while LPP component can process the late and more complicated information, which reflects the activation of motivation system and lasts a longer duration. The research result is also consistent with the two-stage model of risk perception.

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