Investment Behavior of Board Group Decision-making Based on Event-related Potential

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ABSTRACT

With the development of society, group decision-making plays a more and more important role. As an important part of decision-making field, group decision-making has obvious advantages in fairness, scientificalness and rationality compared with individual decision-making. At the same time, the final result of group decision-making is a result from negotiation with each member of the group participated in. Based on this, this paper studies the behavior of board group decision-making investment through electroencephalogram (EEG) experiment, simulates the process of board group decision-making investment behavior, and provides theoretical guidance for the generation of enterprise investment strategy.

Key Words: Event-related Potential, Group Decision-making, Investment Behavior, EEG Experiment

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Introduction

The board of directors has the decision-making power of the company's important matters, and the group decision-making behavior of the board of directors is a hot topic for research in recent years. Hirasawa *et al*., (2017) proposed that group thinking is a kind of common behavior in group decision-making process involves the psychological activities and behavior process of the members and leads to the failure of group decision-making. Franco and Värri (2015) pointed out that the board of directors suffers from "group thinking" as a larger team consisting of elites and making intermittent decisions. Teixeira *et al*., (2016) considered the investment behavior of group decision-making of board of directors plays an important role in the development of enterprises. While promoting the rationalization of group decision-making investment behavior of board of directors, it helps to produce and improve the corresponding theory guidance on the group decision-making of board of directors, enriches the related theories of group decision-making behavior and makes certain contributions to the research in this field.

Social choice theory is the origin of group decision-making research. Scholars such as Nuolas Cusanus and Roman Lull have made important contributions in this field. In modern times, Borda (1781) analyzed and studied the electoral system, and shared some of his views. After that, with the emergence of social choice theory and social welfare function, scholars pay more attention to the researches on group decision-making (Tang *et al*., 2016). Arrow (1951) summed up the previous research results, and put forward the axiom of preference and the theorem of impossibility, which laid a solid theoretical foundation for group decision-making. After that, many scholars have made in-depth studies on the theorem of impossibility and changed it, thus, producing different forms (Inkaew *et al*., 2015). Amartry K. Sen substitutes the choice function into the theorem

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of impossibility to obtain the possibility result of the social decision function. This research also makes a great breakthrough in group choice and social welfare. Some scholars questioned Arrow's theory and made it more scientific and reasonable by studying, so as to get the applicable decision-making rules. However, it was only in the 1980s that China started to study the related theories of group decision-making. The researches mainly focus on the theories and model methods. Compared with the foreign researches, the width and depth of the researches in China should be further improved. This is also the original intention of the author to conduct EEG research on the group decision-making investment behavior of board of directors (Hashemi *et al*., 2016).

To sum up, previous scholars studied group decision-making behavior mostly from the point of view of theories, analyzing and studying theories, model methods and others of group decision-making behavior, without an in-depth study of the behavior of a specific group. Therefore, Jeffrey *et al*., (2016) regarded that it is more realistic to study the group decision-making investment behavior of the board of directors through EEG experiment, which can simulate the process of investment decision making behavior of the board of directors, and further explore the brain nerve mechanism of board of directors in the process of group investment decision-making. From another point of view, Xian *et al*., (2016) reported that on the basis of this EEG experiment, the influencing factors of the investment decision-making behavior of the marketing board of directors are clarified to put forward the reference guidance for the investment development strategy of enterprises.

In the introduction of the paper, the background and significance of the research on the group decision-making investment behavior of the board of directors are expounded, the domestic and foreign research results are sorted out, a research problem is put forward with a basic hypothesis and studied with the EEG experiment, and the process and data results of the EEG experiment are described.

Research Hypotheses

In this experiment, the group decision-making investment behavior of the board of directors based on event-related potential is the research problem. Based on this, the following five hypotheses are put forward.

Hypothesis 1: It is assumed that no individual on the board can make a perfect decision and everyone may make a mistake.

Hypothesis 2: It is assumed that individual participants of the board have the possibility of making mistakes, and the board's investment decision-making is also full of risks and uncertainties.

Hypothesis 3: It is assumed that the result of group decision-making is influenced by individual preference, that's, the preference of individual participants is consistent or compromised, which conforms to Pareto principle.

Hypothesis 4: It is assumed that decision-making rule will affect the quality of the group investment decision-making of the board of directors.

Hypothesis 5: It is assumed that the relationship between the individuals and the board group will directly affect the quality of group decision-making investment.

Computer Experiment Process and Data Results

Experimental purpose

This study selects and makes use of the research method of event-related potential, and simulates the process of board group investment decision-making behavior as real and comprehensive as possible through the experiment paradigm of key-task correlation. Furthermore, we find out the inherent rules and relations of the individual neural mechanism of board individuals participating in decision-making. In this experiment, 16 individuals are randomly selected from the board of directors investment decision-making group to carry out the experimental study through the start-up-detection experiment paradigm, and the above hypotheses are verified by the specific EEG research.

Experimental method

(1) Experimental subjects

The experiment subjects are individuals from a private enterprise who participate in the investment decision-making of the board of directors, at the age of between 30-50 years old. After investigation, they have no any mental illness, and are in sound state without symptoms of physical discomfort. At the same time, they have good mental state and are suitable for participating in EEG experimental study.

(2) Experimental materials
All individuals involved in the experiment sit in comfortable chairs under a quiet experimental environment. They carefully read the experiment guidance, and complete the pre-experiment stage. First of all, on the screen in front of experimental subjects will appear a prompt "Experiment starts", which indicates that the experiment has officially started, and the experimental subjects will adjust their psychological state. Secondly, there will be a specific plan about the investment strategy on the screen, experimental subjects are provided with a certain time to think after carefully reading. At last, some questions about the enterprise investment strategies are put forward on the screen. The subjects read the questions and think, and answer the questions by pressing keys.

(3) Experimental procedure
Through the market investigation, the author knows the investment decision-making of the board of directors over the years, and determines that the investment strategic planning finally provided to the experimental subjects is a new investment strategic planning that the board of directors didn't involve before, in order to improve the scientificalness and reasonableness of the research on the group investment decision-making behavior of the board of directors.

Before the start of the experiment, the subjects should read the experimental procedure and sign the informed consent; the subjects should sit comfortable chairs under a quite experimental environment, and computers are placed at a distance of 90 cm in front of them with electrode caps of the conductive paste. At the same time, the subjects need to read the experimental guidance carefully. In order to make the subjects participate in the experiment better, they need to enter 20 pre – experiment trials to adapt to and familiarize themselves with the experimental situation before the formal experiment begins. In the whole experiment process, the subjects should complete four biock tasks, each of which takes 10 minutes, and at the same time, there is an interval between two tasks. At the beginning of the task, the word "Experiment starts" will appear on the computer screen in front of the subjects to remind them of adjusting the mentality into the experiment and focusing all the attention on the next experiment. Subsequently, there will be a brand new strategic planning of the investment on the screen, the subjects should spend 5 minutes to read carefully, after that, there will be a question about the strategic planning on the screen, and the subjects should carefully consider and answer. As long as the subjects follow the steps, understand the strategic planning of investment from their own perspective, and seriously answer each question. In the whole experiment process, the subjects can answer questions about the strategic planning of investment according to their own ideas, and express their opinions and ideas by pressing keys: 1 indicates agreement and 2 indicates disapproval.

(4) EEG data record
In the process of analyzing the time course of EEG data, the record is measured from 200 milliseconds before the question put forward to 800 millisecond after the question put forward. On this basis, the first 200 milliseconds before putting forward the question is selected as the baseline of data analysis. First of all, it's necessary to record and process the noisy point data presented by the experimental subjects, remove the influence data such as VEOG- blink of the eye, HEOG- movement of the eye, and myoelectricity to obtain the corresponding EEG data through selective processing. Subsequently, the EEG data obtained through the preliminary processing should be further superimposed and averaged, so that the final EEG data can be obtained. After data processing, we can obtain the corresponding ERP and waveform chart, select waveform chart, and analyze the EEG components to obtain the time window of EEG components and the data needed by the author. In addition, the repeated measurement variance to analyze and study various influence factors.

Analysis of behavior data
The so-called behavior data is the data corresponding to the self-behavior of the experiment subjects, specifically, recording the behavior data is to record the key-pressing result of the experiment subjects and the reaction time to a problem, and measure and evaluate the reaction of the experiment to belief. Approval rate of board group decision-making investment = number of key-pressing times for approval/number of all key-pressing times (i.e. number of key-pressing times for approval + number of key-pressing times for disapproval). In the whole process of data processing, the number of times that the experiment subjects don't press a

key is excluded, and the author generalizes this kind of situation as invalid reaction. The reaction time of group decision-making investment behavior refers to the time when the question appears to the time when the experiment subjects make a decision on this question, and also indicates the cognition and understanding of the experiment subjects to this investment decision-making problem, and then a thorough analysis and the research shall be carried out on this basis. In view of four conditions such as development intention, capital situation, market prospects and strategic planning, approval rate analysis and response time analysis are conducted. Based on the previous discussion, in the experiment, the subjects express their wishes by pressing keys, that's, their own recognition of the enterprise's investment strategic planning. Approval rate of board group investment decision-making=number of key-pressing times for approval/number of all key-pressing times (i.e. number of key-pressing times for approval+number of key-pressing times for disapproval).

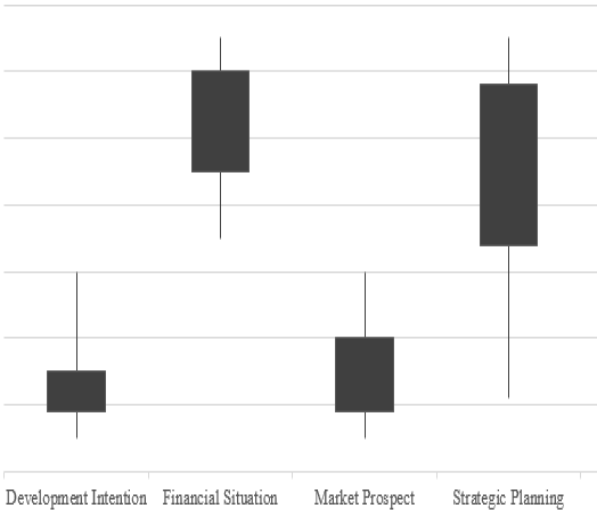

Figure 1. Box-plot of approval rate under four conditions

From Figure 1, it is obvious that the group investment behavior of the board of directors is more concerned with strategic planning and capital situation. Specifically, in terms of development intention, the approval rate of investment decision-making group: mean = 3.35% and standard deviation=3.12%; in terms of capital situation, the approval rate of investment decision-making group: mean=81.52% and standard deviation=15.42%; in terms of market prospect, the approval rate of investment decision-making group: mean=8.12% and standard deviation=7.13%; in the aspect of strategic planning, the approval rate of investment decision-making group: mean=64.15% and standard deviation = 26.95%.

EEG data analysis

(1) Analysis methods and steps of EEG data

By means of Scan4.3 EEG recording and analyzing system, the off-line analysis of EEG data is realized. The concrete process is as follows: merging data → processing and filtering out interference data, and then deleting them→ converting reference electrode → filtering → removing eye electricity → intercepting data segment for analysis → correcting baseline → removing artifact → superposing average → superposition among subjects → statistical analysis.

(2) Analysis of EEG components

Based on the above, the time course of EEG data is 1000ms, so that we can get the EEG wave pattern of development intention, capital situation, market prospect and strategic planning. Because of the time characteristics of EEG data analysis, that's, the difference can only be shown in a specific time window, the author obtains four kinds of EEG patterns through the experiment, analyzes N400 components, and makes analysis of variance by SPSS.

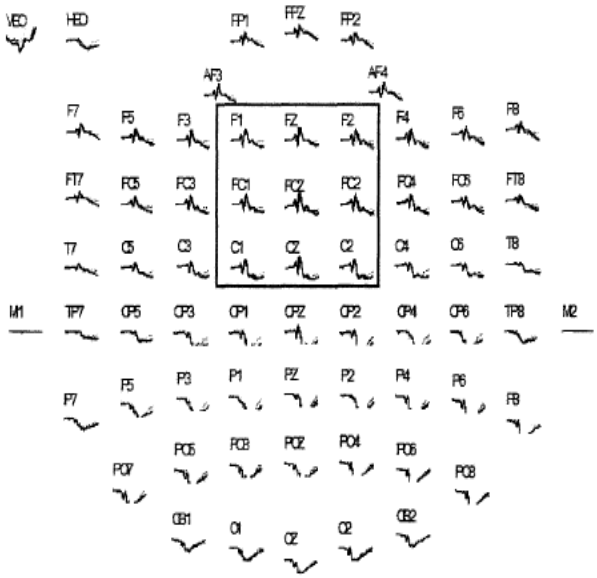

Figure 2. Distribution of electrode points of the whole brain

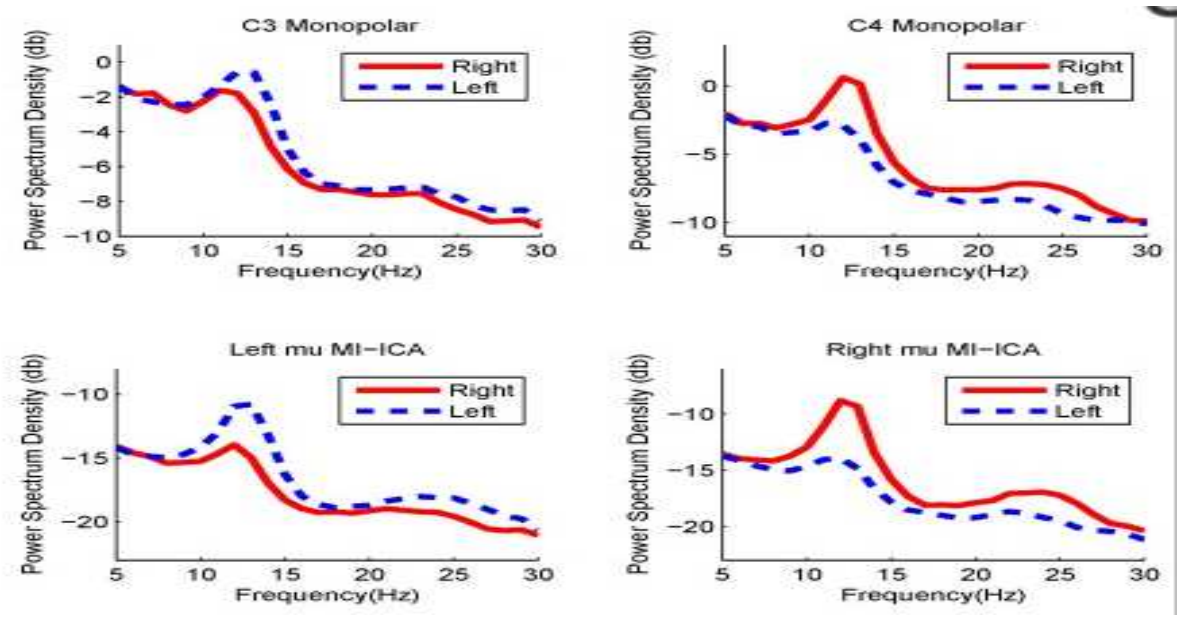

Figure 3. EEG pattern

Figure 4. Brain topographic map under four conditions- N400

Table 1. Analysis of correlation between N400 component and approval rate

Type	1	Z	2	C1	CZ	C2	1	Z	2
Pearson correlation	.256*	.236*	.256*	.234*	.239*	.243*	.247*	.233	.24
Significance (Both sides)	.033	.056	.056	.044	.044	.048	.051	.053	.058
N	4	4	4	4	4	4	4	4	4

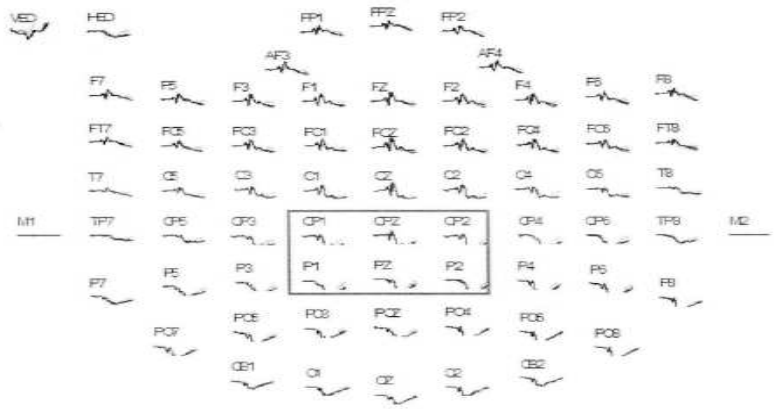

Figure 5. Distribution of electrode points of the whole brain

A. N400 EEG component analysis

The data in the time window of 300ms-400ms are selected and the average value of EEG voltage is analyzed. On the basis of previous studies, the electric wave floatation of N400 component in the anterior and middle areas is greater. Therefore,

according to the actual situation, the author chooses 9 electrodes to carry out the analysis as shown in Figure 2.

According to the above figure, four total average lines can be obtained by superimposing and averaging the four conditions of development intention, capital situation, market prospect and strategic planning. After repeated measurements and tests, combining with the results of variance analysis, the author find that there is a significant effect at the N400 component of various conditions. Specifically, the major effect of the 9 electrodes tested is significant, $F(8,8)=12.256$, $P=0.001<0.05$.

Through SPSS method, the voltage value of N400 component can be obtained to get the difference of development intention, capital situation, market prospect and strategic planning. Besides, the author draws brain topographic map to see the difference of these four aspects more intuitively, as shown in the following figure.

B. Analysis of correlation between N400 component and approval rate

In the process of activity, the brain determines the behavior result directly or indirectly, so the author can judge that there must be some relation between the brain activity and the behavior. Based on this, the author carries on the correlation analysis based on the data obtained above, that's, 9 electrodes of anterior and middle areas of the brain are selected to develop the correlation analysis and confirm the approval rate of the experimental subjects. The specific results are as follows.

From Table 1, the following results are obtained: there is a positive proportional relationship between the EEG components of N400 component of the first 7 electrode points and the approval rate. For example, the Pearson correlation system for F1 is 0.256, $P=0.033<0.05$.

C. LPP component analysis

The so-called LPP components, the late positive components that we often mention, have a specific latency, namely between 550ms and 650ms. The author consults a great deal of researches on LPP components and plotted EEG pattern from the data obtained (see Figure 5). From the practical point of view, the time window of 450ms-600ms is selected and the average value of EEG voltage is counted. On the basis of previous studies, the amplitude of LPP components in the top area reaches the maximum value, so six electrode points are selected as the objects of LPP component analysis, and the electrode points are CP1, CPZ, CP2, P1, PZ, and P2.

Brain waves are four average lines by superimposing and averaging based on four conditions of development intention, capital situation, market prospect and strategic planning. At the same time, after repeated measurement of variance analysis, it's found that the market prospect has a significant main effect on LPP components, while the development intention doesn't have a significant main effect.

It can be found that, from the perspective of market prospect, the behavior of group investment decision-making of the board of directors shows a positive wave with a greater amplitude. From the perspective of strategic planning, the behavior of group investment decision-making of the board of directors is more significant, and its amplitude is greater and more obvious.

To sum up, through LPP EEG patter and related data analysis, market prospects and strategic planning have more significant impact on the behavior of group investment decision-making of the board of directors. In addition, there are significant differences in the brain topographic map of LPP components under the above four conditions.

Conclusions

This study analyzes the behavior data and EEG data, and further explores the influence of four factors, namely development intention, capital situation, market prospect and strategic planning, on the behavior of group investment decision-making of the board of directors. Through EEG data, the influence result of the above four factors on the behavior of group investment decision-making of the board of directors is judged concretely and the previously mentioned hypotheses of the study are verified. According to Hypotheses 1 and 2, the main effect between the individuals of the board of directors and the board of directors as group is significant in investment decision-making behavior due to their thinking habit, behavior market prospect and development strategies. Based on the results of LPP data analysis, Hypothesis 3 is verified: the results of group decision-making are influenced by individual preferences, that's, the preference of participating individuals is consistent or compromised, which is in accordance with Pareto principle.

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