



Effect of Risk Preference on Entrepreneurial Cooperative Behavior in Industrial Clusters: Based on Neuromanagement and Event-Related Potentials Experiment

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ABSTRACT

The tendency and risk preference of individual behavior affect the cooperative intention and behavior choice of entrepreneurs in industrial clusters. In this study, Event-Related Potentials (ERP) experiment was added to IGT, to investigate the influence of high and low risk preference on the entrepreneur's cooperative behavior. We obtained the related behavioral and ERP data to analyze the entrepreneur's behavior selection. The results showed that there is the greater amplitude of P300 and the smaller amplitude of FRN in high risk preference individuals than that of low risk preference individuals regardless of the feedback of cooperative or non-cooperative behavior words. The t-test results showed that there are the significant differences in the selection ratio and the average response of non-cooperative option were found between the two risk preference types. The non-cooperative behavior intention of high risk preference individuals is higher than that of low risk preference individuals. Therefore, the risk preference has a significant influence on the cooperative behavior intention of entrepreneurs, and the non-cooperative behavior intention of the high risk preference individuals is higher than that of the low risk preference individuals.

Key Words: Entrepreneurial Cooperative Behavior, Risk Preference, ERP Experiment

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Introduction

In the cluster market, there exists the relationship of competition and cooperation among cluster manufacturers (Barnett, 1987). There is a "symbiotic" relationship among neighboring manufacturers or enterprises (Chen *et al.*, 2003). Local resources are the keys to determine whether competitions among manufacturers of the same industry in a region occur (Zhou, 2008). Cluster is a dynamic market relationship between cooperation and competition. There is an interactive evolution between a cluster and the entrepreneurs in the cluster. A large number of

studies showed that in the initial stage of cluster development, external effects, clustering factors and collaboration had no much impact on the cluster, while entrepreneurial activities, their aspirations to build new businesses under risks, and their abilities to access to existing technologies and markets are decisive for the emergence of these clusters.

In the process of entrepreneurs' decision on cooperation or not, the individuals' behavior tendency is the risk decision-making (Zhang, 2017). Early scholars explained the cognitive mechanism of selection preference from the

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behavior of risk decision (Song *et al.*, 2016), and focused on the characteristics of brain nerve activity corresponding to various behavior preference functions, such as the active characteristics of brain functional areas (Wang, 2017) and the Event-Related Potentials (ERP) characteristics of corresponding preferences (Organ, 1997). The related behavioral preferences can be explained from the perspective of neuroscience, so that the decision-making and behavior can be more objectively and deeply understood. In this study, ERP experiment is used to evaluate and verify the relationship between risk preference and entrepreneurs' non-cooperation and cooperation in a cluster, promoting the mutual benefit of entrepreneurs in the cluster (Hajcak, 2005).

Methods

This study assumes that the cooperative behavior intention is different based on types of entrepreneurs' risk preference and the non-cooperative behavior intention of entrepreneurs with low risk preference is lower than that of entrepreneurs with high risk preference. The non-cooperative behavior intention of the subjects in the experiment will be inferred from the behavioral indicators of the subjects.

The main purpose of experiment design is to study the influence of risk preference on entrepreneurs' non-cooperative behavior. ERP is used to explore the influence of risk preference on entrepreneur's cooperative behavior which type of entrepreneurs' non-cooperative behavior intention is higher among entrepreneurs with high and low risk preference. The change of their ERP characteristics is studied.

Experimental indexes and objects

(1) Determination of ERP physiological index

P300. P300 is an endogenous component related to mental resources such as attention, cognition and motivation. It is a cognitive process of cognitive evaluation, decision-making and memory updating of stimulus information. Many studies have shown that the P300 is related to risk preference and risk decision-making. Hajtake *et al.*, (2005) found in money gambling task that the valence emotion could induce larger P300 than neutral emotion, and the positive emotion caused a larger P300 than the negative emotion. In the gambling experiment, it was shown that positive feedback could induce P300 wave amplitude (Yeung *et al.*, 2004), and the P300

wave amplitude of individuals with risk preference differ in different scenarios (He *et al.*, 2008).

FRN. The hypothesis of emotional motivation (Li *et al.*, 2008) suggests that FRN is an emotional response of the brain to incorrect behavior or negative feedback. FRN is not a signal of wrong detection. The function of brain processing system reflected by FRN has reached beyond the right and wrong of behavior itself, further has entered the advanced processing of the value of behavior and the relationship between behavior and simulation scenarios. It was revealed that the FRN amplitude of individuals with high risk preference is significantly different from that of individuals with low risk preference (Liu *et al.*, 2012). The component of FRN caused by negative feedback is closely related to passive feedback.

According to the above theory and the results of previous studies, P300 and FRN are considered as the ERP physiological indicators of this research.

(2) Determination of entrepreneurial behavior index

The experimental indexes are selected based on the research in the field of risk decision. Therefore the final behavioral indexes include correct rate, response time, selection ratio, decision-making time, and risk-taking rate, (Zhang *et al.*, 2003; Xiao *et al.*, 2005; Ma *et al.*, 2009; Zhao *et al.*, 2012; Zhong *et al.*, 2013; Zaccone *et al.*, 2017) among which correct rate, the selection ratio and the risk-taking rate belong to the ratio indexes, while the response time and the decision-making time belong to the time indexes. The ratio and the decision-making response time of the risk-taking option are selected as the behavior data indexes. The selection ratio of risk-taking option is obtained through dividing times of selecting risk-taking option by times of selection option appearing, which reflects the risk-taking behavior tendency of the decision-makers to a certain extent. The response time of decision-making refers to the time from beginning of seeing the decision-making simulation scenarios to making choices by pressing the buttons. To some extent, it reflects the cognitive and emotional processing of decision-making psychology.

Paradigm of gambling task in ERP experiment

In the aspect of experimental paradigm, the experimental research on risk preference in the



field of traditional economics is mainly carried out through gambling experiments. A large number of experiments have proven that the subjects' performance in the Iowa Gambling Task (IGT) (Li *et al.*, 2012) fits well with people's decision-making in real life, which verifies the validity of the task (Rogers *et al.*, 2004). There is also a game between risk-taking behavior and risk-avoiding behavior that are the main contents of risk preference in this task. Therefore, it is appropriate to use the IGT to investigate the behavior differences of individuals with risk preferences in the decision-making process.

Based on the gambling experiment of traditional economics, the ERP acquisition system is added to form a new paradigm of ERP gambling task. According to Martin and Pltts's (2009; 2011) experimental paradigm, in our study the original four options of the IGT was changed into two options on operation interface, including cooperative behavior and non-cooperative behavior with entrepreneurs in industrial cluster.

Selection of experimental objects

47 industrial cluster entrepreneurs were selected via the risk preference questionnaire designed by Hsee *et al.*, (1997). The subjects' RPI scores were ranked from high to low, of which the first 8 subjects were selected to be the high risk preference group and the last 8 subjects as the low risk preference group. Their RPI scores were carried out by t-test. The results of t-test were as follows: $t=9.42$ ($p<0.05$), indicating that there were significant differences in the scores of high and low risk preference groups, so 16 subjects were selected to participate in the experiment.

The specific experimental model is shown in Figure 1 below:

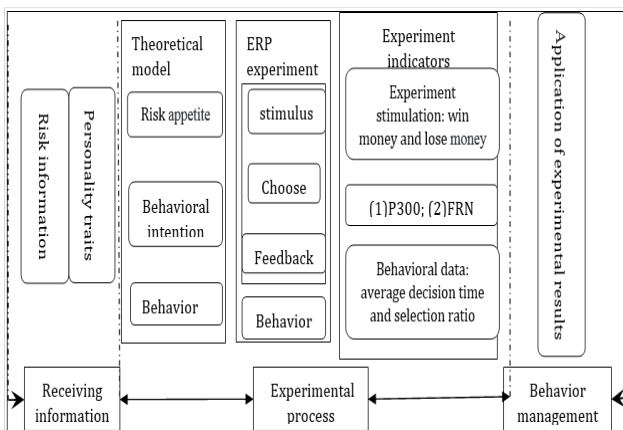


Figure 1. The experimental model

Experimental Process

Experimental materials

The feedback of the two options in the experiment is designed according to the rules of Bechara *et al.*, (1994), and two types of stimulation control are established in the experiment. The first one is cooperative behavior word stimulation, and less reward amount of the subjects are along with less penalty amount, when the options are selected. The second is the word stimulation of non-cooperative behavior, and more penalty amount bring more reward amount, but it is seen as a loss in the long run.

Subsequently, in the high risk option, there are five times of obtaining 125 dollar profits every twelve options, and five times of losses ranging from 75 to 275 dollar, and twice of zero, with a final net loss of 250 dollar. In the low risk option, there are five times of obtaining 75 dollar profits every twelve options, and five times of losing 5 to 45 dollar, and twice of zero, with a final net yield of 250 dollar.

In the experiment, every 12 options are presented at random, but the net yield or net loss amount is fixed. Six of the most common descriptive words are selected from the relevant studies as the material (Nie, 2008; Li, 2010). The descriptive words of cooperative behavior include synergy, economies of scale, lower transaction costs, sharing of resource information, expanding of market share and specialization of labor. Descriptive words of non-cooperative behavior include cost increase, non-durable competitive advantage, leakage of technology, information and resources, brain drain, reduction of strategic space, and retaliatory behavior of other entrepreneurs.

Experimental process

Before the experiment, the subjects are divided into high risk preference group and low risk preference group, with 8 subjects each group. In the experiment, the vertical electro-oculography (VEOG) is placed at 1.5 cm above and below the left eye, and the Horizontal electro-oculography (HEOG) is placed at 1.5 cm lateral of eyes. The reference electrodes M1 and M2 are respectively arranged on the left and right sides of the mastoid. The condition is the impedance between scalp and electrode should be less than 5K. During the sound insulation and magnetic isolation test, subjects are reminded of selecting a comfortable sitting position, with their eyes looking up at the computer monitor. The



stimulation program is generated by E-prime2.0, and the background color is black. if the words are selected on the left side of the screen, press the key "1" on the keyboard; if the words are selected on the right side of the screen, press the key "2" on the keyboard. The experiment has 3 blocks, and each block has 40 trails, 120 trails in total. Each experiment lasts about 10 minutes.

The specific process of each trial is as follows: Firstly, the point of view of 800 ms red "+" symbol is used to remind the subjects to start the experiment and keep attention in the center of the screen. Then the computer screen will present two words, one describing the non-cooperative behavior and the other describing the cooperative behavior. These two words respectively represent two options, the non-cooperative option and the cooperative option. The subject should select one of the two words presented on the screen, and the computer will give feedback to the subject after making the decision. After 900ms, the total bet of the subject (the original amount owned by the subject is 2,000 dollar) appears, and the subject enters the next trial after confirmation.

Experimental equipment and data analysis

In the experiment, Neur One ERP system is used to accomplish gambling task, and 64 conductive caps that conform to international standard are applied to collect ERP data. The response time of the subjects is extracted from the data recorded in E-prime2.0, and the selection ratio of non-cooperative option and the average response time of the subjects are calculated. EEGLAB is used to analyze ERP data (Wang *et al.*, 2016). Data were analyzed by T test and two-factor variance analysis using SPSS17.0 software. P<0.05 was considered significant.

Results

Behavioral data

The selection ratio of non-cooperative option in the high risk preference group was significantly

higher than that of the low risk preference group as shown in Figure 2, and the response time of the high risk preference group is significantly lower than that of the low risk preference group, as shown in Figure 3.

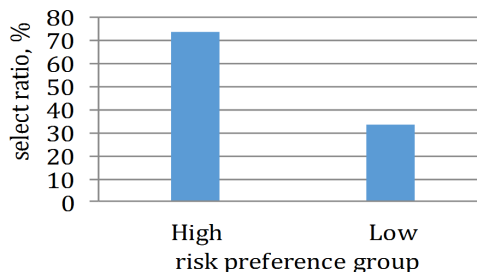


Figure 2. the selection ratio of subjects

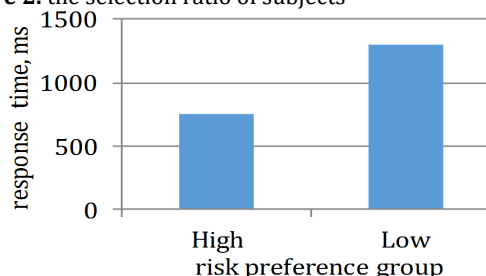


Figure 3. The average response time of subjects

Independent sample T test is performed on the behavior data of the two groups. The results showed that there was significant difference in the selection ratio of non-cooperative option in the high risk preference group ($t=3.647, p<0.05$), as shown in Table 1. There was significant difference in response time between the two groups ($t=-2.190, p<0.05$), (seen in Table 2).

ERP data

When FRN and P300 are selected, AF7, FP1, FPZ, FP2, AF8, AF3 and AF4 of forehead and central region of ERP electrode cap (Ag/AgCl64 connected Neuron electrode cap) are analyzed. According to the selection of different keys (non-

Table 1. Selection ratio analyzed by independent sample T-test

		Levene test		T test			
		F	Sig.	t	df	Sig.(Two-tailed)	Mean difference
Selection ratio	Equal Variances Assumed	1.689	0.221	3.647	10	0.002	46.796
	Equal variances not assumed			3.647	9	0.002	46.796

Table 2. Response time analyzed by independent sample T-test

		Levene test		T test			
		F	Sig.	t	df	Sig.(Two-tailed)	Mean difference
Response time	Equal Variances Assumed	0.569	0.345	-2.190	10	0.043	-4.538
	Equal variances not assumed			-2.190	11	0.045	-4.538



cooperative behavior words and cooperative behavior words) by the subjects in the high and low risk preference groups, two (group of subjects) × 7 (electrode point position) repeated measurement variance analysis is performed on FRN and P300, respectively. When necessary, Greenhouse-Geisser is used to correct p value. FRN is average amplitude of 200-300ms, and P300 is average amplitude of 300-500ms.

(1) ERP analysis induced by non-cooperative behavior option

P300. The results of P300 amplitude induced by the non-cooperative behavior option showed that the main effect of the group type of subjects was significant ($F(1,26)=25.23, p<0.001$); the main effect of electrode position was significant ($F(1,26)=213.98, p<0.001$). The interaction between the group of subjects and the electrode position was significant ($F(1,26)=22.14, p<0.001$), as shown in Table 3. The P300 amplitude induced by the non-cooperative behavior option was shown in Figure 4.

FRN. The results of FRN amplitude induced by the non-cooperative behavior option showed that the main effect of the group type of subjects was significant ($F(1,26)=19.62, p<0.001$); the main effect of electrode position was significant ($F(1,26)=132.83, p<0.001$). The interaction between the group of subjects and the electrode position was significant ($F(1,26)=17.48,$

$p<0.001$), as shown in Table 4. The FRN amplitude induced by the non-cooperative behavior option is shown in Figure 5.

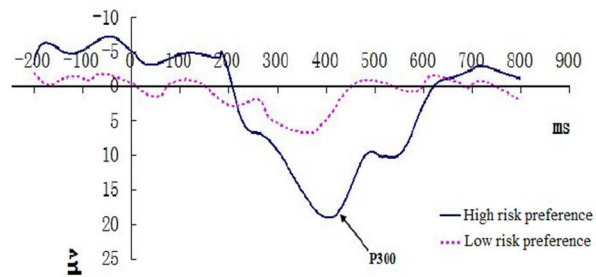


Figure 4. P300 waveform diagram of subjects in high and low risk preference groups in non-cooperative behavior option stage

(2) ERP analysis induced by cooperative behavior option

P300. The results of P300 amplitude induced by cooperative behavior option showed that the main effect was significant ($F(1, 25)=19.05, p<0.001$). The main effect of electrode position was significant ($F(1, 25)=144.20, p< 0.001$). The interaction between the group of subjects and the electrode position was significant ($F(1, 25) = 18.99, p<0.001$), as shown in Table 5. P300 amplitude induced by cooperative behavior option was shown in Figure 6.

Table 3. P300 amplitude variance analysis of non-cooperative behavior option in high and low risk preference groups

	Source of variation	SS	df	MS	F
Intragroup	1 Electrode position	4069.58	1	4069.58	213.98***
	2 Electrode position * Group of subjects	383.68	1	383.68	22.14***
	3 Error (Electrode position)	460.98	26	20.18	
Intergroup	Group of subjects	2389.45	1	2389.45	25.23***
	Error	2400.02	26	89.47	

Note: *** $p<0.01$, (similarly hereinafter)

Table 4. FRN amplitude variance analysis of non-cooperative behavior option in high and low risk preference groups

	Source of variation	SS	df	MS	F
Intragroup	1 Electrode position	1576.58	1	1576.58	132.83***
	2 Electrode position * Group of subjects	323.69	1	323.69	17.48***
	3 Error (Electrode position)	364.35	26	19.50	
Intergroup	Group of subjects	1359.64	1	1359.64	19.62***
	Error	1689.40	26	59.86	

Note: *** $p<0.01$, (similarly hereinafter)

Table 6. FRN amplitude variance analysis of cooperative behavior option of subjects in high and low risk preference groups

	Source of variation	SS	df	MS	F
Intragroup	1 Electrode position	1278.22	1	1278.22	77.57***
	2 Electrode position * Group of subjects	359.34	1	359.34	21.21***
	3 Error (Electrode position)	425.45	25	18.86	
Intergroup	Group of subjects	298.18	1	289.18	6.17***
	Error	1424.96	25	55.69	

Note: *** $p<0.01$, (similarly hereinafter)



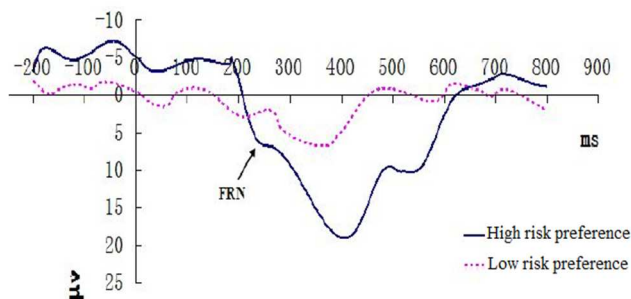


Figure 5. FRN waveform diagram of subjects in high and low risk preference groups in non-cooperative behavior option stage

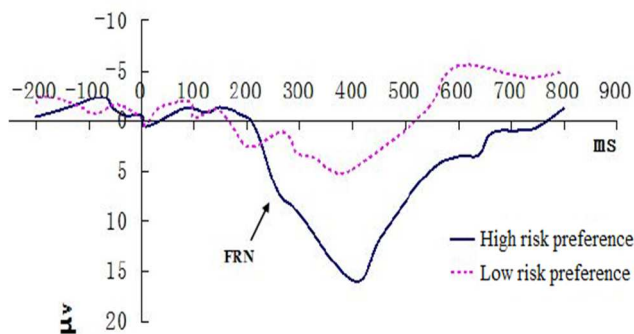


Figure 7. FRN waveform diagram of subjects in high and low risk preference groups in cooperative behavior option stage

Discussion

Coordination Analysis of P300 and behavior data

The ERP data showed that the higher P300 waveform was produced in the high risk preference group whether it is from the word feedback of cooperative or non-cooperative behavior. The behavioral data displayed that the selection ratio of non-cooperative option in the high risk preference group was significantly higher than that of low risk preference group. A number of scholars' studies have also confirmed that the sudden appearance of a different stimulus among the numerous stimuli produces significant P300 amplitude.

In this experiment, when subjects in the high risk preference group chose the non-cooperative behavior, the negative feedback often appears in its expectation. However appearance of the positive feedback makes the individual feel surprised and excited. At this time, the higher positive feedback greatly attracts the attention of the subjects, resulting in the higher P300 amplitude. Conversely for low risk preference group, the high feedback generated by the non-cooperative behavior option is not as strong as those who chose the high feedback generated by the cooperative behavior option therefore the

generated P300 amplitude is small, which is also supported by the behavioral data. When a large amount of feedbacks attract the attention of the high risk preference individuals, they are more likely to select non-cooperative behavior option. So the selection ratio of the non-cooperative behavior option is also higher than that of the low risk preference individuals.

Coordination Analysis of FRN and behavioral data

The change of FRN amplitude induced by cooperative option or non-cooperative option was more significant in low risk preference individuals. Individuals have their original forecast and expectation before making a decision. When the brain's evaluation system finds that the true feedback is lower than the expectation, there is significant alteration in FRN amplitude. The prospect theory also holds that individuals make decisions according to their own criteria rather than the absolute utility value of the decision-making scheme.

According to the hypothesis of Economic Man, individuals expect reward feedback when decision-making. If the actual situation is inconsistent with the preset standard, individuals with both types of risk preference will produce FRN. Therefore, the change of FRN amplitude may not be enough to indicate that individuals with low risk preference disincline to choose the non-cooperative behavior, what's similar is that individuals with high risk preference incline to choose the non-cooperative behavior. The results of behavior data in this study verify the above analysis. Behavior data show that the selection ratio of non-cooperative option in the low risk preference individuals is lower than that of high risk preference individuals. At the same time, low risk preference individuals have more significant FRN than high-risk preference individuals, i.e., low risk preference individuals are desirable to rewards and sensitive to losses during completing related tasks. Nevertheless, if the actual conditions are inconsistent with the expectations of the subjects in the experiment, a significant FRN will be induced.

Conclusions

(1) For cooperative or non-cooperative behavior words, there are the greater amplitude of P300 and the smaller amplitude of FRN in high risk preference individuals than that of low risk preference individuals.

(2) The t-test results show that there are significant differences in the selection ratio and the average response of non-cooperative option between the two risk preference types.

(3) Risk preference has significant influence on entrepreneur's non-cooperative behavior intention. The non-cooperative behavior intention of high risk preference individuals is higher than that of low risk preference individuals. High risk preference individuals are more prone to non-cooperative behavior.

Suggestions

Different from single enterprise resources, the cooperation among entrepreneurs forms the integration ability of industrial cluster resources. Through the cooperation within the cluster, entrepreneurs coordinate and control various resources, enhance the cohesion of the cluster, then serve as the communication bridge within the cluster and between the clusters with outsiders, and finally obtain the external support through the exchange and cooperation with the external environment. For the communication among the related enterprises within the cluster, the entrepreneurs, as the leading core of the enterprises, visit and communicate with each other, which makes the enterprises understand each other and use the same or similar technology, thus bringing competitive pressure to the enterprises. This in turn urges enterprises to continuously carry out technological innovation, further improve the cooperation of the entire cluster, which plays a tremendous role in improving the social status of the cluster.

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