Analysis of Entrepreneur Mental Model and Construction of its Portrait

Yongzhong Zhang[1], Yonghui Dai[2,*], and Haijian Chen[1]

[1] Institute of science and technology, Shanghai Open University,
Shanghai 200433, China
1502235429@qq.com, xochj@sou.edu.cn
[2] Management School,
Shanghai University of International Business and Economics,
Shanghai 201620, China
daiyonghui@suibe.edu.cn

Abstract. Previous studies have shown that the mental model of entrepreneurs has a significant impact on the growth of entrepreneurial enterprises. This paper explores a new method to analyze entrepreneur mental model and construct its portrait. Firstly, according to existing research results, this paper summarizes three key factors that affect entrepreneurial mental model: prior knowledge, personality characteristics and opportunity perception. Since then, the methods of entrepreneur mental portrait are introduced, which including cluster analysis method and fuzzy comprehensive evaluation method. Based on the investigation and analysis of 277 entrepreneurs, our study shows that the above construction method of mental model can accurately describe the entrepreneur mental model. The contribution of this paper is to explore the mental division of different types of entrepreneurs, and give the method of mental portrait of entrepreneurs, which provides a meaningful reference for promoting innovation and entrepreneurship education and training.

Keywords: Entrepreneur mental model, Mental portrait, Innovation and entrepreneurship, Data mining.

1.   Introduction

In recent years, great changes in the global economic situation and the development of information technology have brought opportunities for the development of entrepreneurship. As a new engine of economic growth and enterprise transformation, innovation and entrepreneurship play an active role in promoting technological reform, enhancing product competitiveness and expanding employment. However, after the establishment of the enterprise, it needs to face many problems in the development process of the enterprise, such as the entrepreneurial environment, the entrepreneurial team, the integration of entrepreneurial resources, market competition etc., which makes the failure rate of entrepreneurship very high. Statistical data shows that the average life expectancy of Chinese private enterprises is 3.7 years, and the average life expectancy of SMEs is even shorter, it is only 2.5 years [10]. Previous studies have found that the mental model formed

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* Corresponding author

by entrepreneur personality characteristics, inherent temperament and experience has significant impact on the grasp of entrepreneurial opportunities, risk recognition, team building, social capital utilization and decision-making behaviors, which are the key factors for successful entrepreneurial practices. Therefore, the mental model of entrepreneurs has always been the focus of entrepreneurial education and training in recent years.

This paper is organized as follows. In section 2, literature review of mental model is introduced. In section 3, the analysis of entrepreneur mental model is shown, which including prior knowledge, personality characteristics and opportunity perception. In section 4, the construction of entrepreneur mental portrait is illustrated. In section 5, experiment and analysis are shown. In the end of section, the conclusion of this paper is described.

2.   Literature Review

Mental model was first proposed in the field of psychology. Psychologists believe that the mental model is a combination of a person's inner psychology and the person's own intelligence. It explains the internal cognitive process constructed in people's brain that affects people's understanding, interpretation and facing the world [2][7]. Since then, the mental model has been improved by scholars from different disciplines and developed into a mental model theory [3]. In the definition of mental model, scholars understand from different professions and give their own definition of mental model. For example, some scholars think that mental model is a model that reflects the objective world constructed by individuals after observing the real world. It refers to the individual's interpretation of the objective world or reasoning and decision-making based on the objective world [15]. Mental model is closely related to the human brain. It is a temporary representation of the problem situation in the short-term memory of the brain when people recognize things in life, or the stable representation of the external world stored in long-term memory [4]. The formation of mental model can be seen as a kind of mapping of external things in the brain. It may not only come from the continuous accumulation of experience and knowledge of daily life, but also be formed by the instantaneous stimulation of external things to the brain [6][22]. Mental model is a 'small model' constructed by human brain itself corresponding to the real world after observing various things in the real world are stimulated. The model can be used for prediction, logical reasoning, or as the basis for explaining phenomena [12]. In the mental model, the mind represents the inner psychology of human beings, while the model refers to the external manifestation of human beings, which is related to individual characteristics. Therefore, mental model abstracts the internal characteristics of people's inner thoughts into an external form of expression [20]. Generally speaking, mental model can be regarded as the sum of the human brain's perception of what is seen and heard in real life, and the resultant psychological activities and thinking response ability. The generation process of mental model is shown in Fig. 1.

Entrepreneur mental is the psychological activity and thinking mode of entrepreneurs in the process of starting a business. It is also the sum of their thinking ability to make initial judgment and analysis on external things or events [21]. On the view of entrepreneurship mental model, scholars' research perspectives mainly include the content, influencing factors, cognition and function of entrepreneurship mind. For example, some scholars believe that entrepreneurs are the core factor that determines the success of entrepreneurship, and the minds of entrepreneurs play a key role in it [14]. Some scholars took entrepreneurs
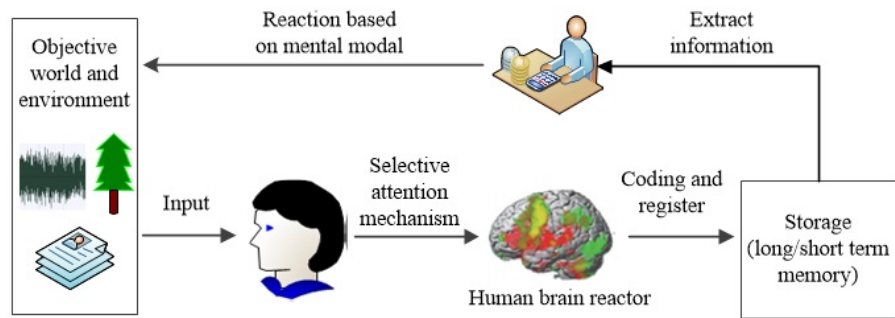
Fig. 1. The generation process of mental model

as the research object and analyzed their management behaviors and put forward the view that unique thinking, independent thinking, and risk-taking are typical qualities of entrepreneurs [5][1]. Some scholars have studied the minds of entrepreneurs from the two dimensions of prior knowledge and belief systems, and pointed out that the knowledge of entrepreneurs' innovation opportunities reflects the Entrepreneur prior knowledge, vigilance, beliefs, cognitive models and other cognitive elements Complex mental process [18][13]. The above research results provide a good reference for the study of entrepreneur portraits in our study.

3.   Analysis of Entrepreneur Mental Model

In the research of entrepreneur mind, although scholars have studied the Entrepreneur mental model from different perspectives, the conclusions obtained are also different to some extent, but on the whole, the research on Entrepreneur mental model can be summarized into three dimensions: prior knowledge, personality characteristics and opportunity perception.

3.1.   Prior Knowledge

Previous studies have shown that entrepreneurs with previous entrepreneurial experience will have an advantage over those without entrepreneurial experience. Entrepreneurs with entrepreneurial experience can quickly form judgments on the current situation and make optimal response plans in the face of sudden changes in the environment. Their accumulated experience and prior knowledge can prevent risks and seize opportunities through vigilance.

Entrepreneurial experience mainly refers to the practical experience and industry experience of entrepreneurs [19]. Under the guidance of previous experience, entrepreneurs can experience more entrepreneurial insights or capture more valuable information in the process of entrepreneurship, so that it is easier to identify the entrepreneurial opportunities in favor of their own enterprises. However, those entrepreneurs who haven¡̄t started a business before, such as college students who start a business for the first time. They haven't entrepreneurial experience and lack the knowledge reserves in this area, so their

understanding of entrepreneurial opportunities and business information is weaker than those with entrepreneurial experience, which affects their entrepreneurial performance. Based on previous research results, we selected accumulated information, technical capabilities and entrepreneurial ideas as the measurement factors.

3.2. Personality Characteristics

Individual personality trait is a description of individual personality characteristics. It is a relatively stable personality characteristic, which has both innate part and acquired part. For entrepreneurs, entrepreneur characteristics are the description of the Entrepreneur internal psychological characteristics, which refers to the Entrepreneur own personality, cognitive bias, motivation and so on. It is the personality characteristics based on personal physiology, which will change under the influence of the surrounding environment and situation. It is the synthesis of the potential innovative thinking and behavior mode of the entrepreneur, such as the entrepreneurial intention of the entrepreneur Different characteristics of willingness and passion, determination and creativity compared with non-entrepreneurs. Some scholars have studied the relationship between personality characteristics and entrepreneurial performance. They found that the stability, extroversion and suitability of personality have a positive impact on team shared mind and team performance [16].

3.3. Opportunity Perception

Entrepreneurial opportunity perception refers to the business opportunities that are beneficial to start-up enterprises. Entrepreneurs can turn the opportunities into valuable products or services and provide them to customers so that they can get benefits. The identification of entrepreneurial opportunities is very important to start-up enterprises, which is an important factor for the smooth development of start-up enterprises. There are also different views on entrepreneurial opportunities due to different research perspectives. Some scholars believe that when supply and demand are unbalanced in the market, there will be entrepreneurial opportunities; some studies believe that the identification of entrepreneurial opportunities is a process of subjective psychological perception; some scholars regard entrepreneurial opportunities as the starting point of entrepreneurship. Entrepreneurial opportunity identification is the thinking process of acquiring and identifying things, and the process of entrepreneurs' perception and discovery of opportunities, and then starting new businesses and new enterprises.

In the dynamic process of entrepreneurship, if entrepreneurial enterprises cannot identify opportunities sensitively, they will easily fall into development difficulties. Some scholars believe that entrepreneurial opportunities are closely related to the ability of entrepreneurs to identify opportunities. Entrepreneurial opportunities change with the environment, market, customers and other factors. For start-up enterprises, the identification of entrepreneurial opportunities needs entrepreneurs to judge whether the opportunities are operable after examining their own qualifications, capabilities and partners. In terms of the source of entrepreneurial opportunities, some scholars believe that entrepreneurial opportunities exist in the objective world, only need entrepreneurs to identify them; entrepreneurial opportunities are created by entrepreneurs using their own talents;

entrepreneurs can identify suitable entrepreneurial opportunities by observing the environment, conditions, etc., using wisdom, technology and other means. Generally speaking, entrepreneurial opportunity identification is affected by the factors of opportunity discovery and opportunity identification.

4. Construction of Entrepreneur Mental Portrait

4.1. Framework of Entrepreneur Mental Portrait

Entrepreneur mental portrait, namely the labeling of Entrepreneur mind. It refers to a labeled Entrepreneur mental model abstracted from the Entrepreneur basic information and entrepreneurial activity characteristics. It is a means of using labels to depict the entrepreneur appearance. Our study combines the mental model measurement methods based on psychological response and physiological index response, and uses cluster analysis, association rule analysis and fuzzy synthetic evaluation to construct entrepreneur mental portrait. The framework of entrepreneur mental portrait is shown in Fig. 2.
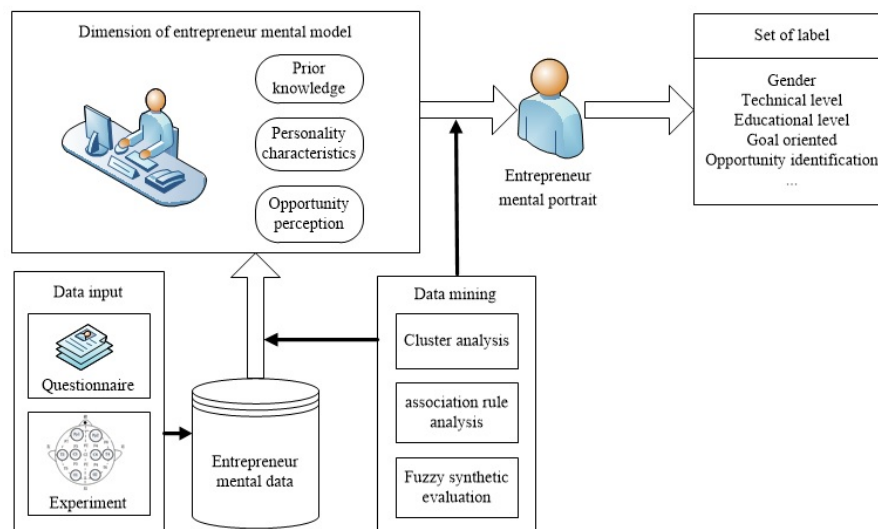

Fig. 2. Framework of entrepreneur mental portrait

It can be seen from Fig. 2 that the mental portrait of entrepreneurs mainly includes the following processes. Firstly, the Entrepreneur mental data are collected through interview survey, questionnaire survey, interview and experimental observation, and then data mining methods such as classification, cluster analysis and association rule analysis are used to draw the three dimensions of entrepreneur mental, namely, prior knowledge, personality characteristics and opportunity perception. After the above process, the set of entrepreneur mental label is given, then the entrepreneur mental portrait is complete. In order to get the ideal portrait, data mining is needed to process the data. The following is the introduction of clustering analysis algorithm and fuzzy synthetic evaluation method.

4.2.   Clustering Analysis

Clustering analysis refers to the process of similar division of data sets by some rules and methods [17]. It originated from numerical taxonomy. In the past, people mainly rely on experience or professional knowledge to classify things. With the advent of information technology and big data era, only relying on experience and professional knowledge cannot meet the complex classification requirements. Therefore, the numerical classification based on mathematical tools is applied to the classification of things, and clustering analysis is produced. After years of development of clustering analysis, the current clustering analysis methods have formed many algorithms, such as k-means algorithm, Clara algorithm, PCM fuzzy clustering algorithm, SOM self-organizing neural network clustering algorithm, etc [8][9]. Among, the process of improved k-means algorithm is shown in Fig. 3.
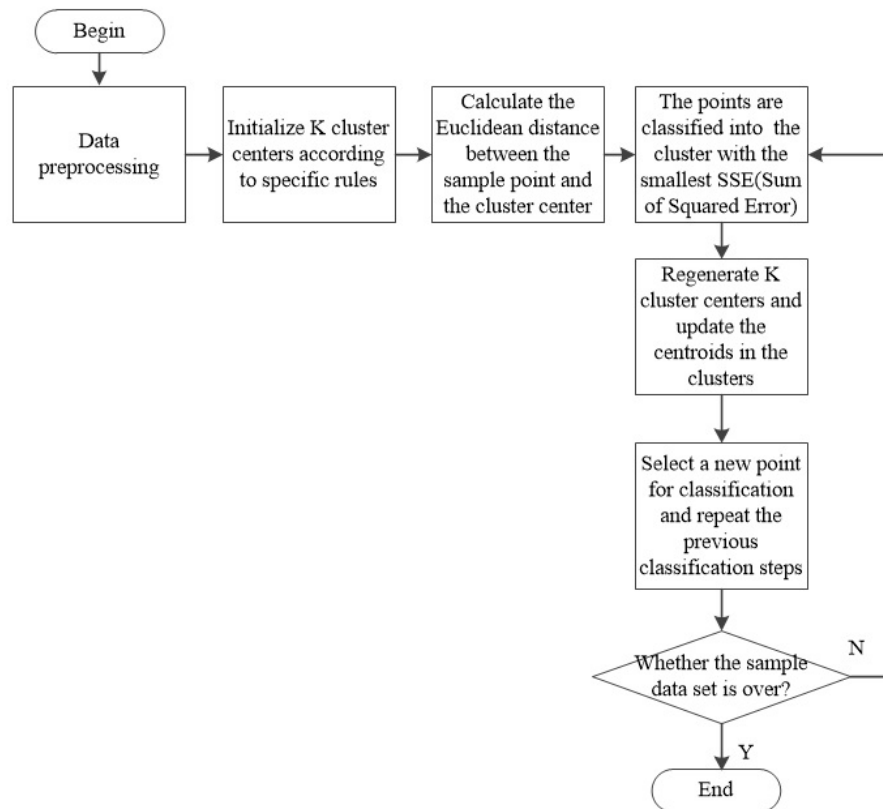

Fig. 3. The improved k-means algorithm

The main steps included in the improved k-means algorithm are as follows:
Step 1: Initialize K cluster centers according to the principle that the distance between the initial cluster centers should be as far as possible.

Step 2: Assign the sample set data D to the nearest cluster according to the principle of shortest distance;

Step 3: Calculate the mean value of the sample center of each cluster, regenerate K cluster centers, and update the centroid within the cluster;

Step 4: Whether the cluster center is no longer changes or the maximum number of iterations n has been reached, if it is yes, then go to Step 5, otherwise repeat to Step 2;

Step 5: Output the final cluster center and k cluster divisions.

4.3.   Fuzzy Synthetic Evaluation Method

Fuzzy synthetic evaluation method is a comprehensive evaluation method based on fuzzy mathematics membership degree theory [11]. This method uses fuzzy relations to quantify some qualitative problems, that is, those factors whose boundary is fuzzy and difficult to quantify are quantified by formula. The advantage of this method is that the results are displayed quantitatively, which is clear and easy to understand, and can solve those problems well Fuzzy and difficult to quantify qualitative problems. The establishment process of fuzzy comprehensive evaluation model mainly includes the establishment of fuzzy comprehensive evaluation matrix, single factor analysis, factor comprehensive evaluation and comprehensive evaluation value calculation.

(1) Establishment of fuzzy synthetic evaluation matrix

Suppose the set $I=I_1,I_2,...,I_n$ is the set of factor index, $F=F_1,F_2,...,F_m$ is the set of factor comments, where F_j (j=1,2,...,m) is the evaluation grade of each factor, and the fuzzy evaluation of each factor is a fuzzy subset of the factor evaluation set S. Suppose that the single factor fuzzy evaluation of factor I is $R_i=r_{i1},r_{i2},...,r_{im}$ (i=1,2,...,n), and r_{ij} is the membership degree of the i-th factor to the j-th comment. The fuzzy vector of $R_1,R_2,...,R_n$ forms the fuzzy relation from set I to set S, and the fuzzy comprehensive evaluation matrix is as follows.

$$R = \begin{bmatrix} R_1 \\ R_2 \\ ... \\ R_n \end{bmatrix} = \begin{bmatrix} r_{11} \ r_{12} \ ... \ r_{1m} \\ r_{21} \ r_{22} \ ... \ r_{2m} \\ ... \ ... \ ... \ ... \\ r_{n1} \ r_{n2} \ ... \ r_{nm} \end{bmatrix} \tag{1}$$

(2) Single factor analysis

Let the fuzzy vector $V_i=(V_{il},V_{i2},...,V_{in})$ The membership degree (k=1,2,...,m) on the set I represents the score of each factor in the single factor evaluation, and the single factor evaluation vector B_i is as follows.

$$B_i = V_i * R_i = (b_{i1}, b_{i2}, ..., b_{im}), (i = 1, 2, ..., k) \tag{2}$$

(3) Construction of comprehensive evaluation vector Suppose that the weight vector of each subset is $X=(X_1,X_2,...,X_k)$ The comprehensive evaluation matrix is $R=(B_1,B_2,...,B_k)$ Therefore, the comprehensive evaluation vector is as follows.

$$B = X * R = (b_1, b_2, ..., b_m) \tag{3}$$

(4) Calculation of comprehensive evaluation value Each evaluation grade of the evaluation set is given a score, and the evaluation set is $C=(c_1,c_2,...,c_m)$ The comprehensive evaluation score is as follows.

$$S = B * C^T \tag{4}$$

After obtaining the evaluation score of the factors, it can be found that the corresponding grade according to the score to know the level of the evaluated things.

5.   Experiments and Results

According to the previous design of Entrepreneur mental portrait, this paper constructs the Entrepreneur mental portrait. First of all, some CEOs and executives of some start-up companies are interviewed about entrepreneurial mind research, and questionnaires are sent out to survey them, and then the wearable device experiment is conduct and construction of comprehensive evaluation vector is built. Then, the survey data are summarized and analyzed, and the entrepreneur mental tag is extracted and the entrepreneur mental portrait is completed.

5.1.   Design of Questionnaire

In the process of entrepreneurship, entrepreneurs judge and make decisions on the competitive market based on their own experience, knowledge and ability, and identify and grasp business opportunities. In the above process, the prior knowledge, personality characteristics and opportunity perception ability of individuals play an important role, which are related to the minds of entrepreneurs. Therefore, based on the above content and the previous scholars' research on the Entrepreneur mind, the survey content of this study is summarized. The example of the questionnaire is shown in Table1.

The scale in the questionnaire is divided into three categories: prior knowledge, personality characteristics and opportunity perception. Among, the first category of ¡®prior knowledge¡¯ is divided into three categories: entrepreneurial experience, related knowledge and technical proficiency after referring to the previous studies. The results of survey data are shown as in Table2.

The second category is 'personality characteristics', which are divided into five categories, and the results of survey data are shown as in Table3.

The third category is 'opportunity perception', which is divided into two categories, and the results of survey data are shown as in Table4.

5.2.   Reliability Test

In the reliability measurement of the questionnaire, the commonly used index is Cronbach alpha coefficient, which is between 0 and 1. The closer the coefficient is to 0, the lower the reliability of the questionnaire, on the contrary, it is closer to 1, the higher the reliability of questionnaire. Generally speaking, if the Cronbach alpha coefficient is greater than 0.8, it indicates that the reliability of the scale is in the ideal range. If the coefficient is less than 0.6, it indicates that the reliability of the scale does not meet the requirements, and it must be rebuilt. The reliability analysis of individual prior knowledge scale, personality characteristics and opportunity perception scale were performed in SPSS 22.0 software. The reliability test results are shown in Table5.

Table 1. Sample of questionnaire of entrepreneur mental

Dimension	Content	Example
Prior knowledge	It is mainly measured from the entrepreneur practical experience, entrepreneurial knowledge accumulation and entrepreneurial thinking.	How much do you know about entrepreneurship related knowledge and entrepreneurial environment? A. Very familiar with B. Relatively familiar C. General D. I don't understand E. I don't know
Personality characteristics	It is mainly measured from five aspects, namely, entrepreneur's values, extraversion, self-cognition, entrepreneurial achievement and stability	How much attention do you pay to new things or technologies? A. Very attentive B. more attentive C. General D. less attention E. Very inattentive
Opportunity perception	It is mainly measured by the ability of entrepreneur alertness and entrepreneur opportunity identification	Do you agree that you have a strong ability to discover opportunities, the products you discover are leading, and it is difficult to have substitutes in the short term? A. Very much agree B. Relatively agree C. General D. Disagree E. Very disagree.

Table 2. Results of prior knowledge

Questionnaire option		Number of answers to questions					Average
		1	2	3	4	5	
Related Knowledge	Question 1	2	7	37	133	98	4.15
	Question 2	1	5	46	112	113	
	Question 3	5	6	35	136	95	
Technical proficiency	Question 1	5	16	92	103	61	3.78
	Question 2	8	15	86	101	67	
	Question 3	7	10	67	115	78	
Related Knowledge	Question 1	14	37	91	86	49	3.38
	Question 2	21	46	72	91	47	
	Question 3	24	39	79	84	51	

Table 3. Results of personality characteristics

Questionnaire option		Number of answers to questions					Average
		1	2	3	4	5	
Extrovert	Question 1	3	5	43	99	127	4.13
	Question 2	5	6	65	94	107	
	Question 3	6	5	62	83	121	
Decisiveness	Question 1	4	15	56	97	105	3.98
	Question 2	3	19	57	102	96	
	Question 3	8	17	63	86	103	
Adventurousness	Question 1	9	18	79	88	83	3.84
	Question 2	8	19	68	94	88	
	Question 3	11	22	52	99	93	
Interest	Question 1	13	24	61	84	95	3.73
	Question 2	14	25	81	75	82	
	Question 3	12	21	77	81	86	
Logicality	Question 1	13	24	69	82	89	3.68
	Question 2	15	26	72	77	87	
	Question 3	16	29	88	71	73	

Table 4. Results of opportunity perception

Questionnaire option		Number of answers to questions					Average
		1	2	3	4	5	
Alertness	Question 1	2	8	84	98	85	3.88
	Question 2	3	10	93	92	79	
	Question 3	3	9	89	94	82	
Feasibility	Question 1	15	30	66	89	77	3.64
	Question 2	19	28	67	91	72	
	Question 3	21	24	65	86	81	

Table 5. Overall reliability and reliability test of each dimension

Test items of scale	Cronbach Alpha	Number of questions
Prior knowledge	0.854	9
Personality characteristics	0.954	15
Opportunity perception	0.915	6
All Questionnaire	0.968	30

It can be seen from Table5 that the alpha coefficients of the three dimensions of the questionnaire are all above 0.8, and the overall reliability coefficient of all questionnaire is 0.968, which indicating that the reliability of the questionnaire is high.

5.3.   Validity Test

After the reliability of the scale has passed the feasibility test, the corresponding validity analysis is needed to verify the validity, and the verification results are shown in Table6.

Table 6. KMO and Bartlett's test of spherical

Kaiser-Meyer-Olkin	measure	0.923
Bartlett's test of spherical	chi square	12635.289
	df	435
	Sig	0.000

When the KMO value is higher than 0.8, the validity is very good. If the value is between 0.7 and 0.8, the validity is good; if the value is between 0.6 and 0.7, the validity of the questionnaire is acceptable; if the KMO value is lower than 0.6, the validity of the questionnaire is poor. The KMO value of the questionnaire for entrepreneur mental is 0.923, which indicating that the validity of the questionnaire is very good.

5.4.   Descriptive Statistical Analysis

According to the descriptive statistical results of 277 valid questionnaires collected, there are 171 male entrepreneurs, accounting for 61.73%, and 106 female entrepreneurs, accounting for 38.27%. In our survey, male entrepreneurs are more than female entrepreneurs, which is consistent with the fact that there are more male entrepreneurs in China. From the perspective of age distribution of entrepreneurs, 22.02% of entrepreneurs are less than 25 years old, 44.77% are 26-35 years old, 18.05% are 36-45 years old, and 15.16% are over 45 years old. Generally speaking, the age of entrepreneurs is relatively young. The descriptive statistical information of entrepreneurs' basic information is shown in Table7.

According to the collected questionnaire data, the labels of three dimensions of entrepreneur mental can be established. At the same time, combined with the basic information of entrepreneur, the entrepreneur mental can be depicted as shown in Fig. 4.

6.   Conclusions

The mental model of entrepreneurs is a research hot issue of entrepreneurial psychology, and it has been the concerned point in recent entrepreneurial education and training, which should be conducted according to the different entrepreneurs' mental models and profiles. However, traditional methods for entrepreneur mental model assessment usually have the limitations of inaccuracy and even leading to inconsistent results. The contribution of this paper is to analyze innate and acquired influencing factors of mental models, and give the

Table 7. Descriptive statistics of the basic information of the questionnaire

| Item	Options	Percentage(%)
Gender	Male	61.73
	Female	38.27
Age	Less than 25 years old	22.02
	26-35 years	44.77
	36-45 years	18.05
	Over 45 years old	15.16
Position	CEO	33.94
	Business executives	66.06
Education level	High school and below	2.17
	Junior college	10.83
	Undergraduate	54.87
	Master's degree and above	32.13
Industry	Biomedical industry	6.13
	New materials or new energy	12.64
	Training, education	15.16
	Information transmission and computer service	21.67
	Clothing industry	13.36
	Life service industries such as hotels and tourism	8.67
	Wholesale and retail	6.86
	Culture, sports, entertainment industry	6.13
	Agriculture, forestry, animal husbandry and fishery	5.05
	Other industry	4.33
Survival years	Less than 1 year	15.52
	1-3 year	48.74
	3-5 year	25.63
	More than 5 years	10.11
Number of enterprises scale	Less than 5 people	7.58
	6-10 people	17.33
	11-25 people	54.51
	26-50 people	11.55
	More than 50 people	9.03
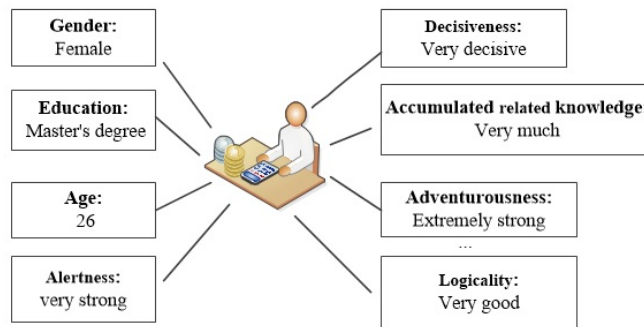
Fig. 4. Entrepreneur mental portraits

methods of mental model measurement and mental portrait construction of entrepreneurs, and it complete mental description and label portrait by combining research methods such as questionnaire, brain cognitive experiment, cluster analysis and fuzzy comprehensive evaluation, which provides a new idea for the study of entrepreneurial mental model.

The proposed method of this paper indicates as the effective way for testing and analyzing the entrepreneurs' mental models. However, as an exploratory research, the questionnaire design and sample size of the survey objects of this paper can be further improved. In addition, future research can introduce more diverse research methods, such as combining with wearable devices to conduct mental model experiments and analysis on entrepreneurs to make the results of the research more accurate.

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Yongzhong Zhang is a professor at the Shanghai Engineering Research Center of Open Distance Education, Shanghai Open University, China. His current research interests include Educational technology and big data analysis. Contact him at 1502235429@qq.com.

Yonghui Dai is the corresponding author of this paper. He is currently a lecturer at the Management School, Shanghai University of International Business and Economics, China. He received his Ph.D. in Management Science and Engineering from Shanghai University of Finance and Economics, China in 2016. His current research interests include Entrepreneurship education and artificial intelligence. His works have appeared in international journals more than thirty papers. Contact him at daiyonghui@suibe.edu.cn.

Haijian Chen is a professor at the Shanghai Academic Credit Transfer and Accumulation Bank for Lifelong Education, China. He received his Ph.D. in Management Science and Engineering from Shanghai University of Finance and Economics, China in 2015. His current research interests include Educational technology and cloud computing. Contact him at xochj@sou.edu.cn.