Innovative Decision-making Mechanism Based on Cognitive Science-Taking Rural Financial Services as an Example

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ABSTRACT

Innovation refers to our ability to break the current state, change the way we think, and establish new things or new connections. As innovative thinking plays a crucial role in the development of human society, the study of cognitive neural mechanisms for innovative thinking is one of the important research topics in scientific work. This paper studies innovative brain neural mechanisms based on the cognitive science, it takes rural financial services as an example, and introduces the current situation, motivation and encountered problems of China's rural financial services innovation. In order to explore the nature of innovative thinking, this paper uses resting-state functional magnetic resonance imaging (FMRI) to study the brain's innovative brain function and brain structure, establishes connections between individual innovative behavior and brain function and brain structure from both perspectives of remote association and trait creativity. The results showed that the brain areas with positive correlations between ReHO values and innovative measurements were mainly concentrated in the frontal area, while the negatively correlated brain areas were mainly concentrated in the temporal, parietal and occipital area; in addition, the white matter density and gray matter density in the same brain area were associated with creativity in a completely opposite state, which is associated to the related functions involved in the brain area. This study provides a reference for the exploration of innovative mechanisms based on imaging, and plays an important role in the study of the nature of innovative brain neural mechanisms.

Key Words: Innovative Thinking, Cognitive Science, Brain Imaging, Rural Financial Services

Introduction

Innovative thinking (Beaty et al., 2016) is no stranger to our lives. It permeates almost every area around us, from individual innovations in learning methods, to the development of society, we can say that innovation is the source of human civilization (Min et al., 2000). The key to innovation is novelty and practicality, and the study of innovative thinking is a breakthrough in cultivating people's creative abilities (Korba, 1993). Therefore, how research innovations occur in the brain (Abraham et al., 2012) and the cognitive neural mechanisms of innovative thinking (Jung et al., 2013) are currently one of the most important directions for scientific research in brain science. Innovation (Osborn, AF, 1953) is a difficult-to-define phenomenon that involves psychology, neurophysiology, and philosophy. Although psychologists have accumulated large amounts of data through historical records, case studies, etc., however, it is still difficult to make major breakthroughs in laboratory research.
Since innovative thinking does not happen controllably, it always happens suddenly at certain moments, so we cannot perform all-day-long magnetic resonance scans (Jr et al., 1989) or other EEG tests on subjects (Fink et al., 2009), and we cannot adopt methods of studying the memory or attention, which has brought difficulties to the study of the cognitive neural mechanism of innovative thinking, and it is difficult to conduct empirical research in the laboratory. With the development of cognitive neuroscience and related brain electricity (Astolfi et al., 2009) and brain imaging technologies (Montandon and Zaidi, 2006), magnetic resonance technology with high spatial resolution, non-invasiveness and simplicity features (Izzetoglu et al., 2007) provides powerful technical support for exploring the cognitive neural mechanisms of innovative thinking. Due to the complexity of the innovative thinking process (Mihardi et al., 2013), several related theories have been proposed to explain it, such as the brain mechanism of epiphany and the brain mechanism of remote association, but there is no universally agreed conclusion yet.

This paper studies innovative brain neural mechanisms based on the cognitive science, it takes rural financial services as an example, uses resting-state FMRI to study the brain's innovative function and brain structure, and provides an important reference and basis for further exploration of the nature of creative thinking.

**Theoretical overview**

**Innovation**

Innovation (Dietrich, 2004) refers to the individual's ability to propose novel ideas or perspectives in the current thinking mode, which can improve or create new things, elements, paths, environments, etc. and can achieve certain beneficial effects, it is a phenomenon that is difficult to define precisely, and involves psychology, neurophysiology and philosophy. Innovation is the source and driving force for the development of human society and science and technology. As innovative thinking plays a crucial role in the development of human society, the study of cognitive neural mechanisms for innovative thinking is one of the important research topics in scientific work. At present, many scholars believe that innovation has both the generality of cross-domain and the characteristic of domain-specificity. How to validate these two characteristics of innovation from the perspective of cognitive neuroscience is a difficulty and challenge in the current stage of brain science research.

**Innovative tasks and measurement**

There are many assessment methods for evaluating innovation, this paper divides the measurement into innovative tasks based on creative cognition and psychological measures based on creative personality. The following figure (1) lists several common innovative tasks and methods of psychological measurement.

**Brain neural mechanisms of innovation**

The two key elements of innovation are "novelty" and "practicality." Although there are many researches on innovation, however, we haven't got a unified conclusion about the research on innovative brain neural mechanisms. (Fink et al., 2009). With the advancement of science and technology, the development of brain electricity and brain imaging technologies provides reliable technical support for the study of the brain neural mechanisms of innovation. The following briefly introduces several explorations of brain mechanisms from different perspectives.
(1) Study of the brain mechanism of remote association
Remote association is the regrouping or linking of seemingly unrelated things to promote a connection that meets new specific requirements. This usually requires that innovators have a large vocabulary reserve and a powerful memory search ability, and the innovative ability to produce new ideas. Through experiments and related EEG detection technologies, it’s found that, when carrying out remote contact tasks, the frontal lobe and temporal lobe of the brain would cooperate with each other, of which the left middle temporal gyrus and right frontal lobes and left cingulate gyrus played a key role. However, due to different measurement methods, the brain orientation which leads to remote association may not be accurate, and it needs further research.

(2) Study of the brain mechanism of epiphany
Epiphany is a process in which we encounter difficulties or resistance when solving a problem, and in the case of a sudden situation, the inspiration arises and the new thoughts solved the problem we are struggling with. In this process, problem-reformulation or set-shifting is the trick for solving the problem. If the new characterization is appropriate, the answers will immediately come to mind. Through the observation and analysis of EEG experiments, it was found that, in contrast with the non-aha effect, the activation zone of aha effect has increased in the area of left frontal lobe, inferior occipital gyrus and cerebellum. The study considers that the left frontal lobe has an important role in breaking mind-set and forming new connections.

(3) Study of the brain mechanism of divergent thinking
Divergent thinking is a diffusion state thinking mode presented by the brain (Vincent et al., 2002), which is manifested as broad range of thinking, one can think from different directions to overcome defects of single-direction thinking and generate a large number of novel and unique ideas, it is one of the important marks for measuring creativity. Through EEG experiments and brain imaging technologies, it is shown that multiple regions of the brain need to work cooperatively in divergent thinking, it involves multiple regions such as the cerebellum, precentral gyrus, right superior frontal gyrus and left inferior temporal gyrus, among which, the left inferior frontal gyrus is mainly related to flexibility and fluency, and the cerebellum helps a lot in improving the efficiency and adaptability of cognitive functions, and superior temporal gyrus is related to complex auditory and verbal functions.

**Rural financial services innovation**

*Financial services*
Service is a sales-provided activity which aims at satisfying the needs of individuals, companies or other groups, it occurs in an intangible manner between consumers and suppliers, goods, or service systems. There are definitions of financial services both in the broad sense and the narrow sense, broadly speaking, it means that the entire financial industry exerts its various functions to promote economic and social development; the narrow sense of financial services means that financial institutions provide various services for customers by conducting business activities, including savings, credit, settlement, commercial insurance and financing investment. The research object of this paper is mainly banking-based finance, and the main services provided are shown in Figure (3) below.

![Figure 3. Main business of a bank](image)

The so-called "rural financial services" only adds geographical restrictions in front of "financial services," which is in contrast of cities, it means finance that serves the farmers, agriculture, and rural areas.

*Theoretical study of financial innovation*
Innovation in financial services is an important phenomenon in the financial sector, it is one of the important means and methods for enhancing
competitiveness in a fierce competitive environment and an important part of innovation. There are also definitions of financial innovation both in the broad sense and the narrow sense, the broad sense financial innovation is a kind of integration of innovation, which includes innovations in various aspects such as financial markets, financial systems, financial institutions, and financial services; narrow sense financial innovation is simply innovation of financial tools. In the theories of innovation motivation, from the perspective of supply, there is constrained-induced financial innovation theory; to study from transaction cost, there is transaction cost innovation theory, moreover, there are institutional school’s financial innovation theory and technical innovation theory, etc.

Innovation motivation of rural financial services

In China, the motivation theory of financial innovation services includes several kinds of financial innovation theories such as “government promotion”, "technology promotion", "pursuit of profit", and "market failure", etc. However, the driving force for the innovation of rural financial services must be analyzed basing on the basic conditions of rural development in China. The following figure (4) sums up the motivations of rural financial service innovation from the supply and demand sides of rural financial services.

Problems in the innovation of rural financial services

In recent years, although rural financial institutions have done a lot of work to optimize fund allocation and financial service innovation, due to factors such as system, talent, and property rights, financial service innovation cannot fit the development of “three rural issues” or meet the service requirement of “three rural issues”. Therefore, in the aspect of rural financial service innovation, there are still many problems, as shown in figure (5) below.

Brain neural mechanism of innovative decision-making

Experimental object and purpose

Innovation plays an important role in the development and progress of society. The purpose of this experiment is to study the innovative cognitive process, to understand which areas of the brain area play a key role in the process of innovation, and how the brain produces innovative ideas, etc.

Figure 4. Motivation of innovation in rural financial services

Figure 5. Problems in the innovation of rural financial services
The subjects selected for this experiment are financial service personnel in several rural banks within the jurisdiction of a city, 50 men and women each, with an average age of 24±2 years. All participants did not have any history of physical or mental illness and had normal vision. All subjects voluntarily signed the informed consent form with a clear understanding of the research process.

Experimental methods
In this experiment, the resting-state brain imaging was adopted, so subjects were not required to lie in the magnetic resonance scanner to solve the creative questions, and the operation was relatively simple and easy. Then, Remote Association Test (RAT) and Williams Creativity Scale (WCS) were used to measure the multi-angle creation behavior of the subjects, and Raven scale was used to measure the general intelligence level of the subjects, at last, multiple regression analysis method was used to establish the relationship between the brain function and the innovative behavior of the subjects.

(1) Remote Association Test (RAT)
The Remote Associate Test (RAT) was originally designed by Sarnoff Mednick, it is a classic test method for the research of creativity. Subjects need to associate the fourth word to connect the first three words which are seemingly irrelevant, it's a process of re-integration of thinking. This experiment gives each subject 100 sets of test questions, the number of completed questions within a specified time is the score of the subject.

(2) Questionnaire of Williams Creativity Scale (WCS)
The WCS measures the personal creative tendencies by testing individual personality traits, including personal curiosity, imagination, adventurism, and challenges. Subjects were asked to answer 50 related questions and then the final scores were calculated to assess the results.

Acquisition and processing of experimental data
In this experiment, the Siemens imaging resonator was used to obtain the resting-state data. Before the experiment, make sure the subjects were not wearing metal accessories. During the scanning, subjects only need to close their eyes, take a rest, and keep their heads in a fixed posture. The total scan time was about 7 minutes, the number of scan layers was 32, the thickness was 3mm, and the repeat time was 2000 milliseconds. The obtained structure image data was pre-processed using Matlab to obtain ReHO parameters, images which were not fully scanned or with poor scan quality were deleted or repaired, and the ReHO local consistency was calculated in the end.

This paper used SPSS14.0 for statistical analysis and processing of data. The multiple regression analysis in SAM8 was used to analyze the relationship between ReHO parameters of brain function data and the density.

Discussion and analysis of experimental results
(1) Data results of the RAT
After performing multiple regression analysis on the data, the brain regions in which the ReHO is negatively related to RAT scores are shown in Figure (7), including fusiform gyrus, precuneus
and angular gyrus of the right brain, and inferior frontal gyrus of the left brain.

After multiple regression analysis of the data, the correlation of gray matter density and white matter density with the RAT is shown in Figure (8). Among them, there was a positive correlation between gray matter density in middle temporal gyrus and superior temporal sulcus of right brain area, and the test scores, while in right cingulate brain area, the two are negatively correlated. For the white matter, there was a positive correlation between its density and the test score in brain area of right middle cingulate gyrus, while in the brain area of left inferior frontal gyrus, the two are negatively correlated.

(2) Data results of the WCS
After multiple regression analysis of the data, the brain regions in which the ReHo has a positive correlation with the RAT scores is shown in Figure (9), including left postcentral gyrus and middle frontal gyrus. No brain area was negatively correlated with the test scores.

![Figure 9. Brain areas correlated with reho and wcs results](image)

After multiple regression analysis of the data, the correlation between gray matter density, white matter density and WCS scores is shown in Figure (10). What are positively related to the test results are the gray matter density in the lingual gyrus of right brain area, and the white matter density in the anterior cingulate gyrus; the gray matter density of the anterior cingulate gyrus in the left-brain area and the white matter density of left posterior cerebellar lobe area are negatively correlated with the test scores.

![Figure 10. Brain areas associated with test results](image)

(3) Discussion and analysis
In this study, we respectively used the RAT and the WCS to study the individual’s ability of remote association and trait creativity, and used the resting-state brain imaging data to establish connections between individual behavior and brain characteristics. Through the above experimental results, it has been found that brain regions related to innovative thinking ability are scattered in the left and right hemispheres of the brain and require interaction and cooperation among multiple brain regions. The results also show that, as a high-level cognitive function of the brain, creativity is a complex process that requires the cooperation of multiple cognitive abilities, as well as time-sharing processing and cooperation of both brain hemisphere.

Conclusions
Based on cognitive science, this paper studies the brain neural mechanisms of innovation. Taking rural financial services as an example, we use resting-state FMRI to study the brain's innovative brain function and brain structure. This paper has reached following conclusions through experiments:
(1) In this paper, the research and theory of innovative thinking is briefly reviewed. Taking the innovation of rural financial services as an example, the motivation of rural financial service innovation and the current problems are proposed. This provides a basis and reference for improving the innovation of rural financial services; however, the essence of financial service innovation still lies in talents and in innovation of thinking. Therefore, the cognitive neural mechanism based on innovative thinking is the main research object of this study.

(2) The experiments in this paper use resting-state FMRI technology and multiple innovative measures including RAT and WCS, it establishes connections between individual innovation behavior and brain function and brain structure. The results showed that the brain areas with positive correlations between ReHO values and innovative measurements were mainly concentrated in the frontal area, and brain areas with negative correlations were mainly concentrated in the temporal, parietal and occipital area.

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References