Brain Mechanism for the Feeling of Education Fairness Based on EEG

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ABSTRACT

Fairness plays a very important driving role in the decision-making process of the human society and is also a basic principle for human life. At present, people's feelings of being treated fairly and the corresponding impacts on their behaviours have received widespread attention from experts and scholars. Considering the individual differences, by using the resting-state fMRI method, this paper investigates the correlation between the internal connections in the brain regions and decision making behaviours related to the feeling of unfairness under the influences of different educational statuses. According to the investigation results, compared with the proponents who receive better education, the subjects were more likely to accept the unfair distribution proposed by those in poorer educational statuses and give better ratings on the unfair distribution. When the proponents in better education status proposed unfair distribution, there were negative correlations between the rejection rate and the functional connectivity of the right mPFC and DLPFC and between the fairness score and the functional connectivity of the left mPFC and the right thalamus. In the resting state, the functional connectivity between the mPFC and the thalamus and DLPFC can help predict individuals' different decision-making processes on the feeling of unfairness.

Key Words: Education Status, Sense of Unfairness, Brain Mechanism

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Introduction

Fairness generally means that any group or individual can be treated impartially in all aspects of social activities like give and take. It plays an important driving role in the decision-making process of the human society and is also a basic principle for human life (Wadsworth and Kana, 2011; Kaiser *et al.*, 2016; Geerligs *et al.*, 2014). In recent years, experts from various disciplines such as pedagogy, psychology, and sociology have begun to pay attention to human beings' feelings of being fairly treated and the corresponding impacts on their behaviours (Farhat, 2007; Snyder and Enna, 1977). Previously, when studying the utility theory of pedagogy, experts generally believed that in terms of educational decision making, people tended to be rational, and thus they ignored the influences of subjective feelings such as the sense of unfairness on education, and came to the conclusion that in any case, people would choose to maximize their benefits (Tangpong *et al.*, 2007; Mills *et al.*, 2010). However, in real life, people do not show a "completely rational" state in educational decision-making and are even willing to safeguard fairness at the expense of their own interests in (Lichtneckert and Reichert, 2005; Nakagawa *et al.*, 2011). In this context, a large number of scholars began to study subjective feelings of unfairness and the corresponding decision-making behaviours from the perspectives of behaviouristics and neuroscience (Annunziata, 2003; Aleshin *et al.*, 1998; Pappius, 1991).

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Scholars began to use the functional magnetic resonance imaging (fMRI) technology when studying the underlying neural mechanisms for the decision-making behaviours related to the sense of unfairness (Maki and Dumas, 2009; Dejda *et al.,* 2011; Qiu *et al.*, 2006). Studies have found that, for the respondents, the activated key brain regions include anterior insula (AI), dorsolateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC) when they receive unfair distribution, which are different from those activated when fair distribution is given. These brain regions form the key brain network for making decisions about unfairness (Johnston and Silverstein, 1985; Naskar *et al.*, 2010).

Through research, it is found that the educational status of the counterparts of the actors also plays an adjusting role in the educational decision-making process. In a UG task, proponents tend to allocate more amount of money to the respondents in poorer educational status than those in better educational status. With the age growing, children will also consider others' educational status when they allocate resources - if there are affluent opponents, everyone will tend to allocate more resources to the poorer ones. This shows that the counterpart's educational status is one of the factors under consideration in the resource allocation process.

However, currently a large number of studies focus on the impacts of the respondents' educational status on the distribution proposed by proponents, and do not pay attention to the impacts of the proponents' educational status on the respondents in their decision-making process (Andersson and Eriksson, 1971). Studies have shown that people who have higher educational and social status receive more resources, while those in lower educational and social status are more likely to have pro-social behaviours and participate in more volunteer service activities. Therefore, in the UG task, people expect that the proponents in higher educational and social status will allocate more resources, and if such proponents do not give fair distribution, the respondents will feel a great psychological discrepancy and generate a strong emotional response and will probably reject the unfair distribution given by the proponents in better educational status.

With the aid of functional magnetic resonance imaging (fMRI), this paper studies the brain mechanism for the decision-making behaviours related to the sense of unfairness under the influence of educational status, in the hope of exploring the effects of the proponents in different educational statuses on the respondents' response. This is of great significance to understanding the internal mechanism and cognitive process of problem solving.

Methods

Basic information on the subjects

The subjects participated in the experiment voluntarily. They learned about relevant information on the experiment and signed the informed consent form. All of them were students studying at colleges and universities, right-handed, with normal or corrected vision. No mental problem was found. The data were screened and statistically analyzed to ensure their validity.

Experimental materials

In the experiment, 72 commonly used Chinese names were presented in abbreviations. For example, "Wang Wei" was abbreviated as "Wang W.". These abbreviations were the names of the proponents, displayed on the screen during the experiment. The educational statuses were randomly distributed to all the names. Some were good and some were poor. This means there were 36 abbreviated names under each educational status. 12 names gave fair distributions and the other 24 gave unfair distributions.

Experimental procedure

The subjects were first scanned through the resting-state fMRI, and then participated in the experiment outside the instrument. The experimental content of behaviouristics is consistent with the research content.

fMRI data acquisition

The brain data of the subjects were collected with the Siemens 3T magnetic resonance imaging system (Magnetom TrioT1M). The author first scanned the positioning image, and then used the T1 weighted imaging scan technology to obtain the structural image data, collected the data through MPRAGE, and finally performed the resting-state fMRI data scan (using the gradient EPI). The specific sequence parameters are shown in Table 1.

Table 1. Sequence parameters

Type	MPRAGE	EPI
TI(ms)	1100	--
TE(ms)	2.34	30
TR(ms)	2530	2000
Scan layer number	192	33
layer thickness(mm)	1	4
FOV(mm)	256	192
Matrix size	256*256	64*64

Data analysis

This paper uses the DPARSFA toolkit in the environment to perform the pre-processing and statistical analysis of resting-state brain data.

The experiment needs pre-processing, which mainly consists of the following steps:

(1). Remove the first 4 whole brain maps to eliminate the effects caused by the instability of the instruments in the beginning;

(2). Correct the time layer to reduce the differences between layer scan time;

(3). Correct the head movement so that each image will align with the first image. If the subject is translated for more than 1.5mm or rotates for greater than 1.5°, the head movement of the subject will be deemed as too large and the data need to be screened;

(4). Register the structural images;

(5). Divide the registered high-definition structural image and normalize it to the MNI space;

(6). Spatially normalize the functional image and recollect samples through voxels;

(7). Eliminate the impacts of linear drift;

(8). Eliminate the components beyond the frequency range of 0.01 to 0.08 Hz (band-pass filtering);

(9). Eliminate the impacts of covariate factors (white matter, head movement and cerebrospinal fluid);

(10). Spatial smoothing (Gaussian kernel).

According to existing studies, with the centre of the circle set with the MNI coordinates of the right thalamus and DLPFC, and the radius set to 6mm, the author constructed spherical seed points. For all voxels and seed points of the brain, the author carried out calculations based on the functional connections between the two, performed Fisher-Z transform, and finally obtained the brain functional connection diagram. Then the author performed regression analysis on the behavioural data and functional connectivity. If the thresholds for the voxel level and the cluster level are less than the brain region activation level, it indicates that the activation of brain regions is obvious. The voxel level threshold should be less than 0.001, and the cluster level threshold should be less than 0.05.

The author used the statistical analysis tool SPSS to analyze the correlations between the behavioural results and the functional connectivity coefficient. If $p<0.05$, it can be considered that the two are significantly correlated. The behavioural results studied in this paper are the fairness scores given and the rejection rate of unfair distribution by respondents for proponents in different educational statuses.

Results

Behavioural results

It is assumed that for proposed fair distribution, the rejection rate of the subjects should be 0% and the fairness score should be full mark. For proposed unfair distribution, if the proponents' education statuses are different, the rejection rates and scores given by the subjects should be different. Through t-test analysis, the results were obtained, as shown in Figure 1 - t(29) was greater than 12.54, and p was less than 0.01. It shows that in the case of unfair distribution, the rejection rate by the subjects with respect to proponents in poorer educational status was significantly lower than that with respect to those in better educational status. In addition, the results in Figure 2 show that t(29) was greater than 8.23 and that p was less than 0.01. This shows that the subjects gave significantly higher fairness scores to the proponents in poorer educational status than those in better educational status.

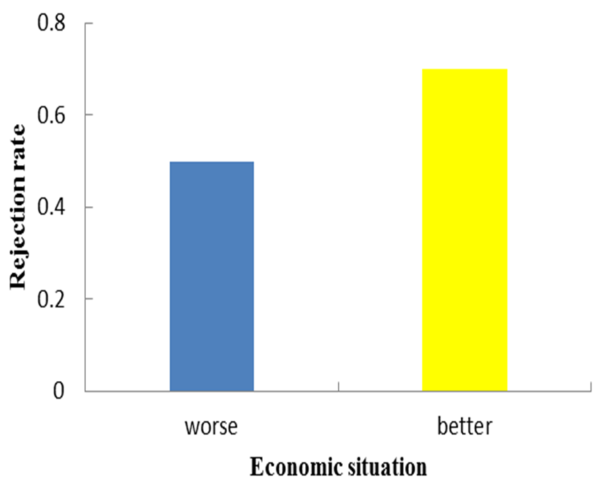

Figure 1. Comparison of rejection rates in case of unfair distribution

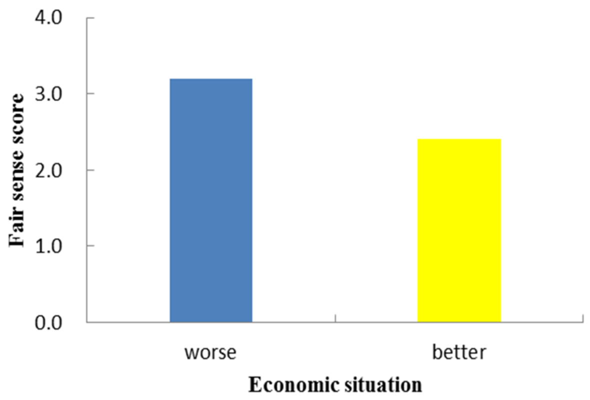

Figure 2. Comparison of fairness scores in case of unfair distribution

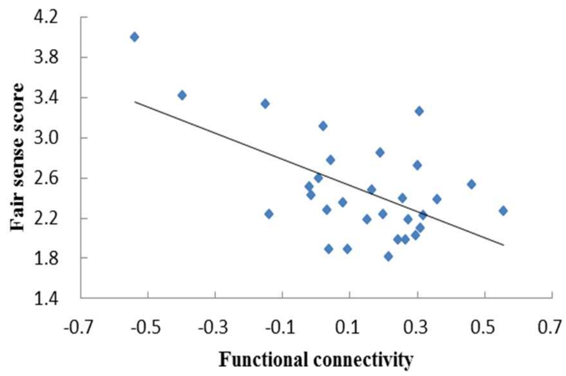

Figure 4. Correlation between the functional connectivity of the brain regions and the fairness score of unfair distribution

Brain data results

According to the results of Figure 3, there was a certain correlation between the rejection rate of unfair distribution and the functional connectivity of brain regions. Specifically, for proponents in good educational status, the rejection rate was negatively correlated with the functional connectivity of the right mPFC and DLPFC. However, for the proponents in poorer educational status, there was no significant correlation between the two.

For unfair distribution, there was also a certain correlation between the fairness score and the functional connectivity of brain regions. Specifically, for proponents in good educational status, the fairness score was negatively correlated with the functional connectivity of the left mPFC and the right thalamus, as shown in Figure 4. However, for the proponents in poorer educational status, there was no obvious correlation between the two, either.

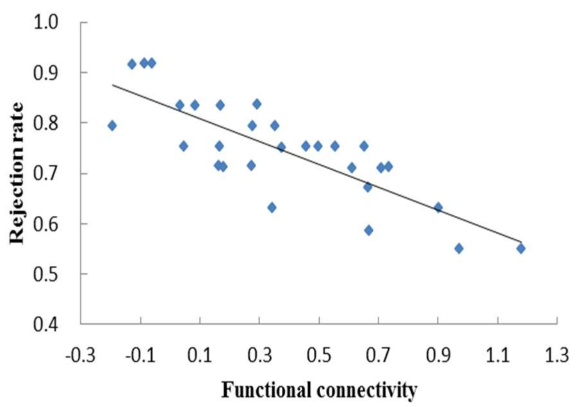

Figure 3. Correlation between the functional connectivity of the brain regions and the rejection rate of unfair distribution

Discussion

Through correlation analysis on the rejection rate of unfair distribution and the functional connectivity of brain regions, it can be found that where the proponents with good educational status make unfair distribution proposals, if the functional connectivity between the DLPFC and mPFC of an individual is strong, the individual is very likely to accept the unfair distribution. According to existing studies, people would combine information on their own activities, the obligations of each other and the consequences, and tend to choose the way that best suits their circumstances. This has a certain correlation with DLPFC. Distinguishing the intentions and purposes of others has some correlation with the function of the mPFC. Because of this, if an individual has a strong functional connectivity between DLPFC and mPFC, such individual can better combine his/her own situation with the purposes of others and better understand the unfair distribution. As a result, the individual will be not so resistant to unfair distribution, and that is why the rejection rate is reduced.

Through correlation analysis on the fairness score of unfair distribution and the functional connectivity of brain regions, it can be found that where the proponents with good educational status make unfair distribution proposals, there was a certain negative correlation between the left mPFC and the right thalamus and the fairness score. If the connectivity between the left mPFC and the right thalamus is strong, the individual will have a stronger feeling of unfairness about the unfair distribution proposed by proponents in good educational status. According to existing studies, social emotional stimulus can adjust the activation of the thalamus to a certain extent. To a person with high social and educational status, people will have stronger emotional responses. Therefore, people generally have stronger negative emotions towards the distribution proposed by persons in better educational status. At the same time, distinguishing the intentions and purposes of others has some correlation with the function of the mPFC. Because of this, if an individual has a strong functional connectivity between the mPFC and the thalamus, such individual will have a strong negative feeling when understanding the purposes of others, especially the proponents in better educational status.

Conclusions

Considering the individual differences, by using the resting-state fMRI method, this paper investigates the correlation between the internal connections in the brain regions and decision making behaviours related to the feeling of unfairness under the influences of different educational statuses. According to the investigation results, compared with the proponents who receive better education, the subjects were more likely to accept the unfair distribution proposed by those in poorer educational statuses and give better ratings on the unfair distribution. When the proponents in better education status proposed unfair distribution, there were negative correlations between the rejection rate and the functional connectivity of the right mPFC and DLPFC and between the fairness score and the functional connectivity of the left mPFC and the right thalamus. In the resting state, the functional connectivity between the mPFC and the thalamus and DLPFC can help predict individuals' different decision-making processes on the feeling of unfairness.

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