Civil Servants' Cognitive Evaluation of Performance Appraisal Based on Computational Neuroscience

Qiuhong Sun[1,2*], Xinhang Xu[3], Qiong Han[4]

ABSTRACT

With social development and scientific and technological progress, China is committed to building a service-oriented government, which will put forward higher requirements for the government administration efficiency and levels, and at the same time incorporates civil servants' perceptions of government management into the thinking of transforming administrative methods. Based on computational neuroscience, this paper studies civil servants' cognitive evaluation of performance appraisal, and more realistically simulates the entire evaluation process. The research results show that there are differences in the cognitive evaluation of civil servants at different stages of performance appraisal. At the same time, under the influence of information interference, cognitive evaluation will also show various changes. Based on computational neuroscience, this paper studies the civil servants' cognitive evaluation of performance appraisal, which is beneficial to the orderly development of performance appraisal and can also promote the transformation of government management concepts and functions.

Key Words: Computational Neuroscience, Civil Servant, Performance Appraisal, Cognitive Evaluation

DOI Number: 10.14704/nq.2018.16.5.1350 **NeuroQuantology 2018; 16(5):468-475**

Introduction

Since the 18th National Congress of the People's Republic of China, China stresses the need to accelerate the transformation of government functions and innovate management methods. Thus, government's performance appraisal is becoming more and more important, especially the performance appraisal of civil servants, which plays a positive role in promoting the transformation of government functions. The civil servants are not only the examinees in the performance appraisal of the government, but also the implementers of the government behavior. Their words and deeds represent the image of the government. Meanwhile, their perception of performance appraisal not only highlights the shortcomings of the current performance appraisal system, but also shows the implementation status of government policies (Hirasawa *et al.*, 2017).

Franco and Värri (2005) believe that differences in attributes lead to changes in the individual's cognitive structure, cognitive motivation, emotions, and attitudes. Due to these differences, an individual will make different choices in decision-making process (Franco and Värri, 2015; Teixeira *et al.*, 2016; Tang *et al.*, 2016). Based on researches, Inkaew *et al.*, (2015) and Hashemi *et al.*, (2016) propose the Social Cognitive Theory, namely SCT. According to this theory, the intrinsic cognition of individuals involves in all aspects of social learning, and cognitive factors are affected to a certain extent by the observation, understanding, and organization of external event (Inkaew *et al.*,

Corresponding author: Qiuhong Sun
Address: [1]Hebei Normal University, Shijiazhuang 050024, China; [2]Hebei University of Science and Technology, Shijiazhuang 050000, China; [3]State Grid Hebei Electric Power Research Institute, Shijiazhuang 050021, China; [4]Baoding Maternal and Child Health Hospital, Baoding 071000, China;
e-mail ✉ sunqiuhong@hebust.edu.cn
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 28 March 2018; **Accepted:** 19 April 2018

2015; Hashemi *et al.*, 2016). Xian *et al.*, (2017) thinks that employee's cognition and expectation of organization directly determine his cognitive value, which can also be affected by and his cognition and expectation of performance appraisal (Xian *et al.*, 2017).

In summary, scholars used to study performance appraisal more often from the theoretical point of view, to analyze and study the methods, concepts, modes, models and other aspects of performance appraisal. But few of them have carried out studies with civil servants as specific research group. Based on computational neuroscience, this paper studies civil servants' cognitive evaluation of performance appraisal, and more realistically simulates the entire evaluation process, and adopt the combined method of the eye movement and brain electricity to observe the subjective psychological quantity and objective physiological quantity of civil servants before, in the middle of, and after performance appraisal. The author collects data of eye movements and brain evoked potentials of 20 civil servants during performance evaluation through eye tracker and electroencephalograph. In this paper, the raw data are processed and the correlations between the processed eye movement data, data of brain evoked potentials and subjective evaluation values are analyzed. A cognitive evaluation model for performance appraisal of civil servants combined with psychological and physiological evaluation indicators is established and its checking calculations have been performed.

Research Hypotheses

The experiment studies the civil servants' cognitive evaluation of performance appraisal based on computational neuroscience. Due to the differences in individual attributes of civil servants, there are differences in their individual cognition, which leads to cognitive errors. Thus it is necessary to find out the factors that cause the error and make appropriate adjustments to the influencing factors so as to control this kind of cognitive error. On this basis, this paper proposes the following three hypotheses.

Hypothesis 1: Speeding up the transformation of government functions can promote the stable social and economic development. Civil servants have developed a certain cognition of performance appraisal.

Hypothesis 2: Individual differences will affect civil servants' cognition of performance appraisal.

Hypothesis 3: Different information received during the evaluation process will affect the civil servant's cognition of performance appraisal.

Methods

If only one of eye movement cognitive analysis, brain evoked potential cognitive analysis and psychological cognitive analysis is used, the experimental results cannot explain the final results of civil servants' cognitive evaluation of performance appraisal. An evaluation method combined with eye movement and brain evoked potential for civil servants' cognition of performance appraisal is put forward in order to provide accurate and reliable data support for and reduce errors of civil servants' cognitive evaluation of performance appraisal.

Design ideas

First of all, civil servants shall read the experimental procedures before participating in the experiment and sign the informed consent form to express their willingness to participate in the experimental investigation. Secondly, the glance, gaze and other behaviors of the eyes are recorded synchronously with the portable eye tracker and the brain evoked potentials of the subjects are recorded synchronously with the electroencephalograph. Finally, the subjects' psychological reaction and preference about the test scheme are determined by the correlation analysis of eye movement, brain evoked potentials and subjective score with the test subjects.

Implementation

In order to better study the civil servants' cognitive evaluation of performance evaluation, the author carries on the research from the level of computational neuroscience. On the other hand, since this paper focuses on the brain evoked potential experiment, the author is committed to provide the basis for the difference and influence of civil servants' cognitive evaluation of performance appraisal, and verify the three hypotheses mentioned above through the data obtained from the experiment:

Hypothesis 1: Speeding up the transformation of government functions can promote the stable social and economic development. Civil servants have developed a certain cognition of performance appraisal.

Hypothesis 2: Individual differences will affect civil servants' cognition of performance assessment.

Hypothesis 3: Different information received during the evaluation process will affect the civil servant's cognition of performance appraisal.

Brain evoked potential process and data results

(1) The subjects are on-the-job civil servants in a certain area, aged between 25 and 50. The investigation show that their body is in a healthy state, without mental illness or any symptoms of physical discomfort. And they are in a good mental state and are suitable for experimental research on brain evoked potential.

(2) Experimental instrument

In the experiment, Dikablis Glasses 2.0, a head mounted eye tracker, produced by Ergoneers in Germany is used to collect eye movement data and Brain Amp 64, electroencephalograph, produced by EGI of USA is used to collect data of brain evoked potentials.

(3) Experimental materials

In a quiet experimental environment, all the individuals are provided with comfortable chairs and a computer placed in front of them at a distance of 90cm. Each subject must wear an electrode cap after putting on the conductive paste. At the same time, he must carefully read the experimental instructions. With a view to allowing the subject to better take part in the experiment, it is necessary for him to participate a pre-experiment before the formal experiment begins so as to adapt to and be familiar with the experiment and complete the pre-experiment stage. First of all, the prompt word "experiment starts" will appear on the screen in front of the subject, indicating that the experiment has officially started, so that the subject can adjust his psychological state. That is to say, the data of brain evoked potentials of the participating civil servants are collected and recorded before performance appraisal. Secondly, the process of performance evaluation is simulated, during which four questions of performance appraisal appear on the screen, and the participants answer those questions successively by pressing the keys. The brain evoked potential data of the subjects are collected and recorded. At the same time, some relevant information will also appear in this process to interfere with the experimental subjects, and the data of brain evoked potentials before and after the information appears need to be recorded. Finally, when the subjects completed the questionnaire, the brain evoked potential data of the subjects are collected and recorded as the cognitive evaluation data for the performance evaluation in the later stage.

Experimental procedure

The sequence of the 20 test subjects is arranged in advance and they are invited to take part in the experiment in order. The specific experimental procedure is as follows:

(1) The 20 subjects are invited to the experimental environment for the experiment in turn.

(2) Subjects watch and understand the instructions. Those who have any doubts could consult the staff in a timely manner.

(3) Sitting on a chair, the subjects shall cooperate with the staff to wear the eye tracker and the electroencephalograph and carry on the experiment inspection and calibration.

(4) The experiment formally starts. Once a question appears on the screen in front of the subjects, the subjects start answering it by pressing the keys in his hand, with the keys numbering 1-5 (1-very poor, 2-relatively poor, 3-normal, 4-good, 5-very good). The question is completed while the key is being pressed down, then it will skip to next question. The entire experimental process ends, until all of the four questions are answered.

(5) The experiment ends and the eye tracker and the electroencephalograph stop recording.

Experimental Data Processing

Data collection

By substituting the experimental data into $p_i=(p_{1,i}+p_{2,i}+\cdots+p_{n,i})/n$, the cognitive evaluation values of all subjects on four questions are obtained, and the data results are sorted and summarized, as shown in Table 1.

Table 1. Civil servants' cognitive evaluation value of performance appraisal

Questions	Question 1	Question 2	Question 3	Question 4
Cognitive evaluation value	3.1	4.8	3.6	3.9

eISSN 1303-5150

Data processing

(1) Four questions appear in the whole experiment process, and the time spent by the subjects to answer one question, that is, the whole time from the question appears to the time the question is answered, is recorded by the experimental instruments. The recorded experimental data were substituted into $y(b_{1\sim n}+c_j+\cdots+E)=(y(1,\ c_j,\ E)+y(2,\ c_j,\ E)+\cdots+y(\mathrm{n},\ c_j,\ E))/\mathrm{n}$ to calculate the average time spent on each of the four questions, as shown in Table 2.

Table 2. Time spent by civil servants in answering questions

Questions	Question 1	Question 2	Question 3	Question 4
Average time spent/s	20.124	36.524	22.326	28.457

(2) Number of fixations

The number of fixations refers to the time of gazes of the subjects' eyes during the period from the appearance of the question on the screen to the end of the answer. By substituting the experimental data into $y(b_{1\sim n}+c_j+\cdots+E)=(y(1,\ c_j,\ E)+y(2,\ c_j,\ E)+\cdots+y(\mathrm{n},\ c_j,\ E))/\mathrm{n}$, the average number of fixations for performance evaluation related questions can be obtained, as shown in Table 3.

Table 3. Civil servant's average number of fixations on the questions

Questions	Question 1	Question 2	Question 3	Question 4
Average number	6	5	8	3

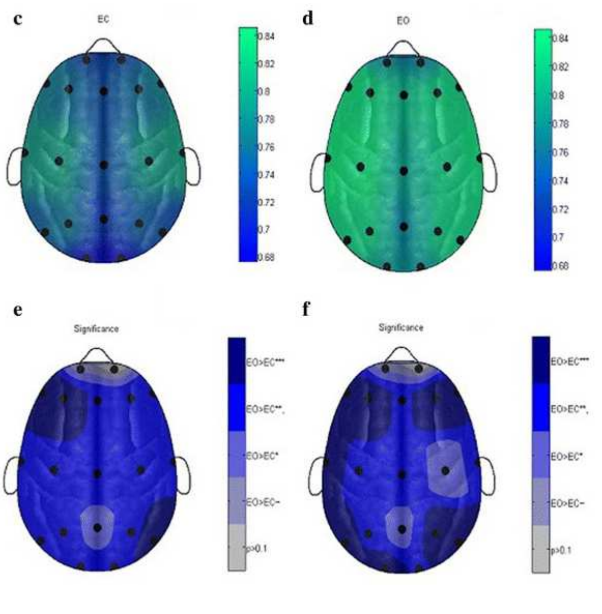


Figure 1. Hotspot graph of the subjects' focuses on different questions

(3) Hotspot graph

By superimposing the fixation time and fixation times of eye movement on different performance evaluation questions for cognitive evaluation, we can obtain the hotspot graph of subjects' focuses, as shown in Figure 1. The deeper the color is, the higher the focus on the area will be.

Processing of brain evoked potential data

(1) Processing of brain evoked potential data

The raw signals collected in the experiment include spontaneous brain evoked potential signal, induced brain evoked potential signal and other physiological interference signals. Spontaneous brain evoked potential signal is the potential change spontaneously produced by the cranial nerves when there are no specific external stimuli (visual, auditory and tactile). Induced brain evoked potential signal is the change in the electrical potentials of the cranial nerves when stimulus is applied to the sensory organs. Other physiological interference signals include electrooculogram, electrocardiogram, electromyography, etc. The induced brain evoked potential signal contains the cognitive evaluation information of civil servants, so it needs to be extracted and analyzed. The brain vision analyzer software is used to extract the induced brain evoked potential signals of 64 electrodes. The specific steps are as follows:

Step 1: To remove physiological interference signals. The amplitude of the induced brain evoked potential signal is about 2~10μV, with high time-varying sensitivity. Other physiological signals such as electro-oculogram, electrocardiogram, and electromyography will interfere with the real brain evoked potential signals. Therefore, they should first be removed.

Step 2: Digital filtering. As low-frequency signal, the brain evoked potential signal is easily interfered by other high-frequency noise signals. Thus digital signal filtering function can be used to remove the noise of brain evoked potential signals.

Step 3: Segmentation of brain evoked potential signal. Since the induced brain evoked potential signal occurs within a period of time after stimulation, only the signals within this period need to be processed when extracting induced brain evoked potential signal. Brain evoked potential data are divided according to the time axis of the experiment. Starting from the time, the experimental stimulation material scheme 1 is presented, and the time period is 1,500 ms, which is the effective time period for the stimulation material 1 to induce brain evoked potential signals. The time is the time at which the test subjects press the scoring key and is also the time at which the test stimulation material scheme 2 is presented. The time period is 1500 ms, which is the effective time period for the stimulation material scheme 2 to induce brain evoked potential signal. The time periods and are the effective time periods for the stimulation material schemes 3 and 4 to induce brain evoked potential signal.

Step 4: Baseline correction. Due to the limited accuracy of the instrument itself, the interference of environmental noise and other physiological signals, the acquired brain evoked potential signal usually has the problem of baseline drift, which is manifested as the irregular changes of the signal baseline. Therefore, it is necessary to eliminate the deviation of brain evoked potentials from baseline through the baseline correction function of software.

Step 5: Average amplitude. However, that amplitude of spontaneous brain evoked potential signal is between several tens microvolt and several hundred microvolts, whereas the amplitude of induced brain evoked potential signal is only 2~10μV. The induced brain evoked potential signal can be overwhelmed by spontaneous brain evoked potential signal, thus cannot be directly observed. The average amplitude function is used to superimpose and average that intercepted brain evoked potential signal of all the subjects corresponding to experimental stimulation materials. Spontaneous brain evoked potential signal is random signal, and its mean value after the superposition is 0. The induced brain evoked potential signal is deterministic signal, and it is basically the same after superposition. After average amplitude processing, induced brain evoked potential signals can be extracted.

(2) Analysis of evoked brain evoked potential topographic map

After extracting the brain evoked potential signals of 64 electrodes, the Brain Vision Analyze, brain evoked potential data processing software, is used to analyze the induced brain evoked potential topographic map, so that the energy distribution of brain evoked potential induced by civil servants' cognitive evaluation can be observed more intuitively in the whole performance appraisal process. The darker the color is, the greater the average energy of Event-Related Potentials (ERP) will be. Under the stimulation of four questions about performance appraisal, the subjects induce brain evoked potential topographic map within 200 to 600 ms.

By comparing the topographic map with the electrocardiograph electrode distribution map of the Electroencephalograph, it is found that active regions of the subjects' brain are concentrated in the frontal lobe, including F3, FC3, FZ, FCZ, F4, FC4, CZ and C3 electrodes. This part is active because the frontal area of the brain is mainly responsible for mental functions and thinking functions.

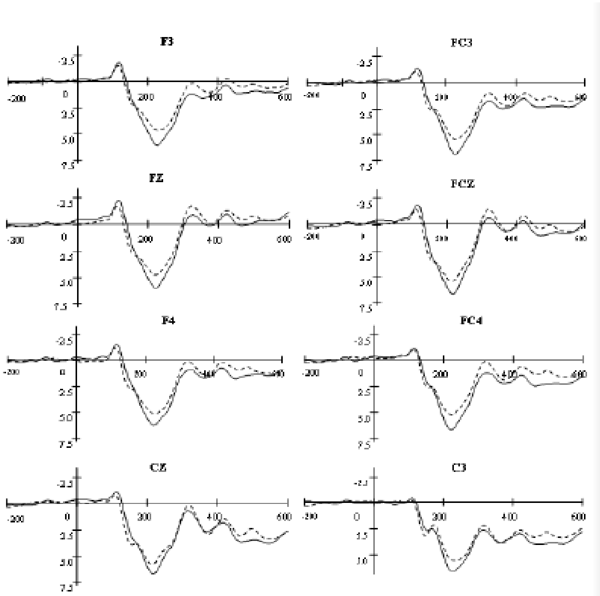


Figure 2. Electrode-induced brain wave diagram

(3) Analysis of Evoked brain evoked potential waveform

The electrodes for the evaluation of aesthetic experience in event-related potential (ERP) include F3, FC3, FZ, FCZ, F4, FC4, CZ, and C3. The classical component of ERP mainly includes P300, which is the positive wave of the event-related middle peak in the range of 200ms ～ 600ms of latency, and is the component related to the cognitive evaluation functions such as attention, recognition, decision-making and memory. P300 is included within 1500 ms of the effective time to induce brain evoked potential. The ERP data of the above ten electrodes will be different in the civil servants' cognitive evaluation of four questions in the experiment. Therefore, the brain evoked potential data of the above ten electrodes

eISSN 1303-5150

need to be compared and analyzed. The brain evoked potential data of the subjects induced by different stimulation materials can be obtained after the electrical signals of evoked brain waves are extracted and processed. The brain evoked potential waveforms induced by F3, FC3, FZ, FCZ, F4, FC4, CZ and C3 electrodes are compared and analyzed as shown in Figure 2.

Through comparative analysis of induced brain evoked potential, it can be found that the peak values of evoked brain evoked potential of the subjects are different upon in the processes of aesthetic experience on four different schemes. The peaks of brain waves induced at the electrodes, *FZ, FC1, F1, F2, F3, F4, F5, F6, F7, F8*, by the four design schemes are shown in Table 4.

Table 4. In Brain wave peaks induced by the four questions at different electrodes µV

Inducing electrodes	Simulated brain evoked potential study on performance appraisal			
	Question 1	Question 2	Question 3	Question 4
FZ	2.4	6.2	5.0	6.0
FC1	4.1	7.8	5.9	6.9
F1	3.6	5.7	5.1	4.9
F2	3.4	7.2	4.8	5.8
F3	1.8	6.1	1.9	4.5
F4	2.6	5.6	1.8	4.4
F5	3.2	6.0	3.0	4.8
F6	2.1	3.6	1.8	3.2
F7	1.9	5.5	2.0	4.2
F8	1.5	3.4	1.9	3.2

Analysis of Experimental Results

Methods and steps

With the aid of Scan4.3 brain evoked potential recording and analysis system, offline analysis of brain evoked potential data is realized. The specific procedure is as follows: Merging data → processing, filtering out and deleting interference data→ converting reference electrode → filtering → removing electromyography → intercepting data analysis segment →baseline Correction → removing artifacts →average superimposition →superimposition between subjects → statistical analysis.

Brain evoked potential component analysis

Based on the above, the time course of brain evoked potential data is 1000 ms, so we can get the brain evoked potential waveform of the subjects when they are answering the four questions. Since there is a temporal characteristic in the analysis of brain evoked potential data, that is, the difference can only be displayed in a specific time window, the author strives to obtain four kinds of brain evoked potential wave forms, analyze N400 components, and analyze variance with SPSS method through the experimental paradigm.

(1) N400 component analysis

The data in the time window of 300ms-400ms are selected and the average value of brain evoked potential voltage is analyzed. According to the previous studies, N400 component has a large fluctuation in the radio waves of the front and the middle zones. Therefore, according to the actual situation, the author chooses 9 electrodes to carry out the analysis, as shown in Figure 3.

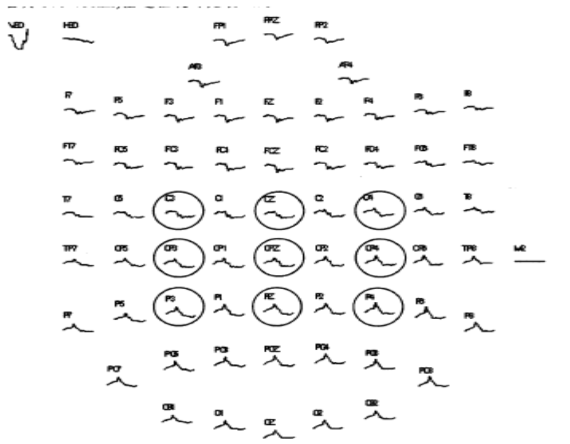


Figure 3. Electrode distribution of the whole brain

According to the above figure, four general mean lines can be obtained by expanding and superimposing to average the data of the subjects towards the four questions. Combining the results of variance analysis, the author finds that conditions of all aspects will have a significant effect on the N400 component. Specifically, the main effects of the 9 electrodes tested and measured are significant F(8, 8)=12.256, P=0.001<0.05.

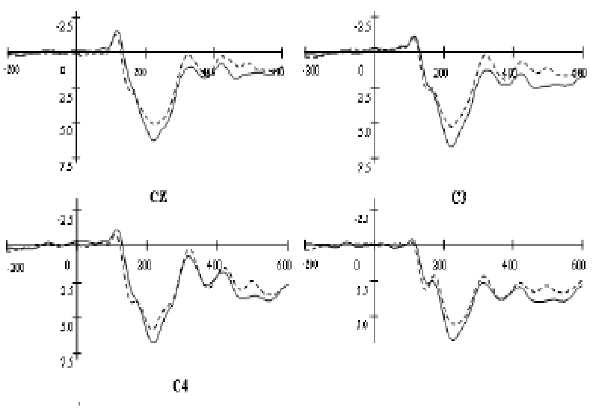
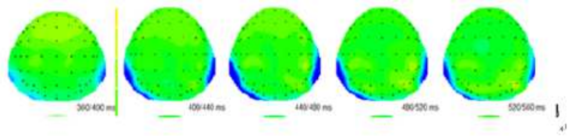


Figure 4. Brain evoked potential waveform

Table 5. Correlations between psychological values, eye movement and brain evoked potential

	Y1	X1	Y2	FZ	FC1	F1	F2	F3	F4	F5	F6	F7	F8
Y1	1	0.95	0.97	0.78	0.9	0.74	0.95	1	0.97	0.99	0.96	1	0.95
X1	0.95	1	0.93	0.94	0.99	0.88	0.99	0.95	0.87	0.92	0.89	0.95	0.98
Y2	0.97	0.93	1	0.78	0.9	0.83	0.96	0.95	0.89	0.94	0.87	0.95	0.88
FZ	0.78	0.94	0.78	1	0.97	0.93	0.92	0.78	0.64	0.72	0.69	0.78	0.89
FC1		0.90	0.99	0.90	0.97	1	0.94	0.99	0.89	0.78	0.85	0.81	0.9
F1	0.74	0.88	0.83	0.93	0.94	1	0.91	0.72	0.56	0.67	0.57	0.72	0.76
F2	0.95	0.99	0.96	0.92	0.99	0.91	1	0.94	0.85	0.91	0.86	0.94	0.94
F3	1.00	0.95	0.95	0.78	0.89	0.72	0.94	1	0.98	1	0.98	1	0.96
F4	0.97	0.87	0.89	0.64	0.78	0.56	0.85	0.98	1	0.99	0.99	0.98	0.91
F5	0.99	0.92	0.94	0.72	0.85	0.67	0.91	1.00	0.99	1	0.98	1	0.94
F6	0.96	0.89	0.87	0.69	0.81	0.57	0.86	0.98	0.99	0.98	1	0.98	0.94
F7	1.00	0.95	0.95	0.78	0.90	0.72	0.94	1.00	0.98	1.00	0.98	1	0.97
F8	0.95	0.98	0.88	0.89	0.94	0.76	0.94	0.96	0.91	0.94	0.94	0.97	1

Prior to information interference:



After information interference:

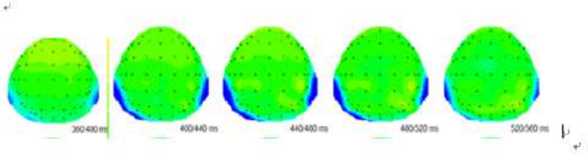


Figure 5. Brain Topography before and after information interference-—N400

The voltage value of the N400 component can be obtained through SPSS, from which the differences in the brain evoked potential data of the subjects in answering the four questions can be obtained. In addition, the author introduces information interference factors to interfere with the subjects. Their influences can be seen more intuitively by plotting the brain topographic map, as shown in the above figures.

(2) Correlation analysis

All the subjects carry out correlation analysis between each two of the psychological value (*X1*), fixation time of eye movement (*Y1*), number of fixations of eye movement (*Y2*) and evoked brain evoked potential, *FZ, FC1, F1, F2, F3, F4, F5, F6, F7* and peak value of *F*8, and the correlation coefficient analysis results among them are obtained, as shown in Table 5.

According to the correlation analysis, the correlation coefficients of 13 indexes such as physiology and psychology are positive in the cognitive evaluation of performance appraisal. Except that the correlation coefficients of F1 and F4, F1 and F6 are 0.56 and 0.57, respectively, all the other correlation coefficients are greater than 0.6, showing strong positive correlation. It can be seen that all the evaluation indexes have a high consistency with the evaluation results of the design scheme.

(3) LPP component analysis

The so-called LPP component, is the late positive component that is often mentioned, which has a specific latency, that is, between 550ms-650ms. The author reviews a large number of studies on LPP components and plots the brainwaves using the obtained data (Figure 6). From the practical point of view, the time window of 450ms-600ms is selected and the average value of brain evoked potential voltage is counted. On the basis of previous studies, the amplitude of LPP component in the top region reaches the maximum value, so we select 9 electrode points as the object of LPP component analysis, including CP1, CPZ, CP2, P1, PZ and P2.

Figure 6. Electrode distribution of the whole brain

Brain waves are four average lines obtained through interposing and averaging based on four questions. At the same time, according to the results of the repeated measurement of variance analysis, it is found that question 3 has a significant main effect on LPP components, but question 1 does not.

Conclusions

This article studies civil servants' cognitive evaluation of performance appraisal, and proposes an evaluation method for civil servants' cognition of performance appraisal using the combination of eye movement and brain evoked potential in view of the psychological/ physiological experience of civil servants in the process of performance appraisal. The results of the experimental study show that there are differences in the cognitive evaluation of civil servants at different stages of performance appraisal, and their cognitive evaluation will also have different degrees of change under the influence of information interference.

References

Hirasawa M, Yamamoto M, Kawano K, Furukawa A. An experiment on extrasensory information transfer with electroencephalogram measurement. Journal of International Society of Life Information Science 2017; 14 (2): 43-48.

Franco P, Värri A. Experiments of the sonification of the sleep electroencephalogram. Finnish Journal of eHealth and eWelfare 2015; 7(2-3):65-74.

Teixeira C, Cardoso A, Gomes MPC, Sales F, Dourado A. An alternative methodology for the estimation of frequency changes in electroencephalogram signals. Experiment@ International Conference 2016; 302-05.

Tang X, Yu K, Liu W, Gao T, Xu Y, Zeng Y, Peng Y. The set partitioning in hierarchical trees algorithm for data compression in ambulatory electroencephalogram systems. Journal of Medical Imaging & Health Informatics 2016; 6(2): 494-98.

Inkaew N, Charoenkitkamjorn N, Yangpaiboon C, Phothisonothai M, Nuthong C. Frequency component analysis of brain evoked potential recording on various visual tasks: Steady-state visual evoked potential experiment. International Conference on Knowledge and Smart Technology 2015; 180-83.

Hashemi SS, Hajiagha SHR, Zavadskas EK, Mahdiraji HA. Multicriteria group decision making with electre iii method based on interval-valued intuitionistic fuzzy information. Applied Mathematical Modelling 2016;40 (2): 1554-64.

Xian S, Dong Y, Yin Y. Interval-valued intuitionistic fuzzy combined weighted averaging operator for group decision making. Journal of the Operational Research Society 2017; 68(1): 1-11.