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**Abstract.** Stress is the source of all diseases, and the detection and management of psychological stress are very essential to everyone. In this paper, a stress evaluating system based on the EEG is designed for evaluating the state of psychological stress objectively. Firstly, the changes of EEG signals are obtained in real-time by using TGAM modules. Then the signal processing and wireless transmission are carried out by using Bluetooth technology to the computer. The pressure eigenvalues of EEG, which includes focal point, the edge spectrum, EEG pressure index and so on, are extracted. Finally, the results of the EEG analysis are to realize the automatic evaluation of stress state. At the same time, the experiment of pressure induction and evaluation is designed for verifying specific groups and combined with the VAS test. The results show that the EEG analysis can detect psychological stress more objectively, comprehensively and accurately.

## 1. Introduction

Stress is the source of all diseases. The main predisposing factor for most adult diseases is stress, and a variety of physical or mental diseases can be leaded by long-term psychological stress. Therefore, people pay more and more attention to the problem of psychological pressure. At present, the objective psychological pressure assessment equipment in the market is based on the analysis of heart rate variability (Heart rate variability, HRV) of ECG signals to evaluate and analyze the physical and psychological stress load of the subject [1-3]. However, only by analyzing the autonomic nerve balance of ECG signals to objectively evaluate the state of psychological pressure has some one-sidedness and limitations.

It has been proved that EEG signals are related to human psychological activities closely in the medical research. Beta wave bands in brain waves directly reflect people's mental stress, emotional excitement or hyperactivity. Therefore, we can evaluate people's psychological stress by analyzing the characteristics of EEG signals. This research idea has been confirmed by many scholars at home and abroad. For example, multi-scale entropy algorithm is used in EEG analysis; some scholars used prefrontal EEG asymmetry to detect the stability of stress and depression level; others based on the self-built physiological signal database to evaluate psychological stress [4]. However, the above-mentioned research angle also has limitations.

In this paper, the psychological pressure analysis system collects the EEG signals of the subjects, and uploads them to the upper computer in real time through the communication module for software analysis. The **software** includes EEG signal preprocessing, EEG rhythm extraction, EEG pressure eigenvalue extraction and calculation. Finally, combined with EEG pressure eigenvalue results, then

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analysis and evaluate the psychological stress status comprehensively. The stress analysis system is designed by modularization, and the EEG is designed independently.

## 2. EEG perception And Analysis

EEG plays an important role in the monitoring and diagnosis of Parkinson's disease, epilepsy and other physiological diseases, depression, insomnia and other psychological disorders, the evaluation of psychological stress, the evaluation of cognitive status and so on [5]. In this paper, the EEG signal is collected at first, and then the digital EEG signal is sent to the upper computer for analysis through Bluetooth communication module, the upper computer first carries on the EEG signal preprocessing based on wavelet transform, including signal dedryness and rhythm extraction. Next, the extraction and calculation of EEG pressure eigenvalues are realized. The characteristic values of pressure are concentration, marginal spectrum, EEG pressure index and other parameters. These eigenvalues are used to objectively measure the psychological stress state.

### *2.1. EEG Signal Acquisition*

EEG signal is weak and easy to be interfered by the surrounding environment and other electrophysiological signals. In order to reduce the interference of environment and movement, the subjects need to remain static in the acquisition process. Because of the large size of the traditional acquisition equipment and the need for wet electrodes, the installation is inconvenient and the comfort is poor, it cannot be portable or even wearable [5]. Considering the need to overcome the "white coat" effect in psychological stress analysis and evaluation, the comfort of the subjects should be satisfied as much as possible, and the volume of brain wave (Electroencephalogram, EEG) recording equipment should be reduced at the same time. In this paper, a wearable Bluetooth headset EEG acquisition device based on TGAM module is used. The invention comprises an TGAM EEG acquisition module (EEG acquisition point), a forehead electrode (reference point), an ear clip electrode (grounding circuit), a Bluetooth transmitting module, a Bluetooth receiving module and a power supply, as well as a computer connected to the device.

The TGAM module is equipped with the ASIC chip system, which can realize the functions of EEG signal acquisition, filtering, amplification, A/D conversion, data processing and analysis, etc. [6]. The original EEG signal is collected at the sampling frequency of 512Hz, at the same time, the noise is filtered out, and the anti-interference ability is strong. Finally, the collected signal is converted into digital signal, and the communication with the computer is maintained by Bluetooth wireless transmission mode. The collected data include the original brain waves and the concentration and relaxation generated by the brain waves [6]. At the same time, the TGAM module has the characteristics of low energy consumption, and use serial port standard output interface, which the output baud rate is 1200, 9600 and 57600. The chip principle is shown in Fig.1.

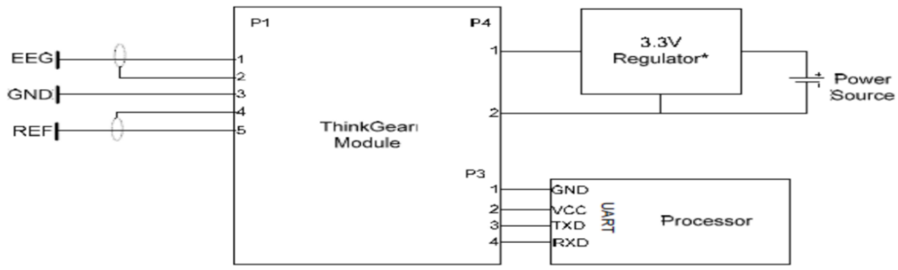



Fig.1. The schematic of TGAM module.

### *2.2. Feature Extraction of EEG Pressure*

The eigenvalues of EEG pressure generally have nonlinear dynamic parameters such as complexity, Hilbert marginal spectral approximate entropy, wavelet entropy, Lyapunov index, concentration and relaxation. In this paper, KC complexity, Hilbert marginal spectrum, mean concentration and psychological stress index are extracted as stress eigenvalues.

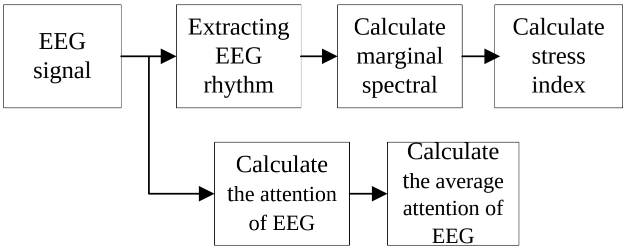



Fig.2. The principle block diagram of EEG analysis.

(1) KC complexity

KC complexity, also known as complexity or L-Z complexity reflects the random degree of time series. In the late 1980s, Kasper et al. studied the complexity of random sequences in the sense of Lem-Ziv, and proposed a specific algorithm for the complexity measure of random sequences. The complexity measure obtained by this algorithm is called KC complexity. Xu Jinghua et al. first applied the Kolmogorov entropy algorithm implemented by Lempel & Ziv to EEG analysis. Because the complexity analysis method does not require the length of the sequence strictly, it is widely used in the field of signal processing.

Before calculating KC, the sequence to be processed is coarse-grained, that is, each point of the sequence is represented by a bit, so the signal information studied can be coarse-grained to form a "0,1" sequence. Suppose the time transmission sequence to be processed is $x(i)$ （i=1，2，…，n）, gets the average value. If $x_i \geq$ average, make $x_i$ =1; If $x_i$ <average, make $x_i$ =0; Then these 0,1 points are formed into a simplified sequence of the original sequence. The KC complexity algorithm calculates the S sequence.

(2) Concentration

Concentration is an algorithm used by NeuroSky to measure a person's current mental state in a digital parameter manner. NeuroSky technology first amplifies the original brain wave signal and filters the interference caused by ambient noise and muscle tissue motion. By calculating the processed signal by eSense algorithm, the quantized eSense parameter value, concentration, is obtained. Among them, the concentration index is very important, whose size is 1~100, and the larger the value is, the higher the concentration is [6]. It is important to note that the eSense value is not a specific value that quantifies the current state of mind, but a value that describes the range of fluctuations in the current state of mind activity. In this paper, the mean value of concentration is used as the evaluation index.

(3) Hilbert marginal spectrum

Hilbert marginal spectrum reflects the amplitude distribution at each frequency point. Its instantaneous frequency is local and adaptive, and can accurately reflect the actual frequency components of the signal. The calculation process of Hilbert marginal spectrum is as follows [7]:

The real part of x(t) is taken to represent the instantaneous amplitude and instantaneous frequency of the signal by time function. The amplitude time-frequency distribution at this time is defined as Hilbert spectrum, that is:

$$H(\omega,t) = \mathrm{Re}(\sum_{j=1}^{n} a_j(t)\exp(i\int \omega_j(t)dt)) \tag{1}$$

$H(\omega,t)$ describes the variation of signal amplitude with time and frequency in the whole frequency range. By integrating the Hilbert spectrum with time, the Hilbert marginal spectrum is obtained, which is defined as follows:

$$h(\omega) = \int_0^T H(\omega, t)dt \tag{2}$$

The energy of the four rhythms of EEG varies with the fluctuation of the brain state. Combined with the characteristics of the stress state, the psychological pressure index based on Hilbert's marginal spectral energy is defined by referring to the existing methods, as shown in the formula:

$$F = \frac{E_\delta + E_\theta}{E_\alpha + E_\beta} \tag{3}$$

Among them, $E_\delta$ , $E_\theta$ , $E_\alpha$ ,and $E_\beta$ are the marginal spectral energies of δ, θ, α and β waves, respectively[7].

## 3. Experiment

### *3.1. Subjects and Environment and Process*

Twenty-eight subjects, between the ages of 19 and 35, 14 men and 14 women, were recruited for the experiment. All come from undergraduates and teachers in colleges and universities. None of the subjects had heart disease or mental disorders such as depression or anxiety.

The test was arranged in a quiet room with as little interference as possible. The subjects sat in a chair, had a mouse and keyboard to answer questions for testing, and could see the test interface on the computer's screen.

In order to verify the designed psychological stress assessment method, the questionnaire commonly used in psychological survey was used as a reference. After the rest period and stress induction test, each subject was asked to show his or her stress status using the visual analogue scale (Visual Analogue Scale/Score, VAS). VAS was used to ask the subject to indicate his emotional state by answering 10 questions about 10 different discrete emotions. One of the emotions is "stressed", the degrees of which are "no stress at all", "less stress", "more stress" and "a lot of stress".

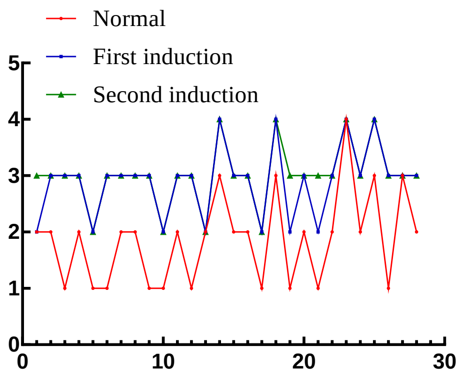
Two stress tests were performed during the experiment. Test 1 is the Norinder test, which is a computational test commonly used in pressure experiments [8-10]. The test is used as a "reference" test to induce stress. The test is used as a "reference" test to induce stress. The test was carried out under time pressure. The subjects completed 30 calculations in 3 minutes. When an error occurs, a red screen appears, the buzzer rings, and the subject must calculate the result again. The countdown timer beeps every 3 seconds from 2 minutes. Test 2, design five tasks that are mentally challenging, such as logical puzzles from IQ tests. The subjects had three minutes to solve the problem. The test is also carried out under time pressure, with the same timer and buzzer as Test 1.

The experimental steps are as follows:

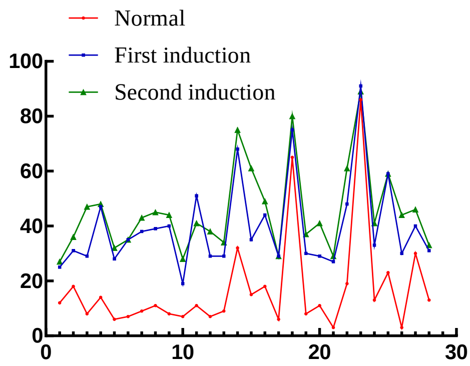
- The subjects first fill out the emotional state questionnaire to evaluate their psychological stress state.
- Using the psychological stress assessment system described in this paper, the results of psychological stress assessment are given from the EEG pressure characteristic value respectively. At the same time, they wear Bluetooth brain wave headsets and ear clip electrodes to keep their foreheads dry. Earlobes do not wear earrings, used to collect brain wave signals. Once the subject is equipped with all the sensors, check on the computer analysis software to ensure that the sensor nodes communicate correctly and that the signal quality is good. The results of psychological stress state were analyzed for 10 minutes.
- Carry out stress test experiment 1, repeat the last two experimental steps.
- The subjects rest for 10 minutes, carry on the stress test experiment 2, and repeat the last two experimental steps.

### *3.2. Experimental Results and Analysis*

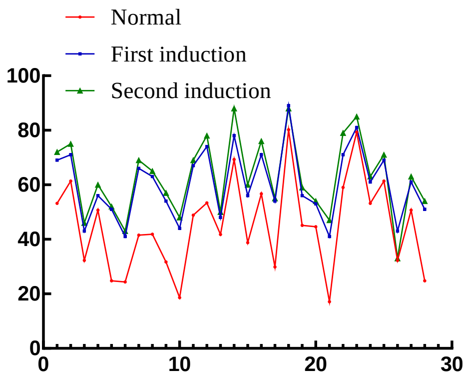
Firstly, the original data waveforms are collected by EEG acquisition modules. Fig. 3 (a) shows that the result of VAS under the normal state, first induction state and second induction state. Fig. 3 (b) and (c) show the pressure exponent of pressure exponent of EEG, and the attention of EEG. The results show that the psychological pressure of the same subject is different after stress test. With the progress of time, the psychological pressure generally has increased, which is related to the concentration of the subjects and fatigue, which is consistent with the actual situation. The indicators of rest and stress state of the same testers are different, which can objectively characterize the mental health status of human beings. At the same time, the evaluation of EEG pressure index for the subjects' psychological pressure is very similar and the results are basically consistent with the results of VAS test. The subjects are all college students, the psychological pressure is small, the pressure index of individual subjects is high because they are currently participating in the subject competition, the test results are consistent with the actual situation, and we can see that the data analysis results are more accurate.




(a) The result of VAS




(b) The pressure index of EEG




(c) The attention of EEG

Fig.3. The results of evaluating pressure (after putting pressure).

## 4. Conclusion

Objective evaluation and management of psychological stress is an important means of clinical examination. In this paper, a non-invasive psychological stress examination system is designed from EEG, and EEG signal acquisition and perception, EEG pressure eigenvalue extraction and analysis are completed. The designed system is used to test the psychological stress index of the subjects in normal rest state and after two stress inducements, and the results are compared with those of VAS. The test results are consistent with the actual state. The designed psychological stress assessment system has an objective, intelligent and portable design style, and can meet the application needs of hospital physical examination, psychological department and psychiatric clinical test. The system is simple in testing, fast in analysis, high in sensitivity, accurate in data, stable in performance, safe and reliable, and has low requirements on user professional level. It can be used in home monitoring, clinical examination of hospital psychology, hospital physical examination, etc. It has a wide range of application prospects. At the same time, there are some limitations in the work of this paper. The data samples that can be used for analysis are relatively small, the type is relatively single, and more complex sample groups are needed to verify the results of the study. In addition, for all the eigenvalues derived from EEG pressure, we only use two of them, which is determined by referring to the results of some researchers. Because of the variability between the subjects, the absolute pressure level characteristics are also impossible. Future work should focus on finding better standardization methods to form certain standards.

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