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Vigilance Degree Computing based on EEG

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Abstract

In daily life, lots of work need people maintain higher attention or vigilance. In the early study of vigilance, blink frequency, the impedance of skin, body temperature and blood pressure and other physiological signals was used to estimate the vigilance. EEG signal can more directly reflect the brain's activity than other physiological signals, and EEG signal have a higher time resolution. In this paper, ERP component and different frequencies of EEG were used to analyze the alert state, according to this study, in the ERP components, N170 can be a good representation of the degree of fatigue of the subject; Through the 10 subjects EEG frequency distribution analysis, and according to the formula defined in this paper, the vigilance degree of this ten subjects was calculated.

Keywords*: electroencephalogram, vigilance degree, event-related potential, frequencies distribute*

1. Introduction

In daily life, lots of work need people maintain higher attention or vigilance, such as long-distance bus drivers, students' learning, lectures, examination. Once they appear in the work of the attention not centralized, may cause very serious consequences. Therefore, research alert on man, has the important practical significance.

In the early stages of vigilance, blink frequency, the impedance of skin, body temperature and blood pressure and other physiological signals was used to estimate the vigilance. Ergonomics research shows that, when a person is in a state of high alert, and palm skin impedance will decrease, and when people are in a state of fatigue, skin resistance will rise. In the study of Ji et al [1], through the accurate positioning of the face, mouth, nose, eyes, eyes closed, closing time, blink frequency, nodding frequency, face towards, gaze direction and mouth opening degree and other features of vigilance on human research. In fact, people start to study exemplary in the nineteen fifties [2-4], at first, the study starts from sleep problems, and the main difference between waking and sleep research in two different conditions. With the further research, people from wakefulness to sleep is composed of several stages, the analysis of these stages which features becomes the focus of the study; until now, with the expansion of the scope of the study, the traditional from consciousness to further subdivide the sleep state between, which clearly put forward the vigilance.

EEG signal can more directly reflect the brain's activity than other physiological signals. EEG signal because of its non-invasive, is easy to use in the study, so the application of EEG signal widely in brain-computer interface system, physiological detection [5-7], related in the cordon area, such as fatigue driving EEG studies have related to [8, 9].

ERP can observe brain activity in the process of the window; it was found that the ERP component is closely related to many and cognitive process. For example: CNV slow potential components of British neurophysiologist Walter report (contingent negative variation), is closely related with the human to look forward to, preparation, action time orientation, pay attention to mental activity; Sutton proposed P300 is composition of ERP and attention, recognition, decision-making, memory and other cognitive function related to the Kutas and Hillyard first proposed N400 promoted; the brain mechanism of human language processing and understanding. According to the basic characteristic of vigilance, determine which cognitive function including attention, memory, motivation, and emotion, cognitive functions such as language, control, and ERP experimental analysis.

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In this paper, ERP component and different frequencies of EEG were used to analyze the alert state, according to this study, in the ERP components, N170 can be a good representation of the degree of fatigue of the subject; Through the 10 subjects EEG frequency distribution analysis, and according to the formula defined in this paper, the vigilance degree of this ten subjects was calculated.

2. EEG Acquisition

The EEG data used in this paper is come from BCI Laboratory of Jiangxi University of Technology; the subjects to relax in a quiet shielding room sat an armless chair in front of the computer, watching the screen, do EEG experiment according to experiment the arrangement and the indication screen stimulation. EEG acquisition is the use of 40 Neuroscan amplifier, were obtained by scan4.3 software, right mastoid is reference electrode, and used 1000Hz as sampling rate, band acquisition using 200Hz low-pass, high-pass 0.05Hz and 50Hz notch.

P300 was discovered by Sutton in 1965, its main feature is a forward wave event in about 300 milliseconds, endogenous components mainly and psychological factors related, its physical meaning is mainly reflected in the latency of the subjects of stimuli or classification required time, amplitude said reflected background or memory updates. So the alert analysis can use P300;

EEG is composed by various band waves, the frequency can be divided into $\delta, \vartheta, \alpha, \beta$. The δ, θ is slow wave, occurs mainly in adults sleep; and α, β is fast wave, occurs mainly in people is vigilant and pay attention external stimulus or when the special mental activity.

In this paper, electroencephalogram EEG selected 10 college students as subjects, including five subjects in the morning to do the experiment, five participants did the experiment in the afternoon (not a nap). The stimulus pattern: first, the screen is a second black state, then will randomly appear in a picture, the picture shows 250 milliseconds, then a second black screen, then will randomly appear in a picture, before the experiment, participants will be asked to write tests in a picture number.

3. Data Processing

This paper analyzes the Vigilance degree from the frequency and ERP components, so data processing, respectively:

The ERP components analysis step is:

Step 1, Block larger drift EEG: in EEG acquisition process, such as the subjects movement, wander, outside sound effects, the EEG signal initial there will be large drift, will follow the EEG signal processing impact, so in the EEG before treatment, to remove this a part of the brain electrical signal;

Step 2, Ocular artifact reduction: the EEG signal in the original, because to blink or look right and left, the impact on the eye electric signal, so before feature extraction and classification, to remove the impact of this part, this paper is mainly to remove the vertical eye film;

Step 3, epoch the data, view the stimulus intervals, and generally 10%-20%, -50, is the common value of -100; the spirit of not more than one event to the principle, in this paper, the interception of data in -100~900ms.

Step 4, baseline correction: the segmented data many not at baseline, so this paper conducted a total of two times the baseline correction and a linear correction.

Step 5, artifact reject: EEG signals collected by the class, there is a part of segmented data caused by various reasons is not good, not only for data analysis useless, it will affect the analysis of the data, so to choose a certain window screening, the window is -80~80.

Step 6, average: This article mainly is ERP analysis of EEG signals, so the same stimulation of the brain electrical signal types were stacked.

The frequency analysis step is:

Step 1: Subjects during the test process, especially in fatigue, unconsciously generate the movement of the body, resulting EEG interference by EMG, so the first step is select the better EEG.

Step 2: On EEG analyzes, the primary band distribution 1~50Hz in this paper, so before do data analysis must filter the EEG signal.

Step 3: Common average: In this paper, we use Hjort derivation to reduce interference from the neighboring electrode,

The Hjort derivation C_i^H is calculated as:

$$C_i^H = c_i - \frac{1}{4}\sum_{j \in S_i} sc_j \quad (1)$$

Where ci is the reading of the center electrode scj, with i=1…30 and j is the set of indices corresponding to the eight electrodes surrounding electrode ci.

Step 4: AR conversion: time-domain EEG data disorganized EEG in order to better highlight the characteristics of EEG signal, we use AR model to convert the time domain signals into frequency domain, and extract the feature from the frequency domain signals.

4. Results and Discussion Conclusion

As shown in Figure 1, the upper left corner Subject said graphics parameters; the upper right corner is the acquisition time, HEO is horizontal EOG, VEO is vertical EOG, electrode FP1 labeled 10-20 under different. The green line is the morning subjects waking state made the experiment, red line is subjects in the case did not take a nap, have been quiet made to wait until four p.m. experimental EEG. FT7 afternoon FIG electrode deviation volatility was significantly higher than the red, green corresponding EEG ERP components also obvious from the other electrodes can be apparent, in order to better able to look at two states contrast, we choose one of the electrodes to discuss.

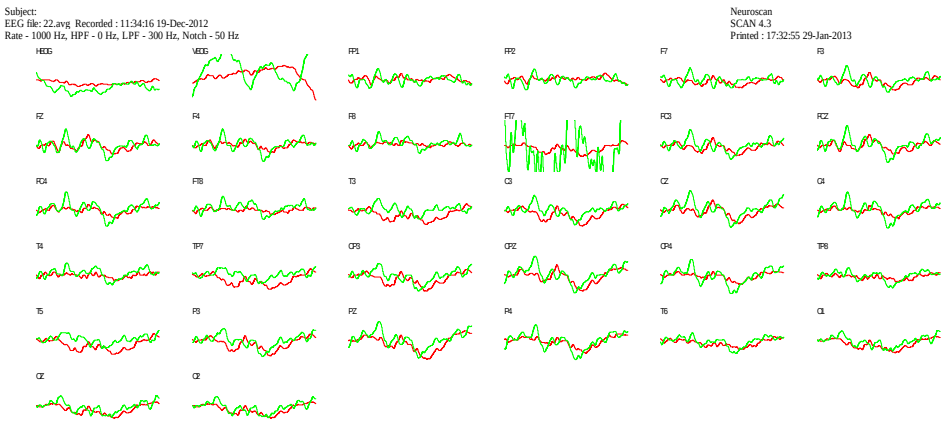

Figure 1. Two States Comparison Chart

As shown in Figure 2, green for waking state, red for mental fatigue, First N170, represents a degree of reflection of the subject of the picture, a green reflected on the picture it is clear, the amplitude reached 7.5 microvolt, while the red-N170 only 2.5 microvolt, only one-third of the green, the information processing P300 blue magnitude more obvious, but the red P300 is very obvious subjects basic loss of information fatigue processing capacity.

Respectively on the five waking state subjects and five fatigue state subjects EEG analysis, the five waking state acquisition of EEG, its N170 amplitude 7.5, 5.3, 6.5, 7.3, 6.8 microvolt, the mean6.68 is microvolt. Five fatigue N170 amplitude, respectively 2.5, 2.0, 1.9, 3.2, 2.8 microvolt, the mean is 2.48 microvolt. Therefore, subjects EEG N170 amplitude analysis, it can be considered when the N170 amplitude than 5 microvolt, subjects in the waking state, the subjects had a higher vigilance degree, while N170 magnitude of less than 3 microvolt when the subject is fatigue state, subjects' vigilance degree is lower.

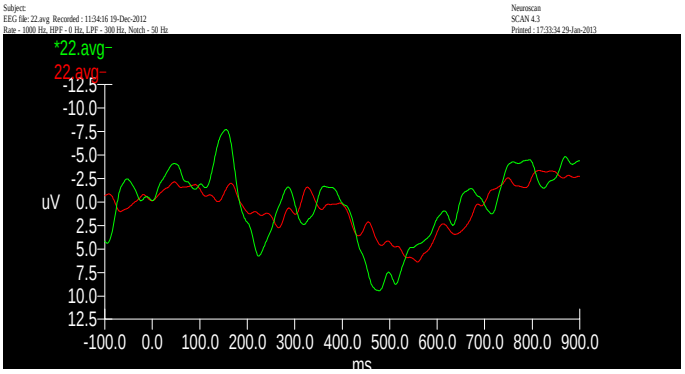

Figure 2. Single Electrode Comparisons

The P300 component of these 10 subjects, from the time of occurrence and magnitude of the five waking state subjects, the P300 amplitude are 2.4, 2.7, 1.8, 2.1, 1.5 microvolt, time of occurrence are distributed in 300 milliseconds to 350 milliseconds. Five fatigue state subjects' P300 amplitude distribution between 0.5 and 1.5, there are two subjects P300 from the superimposed picture point of view not out. From the P300 appear time, the time distribution between 320 milliseconds and 400. So, to vigilance degree the N170 is better than P300.

The main component of the brain wave signal by four bands: $\delta, \vartheta, \alpha, \beta$, the dominant component when human consciousness is α, β; the dominant component when human unconsciousness is δ, ϑ.. The different EEG bands corresponding to the frequency range are: 8~12Hz, for 13~30Hz, 4~7Hz, 1~3Hz. In this paper, the model 2, the subjects' eyes closed state collected EEG analysis.

This paper using the following formula to calculate the proportion of S different states, different frequencies:

$$S(\omega) = \frac{\int_{\omega 1}^{\omega 2} A(t)dt}{\int_{1}^{50} A(t)dt} \quad (2)$$

ω is different frequency band. $\omega 1, \omega 2$ are the lower and upper limits of the band. $A(t)$ is EEG signal function after AR model transformation.

In this paper, the following formula used to calculate the proportion of different bands of the five subjects of the two states:

$$\overline{S}(\omega) = \frac{\sum_{1}^{5} S(\omega)}{5} \quad (3)$$

This article using the following formula to calculate the subjects alert degrees AL:

$$AL = \frac{S(\alpha) + S(\beta)}{S(\delta) + S(\vartheta)} \quad (4)$$

Intercept the EEG collected by subjects' close their eyes time to 246 segments of one second as the period. After data processing is performed according to the method of the above-mentioned, the frequency data obtained in the superposition averaging obtained 10 subjects in the EEG average frequency after conversion of the AR model data, and then according to Equation 2, to calculate each frequency segment proportion. The different frequency bands proportion of five waking state show as Table 1, the different frequency bands proportion of five fatigue state show as Table 2.

Table 1. Different Frequency Bands Proportion of Five Waking State

	α	β	δ	ϑ
1subject	0.3785	0.4516	0.1093	0.0606
2subject	0.3223	0.5073	0.1262	0.0442
3subject	0.3286	0.4690	0.1458	0.0566
4subject	0.3052	0.4993	0.1094	0.0861
5subject	0.3302	0.4595	0.1288	0.0815
average	0.33296	0.47734	0.1239	0.0658

Table 2. Different Frequency Bands Proportion of Five Waking State

	α	β	δ	ϑ
1subject	0.2915	0.4107	0.1985	0.0992
2subject	0.2949	0.4083	0.2229	0.0740
3subject	0.2574	0.4058	0.2290	0.1078
4subject	0.2671	0.3849	0.2404	0.1078
5subject	0.2887	0.3558	0.2420	0.1135
average	0.27992	0.3931	0.22656	0.10046

Table 1 and 2 data show that when the subjects were awake, α band proportion of the total band distributed between 30.52% and 37.85%, an average of 33.30%; subjects in a fatigue state α band proportion of the total band distribution of between 25.74% and 29.49%, an average of 28.99%; when the subjects were awake, β band proportion of the total band distributed between 45.16% and 50.73%, an average of 49.93%; subjects in a fatigue state β band proportion of the total band distribution of between 35.58% and 41.07%, an average of 39.31%; when the subjects were awake, δ band proportion of the total band distributed between 10.93% and 14.58%, an average of 12.39%; subjects in a fatigue state δ band proportion of the total band distribution of between 19.85% and 24.20%, an average of 22.66%; when the subjects were awake, ϑ band proportion of the total band distributed between 4.42% and 8.61%, an average of 6.58%; subjects in a fatigue state ϑ band proportion of the total band distribution of between 7.40% and 11.35%, an average of 10.04%.

Table 1 and Table 2 data show that the subject is awake; the proportion of band α, β higher than the subject is fatigue; the subject is awake; the proportion of band δ, ϑ lower than the subject is fatigue; Comprehensive Table 1 and 2 of these 10 subjects the data according to equation (3) can be calculated The ten subjects alert degrees were: 4.8858, 4.8685, 3.9407, 4.1151, 3.7551, 2.3588, 2.3685, 1.9691,1.8725, 1.8129, according to the state of the subject, when the subjects alert degrees lower than 3, indicating that the subjects have been tired at this time should remind the subjects.

5. Conclusion

When a person is awake, alert will be high; when people in a tired state, human vigilance performance will be followed low, but what to measure, and the detection alert degrees, has been a problem. In this paper, the EEG to analyze people's vigilance performance, respectively, calculated from the ERP and the proportion of different bands. The analysis showed that 10 subjects, when N170 amplitude than 5 microvolt, subjects in the waking state, the subjects had a higher alert, and when the N170 amplitude less than 3 microvolt when subjects in a tired state lower subjects Cautionary;, when the subjects alert degrees below 3, indicating that the subjects have been tired, subjects should remind .

In this paper, the EEG to calculate the subjects alert, extends the degree of vigilance research approach, but the results of this paper only 10 subjects analysis, subjects were from Jiangxi Institute of Technology in the college students, the number of the study population and subjects age distribution is less a single, therefore, to expand the number of subjects and the wealth of subjects age distribution is the next step in this research work.

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