

# Biofeedback EEG can quantify abnormal phenomenon of EEG in psychology

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**Abstract:** TEEG (electroencephalography, EEG) is a kind of single which we know human brain function active. BT (Biofeedback Therapy, BT) is based the method of EEG technology, focusing on the studies of human thoughts and emotions activities. We shall study new points that the two kinds of EEG technology are used simultaneously, to find the BT can be quantified abnormal EEG activities in mental illness, to provide the certain reference value in clinical. We found that BT can quantify  $\beta$  wave,  $\theta$  wave and some abnormal phenomenon of traditional EEG. Therefore, based on the conventional examination of the traditional EEG in clinical, we used BT to further check. The results show not only to quantify the advantages of traditional EEG brain waves specific values occur, such as the specific data of fatigue ( $\theta$  wave) and anxiety ( $\beta$  wave), but also abnormal phenomenon. Quantized data would become more intuitive, and to assess the clinical efficacy of treatment more scientific and objectivity.

**Keywords:** Biofeedback EEG; Quantify;  $\theta$  wave;  $\beta$  wave; Abnormal phenomenon

## Introduction

Usually, we recorded the electrical activity of the brain spontaneously through the electrode, to understand human brain function active. This method is known as “EEG” (electroencephalography, EEG). Nowadays, the EEG biofeedback (Biofeedback Therapy, BT) is based the method of EEG technology, focusing on the studies of human thoughts and emotions activities, and used them to retrain the abnormal brain waves [1]. Our paper will explore the field of EEG and BT.

EEG is one of the basic research methods to understand the physiological functions and pathological changes. Transitionally, we could find some brain diseases and other diseases causing changes in brain function.

Through the change of EEG spectrum, in 1936, Walter [2] described the limitations of the activity, positioning the location of the cerebral hemisphere tumor. Walter and his team [3] found further evidence that the rhythms associated with subcortical lesions. Now, EEG was a kind of routine examinations to know the brain function in clinics.

With the progress of research, people found the brain was a complex system. Not all of the diseases of the nervous system had abnormal EEG; some abnormal EEG had no brain lesions necessarily. So, EEG was only a secondary means of checking. Na S H and his research group [4] found that EEG was nonlinear dynamic parameters with comparing all kinds of EEG, as is marked the EEG would enter into the phase of quantitative research. Today, the analysis skill of

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quantitative EEG has been used in a lot of nerve auxiliary diagnosis of mental illness. Quantitative EEG can help us to understand electrophysiological changes of the psychological and physiological state. Among these skills, BT is one of the electrical technologies basing on the quantitative EEG. Lehrer P [5] studied that BT was widely used in clinical medicine treatment, education and other fields. People can change EEG waveform to adjust the brain function state through BT training for a period of time. But, Arbel Y [6] and Francesco P [7] reported that BT signals were interfered easily by external environment, as to the mental state and attention of subjects.

Therefore, we shall study new points that the two kinds of EEG technology are used simultaneously, to find the BT can be quantified abnormal EEG activities in mental illness, to provide the certain reference value in clinical.

## **Materials and methods**

### **1.1 Subjects**

The patients are from the hospital CC mental hygiene clinics from January to November in 2015. They satisfy the requirement of ICD-10 standard, without physical ailments and showing normal in physical inspect.

### **1.2 Equipments**

The Spirit-mind instruments of blue tooth type, 10 channels 16 parameters, biofeedback apparatus and dynamic EEG recorders.

### **1.3 Methodology**

#### **1.3.1 Relaxed state; routine EEG checks; biofeedback nerves inspect;**

#### **1.3.2 The biofeedback monitoring requires:**

- 1) Turn off all the acceptor of electrical signals, all the phones and patients` phone, set up sound insulation area.
- 2) Untie all the patients` manacles, *e.g.* Waist tie, take off shoes, watch and remove the other decorations.
- 3) Patients presents in half-lying state on couch, to adjust to the most comfortable gesture. A thick blanket or a thin one is needed according to the season.
- 4) Firstly, three parts should be cleaned for the patients `s with alcohol, forehead, post aurum and finger pulp. Then electrode slice will be places on the body connected with biofeedback and adjusted to work.
- 5) Notice: Patient should close the eyes all the time during adjusting and open the eyes with command to lessen the interfering signal of the visuals and eyes moment. Patients just need to keep calm to be tested.

### **1.4 statistic methods**

SPSS19.0 will be statistical analysis tools.

## **Results**

### **BT can quantify $\beta$ wave of traditional EEG**

BT can quantify the amplitude of traditional EEG in  $\beta$  wave. It could be found some  $\beta$  waves in a plenty of patients, EEG, if the patients see a doctor because of anxious problems. We may check their anxiety through psychological assessment. But the methods were impacted by doctor`s subjective evaluation and patient`s subjective feelings. BT has not the subjective effect. It is be found the random results in 49 patients to its 126 obsessive-compulsive disorder patients. See figure 1, we find some  $\beta$  waves in EEG. From Tab.1, we can see clearly the amplitude of  $\beta$  wave. The quantified data can help us in clinical how to use anxiolytics and to observe the efficiency and

reasonable dose. It can also reduce the risk of drug abuse and side effects.

### **BT can quantify $\theta$ wave of traditional EEG**

In the traditional EEG, the frequency of  $\theta$  wave is 4-8 Hz, called slow wave. The  $\theta$  wave appears very low in the normal EEG. Our brains will current a little  $\theta$  wave in the temporal region after 40 years old, and others areas will appear when our ages will be 60 years, which indicates the brain aging phenomenon<sup>[8]</sup>. If we find the early aging signal in the brain, we need to understand why these are: excessive tension, too tired, or a certain mental illness. It is be tested 53 patients brain states are fatigue in 126 obsessive-compulsive disorder patients.

We can conclude the early  $\theta$  wave in the traditional EEG (*Fig. 2*), but it is only fuzzy data as the clinical treatment. It is obvious to be presented amplitude of  $\theta$  wave (*Tab. 2*) after the use of BT. It is so informative for us to understand the severity of the brain aging and treat effectively.

### **BT can quantify some abnormal phenomenon in normal traditional EEG**

Generally, the normal EEG shows certain amplitude from several to 75uv and it is a little lower to mental activity, only 2 to 10uv. Above or below its range. It is not normal <sup>[9]</sup>. In traditional EEG test, about 19% of patients show normal although they have continued epilepsy seizures <sup>[10]</sup> and seizure-free in clinical, which does not mean no abnormal brain discharges <sup>[11]</sup>. The factors will affect the epilepsy seizure, including the causes of seizure, seizure type, age of onset, antiepileptic drug response, abnormal EEG, neuropsychiatric symptoms and so on<sup>[12]</sup>. Under such situation, the doctors need to judge comprehensively based on their clinical experience and past medical data.

Our team checked 126 OCD patients and found, the traditional EEG of them has no problems, but among the 22 cases were abnormal BT, about 17.46%.

There were four types in abnormal phenomenon: false sharp wave(4 cases), high amplitude (8 cases), low amplitude (7 cases), mixture of high and low amplitude (3 cases). See Fig.3 was high amplitude change of BT. See table 3, we can understand clearly these changes. It would help us to analyze the reasons and choose the appropriate treatment methods.

## **Discussion**

EEG is the result of the cerebral cortex activities, and related to complex cognitive processes of brain. Compare to a lot of various research methods, the research on EEG has been the forefront of research. BT is a sensitive instrument that can reflect the change of individual emotion and physiological index. Today, BT is mainly used for individual physiological and psychological treatment, but it has been more and more used in academic research <sup>[13]</sup>. Our team had been found the relationship between the  $\theta/\beta$  ratio and OCD which used BT, and proved that OCD was a kind of thought disorder expression <sup>[14]</sup>.

The brain is a complex organ to human beings, and mental, psychological. Activity is more complex than former. The different psychological state will shows and sends the dissimilating signals correspondingly. Traditionally the EEG plays regular function of checking abnormal signal for brain. While, we are exploring a new checking method for EEG, to apply biofeedback on the appliance, working with high and low amplitude theory, to compensate the EEG defects to fulfill the comprehensive examination for the mental patients. It does help to exhibit the mental illness records more obviously under the violated usage for the EEG record with the biofeedback signals, which provides more evidences and furthers the clinic research with theoretical supports.

Therefore, based on the conventional examination of the traditional EEG in clinical, we used BT to further check. The results show not only to quantify the advantages of traditional EEG brain waves specific values occur, such as the specific data of fatigue ( $\theta$  wave) and anxiety ( $\beta$  wave), but also abnormal phenomenon.

These would help us to further clinical study functional status about human brain, the assessment of disease and more treatment options. Quantized data would become more intuitive and to assess the clinical efficacy of treatment more scientific and objectivity.

Of course, it is inevitable that the results are not accurate enough because our research conditions were limited and the machine equipment had more limitation.

## Future

Now, our team had studied some of mental illness with BT for eight years, including OCD, depression, and so on. We hope to find some active of the brain and the cause of mental disorder. In future, the quantification of psychology will be the leading edge of these discipline boundaries. It means that will study from the severe psychology to mental problems, prevention and etiology.

So, our team will continue to use this approach to study other psychiatric and neurological areas.

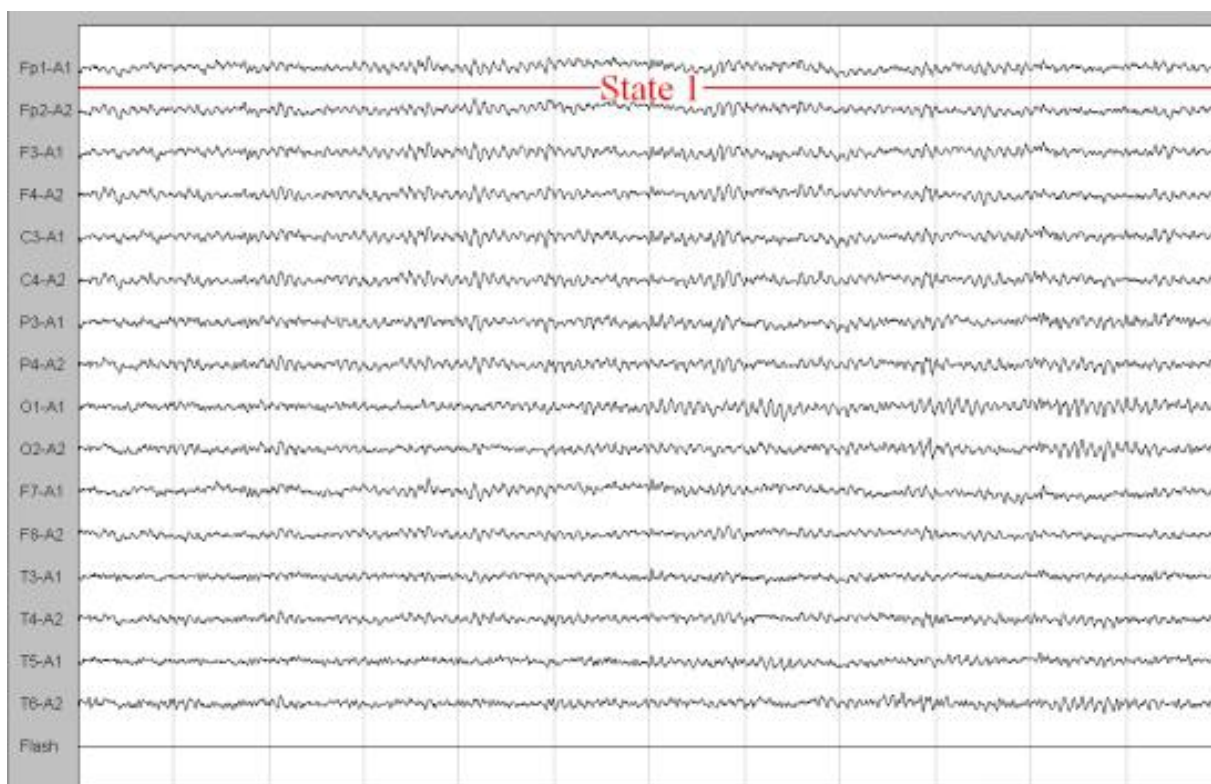


Fig. 1 EEG (Patient, female, 48y, General anxiety disorder)

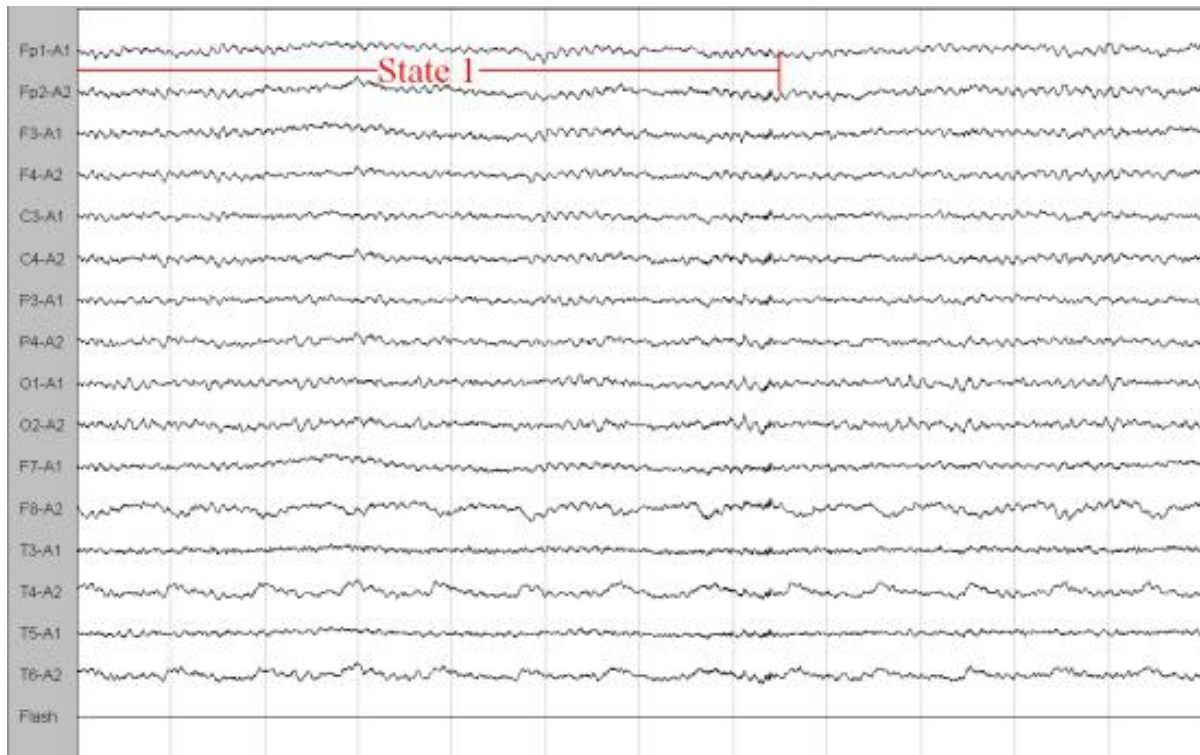


Fig. 2 EEG (Patient, male, 62y, Obsessive-compulsive disorder)

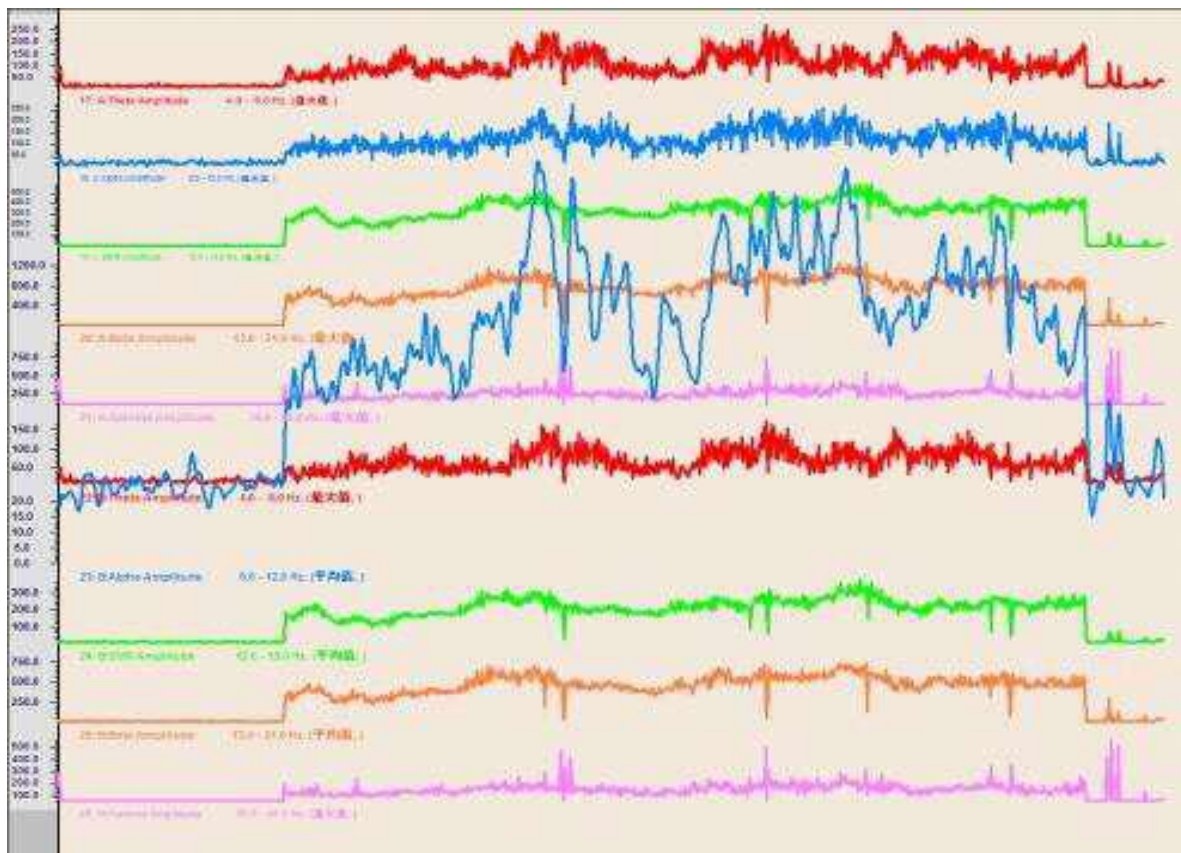


Fig. 3 (high amplitude)

Tab. 1 BT (Patient, female, 48y, General anxiety disorder) Amplitude (uv)

	Min	Max	mean	Variance	Standard deviation
A: Theta	0.99	34.78	9.02	16.38	4.05
A: Alpha	0.29	75.31	18.76	111.68	10.57
A:SMR	0.31	25.09	6.31	10.51	3.24
A: Beta	0.43	66.05	15.21	64.00	6.05
A: Gamma	0.49	62.28	13.06	51.33	7.16
B: Theta	1.31	31.50	9.96	15.37	4.40
B: Alpha	0.53	95.51	21.48	139.56	11.83
B: SMR	0.20	29.61	7.46	15.20	3.90
B: Beta	0.20	66.58	12.18	72.08	8.49
B: Gamma	0.95	18.30	14.06	45.40	6.74

Tab. 2 BT (Patient, male, 62y, Obsessive-compulsive disorder) Amplitude (uv)

	000	false sharp wave	high amplitude	low amplitude	high and low amplitude
A: Theta	11.34±3.11	166.57±31.10	1.86±0.96	218.15±59.73/0.60±0.40	
A: Alpha	11.22±1.45	119.76±24.40	1.60±0.94	125.72±31.53/0.45±0.02	
A: SMR	5.00±2.58	96.72±14.11	0.81±0.34	80.45±18.89/0.36±0.00	
A: Beta	6.53±2.32	131.58±21.71	1.20±0.51	99.51±29.63/0.54±0.01	
A: Gamma	3.06±0.41	81.37±15.04	0.72±0.25	72.28±8.42/0.37±0.01	
B: Theta	12.47±3.58	136.61±43.06	9.49±2.06	10.33±1.96/9.83±1.82	
B: Alpha	12.33±2.69	108.00±34.12	9.69±2.19	13.38±3.70/12.98±3.89	
B: SMR	6.05±3.69	172.85±114.23	5.15±1.26	6.82±1.26/6.03±1.54	
B: Beta	7.64±3.16	254.86±177.67	7.85±1.84	9.38±1.21/8.50±1.46	
B: Gamma	3.16±0.66	60.36±19.28	4.61±1.77	3.84±0.25/6.68±1.41	

Tab. 3 BT (Abnormal phenomenon)

	Min	Max	mean	Variance	Standard deviation
A: Theta	0.92	39.17	13.77	31.03	5.64
A: Alpha	0.35	34.00	12.30	24.09	4.90
A: SMR	0.28	9.57	2.72	2.36	1.54
A: Beta	0.28	13.73	2.96	4.39	2.10
A: Gamma	0.20	7.59	2.30	1.38	1.17
B: Theta	1.24	37.79	14.33	34.97	5.91
B: Alpha	0.57	32.50	12.74	25.14	5.11
B: SMR	0.28	13.62	3.25	3.25	1.80
B: Beta	0.28	25.44	4.08	7.20	2.01
B: Gamma	0.28	18.50	3.58	5.12	2.26

## Reference

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1. Hammond DC. Neuro feedback with anxiety and affective disorders. *J Child Adolesc Psychiatr Clin N Am*, 2005, 14:105-123.
2. Walter WG. The localization of cerebral tumors by electroencephalography. *Lancet* 1936, 2:205-308.
3. Walter WG, Dovey VJ. Delineation of subcortical tumors by direct electroencephalography. *Lancet* 1946, 1:5-9.
4. Na S H, Jin S H, Kim S Y *et al.* EEG in schizophrenic patients: mutual information analysis. *Clin Neurophysiol*, 2002, 113(12):1954-1960.
5. Lehrer P. Applied psychophysiology: beyond the boundaries of biofeedback (mending a wall, a brief history of our field, and applications to control of the muscles and cardio respiratory systems). *J Appl Psychophysiology Biofeedback*, 2003(4)28:291-304.
6. Arbel Y. Brain-computer interface: transforming electrical brain activity into communication. *The ASHA Leader*, 2007, 12(12):14-15.
7. Francesco P, Konstantions P, Stefano S *et al.* Integration of a P300 brain computer interface into virtual environment. *Virtual Rehabilitation*, 2007, 27:88.
8. Sieg KG *et al.* Brain imaging: evoked potential, quantitative EEG and SPECT abnormalities in schizophrenia, *J-psychiatry-Neurosci*, 1991, 16(1):4-44.
9. Schenton ME *et al.* Correlations between abnormal auditory P300 topography and positive symptoms in schizophrenia, preliminary report, *Biol-psychiatry*, 1989, 25(6):710-716.
10. John S. Ebersole, Timothy A. Pedley. *Current Practice of Clinical Electroencephalography*, 3th edition. People's Medical Publishing House, 2009, 8:449-456.
11. Schagass C *et al.* Evoked potential Topography in unmedicated and medicated schizophrenia, *Int-J-psychophysiol*, 1991, 10(3):231-224.
12. Breslau J *et al.* Topographic EEG changes with normal aging and SDAT, *Electroeph Clin Neurophysiol*, 1989, 72(4):281-289.
13. ZHANG Ping, *et al.* Impact of Cognitive Reappraisal Intervention on State Gratitude in College Students. *Chinese Journal of Clinical Psychology*. 2016, 24(1):164-168.
14. Hong-ying YIN, Meisheng ZHAO, *et al.* Preliminary Evidences of Obsessive Compulsive Disorder as Thinking Disorder. 2014 International Conference on E-commerce and Contemporary Economic Development, ECED2014:355-359