34th Annual International Conference of the IEEE EMBS
San Diego, California USA, 28 August - 1 September, 2012

EEG EPs Analysis of Magnetic Stimulation on Acupoint of Shenmen(HT7)*

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Abstract—**Acupuncture is a useful irritation therapy clinically. Acupuncture at acupoints is proved to have specific function on human body. Magnetic stimulation is a new kind of stimulating technique of non-invasive, painless and effective. The effect of magnetic stimulation on acupoint is a new subject in recent years. In this paper, the electroencephalogram (EEG) evoked potentials (EPs) of magnetic stimulation by stimulating the acupoint of Shenmen(HT7) are studied. The experiments are divided into four groups: quiet, acupoint stimulation, mock stimulation and mock point stimulation. The EEG EPs are collected and an obvious P150 component is obtained. The amplitudes of P150s are analyzed and compared. The P150s are localized in brain by dipole model and the coronal, sagittal and axial plans are painted and observed. The results show that acupoint stimulation on acupoint of Shenmen(HT7) can evoke stronger nerve activity of somatosensory than stimulation on common surface. The dipole source of acupoint stimulation and common surface stimulation are both focused on the cingulated gyrus which related to somatosensory.**

I. Introduction

Transcranial magnetic stimulation (TMS) is a stimulating technology which generates the time-varying magnetic field on the scalp and the limb cortex and the inducing current will affect the neuron active potential on the cortex of the scalp and the limb [1].

Magnetic stimulation is a kind of stimulating therapy, it stimulates neural organization by injecting time-variant current and induces time-variant pulsed magnetic field to induce current in biological tissues. Because of advantages of painless, non-invasive，effective and operating simply, it is widely used in the study of activity and cognitive function and related clinical treatment [2]. Now the theory of acupuncture is under study. It is found that there are a large number of receptors and mast cells under acupoints. Acupoints are concentrated area of vascular, nerve bundle, nerve branch, free nerve endings and other nerve receptors [3]. The study results of China Union Medical University show that the receptive areas distribution of cutaneous nerves and muscular nerves are related to the acupoints. Modern medicine has proved that acupoint has the physics and chemical relative specificity of acoustics, optics, electricity, magnetic, temperature, ion concentration etc. Acupoint can be seen as an actor which can not only accept information from outside but also transfer information from body to outside [4]. Yin et al [5-7] of P.L.A General Hospital studied the experimental evidence of the change of brain function when acupuncture at acupoint of Zusanli. The results show that acupuncture at Zusanli can evoke functional changes at autonomic nerve centre and temporal lobe. The acupuncture is familiar to us as a method of stimulation. Magnetic stimulation on acupoint also can be a new stimulation method, it can induce current in tissue to affect and control the information of body. Li et al [8] have studied the heart rate changes of drivers under magnetic stimulation on acupoint. Evoked Potentials (EPs) tests measure how long it takes for stimulation of different nerves to reach the brain and how big the response is. It is showed as average EEG peaks. The amplitude and delay time of the peak can give important information about the brain and spinal cord [9]. Researchers have studied mechanism of acupuncture and magnetic stimulation by EEG analysis. Zhongshan School of Medicine Physiology research group has studied the changes of EPs under electric acupuncture on epidermis [10]. Based on the works of previous researchers, this study evaluated effects of EEG by magnetic stimulation on acupoints by EPs analysis and dipole reconstruction. The acupoint selected is acupoint of Shenmen(HT7) which is related to mind activities.

II. Methodology and Materials

A. Methodology and materials

The experiment is divided into four groups. The first is quiet experiment which the volunteers sit and close eyes in a quiet environment about 10 minutes, the machine registered EEG signals. The second is acupoint magnetic stimulation experiment. The center of eight winding of TMS is placed at 1cm above HT7 of volunteer's right hand and the acupoint is stimulated. The intension of magnetic stimulation is 80% threshold (2.2T) and the frequency is 1HZ. The third is mock stimulation experiment with conditions same as the acupoint magnetic stimulation experiment but the stimulation is not applied to human body. It is only have the same vocal stimulation. The forth is mock point stimulation experiment with conditions same as the acupoint stimulation experiment but the stimulated point is not HT7 but an ordinary point next to it. The points of HT7 and mock point are shown in Fig.1.

B. Materials

12 healthy and right-handed volunteers are studied (6 males and 6 females). Their ages range from 20 to 30. Average is 23.4.

*Resrach supported by the Natural Science Foundation of CHINA under Grant 31100711.

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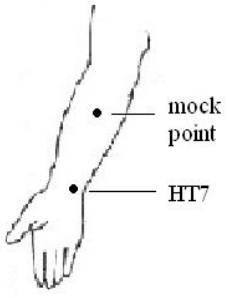


Fig.1 Schematic diagram of HT7 and mok point

C. Instrument

The EEG signals are collected using a 128 channels electroencephalograph from Neuroscan Co.,Ltd.. The experiments collect EEG signals using 64 channels. Magnetic stimulation uses Magstim 2 of Magstim Co.,Ltd.. Eight winding (inner diameter is 53mm and outer diameter is 73mm) of TMS is used.

D. Methodology of the Signal Process

The off-line processes are made after the EEG data are collected. The processes include ocular artifacts correction, digital filtering, signal epoch, baseline correction, linear correction, artifacts correction and superposition average. After off-line processes, the EPs can be extracted. Statistical analysis is made on EPs amplitudes of every sample. Statistical method is paired sample t test.

Dipole localization is based on the electric field theory and mathematical method. The method is to calculate the dipole source in the skull by EEG signals collected from the electrodes placed on the scalp. It uses forward problem and inverse problem calculation to obtain the location and intensity of the dipole.

In the case of static state and Approximation, potentials of conductor surface and current dipole source are linear relationship. The dipole model can be described as

$$\Phi = L_V Q \tag{1}$$

where L_V is lead field matrix of potentials, Q is matrix of electrical dipole moment weight. Optimized objective function is defined as

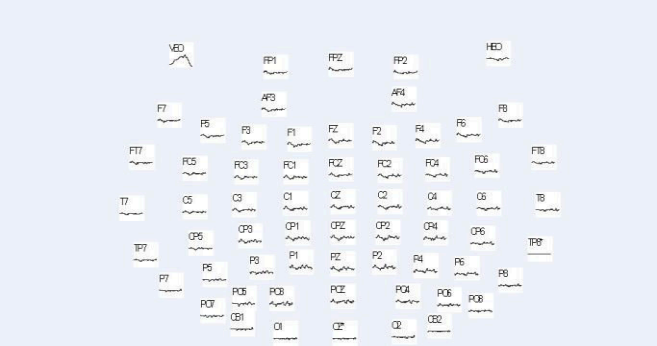
$$F = \left\| \Phi_d - \Phi_c \right\|^2 = \left\| \Phi_d - L_V L_V^{+} \Phi_d \right\|^2 \tag{2}$$

where Φ_d is measured value, Φ_c is truth value of potential in the scalp evoked by the supposed source.

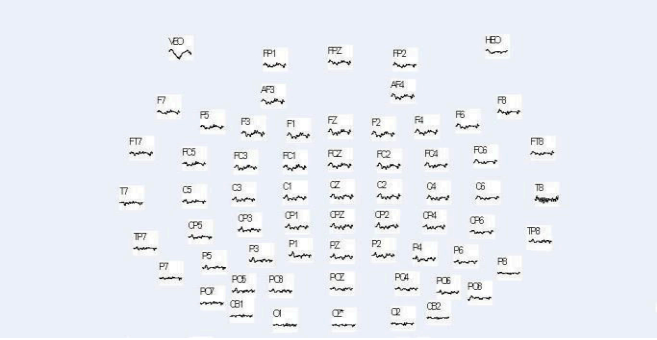
Principal component analysis (PCA) is a method to transform many indexes into a few general indexes [11]. Because the recording EEGs are active results of different encephalic region in different time period and the number and location of independent sources are unknown, the independent mapping components must be extracted. Principal component analysis is an effective method to determine the number of independent dipoles.

III. Results And Discussion

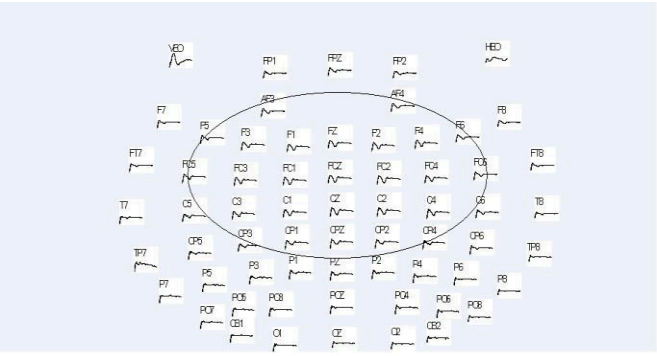
After off-line processes, EPs maps of 64 electrodes are obtained. Four groups EPs maps of volunteer 1 are shown in Fig.2. According to (a) and (b), we can see that quiet and mock stimulation maps have no obvious EPs. According to (c) and (d), mock point stimulation and acupoint stimulation maps have EPs in some regions which are circled with black line. The regions are mainly distributed in central lobe cortex, frontal lobe cortex and their middle region which are coded C, F and FC of electrodes in the EPs maps.



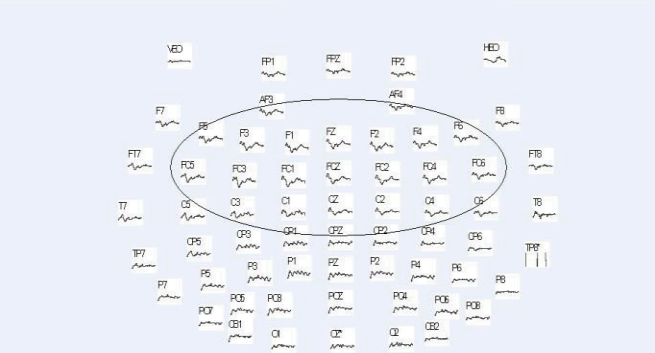
(a)Quiet



(b)Mock stimulation



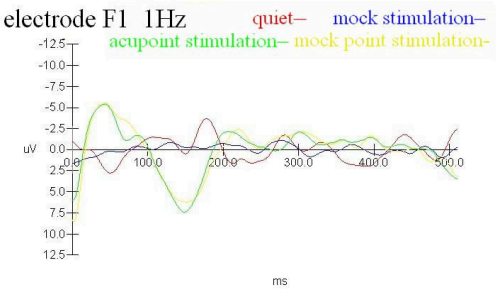
(c)Mock point stimulation



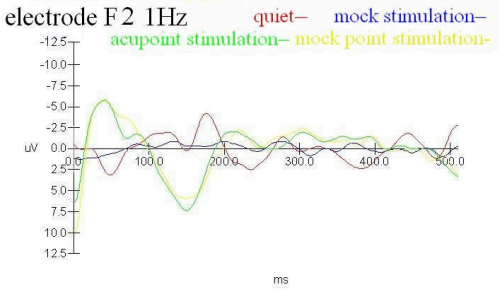
(d)Acupoint stimulation

Fig.2 Schematic diagram of EPs maps

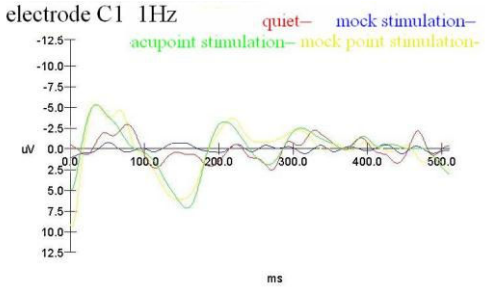
Detailed analysis was made on the EPs of central lobe cortex and frontal lobe cortex. We selected four electrodes to be example which are F1, F2, C1, C2. EPs schematic diagrams of four groups' experiments of F1, F2, C1, C2 are shown in Fig.3. In Fig.3, we can see that the obvious EPs of mock point stimulation and acupoint stimulation are the EPs of P150. P150 is related to early work process in reading activity [12]. It also reflects some mood information process in psychology. Thus P150 is an endogenous EP component related to psychological reactions. There are no language and thinking actions in the experiments, so P150 must be a psychological reactions evoked by somatosensory stimulation.



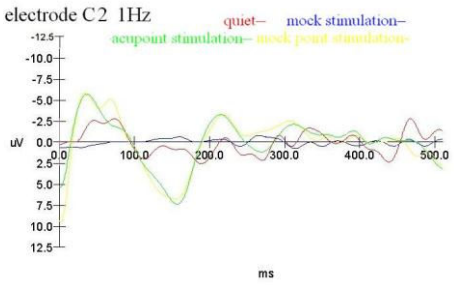
(a) electrode F1



(b)electrode F2



(c)electrode C1



(d)electrode C2

Fig.3 Schematic diagram of EPs under 1Hz

According to Fig.3, amplitudes of P150 of acupoint stimulation (green line) are a little higher than that of mock point stimulation (yellow line) in four schematic diagrams. Most electrodes which have P150s have the law. After statistical analysis of P150 amplitudes on 12 volunteers, it is found that there are statistical difference ($P<0.05$) between acupoint stimulation and mock point stimulation as shown in Tab.1. The P150s evoked from acupoint stimulation and mock point stimulation proved that P150 is not only an EP component related to mood psychology but also related to somatosensory. The statistical difference of amplitudes of acupoint stimulation and mock point stimulation probably indicates that acupoints are different from common human surface in somatosensory. The high EP amplitudes of acupoint stimulation probably mean that the somatosensory of acupoint is stronger than that of common surface. It is probably because the acupoint is a surface area where nerve clusters are very dense. Liu et al [13] proved that the density of A-fiber and C-fiber in acupoint area of rats is higher than that in non-acupoint area and it may partly explain the results above.

TABLE I. STATISTICAL ANALYSIS OF P150 AMPLITUDES

Electrode	Amplitudes of P150（μV）		P
	Acupoint stimulation	*Mock point stimulation*	
F1	7.35±0.48	6.16±0.45	0.032
F2	7.81±0.54	6.64±0.43	0.004
C1	7.36±0.52	5.92±0.57	0.001
C2	7.54±0.83	6.38±0.42	0.008

Source localization was made on P150s of volunteer 1. The PCA of 1Hz magnetic stimulation P150 shows that there are three dipoles in the skull and the PCA of 1Hz mock point stimulation P150 shows that there are two dipoles in the skull. The coronal, sagittal and axial plans of acupoint stimulation

and mock point stimulation are shown in Fig.4. The plans show that the sources of P150 of acupoint stimulation and mock point stimulation are both at the cingulate gyrus in the skull. Other volunteers all have the character. It suggests that the cingulate gyrus is a brain region related to somatosensory. The result verifies the relationship of cingulate gyrus and somatosensory from the EEG point of view and confirms the understanding of the cingulate gyrus before [14]. The difference of P150 dipoles between acupoint stimulation and mock point stimulation still need further study.

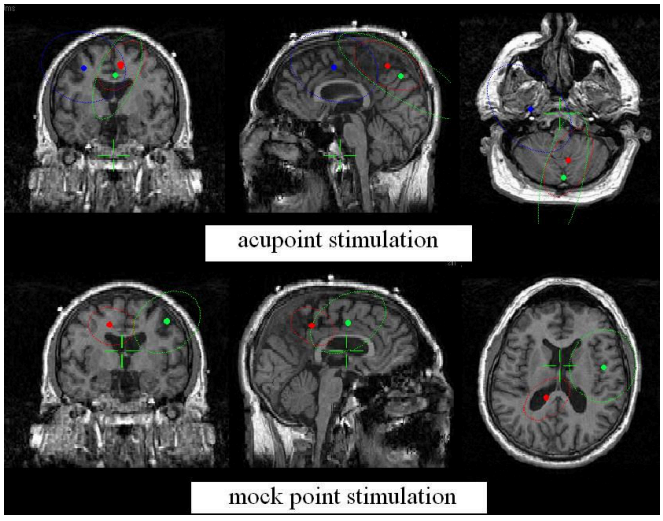


Fig.4 Coronal, sagittal and axial plan of EP source

IV. Conclusion

Schematic diagrams of EPs of quiet and mock stimulation are nearly smooth, therefore there is no obvious nerve activity in the two experiments. Amplitudes of P150 of acupoint stimulation are higher than that of mock point stimulation statistically. It implies that somatosensory of acupoint under magnetic stimulation is stronger than that of common surface. The acupoints are different from the common surface in physiology and magnetic stimulation on acupoints may be an effective stimulating therapy. The dipoles of P150s of acupoint stimulation and mock point stimulation focuse on cingulate gyrus which indicates that cingulate gyrus is a brain region related to somatosensory. The study is a preliminary research of acupoint magnetic stimulation. The neural mechanisms of magnetic stimulation and internal neural activities of acupoint still need further research.

Acknowledgment

This work was supported by the Natural Science Foundation of CHINA under Grant 31100711.

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