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Recognition and Analyses of EEG&ERP Signals Related To Emotion: From the Perspective of Psychology

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Abstract– **Electroencephalographic (EEG) is widely used to record activities of human brain in the area of psychology for many years. With the development of technology, neural basis of functional areas of emotion processing is revealed gradually. In order to extract the useful information of emotion out from the background of EEG signals and noise, we propose it is needed to combine the methods of psychology and the technology of signal processing such as pattern recognition, etc. In this paper, we first review the psychological methods and signal processing technology in the field of emotion research, and point out the junctions of these two approaches. Secondly, we introduce a method to evaluate emotion competence objectively, which involves the analyses of frequency fluctuations of EEG signals and frontal EEG asymmetry. Then, we take an example of event-related potentials (ERP) study about the face recognition task and the discrimination of sad/happy/neutral emotional facial expressions task. Finally, we indicate the present difficulties in this research area, and advance the possible solution to resolve these problems.**

Keywords– **Emotion; EEG; ERP; Signal Processing**

I. Introduction

Emotions play an important part in people's everyday life. They motivate us and influence our every decision, even when we are unaware that we are making decisions. Understanding how emotions function and why they sometimes malfunction is critical to our individual and societal health. However, there are many difficulties to research emotion in the area of psychology. Individual's emotional state may be influenced by kinds of situations, and different people have different subjective emotional experiences even response to the same stimulus. That how to evaluate individual's emotional state objectively and find out the functional areas of emotion processing comes to be the most attentional issue.

In the last century, there appeared kinds of functional brain imaging techniques such as such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), electroencephalography (EEG), etc. The obvious advantages of EEG as a measure are less invasive, less expensive, and more widely available than other functional neuroimaging techniques.

Since Richard J. Davidson suggested that frontal brain electrical activity was associated with the experience of positive and negative effect in 1978 [1], EEG was used to study the individual's emotional state for more than two decades. Frontal EEG asymmetry is regarded as a measure of an underlying approach-related or withdrawal-related motivational style [2], or as both a moderator and a mediator of emotion-related and motivation-related constructs [3].

With the rapid development of computer science and electronic technique, event-related potentials (ERP) has been used to research cognition and emotion. Using this technique, some special emotion-related components during emotional processing have been found to interpret the relationship between psychological activities and changes of brain potentials.

II. Methodology

EEG signals record the normal information of the individual's brain activities, which may indicate the physiological and emotional state of the subject; ERP signals record the evoked brain potentials of the subject, which may indicate the subject's responses to the stimuli. In this paper, we pay more attention to ERP signals.

A. Method of EEG

Studies show that higher left activity is associated with approach/positive emotional state, while the higher right activity is associated with withdrawal/negative emotional states [3]. The area of research examining frontal EEG asymmetry in emotion is now over two decades old, data reduction and analytic techniques have varied across studies, but there are many common approaches that transform raw EEG signals to metrics that provide the basis for making inferences about the role of frontal brain activity in emotion [4].

The first step is transforming EEG signals into metrics that putatively are related to how active various

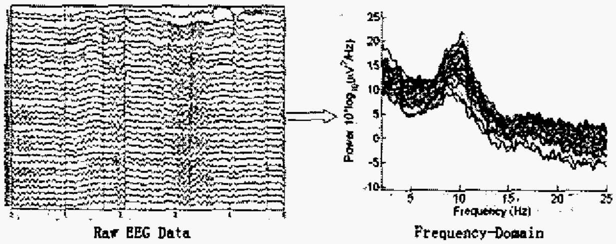

Fig.1. From raw EEG data in time-domain to a frequency-domain representation

brain regions may be. This process involves taking a signal collected in the time-domain, and transforming it to a frequency-domain representation, usually in the form of a power spectrum. (See Fig.1)

Then we process the signals with the Hamming window. By windowing, the discontinuity is avoided. After windowing, we use fast Fourier transform (FFT) to attain two spectra, a power spectrum and a phase spectrum.

As alpha power (8–13 Hz) is most often examined, researchers often use a difference score (ln (Right) − ln (Left) alpha power) to conveniently summarize the relative activity at homologous right and left leads. In fact, we use a modified natural log difference score computed as (R−L)/(R+L) to examine the asymmetry. The most attentional result is contribution of activity in each hemisphere, which will require analyses involving the examination of data from each hemisphere as a difference metric. The most straightforward approach involves analyzing (ln-transformed) power at left and right sites in an analysis of variance (ANOVA) or the more general linear model (GLM), with not only region as a factor, but also hemisphere [4].

B. *Method of ERP*

There are several emotion-related ERP components elicited by different stimulus material different experimental designs. In this paper we take an example of event-related potentials (ERP) study about the face recognition task and the discrimination of sad/happy/neutral emotional facial expressions task. As we all know that the N170 (negative waveforms, which latent time is about 170 millisecond after the presentation of the stimuli) is the face-specific components, which indicates that faces are processed in different brain regions compared to other control stimuli. We did an experiment to check up the special components related to face recognition and the emotional processing of the facial expression. In this experiment, stimulus material was taken from the set of pictures of facial affect of Ekman and Friesen (1976) and consisted of slides of the faces, presenting a sad, a happy and a neutral face. Photographs of three geometric graphics presented randomly were used as control stimuli. The subjects were asked to finish two tasks. One is the face recognition task, in this task, subjects were asked to tell faces from geometric graphics. In another task, subjects were asked to distinguish the three kinds of sad/happy/neutral faces and response differently towards varied facial expression.

III. Results

The amplitudes elicited by faces were very significant. The grand mean ERP to faces at the electrode location Cz is shown in Fig.2. The N2 component was very clear, which was peaked at approximately 166.0 ms in response to faces.

The grand mean ERPs at the electrode Cz elicited with sad, happy and neutral faces are shown in Fig.3.

There are no significant differences among the N170 components evoked by the different facial expression. But the later components between 250ms and 600ms have significant differences, the results are different with reference [5], perhaps the causes are the subject's different responses to the different facial expression or

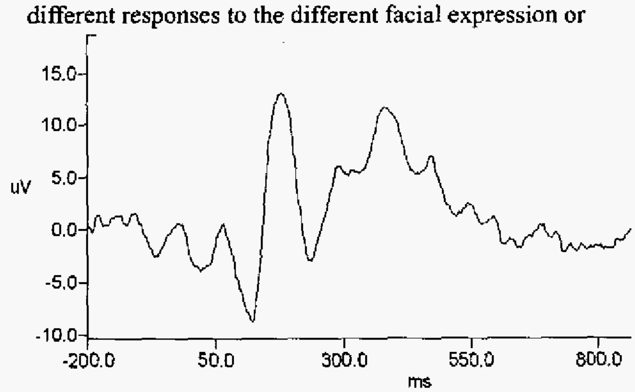

Fig.2. Grand average curves at Cz electrode site for faces

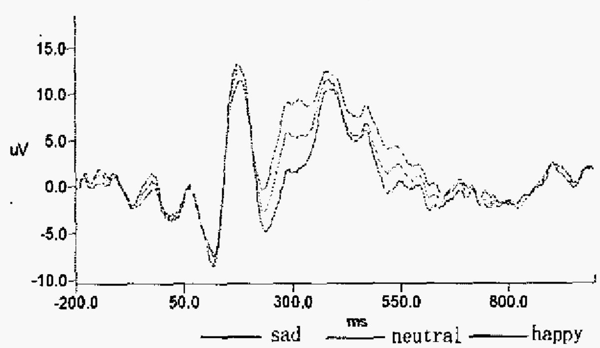

Fig.3. Grand average curves at Cz electrode site for sad, happy and sad facial expressions

the wrong responses which give the bad emotional experience in the mind of the subject.

IV. DISCUSSION

The results indicate that face perception at this early stage is independent from the emotional content of the facial expressions. Different facial expressions did not differ in their associated brain activation at the component N2 (negative waveforms, the latent time is about between 150ms and 250 ms). The decoding of different facial expressions is probably a separate process which may be reflected in later ERP components. Further research will apply this experiment in children and the study cultural difference caused by the faces from the different nations.

V. CONCLUSION

A. Perspectives of Psychology

Although frontal EEG asymmetry has greater construct validity as a measure of this motivational style than does any neuroimaging measure to date, the evidence linking frontal EEG asymmetry to the activity of underlying neural systems involved in the experience, expression, and regulation of emotion is considerably lacking [1]. So it is very important to find out the valid algorithm to interpret the relationship between the appearances of potentials and the activities of the neural system.

We are interested in the emotional competence of the children, especially the course of emotional development. We consider that frontal EEG asymmetry may be a remarkable sign of the development of motional competence. So it is needed to collect plentiful EEG data of children to establish a database, which may be used to evaluate the emotional competence of children.

Emotions are individual's subjective experiences; it is hard to arouse emotional responses to the control stimulus objectively in the experimental conditions, especially in the filed of children research. The best situation is to study emotions in the natural environments, but according to the current technology and experimental methods, it is very hard to estimate individual's emotional state and responses to the emotional stimuli in the natural environments. At present, the material used in the EEG&ERP research of emotions are emotional pictures (such as International Affective Picture System, etc), facial expression (such as Pictures of Facial Affect, etc), and so on. Considering the character of children, not all these stimuli are suitable. We want to research emotions of children when they are playing games, learning, so it is necessary for us to design new experimental paradigms and new stimulus material.

B. Perspectives of Signal Processing

The EEG method commonly records and analyses the resting EEG signals, and sometimes the responses to the emotional stimulus. Although there are a lot of methods to process EEG signals, but techniques which can be used in recognition and extracting emotion-related information from EEG signals are lacking. It is needed for researchers to combine the knowledge of psychology and signal processing technique to find effective algorithm to work out this problem.

The ERP method needs to repeat the same stimulus for many times in order to extract the low ERP signal from the background of high EEG signals. However, it is hard to ask subjects to repeat the same emotional states in several minutes, so developing new paradigms to research emotions is very important. By using the signal processing technique such as pattern recognition (PR), wavelet transform (WT), neural-networks (NN), or support vector machine (SVM), it is possible for researchers to find out the approaches to extract the single trial ERP elicited by the stimulus which would be presented for once in the experiment. In further research, we will try to do this work to improve the analyses of ERP signals.

C. In General

On one hand, at present, there are rare studies which research EEG and ERP at the same time. We believe that there are common joints between EEG and ERP technology, and in the area of emotion research, it is promising to combine EEG and ERP technique together to interpret the individual's emotional appearance and behavior. On the other hand, the combination of psychology and engineer technique such as signal processing may provide new methods to the research of emotion.

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