Event-Related Potential Studies of Attention to Shape Under Different Stimuli Tasks

Xu Guizhi, Zhang Ying, Hou Huijuan and Yan Weili

Abstract—**Event-related potential (ERP) is a basic, non-invasive method of electrophysiological investigation. It can be used to assess aspects of human cognitive information processing. Recordings of ERPs from normal individuals have played an increasingly important role in our understanding of the mechanisms of attention. This paper focused on studies of specific cognitive subsystems such as visual pathway and attention with ERPs in different kinds of visual stimuli tasks using a 128-channel EEG system. The results have showed all potential amplitude of 19 electrodes varied largely with increasing stimuli task complexity and the P100, N200, P300 are elicited.**

I. Introduction

THE recording of brain responses to auditory, visual, and somatosensory stimuli with ERPs is a non-invasive electrophysiological investigation method. ERPs are small voltage fluctuations resulting from evoked neural activity. ERPs recorded from scalp electrodes have been used widely to study human cognitive processes and their neural substrate [1], [2].

In the early years of cognitive psychology, reaction-time measurements were incredibly useful for understanding a broad range of cognitive processes, ranging from perception to memory, language, and motor programming. As we enter the 21st century, the techniques of cognitive neuroscience, especially event-related potentials (ERPs) and functional neuroimaging techniques, are beginning to serve as high-tech substitutes for reaction-time measurements. There are three main reasons for this. First, and most obviously, they provide a link to the exploding field of neuroscience. Second, and less obviously, they are intrinsically multidimensional measures of processing and are therefore well suited to separately measuring the subcomponents of cognition. A third valuable aspect of these techniques is that they allow processing to be measured in the absence of overt responses; in attention research, this is particularly important because it is useful to compare the processing of attended and unattended stimuli without requiring subjects to respond to the unattended stimuli [3].

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Attention is the taking possession by the mind, in clear and vivid form of one out of several simultaneously possible objects or trains of thought. Perceiving, and remembering need attention and attention is initiated by appraisal that this is good to know, good to do, and want to do-good to want result in wanting and approaching it. One of the most common daily activities is to select something to focus on. That is the operation of attention. The basic assumption is that we are limited in only being able to focus on a few things or carry out a few skills at the same time. Attention is switchable from one focus to another [4].

The fact that we recognize structures in our environment without any effort, although these structures are always embedded variety of visual contexts, actually we use two different attentional systems voluntary or active (endogenous), which involves the attention-paying process that results from intention, instructions, etc.

In this paper, we have studied visual pathway and attention with ERPs in different kinds of visual stimuli tasks using a 128-channel EEG system.

II. Methods and Materials

A. *Subjects:*

The fifteen undergraduate or graduate students between the ages of 20 and 32 years from Hebei University of Technology participated in the study. All had normal or corrected to normal vision.

B. *Stimuli，Tasks and Procedure*

The subject was seated comfortably approximately 70 centimeters from the computer monitor that delivered the stimuli. A large, threefold screen obscured the back of the monitor and the back part of the room from the subjects view.

The 2D or 3D stimuli targets are shown in Fig.1, which produced by program suing STIM2 soft system (NeuroScan Company). There are four tasks with different complexity as following:

Task1, 10 2D square images and 20 2D circular images presented in the center of screen randomly;

Task2, 10 2D square images and 20 3D cube images inclining the direction of left presented in the center of screen randomly;

Task3, 10 2D square images, 20 3D cube images inclining the direction of left and 40 3D cube images inclining the direction of right presented in the center of screen randomly;

Task4, 10 2D square images, 20 2D circular images, 30 3D cube images inclining the direction of left, 40 3D cube images inclining the direction of right and 50 3D sphere images presented on the left or right sides of screen randomly.

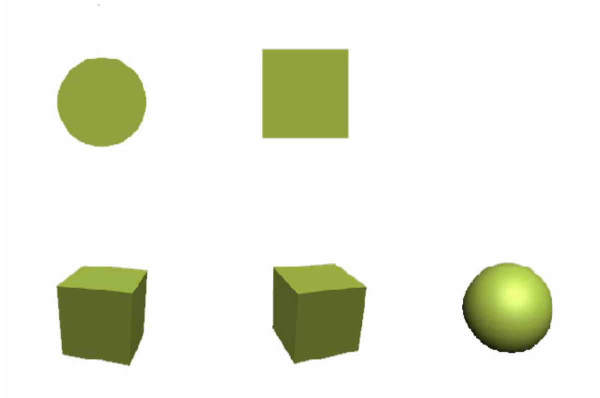

Fig.1.the five kinds of stimuli shapes, two are 2D image, three are 3D image

Task1 is used as training experiment, and other three tasks are used as testing. Before doing the test, subjects are given training with task1, which was to make subjects familiar with the specific task requirements and to make sure that they did not show excessive eye blink activity. Stimulus duration was 300ms, stimulus intervals is 1000ms. The subjects were to discriminate whether the targets are 2D or 3D images, instructed to press a button with their dominant hands when target was presented. In each experiment, 300 stimuli trials were presented respectively in the Oddball and Go/Nogo paradigm. Both accuracy and speed were emphasized. The scalps potentials of subjects are measured in order to analysis their attention to the spatial shape of targets on-line.

1) Signal amplifying: Electrical signals from the head are quite small and need to be amplified in order to be studies. In research settings, this is usually accomplished by using a set of high gain physiological amplifiers. Systems such as these can be used to amplify as many as 64 or even 128 different physiological signals simultaneously. In this paper, EEG was amplified (Neuroscan SynAmps, as shown in Fig.2) with a gain of 500 and band pass filtered at 0.01-40 Hz. Electrode impedance was kept below 2 kΩ. EEG and EOG were sampled at a digitization rate of 1000 Hz.

2) Data analysis: The averaging process tends to decrease the influence of random activity (i.e., the background or non-event related EEG) while maintaining the consistent event-related activity.

C. Data Recordings and Data Analysis

1) ERP recording: Data collection ERP was recorded in an electrically shielded, sound-attenuated, darkened room. Recordings were made using tin electrodes in a 128 channel modified quick cap (NeuroScan, Inc). The electrodes were evenly spaced and symmetrically covered the scalp from nasion to inion and from left to right ears, according to the 10-20 system. Horizontal EOG recording electrodes were positioned at the outer canthi of both eyes and vertical EOG recording electrodes were placed above and below the left eye. The reference electrode was positioned on the tip of the nose. All the trials recorded responses together averaged after presentation of target stimuli separately from those recorded during target stimuli.

Fig.2. the 64 or 128 channel amplifiers （Neuroscan SynAmps）

After doing each sub-experiment, raw EEG data (CNT documents) are analyzed using Neuro SCAN4 software system including: removal of EMG, EOG, as well as artefacts, emendation of base line, making average, epoch and others. 19 signals from 128 electrodes are selected to make more analysis, as shown in table I.

TABLE I
19 ELECTRODES BASED ON 10-20 INTERNATION SYSTEM

Position of electrodes	Symbol of electrodes
Frontal pole	Fp1,Fp2
Inferior frontal	F7,F8
Frontal	F3,Fz,F4
Temporal	T3,T4
Central	C3,Cz,C4
Posterior temporal	T5,T6
Parietal	P3,Pz,P4
Occipital	O1,O2

2) ERP source analysis: Source analysis was used by seeking the source of brain activation with CURRY (NeuroScan software), This method places a proposed set of voltage dipoles in a three-shell spherical head model, and adjusts the strengths and orientations of the dipoles iteratively to obtain the best possible fit between the observed and computed voltage distributions.

III. RESULTS AND ANALYSIS

Grand-average ERPs over the 14 subjects are elicited by stimulation with different tasks. The event-related potentials and brain electrical activity mappings (BEAM) are gotten respectively in different tasks under the Oddball and Go/Nogo paradigm. Base on the topographical maps, all potential amplitude of 19 electrodes varied largely with increasing stimuli task complexity (task 2 to task 4), Fp1, Fp2 in frontal area have more visual reaction. C3, Cz, C4 in center area are only a little change. P3, Pz, and P4 in parietal and O1, O2 in occipital have more latency. The event-related potentials of O1, O2 electrode under Oddball paradigm are shown in Fig.3, Fig.4, Fig.5 and Fig.6, P100, N200, P300 are elicited. "P300" positivity summed distinct contributions from several classes of frontal, parietal, and occipital processes. The event-related potentials of O1, O2 electrode under Go/Nogo paradigm are shown in Fig.7, Fig.8, Fig.9 and Fig.10, P100 and N200 are elicited.

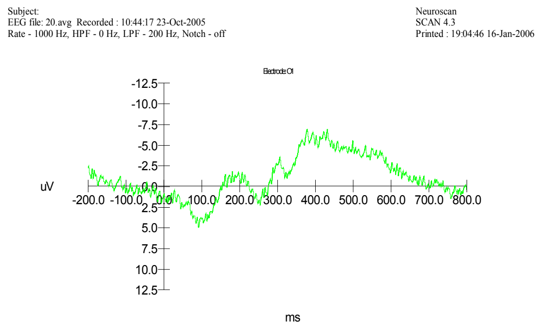

Fig.3 ERP distribution of task2 in O1 electrode under Oddball paradigm

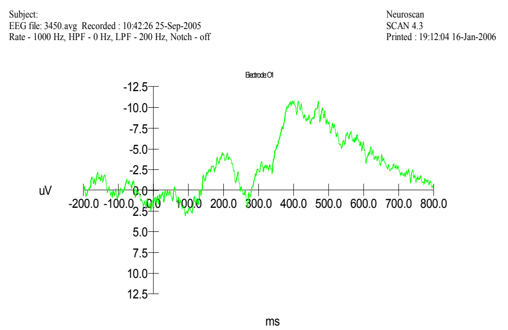

Fig.4. ERP distribution of task4 in O1 electrode under Oddball paradigm

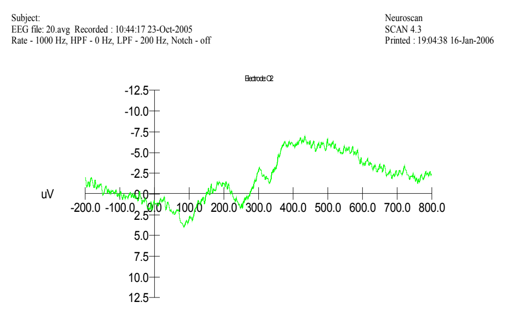

Fig.5. ERP distribution of task2 in O2 electrode under Oddball paradigm

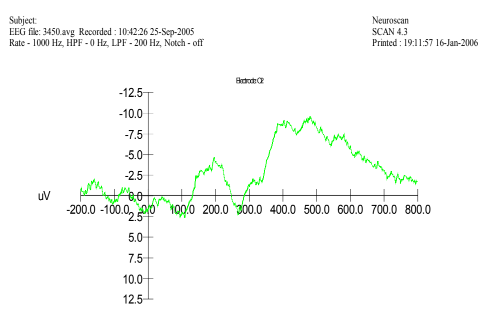

Fig.6. ERP distribution of task4 in O2 electrode under Oddball paradigm

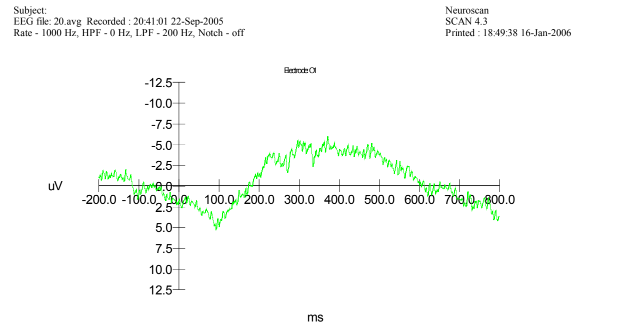

Fig.7 ERP distribution of task2 in O1 electrode under Go/Nogo paradigm

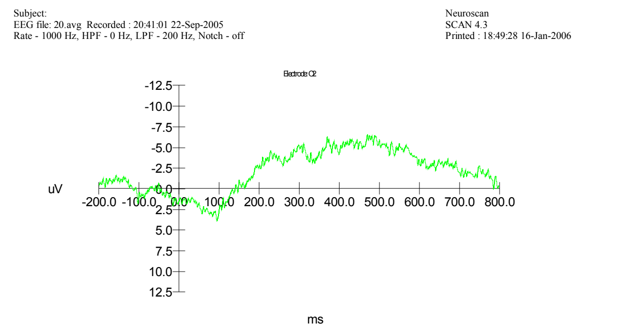

Fig.8. ERP distribution of task4 in O1 electrode under Go/Nogo paradigm

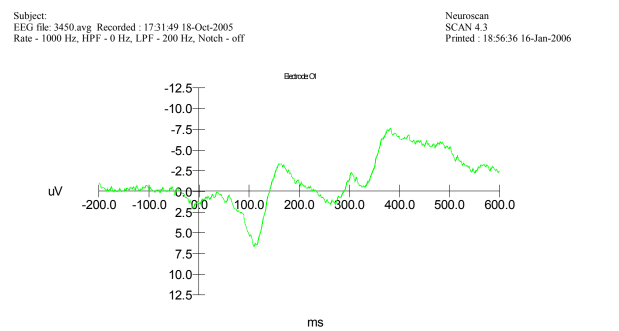

Fig.9.ERP distribution of task2 in O2 electrode under Go/Nogo paradigm

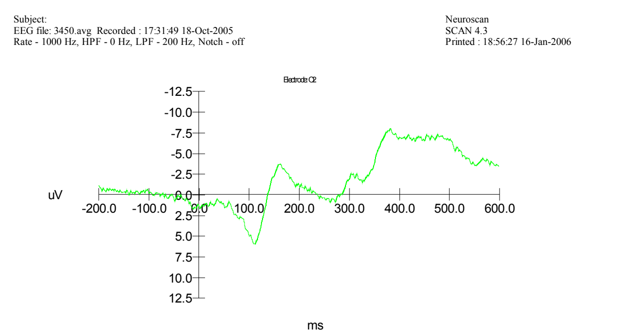

Fig.10.ERP distribution of task4 in O2 electrode under Go/Nogo paradigm

The brain electrical activity mappings about task2, task3, task3 trials under Oddball paradigm are shown in Fig.11, Fig.12, and Fig.13. The brain electrical activity mappings about task2, task3, task4 trial under Go/Nogo paradigm are shown in Fig.14, Fig.15, and Fig.16. From the each BAMSs, the first images have same location of brain activity, after that they changed largely with the increasing stimuli time and the task complexity and activity area from frontal to occipital, and back to parietal.

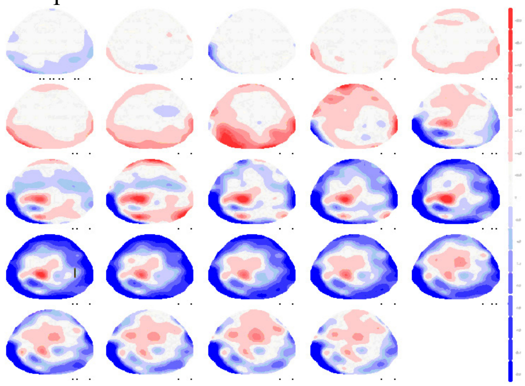

Fig.11 BEAM about Task2 trial under Oddball paradigm

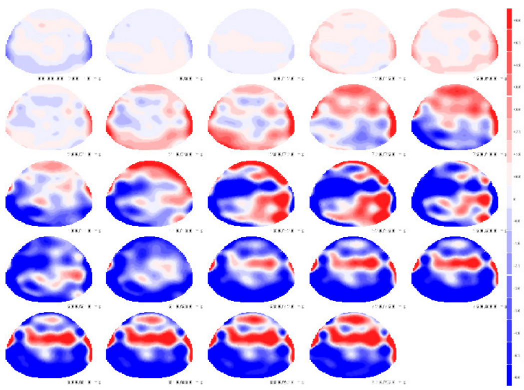

Fig.12 BEAM about Task3 trial under Oddball paradigm

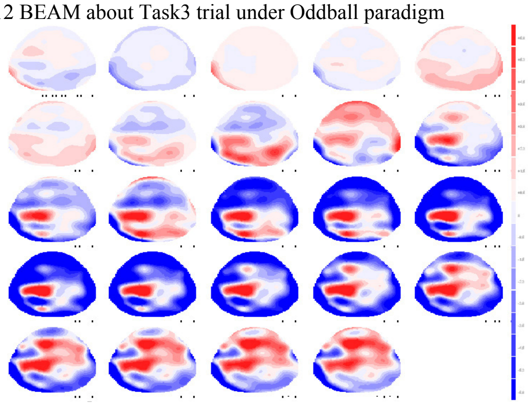

Fig.13 BEAM about Task4 trial under Oddball paradigm

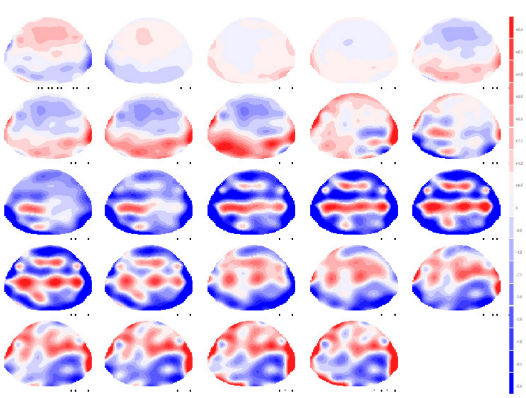

Fig.14 BEAM about Task2 trial under Go/Nogo paradigm

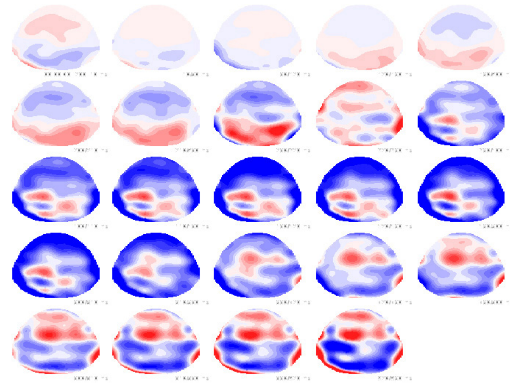

Fig.15 BEAM about Task3 trial under Go/Nogo paradigm

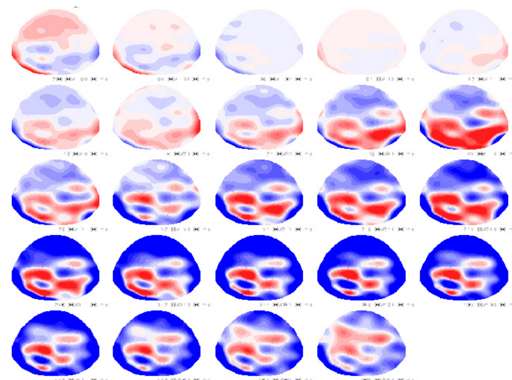

Fig.16 BEAM about Task4 trial under Go/Nogo paradigm

IV. CONCLUSION

The recording of brain responses to auditory, visual, and somatosensory stimuli with ERPs is a non-invasive electrophysiological investigation method. ERPs are small voltage fluctuations resulting from evoked neural activity. This paper has several conclusions by the different kinds of visual stimuli tasks using a 128-channel EEG system as following:

First, each task involved in brain occipitoparietal region;

Second, “what” pathways of brain not is not solitude, but complicated and mutual influence;

Finally, the P100, N200, P300 are elicited.

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