

Detection and Analysis of Event-Related Potential P300 in EEG by 4-Stimulus Oddball Paradigm

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Abstract— P300 component of the event-related potential(ERP) has been studied for theoretical, empirical, and clinical applications. Nowadays the 1-, 2-, and 3-stimulus oddball paradigms are used for eliciting P300 component of EEG in the auditory stimulus experiments. In this paper, we used a method to add one more stimulus to the 3-stimulus auditory paradigm. The adding stimulus has not the same volume but the same tone of the target stimulus. The 4-stimulus oddball paradigm to use two targets is used to elicit the P300 event-related potentials. In 4-stimulus oddball paradigm, an infrequent non-target ($p=0.10$) is presented in addition to two infrequent targets ($p=0.10$) and a frequent standard ($p=0.70$). Two target stimuli elicited a P300 component with a parietal maximum distribution. The amplitude of the P300 in target 2 was larger than that in target 1 and the latency of the P300 in target 2 was longer than that in target 1. The P300 component due to target 2 stimuli was larger than that due to target 1 stimuli.

The experimental results approve that the 4-stimulus oddball paradigm can elicit P300 component clearly. The results are compared with the results of the traditional oddball paradigm.

Index Terms— Brain Wave, P300, Event-related Potential, EEG, 4-Stimulus Oddball Paradigm, Target, Non-target, Standard, Amplitude, Latency.

I. INTRODUCTION

Human brain activity has been estimated due to instrumentation and analysis of EEG (Electroencephalography). The EEG is popularly known as brain waves. The electrical activity of the brain related to the EEG is determined by neuron, glia cell and blood-brain barrier. It has been reported that the EEG variations become larger, faster and more various because of the neuron's activity[1].

The P300 is an ERP(Event-Related Potential) to obtain via the EEG. The P300 is a signal that causes by various stimuli to have a specific information. The brain activity related to the stimuli can be estimated by the P300 components. In the EEG signals, there are many components related to stimuli besides the P300s. After the P300's signification was discovered, studies about the

P300 become more active[2].

Generally, the P300 is obtained using the so-called 'oddball' paradigm in which two different stimuli are presented in a random series[3][4]. In this study, we use 4 stimuli with 3-tone and 2-volume. This is a method to use two target stimuli with the same frequency but different volume. Firstly, we detected the P300s from the experiments using the method as mentioned above. Next, we analyzed the experimental results to compare with the traditional 'oddball' paradigm to use 3 stimuli[5].

II. INSTRUMENTATION AND ANALYSIS OF EEG SIGNALS

A. Experimental Methods

Seven young adults served as participants and all participants reported being free of neurological or psychiatric disorders. PolyG-A by LAXTHA is used for recording EEG. The EEG activity was recorded at Fp1, Fp2, F3, Fz, F4, P3, Pz, P4, C3, Cz, C4, T3 and T4 electro sites of the 10-20 system using gold-plated electrodes affixed with electro paste[6]. Linked earlobes were used as the reference with a forehead ground.

EEG recording in our first experiment was carried out with a 4-stimulus paradigm using auditory stimuli. The '4-stimulus' paradigm is a modification of the oddball task in which infrequent non-target stimuli are inserted into two target stimuli and standard stimuli. Non-target stimuli, two target stimuli and standard stimuli were presented with probability of 0.10, 0.10, 0.10, 0.70 respectively. Because it has been hypothesized that relatively infrequent events elicit large P300 amplitudes[7][8][9]. Stimuli were presented in a random series. The standard tone employed 500Hz, one target tone(target 1) employed 2000Hz, the other target tone(target 2) employed 2000Hz with 20dB lower than target 1 and the non-target tone employed 1000Hz. Stimuli were presented binaurally through headphones in a random series every 2 second. Target 1, standard and non-target stimuli were presented at 60dB and target 2 stimuli were presented at 40dB.

Second experiment was carried out with the same method as the first experiment except presentation of the target 2 stimuli. In this experiment, we used target 2 stimuli 20dB higher than target 1 stimuli. Each probability of 4 stimuli was the same as the first experiment. The subjects were instructed to press a button with their

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preferred hands when the target stimulus was detected for their concentration.

B. Experimental Results

Figure 1 shows the grand averaged ERP waveforms elicited by target 1, target 2 at the Fz, Cz, and Pz electrode sites. In this figure, P300 elicited by target 1 and target 2 stimulus was yielded more significant than those from either the standard stimulus or non-target stimulus.

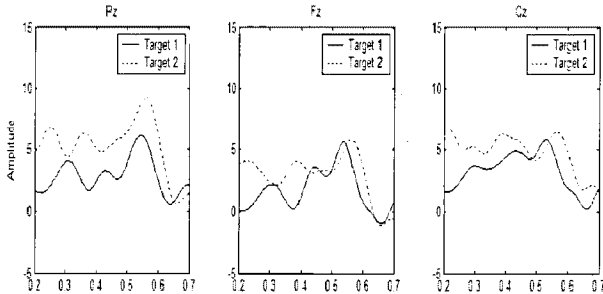


Fig. 1. Grand averaged ERPs from target 1 and target 2 stimulus for each electrode site.

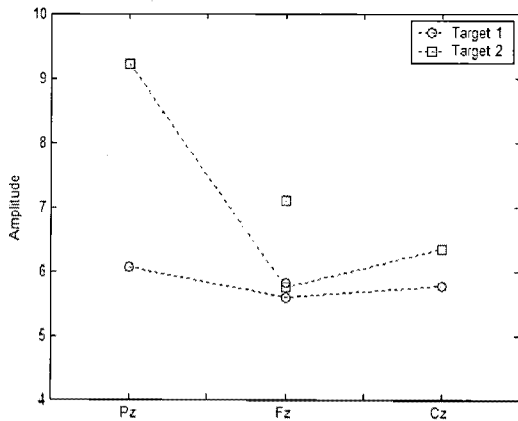


Fig. 2. Target 1 and target 2 amplitude at Pz, Fz, and Cz electrode site.

Figure 2 show P300 peaks for target 1 and target 2 at each electrode sites. The P300 peak amplitude at Pz electrode site was larger than that at Cz and Fz. This result was the same as the traditional 3-stimulus oddball paradigm. Figure 3 illustrates that the P300 peak amplitude from target 2 is larger than that from target 1.

Waveforms in figure 3 illustrates grand averaged ERPs elicited from two targets at the 3 electrode sites, Fz, Cz and Pz. This figure shows that the ERP waveform from target 2 is larger than that from target 1. In this result, we can suppose that the task by target 2 is more difficult than that by target 1 because it has been reported that P300 amplitude was smaller for the more difficult relative to the easier tasks[10]. Task difficulty

affected P300 amplitude and peak latency and there were some studies about the relation between task difficulty and P300 latency[10][11][12].

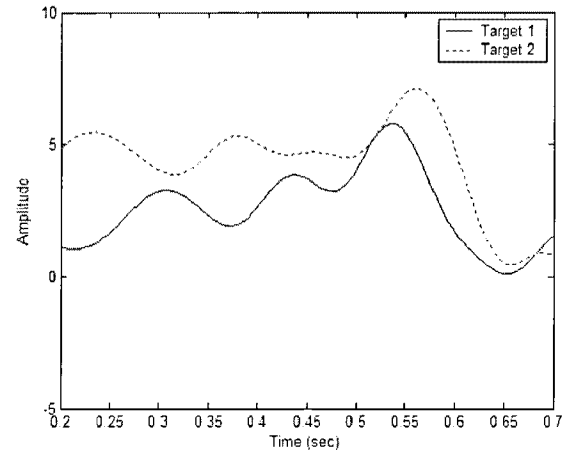


Fig. 3. Grand averaged ERPs from target 1 and target 2 stimulus.

TABLE 1
TARGET 1 AND TARGET 2 LATENCY FROM Pz, Fz, AND Cz ELECTRODE SITE

	T1(ms)	T2(ms)
Pz	543	559
Fz	535	562
Cz	531	562

Figure 4 and Table 1 illustrate latencies from target 1 and target 2. Figure 4 shows that processing time of target 2 need more time than that of target 1. In this experiment, we can obtain the result that P300 latency was longer for the more difficult relative to the easier tasks.

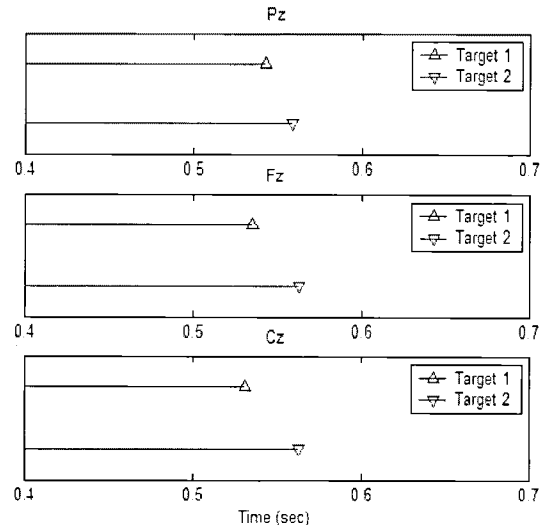


Fig. 4. Target 1 and target 2 latencies.

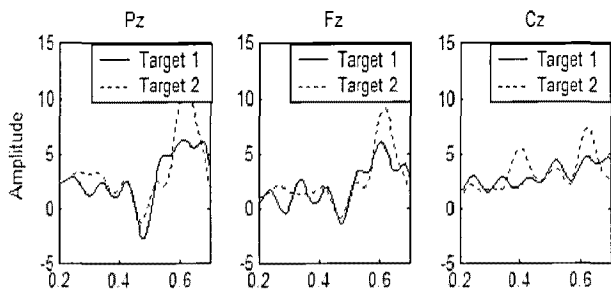


Fig. 5. Target 1 and target 2 waveforms at Pz, Fz and Cz electrode sites.

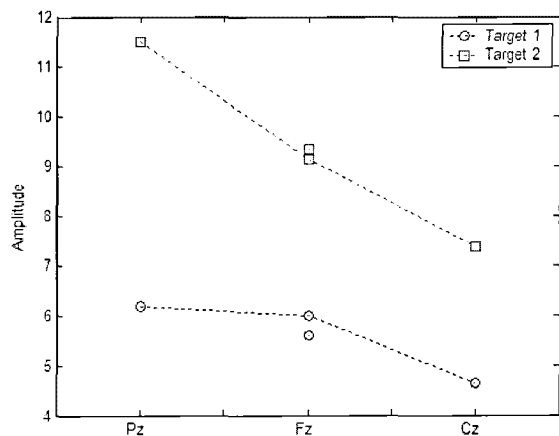


Fig. 6. Amplitude comparison between target 1 and target 2

Figure 5 illustrates grand averaged ERPs from target 2 to be presented 20dB higher than target 1. This figure shows that P300s elicited from two target stimuli were yielded more significant than those from the standard stimuli or non-target stimuli. Figure 5 and figure 6 demonstrates the same results as the first experiment.

Figure 7 shows grand averaged ERPs from target 1 and target 2. We can observe that P300 amplitude from target 2 is larger than that from target 1 and P300 latency from target 2 is longer than that from target 1 in this figure.

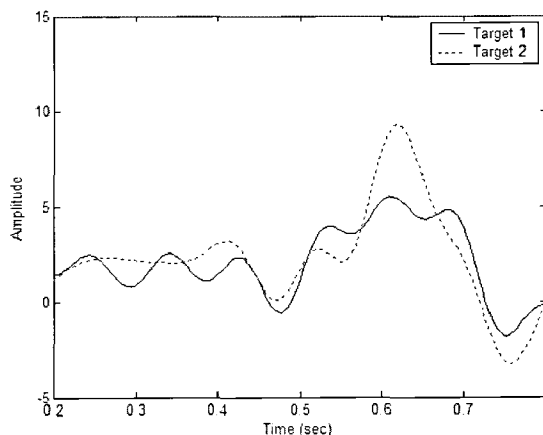


Fig. 7. Grand Averaged ERPs from target 1 and target 2 stimulus.

III. CONCLUSIONS

In our study, we used the method to add second target stimulus into 3-stimulus auditory paradigm. The second stimulus had the same tone but different volume as the first target stimulus. We employed 3-tone and 2-volume oddball paradigm to elicit the P300 ERPs. We tried to estimate the cognitive activity of the subjects by the paradigm as represented above.

In the experimental results, P300 latency from target 2 was longer than that from target 1. It was possible to suppose that the task by target 2 was more difficult than that by target 1 according as the report that P300 latency increased as task difficulty increased[10].

This conclusion demonstrated that the task to discriminate target 2 was more difficult than that to discriminate target 1. Target 1 stimulus had the same volume as standard and non-target stimulus and target 2 had different volume from standard and non-target stimulus. It was supposed that the task to concentrate attention on two features (frequency and volume) was more difficult than that on one feature (frequency) although discriminating new feature was very easy task.

In our study, we can detect P300s using the 4-stimulus oddball paradigm and observe the same results as reported traditionally. The findings suggest that the 4-stimulus paradigm may prove useful in experimental to know human cognitive activity more variously.

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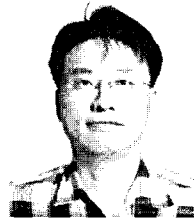
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