

# ANALYSIS OF P3 VISUAL STIMULUS EEG

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## Abstract

In this paper, visual stimulus EEG (VSE) signals are extracted during a modified delayed matching-to-sample paradigm. These VSE signals are used to investigate the differences in object recognition and decision-making process between non-amnesic alcoholic and non-alcoholic subjects. P3 responses are used in the investigation since they are widely associated with object recognition and decision-making ability. Our experimental results indicate that the P3 responses show differences between alcoholics and non-alcoholics. Specifically, the results indicate that alcoholics exhibits lower P3 amplitude and slower P3 response as compared to non-alcoholics.

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Keywords: Alcoholics, Digital Filter, Object Recognition, P3, Short-term Visual Memory, Visual Stimulus EEG

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## 1. Introduction

Visual stimulus EEG (VSE) is typically generated in response to external visual stimulus [4]. In the recent years, VSE analysis has become very useful for neuropsychological studies and clinical purposes [1-3, 8]. Specifically, VSE has been used to investigate differences in non-amnesic alcoholics and non-alcoholics using a variety of evoked response components like c247 [8], P3 [1,3] and N4 [1].

In this paper, we analyse P3 responses from ensemble-averaged VSE signals. Ensemble averaging is performed to remove background EEG from these VSE signals. These signals are extracted during object recognition of a modified delayed matching-to-sample paradigm proposed by Zhang et. al [8]. P3 or P300 component is the third positive component, which generally occurs from 300 to 600 ms after stimulus onset and is maximal at midline parietal [1,3]. It is evoked in a variety of decision-making tasks and in particular, when a stimulus is recognised. Most research work use oddball experimental procedures to evoke P3 responses [3, 5]. However, in this paper, we analyse P3 responses obtained during object recognition of three types of visual stimuli: a single stimulus (S1), a second stimulus in matching condition (S2M) or a second stimulus in non-matching condition (S2N). This experiment involves

stimulus perception, short-term memory encode/access, recognition and decision-making. The objects shown are from the Snodgrass and Vanderwart standardised picture set [7].

It has been reported that P3 voltage is lower for alcoholics as compared to non-alcoholics using oddball experimental procedure [1, 3]. Our results indicate difference between alcoholics and non-alcoholics using the modified delayed matching-to-sample paradigm. Specifically, the results indicate that alcoholics exhibits lower P3 amplitude and slower P3 response as compared to non-alcoholics.

## 2. Method

Twenty subjects participated in the experimental study consisting of 10 alcoholics and 10 non-alcoholics. The alcoholics are non-amnesic and have been abstinent for a minimum period of one month and are also off all medications for the same period of time. Most alcoholics had been drinking heavily for a minimum of 15 years. The non-alcoholic subjects are not alcohol or substance abusers. The subjects are seated in a reclining chair located in a sound attenuated RF shielded room. Measurements are taken from electrodes placed on the subject's scalp, which are sampled at 256 Hz. The electrode position is located at Pz (standard sites using extension of Standard

Electrode Position Nomenclature, American Encephalographic Association). The signals are hardware band-pass filtered between 0.02 and 50 Hz. Nose electrode is used as reference.

The VSE signals are recorded from subjects while being exposed to two stimuli, which are pictures of objects chosen from Snodgrass and Vanderwart picture set [7]. These pictures are common black and white line drawings like an airplane, a banana, a ball, etc. executed according to a set of rules that provide consistency of pictorial representation. The pictures have been standardised on variables of central relevance to memory and cognitive processing. These pictures represent different concrete objects, which are easily named i.e. they have definite verbal labels.

The second stimulus is shown in either matching (S2M) or non-matching (S2N) condition to the first sample stimulus (S1). Stimulus duration of each picture is 300 ms and inter-stimulus interval is 1.6 s with an inter-trial interval of 3.2 s. The presentations of matching and non-matching trials are random. The stimuli are shown using a computer display unit located 1 meter away from the subject's eyes. The subjects are asked to decide whether the second picture (S2) is the same as the first (S1). They are asked to press a mouse key in one hand if S2 matched S1 and to press a mouse key in the other hand if S2 differed from S1, after the presentation of S2 on each trial. The designation of the hand indicating match or non-match is alternated across subjects. Response accuracy and speed are stressed equally. One-second measurements after each stimulus onset are stored. For further details of the data collection process, refer to Zhang et. al. [8].

In this study, VSE signals with eye blink artifact contamination are removed using a computer program written to detect VSE signals with magnitudes above 100  $\mu$ V. These VSE signals detected with eye blinks are then discarded from the experimental study and additional trials are conducted as replacements. The threshold value of 100  $\mu$ V is used since blinking produces 100-200  $\mu$ V potential

lasting 250 milliseconds [4]. A total of 40 S1, 20 S2M and 20 S2N artifact free trials are used in the analysis for each subject. These trials are from the correctly elicited responses only.

The extracted VSE signals from S1, S2M and S2N are low pass filtered using a 9<sup>th</sup> order forward and 9<sup>th</sup> order reverse Butterworth digital filter with a 3-dB cutoff frequency at 8 Hz. Cut-off frequency of 8 Hz is chosen based on the research by Begleiter et. al. [3]. Order 9 is used since it gives a minimum attenuation of 30 dB in the stop band with a transition band from 8 to 12 Hz. Forward and reverse filtering are performed to achieve zero phase response (i.e. no phase distortion). Mean from the data are removed. This is to set the pre-stimulus baseline to zero [5].

Averaging based on each type of stimulus and for each subject is performed to reduce background EEG effects. A total of 10 averaged trials for each S1, S2M and S2N stimulus are used in the analysis for alcoholics. Similar number of trials is used for non-alcoholics.

### 3. Results

Table 1 gives the results of t-Test analysis of differences between alcoholics and non-alcoholics for each stimulus using latencies of P3 responses. The alternative hypothesis tested in the t-Test analysis is that the latencies of alcoholics are significantly higher than the latencies of non-alcoholics, i.e. P3 responses for non-alcoholics are faster than alcoholics.

Table 1 shows that the P3 latencies are higher for alcoholics as compared to non-alcoholics for stimuli S1. However stimuli S2M and S2N does not show any significance.

**Table 1: t-Test results of P3 latencies with alcoholics > non-alcoholics alternative hypothesis**

Stimulus	Results
S1	t(17)=2.17, p=0.022
S2M	t(10)=0.68, p=0.26
S2N	t(17)=0.42, p=0.34

Table 2 gives the results of t-Test analysis of differences between alcoholics

and non-alcoholics for each stimulus using amplitudes of P3 responses. The alternative hypothesis tested in the t-Test analysis is that the amplitudes of alcoholics are significantly lower than the amplitudes of non-alcoholics, i.e. P3 responses for non-alcoholics are higher than alcoholics.

From Table 2, we can see that the P3 amplitudes are higher for non-alcoholics as compared to alcoholics for stimuli S1 and S2M, with the significance of differences in descending order. However, the difference for stimulus S2N is not significant.

**Table 2: t-Test results of P3 amplitudes with alcoholics < non-alcoholics alternative hypothesis**

Stimulus	Results
S1	t(12)=-2.66, p=0.010
S2M	t(15)=-1.82, p=0.045
S2N	t(17)=-0.19, p=0.43

#### 4. Conclusion

In this paper, P3 responses from ensemble averaged VSE signals have been used to analyse the electrophysiological differences in alcoholics. It has been reported that alcoholics exhibit lower P3 amplitude [1,3] in comparison to non-alcoholics. Our analysis, using modified delayed matching-to-sample paradigm, indicates that the P3 response times are lower in alcoholics. However, this difference is indicated only by S1. This shows that the slowing of P3 response for alcoholics is more clearly indicated by simpler tasks (like S1) rather than complex ones (like S2M or S2N).

The P3 amplitude is higher for non-alcoholics as compared to alcoholics. This indicates that non-alcoholics are able to make more confident decisions and exhibit higher object recognition ability. However, the difference is elicited only for simpler tasks like S1 and S2M, while there is no difference indicated for S2N.

The study by others using component c247, showed that alcoholics and non-alcoholics exhibit differences in visual short-term memory for stimuli S2N [8]. In conclusion, the results from our P3 analysis indicate that these differences of

P3 amplitudes and latencies between alcoholics and non-alcoholics are significant for stimulus S1. For stimulus S2M, the difference exists only for P3 amplitude. Stimulus S2N does not indicate any difference.

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