GAMMA BAND ANALYSIS OF VEP TO STUDY THE ELECTROPHYSIOLOGICAL DIFFERENCES IN ALCOHOLICS

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Introduction

In this paper, we analyse Visual Evoked Potential (VEP) in the gamma band range of 30-50 Hz to study the electrophysiological differences between alcoholics and non-alcoholics. Gamma band spectrum is used specifically in the analysis because it has been shown to be closely related to higher brain functions like memory and object recognition [1]. However, the use of gamma band spectrum to analyse electrophysiological differences in alcoholics is novel. The VEP signals are extracted from 64 electrodes while the subjects are seeing 2 visual stimuli (presented with an interval in-between) from the Snodgrass and Vanderwart picture set. The experimental paradigm is designed to evoke visual short-term memory and object recognition abilities. Twenty subjects participated in the experimental study consisting of 10 alcoholics and 10 non-alcoholics. Forward and reverse Butterworth digital filter is used to extract VEP signals in gamma band spectral range. Parseval's theorem is used obtain the equivalent gamma band spectral power. The results using t-Test analysis indicate that alcoholics give lower gamma band spectral power as compared to non-alcoholics in certain channels located in the central, occipital and parietal regions. This shows that some alterations to the brain processes that involve visual short-term memory and object recognition are caused by long-term use of alcohol. The nature of these alterations is still traceable after a period of time, which is indicated by the fact that the studied alcoholics had been abstinent for a period of more than a month.

Data and Methodology

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 (through closed ward hospitalisation) and are also off all medications for the same period of time. Most alcoholics had been drinking heavily for a minimum of 15 years and started drinking at approximately 20 years of age. 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 61 channels placed on the subject's scalp, which are sampled at 256 Hz. The electrode positions (as shown in Figure 1) are located at 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 VEP signals are recorded from subjects while being exposed to two stimuli, which are pictures of objects chosen from Snodgrass and Vanderwart picture set [4]. 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. Figure 2 shows some of these pictures.

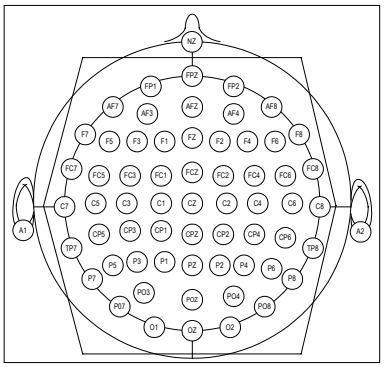

Figure (1) Electrode positions

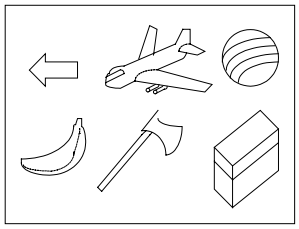

Figure (2) Some objects from Snodgrass and Vanderwart picture set

The second stimulus is shown in either matching (S2M) or non-matching (S2N) condition to the first sample stimulus (S1). Care is taken to ensure that the S2N is different from S1 not only in visual form but also in terms of semantic. 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 [5].

In this study, VEP signals with eye blink artifact contamination are removed using a computer program written to detect VEP signals with magnitudes above 100 μV. These detected VEP signals with eye blinks are then discarded from the experimental study and additional trials are conducted as replacements. The threshold value of 100 μV is used since blinking produces 100-200 μV potential lasting 250 milliseconds [2].

In the experimental study, a total of 40 S1, 20 S2M and 20 S2N artifact free trials are used in the analysis for each subject, giving an overall total of 400 S1, 200 S2M and 200 S2N trials for alcoholics and likewise for non-alcoholics. These trials are from the correctly elicited responses only.

The VEP signals are averaged across trials to remove background EEG. Next, the VEP signals are band-pass filtered using Butterworth filter from 30-50 Hz, i.e. in the gamma band range. Order 10 is sufficient to obtain 30 dB suppression below 25 Hz and above 55 Hz. Forward and reverse filtering are performed to achieve zero phase response i.e. to avoid any phase distortion. Parseval's time-frequency relation is used to obtain the total power of the VEP signal in gamma band range. T-Test analysis is conducted to study the differences of mean between alcoholics and non-alcoholics for all the 3 different stimuli.

Results

Table 1 shows the t-Test results. The alternative hypothesis tested is that the mean of gamma band spectral power of alcoholics is less than non-alcoholics. The t-Test assumes non-equal sample variances (heterodastic) where the degrees of freedom (DF) [3] is calculated using

$$DF = \frac{\left(\frac{S_A^2}{N_A} + \frac{S_{NA}^2}{N_{NA}}\right)}{\left(\frac{\left(S_A^2 / N_A\right)^2}{N_A - 1} + \frac{\left(S_{NA}^2 / N_{NA}\right)^2}{N_{NA} - 1}\right)} \qquad (1)$$

where S_A denotes the sample variance for alcoholics group and N_A is the number of samples for alcoholics group. Similarly, the subscript NA refers to the non-alcoholics group. The DF is rounded to the nearest integer. The mean of alcoholics is lower than non-alcoholics is the alternative hypothesis tested. These results are obtained using Microsoft Excel Analysis Toolpak (Microsoft Corporation). In the table, the DF and t-test one tail probability is shown in brackets.

The significance level used is at 0.1 and to save space, only channels that satisfy the alternative hypothesis is listed. From Table 1, it can be seen that only certain channels exhibit lower gamma band spectral power for alcoholics as compared to non-alcoholics for the 3 tested stimuli. Most of these channels are located in central, parietal and occipital regions, where the channels in bold give lower gamma band spectral power for all 3 stimuli.

Table {1} Channels that exhibit lower gamma band spectral power for alcoholics as compared to non-alcoholics

S1 (DF, P)	S2M (DF, P)	S2N (DF, P)
F8 (15, 0.07)	C4 (10, 0.06)	C5 (10, 0.07)
T7 (10, 0.09)	CP6 (12, 0.03)	**C1** (9, 0.04)
C4 (13, 0.02)	PO2 (15, 0.08)	C2 (9, 0.08)
PO2 (11, 0.06)	O2 (10, 0.04)	**PO8** (12, 0.06)
O2 (10, 0.02)	FT8 (12, 0.06)	**P2** (14, 0.05)
FT8 (11,0.05)	**C1** (10, 0.07)	
C1 (9, 0.04)	**PO8** (12, 0.02)	
C2 (9, 0.08)	**P2** (16, 0.09)	
PO8 (10, 0.008)		
OZ (13, 0.08)		
P2 (15, 0.08)		

Conclusion

The results from the study show that gamma band spectral power from certain channels could be used to discriminate between alcoholics and non-alcoholics. These could be used in experiments to classify alcoholics and non-alcoholics. The results give the location of brain that shows alteration caused by long-term use of alcohol. This could be useful to analyse the behaviour of alcoholics and to reform the alcoholics.

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