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CorrelationalStudy of Memory Task Performance and EEG Alpha Band Power

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Abstract: EEG signals are acquired by placing electrode on the scalp. The 10-20 system provides the electrode placement sites. A basic EEG acquisition system has about 32 electrodes which are effectively separated from one another and it providesa high resolution brain dynamics. In study related to task based brain activation, we need not require to acquire data from all these electrodes. In this paper we verify that verbal and non verbal memory tasks induces activity in occipital lobe. A statistical inter class study involving calculation of Pearson correlation coefficient between EEG power and memory span verifies that occipital region of brain is activated during working memory tasks.Alpha activity increases in the relaxed state and reduces during memory recall cycle. This fact is validated in this study

Keywords: Alpha Band Power, CORSI, DSPAN, Memory Task, Occipital Electrode,Psychological Experiment Building Language (PEBL).

Introduction

EEG is the record of electrical activity of brain[1]. The collective firing of neuron generates temporal extracellular field potential which can be picked up by scalp electrodes[2]. The electrical activity in brain can be induced through various tasks and the regions which get stimulated are specific to stimuli. Working memory task generated high degree of activity in frontal, parietal and occipital lobes. Figure 1 depicts these regions. EEG signals analysis in frequency domain utilizes spectral features like entropy, power spectra wave shape, mean power etc for different bands delta theta alpha and beta to classify cognitive states [3]–[6].

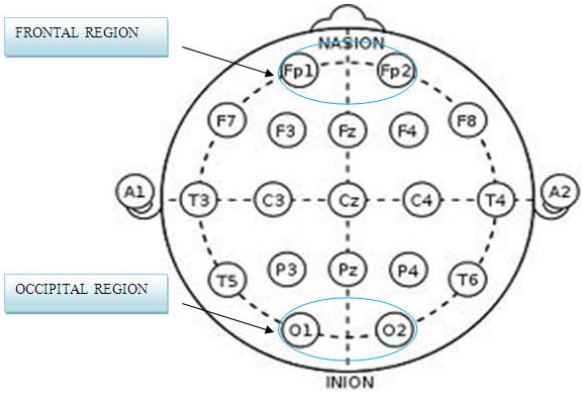

Figure 1 Frontal and occipital region of brain

Memory assessment task are used for identification for mental dysfunction[7], the variant of these psychological assessment can be utilized for the estimation of information retaining capacity in human. There are computer based psychological assessment platform available like Psychological experiment building language (PEBL) and PsychoPy[8]. N back task is used along with non invasive brain mapping technique to measure the brain activity[9], digit recall task with varying workload is used to classify the mental state [3].

Here we have used forward digit span(verbal memory task) and Corsi(spatial memory task)[10]–[14] task for establishing a correlation between task performance and EEG rhythmic activity among individuals. Pearson

coefficient is calculated because it does not require normalisation and gives a relation between two dependent parameters.

Material and Method

The study consists of the verbal and non verbal memory tasks. D-span task which is a forward digit span task is a verbal memory task. In this task the participant memorizes a sequence of digits and after a brief interval of time recreates it in the same order. CORSI is a non verbal spatial memory task. In this task a series of spatial changes appears on the screen. The participants learn these change and they give response by recreating the same sequence of events [12].

PARTICIPANTS

14 healthy individuals have been selected for this study. All the participants are in the age group of 19 to 25 years and are engaged in graduation and post graduation inengineering from Thapar University Patiala. All subjects have normal vision or corrected to normal vision. No one has any psychological and psychiatric disorder. The subjects were informed about the experimental procedure. Each one of them participated in the study voluntarily.

PSYCHOLOGICAL TASK

The tasks were performed by the subject on laptop PC placed at a distance of 70 cm but the subjects were also asked to adjust their position as per their comfort.A verbal memory tasks D-span require the participant to enter their response using keyboard of the laptop. The other task is CORSI; it is a spatial memory taskin which participants require to give their response using a touch pad.

EEG RECORDING

EEG is recorded through Bio-Pac MP150 EEG 100cdata acquisition hardware over 2 channels. These channels are connected to two electrodes mounted over a cap designed as per the 10-20 system. The hardware power line cable and acquisition laptop are placed around 3 meters from the subjectto avoid any interference. The hardware is configured with 50 Hz notch filter, 35Hz low pass filter and 0.1Hz high pass filter to remove the effects of power line noise if any and to get desired frequency band for analysis. The gain of the amplifier is set to 20000. The data is acquired at 1 KHz and sampled and stored at 500 Hz.

First baseline reading was acquired in which the subjects were instructed to sit in relaxed state.The subjects were asked to close their eyes for two minutes. Then the two minute eyes open baseline reading was acquired. In order to reduce the effect of EMG and EOG artifacts the subjects were asked to avoid any muscle and eye movement to the extent possible during the task. The tasks CORSI and DSPAN were performed after the baseline reading acquisition and also EEG reading was acquired simultaneously.

Table 1: Data acquisition specifications

SPECIFICATIONS	
ACQUISITION FREUENCY	1000 Hz
SAMPLING FREQUENCY	500 Hz
LOW PASS FILTER	0.1 Hz
HIGH PASS FILTER	30 Hz
NOTCH FILTER	50 Hz
COMB FILTER	Line frequency
GAIN	20,000
REFERENCE ELECTRODE	EARLOBE

PSYCHOLOGICAL AND EEG DATA ANALYSIS

Psychological task D-span and Corsi generates memory span at the end of the task [12 and 14]. For the task Dspan the memory span is the maximum length of digit recalled by the subject and for the task Corsi it is given by the equation 1.

$$corsi\ memory\ span = \frac{Startlength + Total\ Correct}{Trials\ Per\ Length} \quad (1)$$

EEG signal is a time domain signal acquired in an ACQ knowledge software program. The power spectrum density is calculated for the entire waveform. Then power is calculated for four bands of EEG. Table 2 depicts the frequency range of each EEG band. The band power is calculated for each bandusing the equation 2.

$$PSD = \frac{\sum AMPLITUDE\ OF\ POWER\ SPECTRUM\ DENSITY}{TOTAL\ NUMBER\ OF\ SAMPLES\ IN\ FREQUENCY\ BAND} X\ FREQUENCY\ BAND\ RANGE \quad (2)$$

Table 2: EEG frequency band

EEG signal	Frequency band(Hz)
DELTA	0.5-4
THETA	4-8
ALPHA	8-13
BETA	13-20

Pearson Coefficient is calculated between the power and parameters obtained from Psychological task. Pearson Coefficient is give by equation 3.

$$r = \frac{\sum_{i=1}^{n}(x_i-\bar{x})\,(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i-\bar{y})^2}} \quad (3)$$

Where r Pearson Coefficient, x_i is first vector, y_i is second vector, $\bar{x}, \bar{y}$ are mean values.

Results

Table 3depicts the memory span of DSPAN memory task and EEG alpha band power obtained for subjects participated in the experiment.

Table 3: DSPAN task memory span and EEG alpha band power over occipital electrode

Subject Number	DSPAN Memory Span	ALPHA BAND POWER OCCIPITAL ELECTRODES (mV)	
		O1	O2
1	6	3.49E-09	2.26E-09
2	8	1.57E-08	1.92E-08
3	9	2.88E-09	5.01E-09
4	9	1.98E-09	5.47E-09
5	7	1.52E-08	1.04E-08
6	5	7.21E-09	2.39E-08
7	8	1.48E-08	1.28E-08
8	5	7.65E-09	1.6E-08
9	7	1.11E-08	2.07E-08
10	8	5.11E-09	1.34E-08
11	8	1.12E-08	1.5E-09
12	7	1.34E-08	1.55E-08
13	9	1.58E-08	7.18E-09
14	6	1.24E-08	1.53E-08

Table 4 depicts the alpha band power obtained over occipital electrode during CORSI memory task.

Table4: CORSI task memory span and EEG alpha band power over occipital electrode

Subject Number	CORSI Memory Span	ALPHA BAND POWER OCCIPITAL ELECTRODES $(mV)^2$	
		O1	O2
1	7	5.06E-09	6.43E-10
2	5.5	3.23E-09	5.35E-09
3	7.5	4.8E-10	1.18E-09
4	5.5	2.27E-08	2.1E-08
5	6.5	9.32E-09	1.2E-08
6	6.5	7.79E-09	1.51E-08
7	6.5	7.66E-09	1.29E-08
8	5.5	1.45E-09	2.29E-09
9	6.5	9.11E-09	1.5E-08
10	6	5.75E-09	1.08E-09
11	4.5	5.88E-08	8.78E-09
12	5	3.78E-08	1.12E-08
13	7	9.12E-09	1.18E-08
14	6.5	1.55E-08	1.93E-08

The Pearson's coefficient calculated between the memory span of DSPAN and EEG alpha band activity for O2 electrode comes out to be -0.50385. The figure 2 depicts the relation between the memory span of task DSPAN and EEG alpha band power.

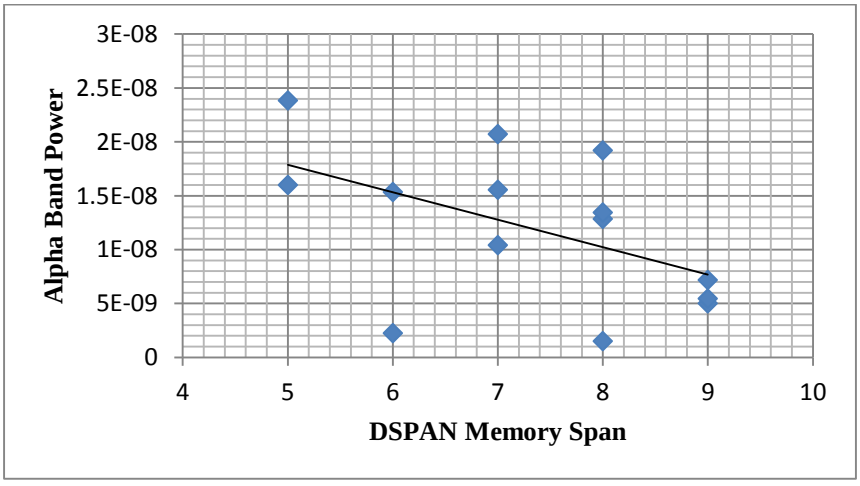

Figure2:Relationship between EEG alpha band power of O2 electrode and DSPAN memory span

The Pearson's coefficient of EEG alpha band power with the memory span of corsi comes out to be -0.72151. It is a high value of negative correlation. The figure 3 depicts the relation between the alpha band power and memory span of CORSI over O1 electrode.

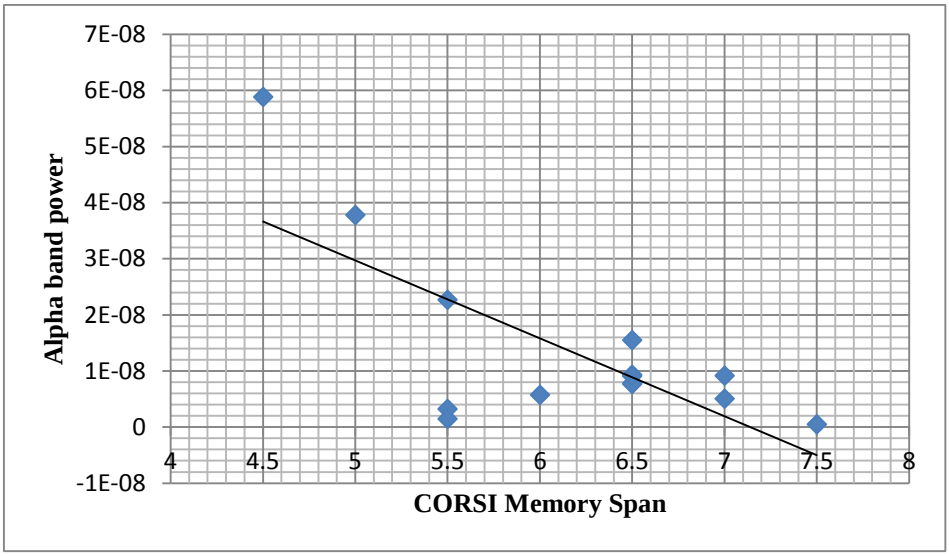

Figure3: Relation between CORSI memory span and EEG alpha band power

Conclusion

The Pearson's Correlation value is calculated between memory span and EEG alpha band power. It was found that there is high degree correlation between the EEG alpha band-power of O2electrode with the Memory span of DSPAN. Also a high correlation coefficient is obtained between the EEG alpha band-power of O1 electrode with the memory span of CORSI. It may be concluded from the correlation value that the memory task Dspan and Corsi has a significant effect over occipital region of brain. It may be due to the tasks are computer based and the visual stimuli are processed in occipital lobe.Alphaactivity increases in the relaxed state and reduces during memory recall cycle [15]. This fact is validated in this study.

Future scope

In this research we have observed that the memory tasks stimulate the occipital lobe. The correlation between the task and alpha ratio determines that alpha ratio decreases as memory span increases. These tasks and electrode sites can be used to study the memory enhancement and relaxation related studies.

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