ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 10, October 2014

A Study on EEG Patterns of Subjects with Corrected vision

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ABSTRACT: A need exists to develop a better predictive tool for estimating deterioration in the visual system. This pilot study examined changes in EEG spectral power of subjects with varying visual impairments. EEG activity of four subjects was recorded while playing a driving game both with and without their corrective glasses. The spectral power at three channel locations at the occipital lobe were obtained and compared. Subjects having better visual acuity displayed higher spectral power in both the theta and alpha band regions. An increase in average spectral power for the alpha band region, with changes in spectral power topographies in the theta band region, was observed. The results suggest that spectral power in the alpha and theta bands may depend on activation in the visual system. This focus, to better understand the interactions between the human brain and the visual system, will aid in developing improved visual prosthetic devices.

KEYWORDS: Visual acuity, EEG, Spectral bands, Visual Prostheses, Artificial Vision

I. INTRODUCTION

There have been limited successes in developing useful visual prosthetics, creating a need to develop better predictive tools for estimating deterioration in the visual system. An approach to consider for improving performance in both controlling and monitoring devices is the use of EEG signals.

Novikova et al. [1] conducted experiments on brain wave patterns of subjects having varying levels of visual loss, showing a correlation that predicted the degree of impairment. This research was limited to subjects having a visual acuity of 0.05 or less. Other studies have shown differences in EEG patterns for subjects with eyes open and eyes closed [2]. An artificial neural network model has also been developed to predict the features of visual sensations [3].

Schier [4] studied the EEG patterns of subjects playing a simulated driving game. The relative alpha power at each electrode was calculated and showed that a significant relationship existed between driving behavior and EEG activity. Sheikholeslami et al. [5] explored the dynamics of brain activity during a continuous video game, showing an increase in brain activity over time while playing video games.

The literature suggests that alpha activity represents the working of the visual system, with EEG patterns differing in topography as well as spectral power depending on visual acuity. These studies investigated changes in the EEG patterns of normal subjects when their eyes were both closed and opened. They also explained the decrease of the alpha activity in blind subjects [6].

The purpose of this research was to examine the possibility of using EEG as a predictive tool for discovering the degree of impairment in the visual system. This focus, to better understand the interactions between the human brain and the visual system, will aid in developing improved visual prosthetic devices.

DOI: 10.15680/IJIRSET.2014.0310060

IJIRSET

ISSN: 2319-8753

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II. MATERIALS AND METHODS

2.1 Participants

This pilot project explored the electroencephalographic (EEG) patterns of four subjects with varying levels of visual acuity.

The test group had a mean age of 24.5 years (SD 0.5). All four subjects had myopic eye sight (Table 1) and wore glasses that corrected their visual acuity to normal. The Ethics Committee at LBRCE approved the procedures. Subjects gave informed consent.

2.2 Experimental Procedure

The study took place in a noise isolation chamber in the Cognitive Science Research Centre at LBRCE. The pre experimental preparation for each subject lasted between 40 and 60 minutes. The subjects were comfortably seated in a chair and fitted with a 32-channel Neuroscan electrode cap. An electrolytic gel was applied at each channel location on the cap until electrical impedance went below 5000 ohms. After completing the pre experimental procedures, the subject was given a brief introduction to the test and the car driving game task.

EEG data were then recorded from the subjects while they played a simulated car driving game. In this game the subject raced against another car controlled by the computer on a closed circuit course. All subjects were given the same circuit to negotiate. The game was presented on an HP Pavilion dv6000 laptop with an outside-car view, located 20 inches from the subject. The subjects used a keypad to control both the direction and speed of the car.

In the first trial, subjects performed the simulated driving game without their corrective glasses. This condition was used as a baseline. A break of one minute was provided the subject to prepare for the second trial, in which they used their corrective glasses.

TABLE I
VISUAL ACUITY VALUES OF SUBJECTS

Subject	Age(Years)	Visual Acuity without corrective glasses
Subject 1	24	20/200
Subject 2	25	20/80
Subject 3	25	20/100
Subject 4	24	20/30

2.3 EEG Signal Processing

Data were collected at three electrode locations (O2, O1 and Oz) near the occipital lobe of the subject. EEGLAB 7.2.7.18b with MATLAB R2007b was used to perform the data analysis. The raw EEG signal was first visually inspected to detect artifacts. A basic FIR filter was then applied to reject data beyond the desired frequency. After removing unwanted frequency components from the raw EEG data, the eye and muscle artifacts were removed using independent component analysis. After obtaining the independent sources, both eye and muscle artifacts were detected by noting the topography of the power spectrum. After detecting and removing the artifact components, the spectral power for the required electrode locations was calculated using the Fast Fourier Transform [7, 8].

2.4 Data Analysis

Samples of 4096 data points were selected from the artifact free data to perform the spectral analysis. A Hanning window was applied to the selected data and a Fast Fourier Transform was then calculated. The collected EEG data

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were analyzed using EEGLAB™ and MATLAB™ software. The magnitude of the artifact-free EEG signal ranged from -50µV to +50 µV.

III. RESULTS

Samples of 4096 data points were selected from the artifact free data to perform the spectral analysis. A Hanning window was applied to the selected data and a Fast Fourier Transform was then calculated. The collected EEG data were analyzed using EEGLAB™ and MATLAB™ software. The magnitude of the artifact-free EEG signal ranged from -50µV to +50 µV. The subject with the best uncorrected visual acuity had the highest mean spectral power, agreeing with the results of [1], which showed a relationship between alpha activity and the degree of visual impairment, revealing that alpha activity decreased as visual acuity or visual acuity perception decreased. This decrease in alpha activity was supported by several other studies [6].

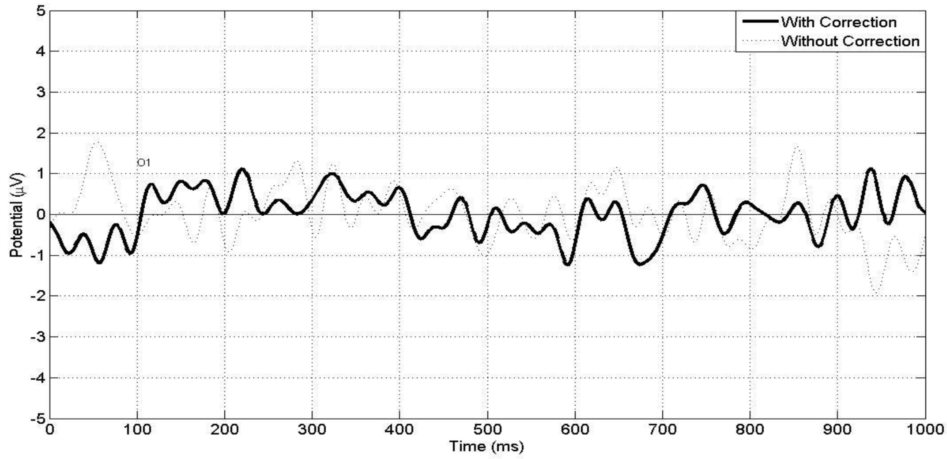

Fig.1 ERP at channel location O1

When our subjects performed the task using their corrective glasses, we found an increased activation of the subject's visual system, with a correspondingly higher spectral power. So, stimulation of the visual system can be examined by comparing the spectral powers in the alpha frequency band. Table 2 summarizes the mean spectral power of all subjects in the alpha frequency band.

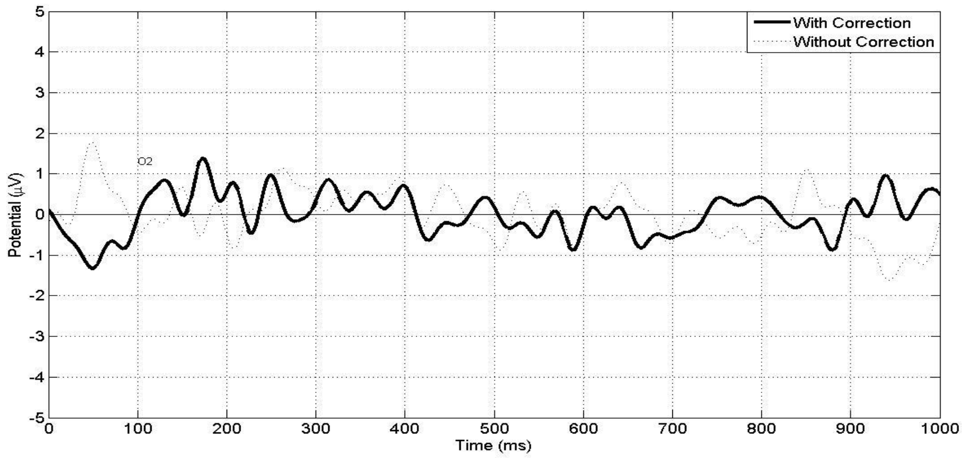

Fig.2 ERP at channel location O2

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Figures 1, 2 and 3 gives a comparison of Event related potentials at channel locations O1, O2 and Oz. A peak around 100 ms latency would reflect the working of visual system. A shift in peak latency during without correction can be observed at all the three channel locations. This indicates level of activation of the visual system during without correction condition.

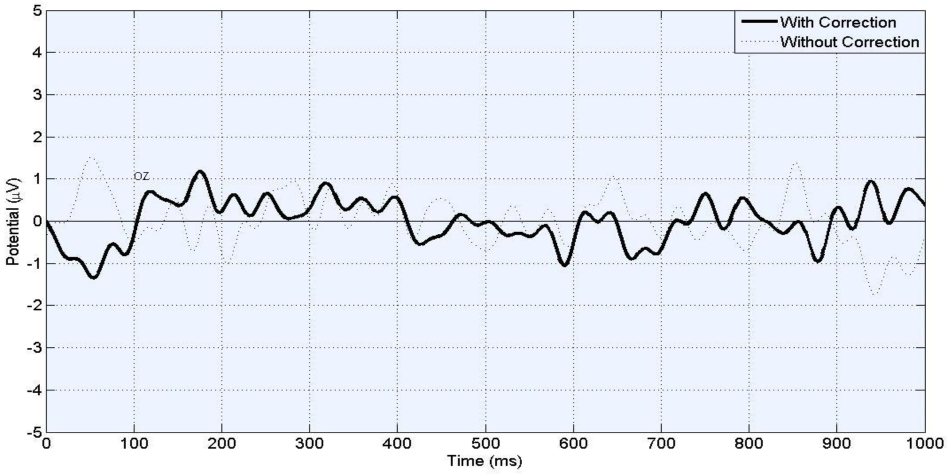

Fig.3 ERP at channel location OZ

In this study, the spectral averages of the subjects did not increase in any frequency band, in contrast to the findings of [9]. This supports that changes in the spectral averages are not because of stress, but instead to changes in the visual stimulation.

TABLE II
MEAN SPECTRAL POWERS

Channel	Subject1		Subject2		Subject3		Subject4	
	1	2	1	2	1	2	1	2
O1	0.37	0.44	0.47	0.46	0.48	0.03	0.55	0.75
O2	0.35	0.40	0.33	0.71	0.42	0.03	0.61	0.72
OZ	0.38	0.47	0.34	0.59	0.43	0.03	0.59	0.37

These initial results suggest that spectral averages increased in the theta band (4 Hz to 7.5 Hz) and alpha band (8 Hz to 10 Hz). The average spectral power in trial 1 decreased with decreasing visual acuity, most prominently in the 5.73 Hz to 6.22 Hz frequency range. This relation between spectral power and visual acuity can be observed from Figures 1, 2 and 3. The decrease in average spectral power might be due to decreased activation of the visual cortex. These results demonstrate the ability of the EEG analysis to detect changes in visual cortex activation level.

IV. CONCLUSION AND FUTURE WORK

Subjects with varying amounts of visual acuity correction were tested, both with and without their glasses, while playing a simulated driving game in which they competed against a computer. The simulated driving game was a visually stimulating task. Depending on the subject’s corrective visual requirements, the task varied in difficulty. The data from channel locations O1, O2 and OZ were studied in this research. These channel locations were positioned at the occipital lobe of the subject to capture the neural activity of a subject’s visual system. The subjects having better visual acuity displayed higher spectral power than those having lesser visual acuity. This difference in spectral power

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International Journal of Innovative Research in Science, Engineering and Technology

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was observed in both the theta and the alpha band frequencies. This approach differentiated the subjects with better visual acuity, suggesting the ability of EEG to detect deterioration in the visual system.

Future research will focus on expanding the number of subjects and their visual characteristics to develop a better predictive tool for estimating deterioration in the visual system. This focus, to better understand the interactions between the human brain and the visual system, will aid in development of improved visual prosthetic devices.

ACKNOWLEDGEMENTS

This study was supported by Department of Science and Technology, Cognitive Science Research Initiative (Ref no SR/CSI/16/2011).

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