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Cognitive Performance of Student's Assessment by Resting-State EEG Analysis

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ABSTRACT *- Cognitive skills are driven by neural mechanism of the brain in individuals. In particular, it is very important to know the cognitive level of students that may help to adapt effective method of teaching in classrooms. We measured EEG signals from select group of student's scalps by stimulating the cortex from specific mathematical tasks. The signals were analyzed by ERSP (Event Related Spectral Perturbation), ITC (Inter-trial Coherence) methods and visualized for resting-state EEG. The results show that the frontal region of the brain is activated during arithmetic calculations. It is also observed that the neurons are networked together and will not have dominant amplitudes in EEG signals indicating that the resting-state EEG analysis could reveal cognition level in the participants.*

KEY WORDS: *EEG; Cognition; Neuronal network; Brain lobes*

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I. INTRODUCTION:

Cognition is functionality of the brain that is related to mental activities of an individual. The cognition relies upon inner speech and visual imagery. Assessment of these two components indicates the cognitive level of the person which is a measure of neuronal activity of the brain. Particularly in students it is very important to know their cognitive level that helps to adapt effective method of teaching. According to Literacy statistics of United States, about 14% of youths remain high school drop outs due to the difficulties in understanding basic subjects involving text reading and mathematical problem solutions [1]. The smart brain controls both voluntary and involuntary actions of the person. Human brain has four departments; i.e. lobes, through which the main actions are performed. The four lobes of cerebral cortex are, frontal, parietal, occipital and temporal which are fully packed with neurons. The frontal lobe, which is situated at the front of the brain, is involved in higher level of cognitive skills such as memory, problem solving, language, and understanding the world. Studies have shown that a portion of the frontal lobe covered behind the forehead existed in both right and left hemispheres of the brain is the prefrontal cortex which is mainly responsible for problem solving, reasoning, emotion and thought processes. Aptitude for mathematics among youngsters is normally tested by their skill at solving arithmetic, algebra and fractions which are domains of mathematics. Most of the students struggle in solving numerical problems in their classes. These cognitive skills are driven by neural mechanism of the brain in individuals. It is very interesting to understanding about the functions of other lobes of the brain while performing tasks like problem solving. In other words, it is important to know excitation of neurons in neighboring lobes of the prefrontal cortex during cognition.

Several researchers have investigated the complexities in adults while solving mathematical problems by functional brain imaging and electrophysiological tests. It is interesting to note that their findings do not have common correlation of neuronal with the mathematical tasks. Delazer, et al. [2] demonstrated that parietal region was greatly activated during the process, whereas Gruber et al. [3], Ischebek et al. [4] and Rao et al. [5] have reported that frontal region was dominated during the process in adults. Collectively, the research findings indicate that all the regions have spatial signals during the mental arithmetic tasks in adults that have neuronal networks.

It is believed from the reported data [6] that the four lobes may not exhibit distinct frequency of oscillations, but each neuron of the brain cortex has harmonics of waves in the range from delta to gamma frequency bands. The functional connectivity between these regions can be assessed through spaciotemporal fluctuations. When the brain is not performing any task or without functional stimulation to the brain, it can still be monitored by resting-state EEG (Electroencephalography) acquisition [7] [8]. EEG for cognitive studies are widely used than imaging techniques because of the fact that EEG measurement is a noninvasive, portable, relatively less expensive, possibility of continuous measurement for any number of repetitions and greater temporal resolution. In this paper, we intend to focus on resting state EEG that could form a network on neural

oscillations among cerebral cortex regions. It is also aimed to experimentally demonstrate the potential region of the cortical brain emanating dominant oscillation frequency band during the task.

II. METHODOLOGY:

A. Subject Preparation

In this study, ten male students of native speaking in the age group of 25 (+/-5) years have participated. The subjects volunteered in the study were healthy and normal without history of any neurological or psychiatric diseases. They were asked to relax for 30 minutes before the test begins. It was informed in advance that each person will undergo for ten trials divided in to three sessions. Each session will be of 5, 10 and 15 seconds consequently. During every session, they were asked to memorize the multiplication table of 13 number during which their brain activity was recorded by EEG.

B. Data Recording and Processing

EEG data in the study was acquired using 32 channel BioSemi ActiveTwo (BioAmsterdam, The Netharlands) EEG system. The data was sampled at a sampling frequency of 256 Hz. Internationally standardized 10-20 electrode system was used with an EEG cap referenced to the CMS-DRL ground. The location of scalp electrodes in 10-20 electrode system is shown in fig. (1). In the figure, it is noted that Fp1 and Fp2 are prominent positions of electrodes in frontal region. The signals were displayed in real time using EEGLAB (Swartz Center for Computational Neuroscience, University of California) software. Acquired EEG data was filtered through a band filter of 1-30 Hz to remove slow frequency and electric power line artifacts.

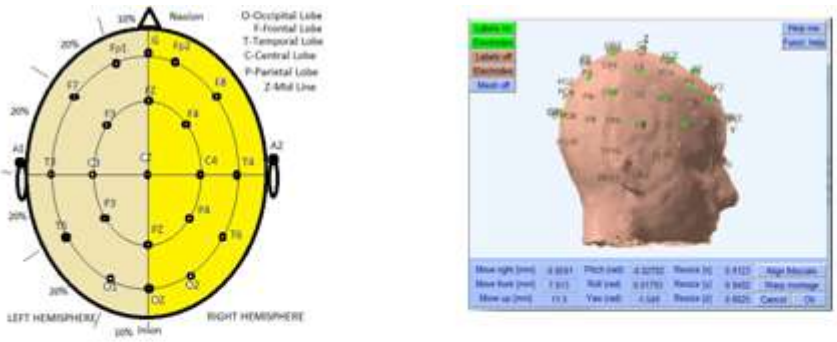

Fig. 1: Location of scalp electrodes in 10-20 EEG standard electrode configuration. A sketch from top view and side view from EEGLAB software are shown.

Data Analysis

Generally, the brain dynamics of live persons is never stationary and hence the measured EEG signal at any instant will not be stationary [9]. To understand the hidden factors of the brain activity we analyzed the measured EEG data by independent component analysis (ICA) method [10]. Then the power spectral densities were estimated for three frequency bands of theta (4-7 Hz), alpha (8-13 Hz) and beta (14-30 Hz) over three different scalp sites (FC6, CP6 and T8) to identify whether the person under test making any mistakes in the given task. The temporal brain dynamics in spectral changes were visualized by an Event-Related Spectral Perturbation (ERP) tool. For assessing the local properties of functional neuronal network of the brain regions during the specified task, BrainNet Viewer software [11] was used.

III. RESULTS AND DISCUSSION:

The complex brain dynamics for the chosen stimuli of arithmetic task was analyzed in Matlab supported EEGLAB software by Event Related Spectral Perturbation method (ERSP) [12]. We applied both ICA and ERSP methods to the EEG data acquired from each subject continuously for each session of the task. Figure 2 shows ERSP spectrographic image for frontal region electrode FC6.

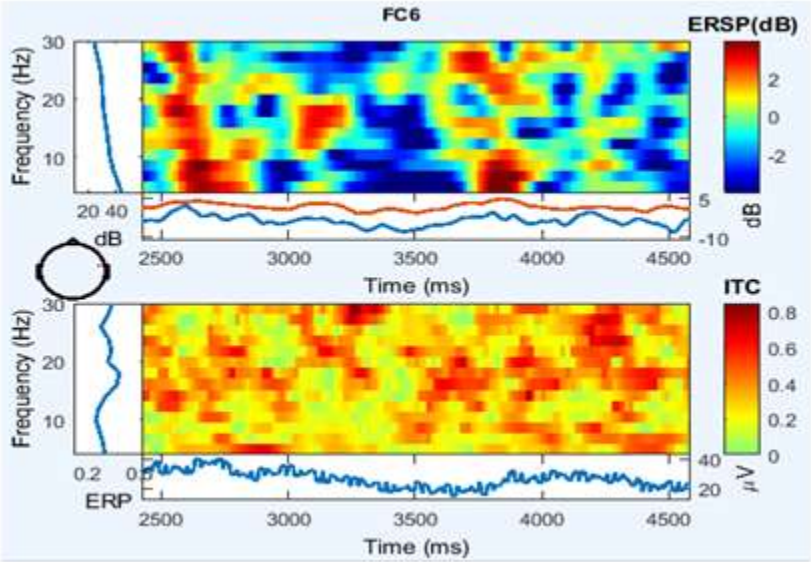

Fig. 2: Spectrographic image of the Subject measured from EEG at FC6 scalp electrode. (Top: Event Related Spectral Perturbation and Bottom: Inter-trial coherence analysis).

The time interval of epoch for brain activation was 2-5 sec. From the diagram, it can be noted that the theta band of frequency (4-7 Hz) has highest values of ERSP in the time intervals of 2.5 to 3 sec and 3.5 to 4 sec. which implies that the subject is exercising greater mental effort during the task which means that he is feeling difficult in arithmetic multiplication or in other words his cognitive level in mathematics could be challenging. Further, the similar observation can be seen from inter-trial coherence (ITC) analysis which is a measure of event related to neuronal activation. Although the peak energy level exists in that region of the brain, neurons ensembled from nearby lobes remain functionally active but less significant during the task. In the non-cognitive state of the brain also we measured the EEG and found that there were no significant peaks in amplitudes among the brain regions which is an indicative of resting-state EEG viewed from BrainNet Viewer software package.

IV. CONCLUSIONS:

Experimentally, we assessed the cognitive performance of the students while executing an assigned mental task. The results show that the frontal region of the brain plays major role in arithmetic calculations and recollecting from memory. The findings are derived from two methods of analysis; ERSP and ITC. Both methods agree with hypothesis in the study. We also analyzed the role of neuronal networks in the cerebral cortex by viewing through BrainNet software. From the results, it shows that the neurons are networked together and will not have dominant amplitudes in EEG signals indicating the resting-state when the person is not participating during the cognition.

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