Autism, EEG and Brain Electromagnetics Research

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Abstract.
There has been a significant increase in the incidence of autism. We report the work on autism by our international group, on the growing attention paid to EEG based diagnosis and the interest in tracing EEG changes to brain electromagnetic signals (BEMS), seeking the cause of autism and the brain regions of its origin. The time- and frequency domain and principal component analysis (PCA) of these EEG signals with a Multilayer Perception Neural Network (MLP) identifies an autistic subject and helps improve classification accuracy. We show differences between a working brain and a relaxed brain, especially in the Alpha waves used for diagnosis.

1. Introduction

As new medical diagnostic tools such as EEG are combined with powerful signal processors, new features are observed which make it possible to get new information from the signals measured, providing better windows to understanding brain science and functioning. The EEG signals are electric potentials induced on the electrodes by brain electromagnetic signals (BEMS). Since greater and more minute information of BEMS may be extracted from EEG signals, there is now a greater possibility of understanding, early detection and diagnosing neurological illnesses such as alzheimer disease and autism, which are progressive [1]. About 1 in 150 children is affected by the Autism Spectrum Disorders (ASD). Autism, Asperger's syndrome and Pervasive Developmental Disorder are collectively referred to as ASD. Moreover, the number of children affected is rapidly increasing [2-4]. Our objective is to seek a deeper understanding between BEMS observed through EEG and the cognitive functions of autistic and normal children. The EEG signals obtained undergo preprocessing before extraction of specific features followed by classification. Following this approach, Wafaa and Abdul [5] have used poor motor movement in very young children for early diagnosis. It is known that the EEG signals are non-stationary, non-linear, vary with time and represent stochastic systems besides being affected by noise from electrodes and child movement which cannot be controlled or restricted for a long time [6]. In this study, time- and frequency domain and principal component analyses (PCA) were applied to extract features from EEG for autistic and normal subjects. An MLP was also used as a classifier to detect an autistic subject performing the tasks of motor movements and opening of eyes. We find that the PCA features improve accurate classification. Another study [7] looked from a different angle at autistic disorder. The visual task for autistic and normal children reveals differences in the EEG alpha waves, which suggests that the autistic child has visual disorder from an early age. EEG signals were recorded for normal and autistic children employing Visual Evoked Potential (VEP).

2. Tracing the Electromagnetic Fields of the Brain

At Taylor's University with its overseas collaboration, the work focuses on relating the measured EEG to the BEMS, hence seeking to get a deeper understanding of the differences between the brain matter and function of an autistic and normal brain - seeking also to localize the specific area or region inside the brain from where these differences originate. There are two possibilitites open to us to trace back the EEG signals and changes in the EEG signals into the brain itself. Autism caused changes in the brain may be due to either (a) changes in the chemical property of certain regions of the brain over which BEMS travel, thus affecting the potential induced through changes in electric properties of the brain tissue, or, (b) the electric current source that produces the BEMS is changed due to autism. Since one of the major functional changes observed in autistic children is their emotional life, or lack of it, the region of change could well be the most active during emotional activity (e.g. a hug from the

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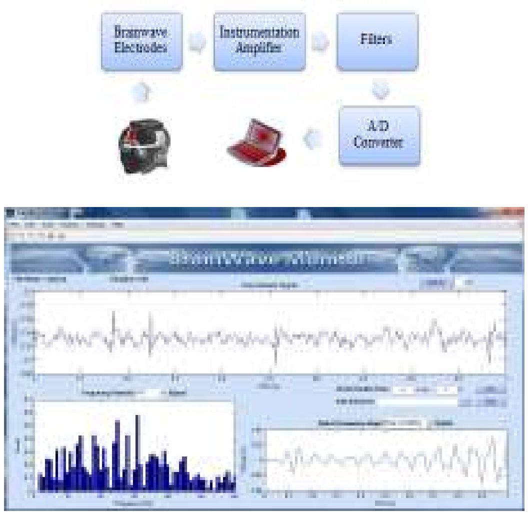
mother which produce feelings of happiness and a smile on the face of a normal child, produces a freeze in the facial expression of the autisitc chid, a desire to escape). The electric current sources inside the brain which produce the BEMS are adequately represented by electric dipoles [8.9]. The signal frequencies closely associated with autism are the beta band (15 to 35 Hz) and Mu band (8 to 13 Hz), as captured by our system (Fig. 1). In parallel with exploring the complex, smart antenna method for localization [10], we also pursue a one dimensional electric circuit model representation of the progress of the BEMS from source to scalp, to focus on exploring both the source current and material change associated with autism, to get a better understanding of the cause and location of changes. Typical values of R and C for biological tissues are R = 17 ohms/mm and C = 10 pF/m. The diffusion of BEMS is represented by the electric circuit diffusion equation giving a travelling potential:

$$V = A\int_0^u e^{-\frac{RC}{4}u^2}\,du + c = A * erf\left[\left(\frac{RC^{\frac{1}{2}}}{4}\right)u\right] + c$$

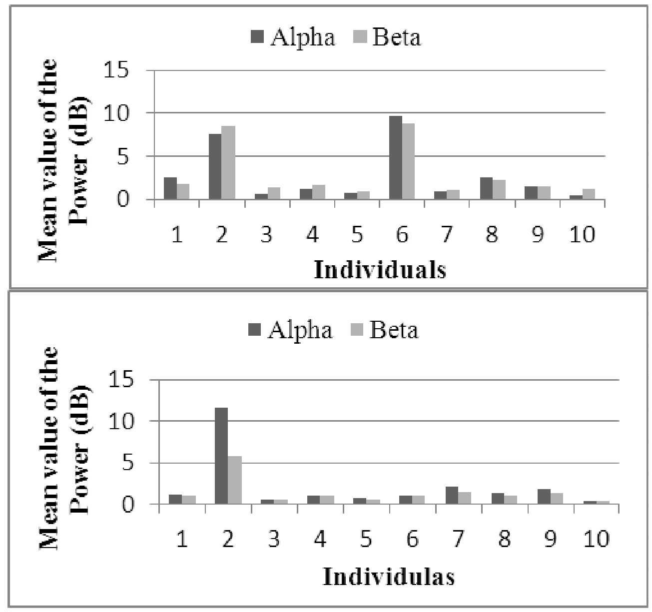


(a) The Measuring system (b) Time domain EEG and Spectral Lines

Figure 1: The EEG System

where erf is the error function and $u = z/y^{0.5}$, and A incorporates the constants introduced in making the integral fit the form of the error function. A and c are determined by using suitable boundary conditions. The EEG potentials measured are induced by the BEMS potentials *V* that travel through the brain and induce the EEG potentials. The circuit model of the brain tissue through which the BEMS travel to produce the spikes and pulses of EEG, is dependent on the material properties of the brain, and provides us with a basic tool to trace back the EEG signals through the internal path.

3. Results and Conclusions



a) Before commencement of listening to relaxing music. (b) While listening to music

Figure 2: The intensity of the Alpha and Beta BEMS picked up by EEG

The relationship between human brainwaves and relaxation indicates that the Alpha wave tends to increase in intensity while the Beta wave tends to decrease when the person is in a relaxed mood. We studied the effects of relaxation music on Alpha and Beta rhythms of the EEG.

This study involved ten young adults aged 23 to 25 years. The experiment was conducted in a room with a controlled environment. During the recording sessions, the people sit on a chair with eyes closed and were instructed not to move. They listen to the relaxation music stimuli through headphones. For each person, the brainwave (EEG) was first recorded without any music, with eyes opened. Subsequently the person needs to listen to relaxing music for three minutes with closed eye and the EEG is recorded from the beginning to the end of the session. During this period samples at every two seconds were recorded for each person. All the signals were downloaded by the hardware system and were analyzed using the software program built in MATLAB. In order to compare the influence of music in Alpha and Beta bands we used statistical parameters, namely, the minimum value, the mean and the standard deviation of the signal.

The analysis in the frequency domain was proven to be more significant than in the time domain. The Alpha wave magnitude increased towards the end of the relaxation session. On the other hand, the Beta component decreased over the time that the people listened to relaxing music. This impact of music on both the Alpha and Beta waves was seen in all three statistical parameters of the measurement: the maximum value, the mean and the standard deviation of the Fourier transformed signal for almost all ten people. During the time of listening to relaxation music, an increasing Alpha level, when compared to the Beta level, suggested that the subject was in a calmer, relaxed state.

Abnormalities in the EEG Alpha waves are associated with early age autism. Fig. 2 shows the Alpha EEG-BEMS (7.5 to 12.5 Hz) signal intensity, associated with relaxation and reflection, and the Beta EEG-BEMS (above 12.5 Hz) signal intensity associated with working and alertness. Of the ten 22-25 year olds tested, there is an overall pattern of decrease in the Beta to Alpha power density ratio. Music may help autistic children to better function and relate normally. The time- and frequency domain and PCA from these EEG signals permits their classification using an MLP to detect an autistic subject engaging in motor movements and opening of eyes. Thus the PCA features improve classification accuracy. Further investigations are expected to help understand the relationship between the performance of the autistic brain and BEMS in the part of the brain where music has a greater impact.

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