



EEG Brain Mapping of Developmental Dyslexia- A Case Study Report

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Received: 22 February 2013

Reviewed & Received: 28 February 2013

Accepted: 28 February 2013

Abstract

Developmental dyslexia is a specific and significant impairment in reading abilities which is unexplainable by any kind of deficit in general intelligence, learning opportunity and general motivation or sensory acuity. The main objective of the study was to measure the absolute powers of beta, alpha, theta and delta of the dyslexic case with the help of the intervention programme on relaxation techniques. The experimental sample for the present study was a single dyslexic case and control group for comparison with quasi experimental approach. Brain waves of the control samples including the experimental case were recorded for pre test using Electro Encephalogram (EEG) and relaxation therapy was given for the experimental case alone and post test was recorded. Statistical analyses were done on the different brain waves. It was found that increase in absolute powers of Alpha and decrease in Beta brain waves in dyslexic case was due to relaxation techniques because of the internal mental operations and thereby relaxed and

alert condition of the case was increased. Then decreasing absolute powers of theta and delta brain waves were mainly due to the changes in cognitive processing during relaxation.

Keywords: Brain Waves, Developmental Dyslexia, EEG, Relaxation Techniques

Introduction:

Developmental dyslexia is defined as a specific and significant impairment in reading abilities, unexplainable by any kind of deficit in general intelligence, learning opportunity, general motivation or sensory acuity (Critchley, 1970; World Health Organization, 1993). Children with this condition often have associated deficits in related domains such as oral language acquisition (dysphasia), writing abilities (dysgraphia and misspelling), mathematical abilities (dyscalculia), motor coordination (dyspraxia), postural stability and dexterity, temporal orientation (dyschronia), visuo-spatial abilities (developmental right-hemisphere syndrome), and attentional abilities (hyperactivity and attention deficit disorder) (Weintraub & Mesulam, 1983; Rapin & Allen, 1988; Dewey, 1995; Gross-Tsur et al., 1995, 1996; Fawcett et al., 1996). EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain (Niedermeyer E. & Da Silva, 2004). EEG is a useful source of information on the background state of the brain, indexing the substrate of cognition and behaviour. EEG studies under resting state provided important information about basic differences between normal and impaired readers, a significant advance in the research on electrophysiological correlates of Developmental Dyslexia has been reached only recently, by using experimental paradigms aimed at stressing (through specific stimuli or tasks) the functional cognitive processes assumed to be potentially impaired in dyslexics (i.e., linguistic, perceptual, attentional) (Ackerman, McPherson, Oglesby, & Dykman, 1998; Rippon & Brunswick, 1998, 2000). Measurement of Absolute power from EEG spectrum is the amount of EEG in one band without relationship to other bands. The differences between pre and post tests absolute power of the Developmental Dyslexic case on Beta, Alpha, Theta and Delta are observed with Relaxation Therapy as an intervention programme, which can be employed as one element of a wider stress management programme and can decrease muscle tension, lower the blood pressure and slow heart and breath rates, among other health benefits (Daniel Goleman, 2006).

Colon et al., 1979, aimed to compare EEG power-density spectra between dyslexic and normal children. Children with age groups 8, 9, 10 of specific reading and writing tasks were selected excluding organic diseases and mental disorders. In the 8-year-old group the power in the alpha band is higher in normals, in the 9-year-old group there was a higher power of the mu rhythm in normals and in the 10-year-old group the power in the temporal theta band is lower in normals. Soininen et al., 1991, studied the

absolute and relative power and amplitude of EEG spectra (T6-02) of 24 patients with "probable" Alzheimer Disease (AD) at the early stage of the disease and 1 year later and also compared the values to those of normal elderly controls. The AD patients had significantly higher absolute theta power and lower beta power values compared to controls but absolute delta and alpha values did not differ. Fein et al., 1986, studied the resting eyes open and eyes closed EEG in carefully screened samples of 9-13-year-old dyslexic and control boys within a 2-cohort cross-validation design with repeat testing 1-3 years later. It was concluded that dyslexia per se is not associated with increased absolute power in the delta and theta bands; lower power in the high beta band is reliably found in these samples of dyslexics without other disorders; and alpha power levels are not consistently lower in the dyslexic group.

Objectives of the Study:

- ◆ To find out the impact of relaxation therapy on absolute powers of beta, alpha, theta and delta of dyslexic case.
- ◆ To improve the quality of academic life of dyslexic case.

Research Question:

- Does relaxation therapy change the absolute powers of various wave patterns of the brain?

Design of the Study:

Out of 150 slow learners (age range 14 - 17 years) 18 Dyslexic students were chosen, from which eight dyslexic students were randomly selected from special school for learning disabled and they are called as control group. Initially Simple Random Sampling Technique was adopted for control samples' selection and Selective Sampling Method was used to select the Experimental Sample. Subjects were free from medical and sleep disorders as determined by history, physical examination, biochemical screening tests, electrocardiograms, and psychological screening questionnaires. Quasi-Experimental design is used for the study. Under that Single Case pre test and post test having control group design is framed for the present study. In order to measure their brain waves permission had been requested from the school authorities and parents of the selected students. After receiving the permission, Electro Encephalogram was recorded for all the students to measure their brain activation waves and these values were considered as pre test values. After that, one student had been taken randomly from the control group as a case for present research. Relaxation therapy was given to the single case for about a month. Post-test was recorded on brain waves while doing relaxation therapy for the experimental case at the end of the intervention programme. A method proposed by Crawford and Howell (1998) that treats the control

sample statistics as sample statistics (Crawford & Garthwaite, 2002) is used to compute the significance of difference between pre test and post test of the dyslexic case.

Statistical Analyses and Results:

Table 1: Differentiation of pre and post test absolute power of Beta, Alpha, Theta and Delta from Dyslexic Case

Case Category	Control Group N	Brain Waves	Pre-Test Mean	Post-Test Score
Dyslexic	8	Beta	11622.24	2113.86**
		Alpha	1452.64	1986.16 ^{N.S}
		Theta	11890.14	4058.54**
		Delta	55080.17	5924.92****

P* < 0.05, P < 0.01, P*** < 0.001, P**** < 0.000**

It is clear from the table 1 that the calculated ‘t’ values of Dyslexic Case are significantly greater than that of the table ‘t’ values for beta (p<0.01, N=8), theta (p<0.01, N=8) and delta (p<0.000, N=8) and it is significantly lesser than the table ‘t’ value for alpha. Hence it is proved that there are significant differences between Pre Test and post test scores of Beta, Theta and Delta Brain Waves of Dyslexic Case before and after applying Relaxation Therapy and the hypothesis is accepted for Alpha Brain waves.

This study is supported by the following research studies. (Fein et al., 1986) (N=113) were able to consistently show decreased beta power (19-24 Hz) in dyslexics (eyes closed condition). Similarly, adults receiving 15 min of massage therapy showed a pattern of decreased beta power (Field et al., 1996), suggesting increased relaxation and alertness (Niedermeyer, 1982). (Ikemi, 1988) studied with Self-Regulation Method (SRM) before vs. during, Self-Regulation Method (SRM) vs. during drowsiness, having novices (N=12) samples resulted decreased beta power in meditation state.

The EEG signal generated by alpha (8–12 Hz) activity was first described by Hans Berger in 1929, when he demonstrated that closing the eyes decreased sensory input and increased alpha power over the occipital scalp (Berger, 1929). EEG studies have used these methods to limn the neurophysiological changes that occur in meditation (Rael Cahn & John Polich, 2006). (Lagopoulos et al., 2009) observed alpha power increase over the posterior regions. Alpha power increase is one of the more consistent findings about meditation state effects: alpha is generally associated with relaxation (Aftanas & Golocheikine, 2001).

The most dominant effect standing out in the majority of studies on meditation is a state-related slowing of the alpha rhythm (8–12 Hz) in combination with an increase in the alpha power (Hirai, 1974). These findings were relatively robust, because they did not depend on either a certain meditation tradition or the experience of the mediators.

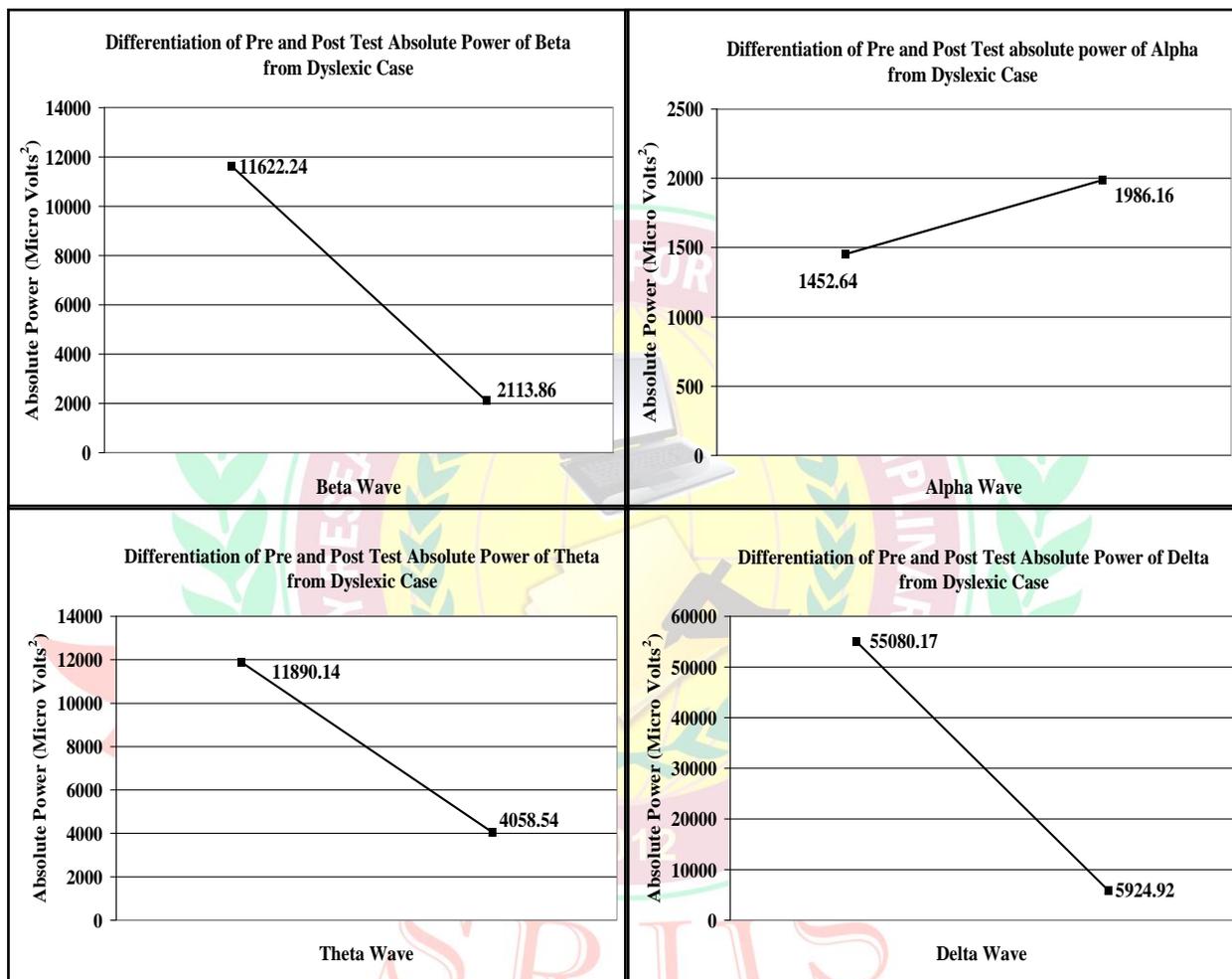


Figure 1: Shows Differentiation of Pre and Post Test Absolute Power of Beta, Alpha, Delta and Theta from Dyslexic Case (from Clockwise Direction)

(Anand et al., 1961) worked with Raj yoga meditation type having the experimental design of ((N=6) and Rest vs. meditation) showed that increased alpha power during Samadhi in meditation state. (Travis, 1991) studied with Transcendental meditation (TM) type having LTM and STM design (N=20), showed that increased alpha power in their meditation traits. (Lee et al., 1997) analyzed with Qigong meditation type having Rest and meditation group (N=13) showed increased alpha power in their states.

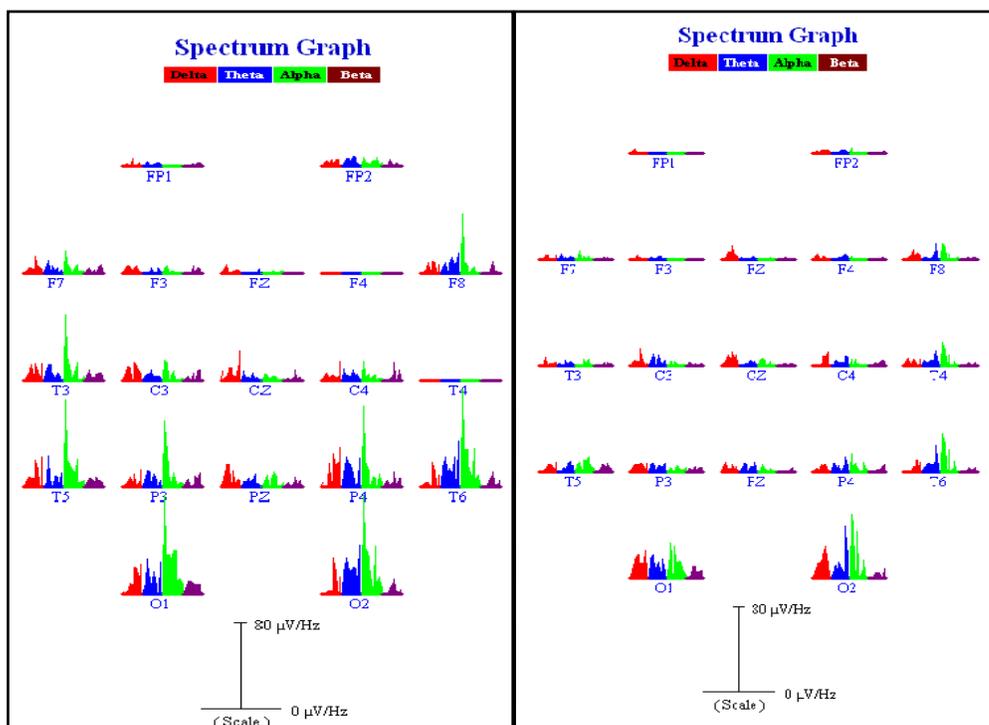


Figure 2: Figure 2(a) shows the Spectrum Graph for Pre-Test of the Dyslexic Case and Figure 2(b) shows the Spectrum Graph for Post-Test of the Dyslexic Case

Slow wave EEG activity (delta power) is associated with lower arousal and relaxation (Niedermeyer & Rodriguez, 1982), as were decreased in heart rate (Mok & Wong, 2003). (Dunn et al., 1999) (N=10) used Breath-focused Concentrative vs. Mindfulness Relaxation techniques for the experimental design of (N=10) (Relaxation and 2 meditation conditions counterbalanced, each practiced for 15 min) and found that meditation vs. relaxation resulted in decreased delta and theta power in meditation state. Post-qEEG data from ADHD sample showed that the neurofeedback-trained group but not the control group showed reduced EEG theta power (Gevensleben et al., 2009 a).

Bootstrap analysis with False Discovery Rate (FDR) corrections for multiple comparisons analysis of the sensor data indicated decreased delta power during meditation relative to control period at bilateral frontal electrodes (F3, F4, F7, F8, C3, and C4, all $P < 0.05$). Frontal delta power at electrodes F3 and F4 was analyzed separately as delta activity at these electrodes was shown to be most significantly decreased in the bootstrap analysis of the scalp data (Rael Cahn, Arnaud Delorme & John Polich, 2010).

A significant interaction among state, order of experimental sessions (meditation → control vs. control → meditation), and midline electrode location was found, $F(2, 28) = 4.70, P = 0.017$. This outcome suggests decreased midline delta power during meditation relative to rest specifically for those

participants doing the control period prior to the meditation period, but not those meditating first. Breakdown of this interaction with Tukey post hoc testing indicated that when the control period occurred first, midline delta power was decreased in the subsequent meditation session at Fz ($P = 0.0004$) and Cz ($P = 0.027$) but not Pz ($P = 0.30$) (Rael Cahn, Arnaud Delorme & John Polich, 2010).

A second covariate interaction was found for the state \times reported drowsiness \times midline electrode location during meditation, $F(2,28) = 3.39$, $P = 0.06$, indicating that only those subjects not reporting drowsiness during meditation showed a tendency for decreased midline delta power in meditation (Rael Cahn, Arnaud Delorme & John Polich, 2010).

Discussion:

As a result of the present research findings decrease in beta power and increase in alpha power by relaxation therapy in dyslexic case is because of the internal mental operations thereby relaxed and alert condition of the case is increased. Considerable previous research findings indicate that, participants receiving facial massage therapy exhibited decreased beta power, an EEG pattern that may reflect attention and alertness (Klimesch et al., 1998; Shagass, 1972; Nunez, 2000). It was shown that a pattern of decreased beta power using EEG (Field et al., 1996) in massage therapy, suggesting increased relaxation and alertness (Niedermeyer, 1982). This finding was found to be true in the present investigation. In Alzheimer's disease (AD), the decrease in beta power was interpreted as a sign of compromised function of the affected brain areas (Gianotti, 2007). The structural cause of decrease in beta power might be a loss of cholinergic and glutamatergic neurons in the course of the disease (Mann, Oliver & Snowden, 1993). Alpha oscillations are known to arise from an increase of internal attention (Ray & Cole, 1985) which of course does not only occur due to meditation. Various studies showed an increase of alpha power related to internally driven mental operations, like the imagery of tones (Ray & Cole, 1985; Cooper et al, 2003; Cooper et al, 2006) or working memory retention and scanning (Jensen, 2002; Klimesch, 1999). Increase in alpha power was often observed when meditators are evaluated during meditating compared with control conditions (Aftanas & Golocheikine, 2001; Anand, Chhina, & Singh, 1961; Arambula, Peper, Kawakami, & Gibney, 2001). Several EEG meditation studies reported sleeplike stages during meditation with increased alpha power (Pagano, Rose, Stivers, & Warrenburg, 1976; Younger, Adriance, & Berger, 1975). The association between alpha changes and cortical activation had been assessed with combined EEG and fMRI-PET studies, with increased alpha power related to decreased blood flow in inferior frontal, cingulate, superior temporal and occipital cortices (Goldman, Stern, Engel, & Cohen, 2002; Sadato et al., 1998).

In the present research, decreasing theta and delta power are recorded on the experimental case compare with the control group with the help of relaxation therapy. Decreasing theta and delta are mainly

due to the changes in cognitive processing during relaxation. Previous research literature also shows that cortical EEG analyses by Low Resolution Electromagnetic Tomography method (LORETA) revealed significantly decreased theta activity in the hippocampus, para- hippocampal regions, and the cingulate cortex areas are known to play a role in cholinergic-associated cognitive functions (Browne et al., 2006). The pattern of meditation-induced increase in parieto-occipital gamma activity, concomitant decrease in frontal delta power, and a shift to a more frontal distribution of theta activity suggested that sensory processing and cognitive processing were altered during meditation relative to the control state (Cahn & Polich, 2006). Correlation analyses revealed that a decrease in prefrontal delta and, theta power correlated with an improvement in cognitive performance. Moreover, drowsiness was positively correlated with theta power in parietal and medial prefrontal regions and beta-1 and beta-2 power in occipital regions (Saletu, 2007). Neuro feedback aimed at decreasing theta activity might lead to the normalization of dysfunctional neural network and thus improve clinical symptoms (Koprivova et al., 2007). Power decreases in the delta and beta-1 bands were found predominantly over the temporo-parieto-occipital junction, whereas theta power was reduced in the temporo-medial cortex and in fronto-medial regions. (Riba et al., 2004) suggested the involvement of uni-modal and hetero-modal association cortex and limbic structures in the psychological effects elicited by ayahuasca (Amazonian beverage ayahuasca).

Acknowledgements:

We mention our deep sense of gratitude to University Grants Commission for Junior Research Fellowship and also we would like to express our heartfelt thanks to all the children those who participated in our research, their parents, school authorities, neuro-physician and technicians.

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