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Neurophysiological Correlates of Event Related Potential (P300 Wave) in Children with Attention Deficit Hyperactivity Disorder

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Abstract: P300 wave is an event related potential (ERP) component elicited in the process of decision making, it is considered as endogenous potential. The present study was designed to evaluate the neurocognitive entrained attentional mechanisms that are stimulus – locked in ADHD children in terms of neural dynamics of P300 wave through assessing and comparing the amplitude (microvolt) and latency (millisecond) of endogenous ERP – P300 wave on auditory oddball task in ADHD and healthy controls. The auditory oddball paradigm consisted of frequent (high tone) and target (low tone) stimuli spread through the domains of active tasks, wherein the participants had to count the number of target low tone stimuli. The latency values of peaking of ERP in milliseconds (ms) across the central EEG electrode lead pairs of Fz and Cz were observed to be of higher magnitude in children suffering from ADHD as compared to that observed in normal healthy control with P values of 0.001 [S] and 0.002 [S], no statistically significant difference could be appreciated in the amplitude values of the ERP wave form so studied in both the comparative groups of ADHD and normal healthy children.
Keywords: Attention Deficit Hyperactivity Disorder (ADHD), Diagnostic and Statistical Manual (DSM V), Electro Encephalo graphy (EEG), Event related potential (ERP), Positive value at 300ms (P300).

INTRODUCTION

The ERP components, which form a good framework for understanding and interpreting the broad domain of brain, mind and behavior sciences, sum together and culminate into the observed ERP wave – form [1].

The ERP components are usually labelled by the letter *"P"* that depicts the positive – wave response post stimulus and the postscript that follows the letter *"P"* in form of numerical reveal the place value of the wave – form that is observed as result of the stimulus, namely P1, P2, P3 that denote the first positive wave, second positive wave, third positive wave, respectively. Similarly, N1, N2, N3, N4 wave forms represent first negative wave, second negative wave, third negative wave and fourth negative observed in the EEG time series post – stimulus [2, 3]. P3 wave is a neural signature of attention and/or the amount of working memory required for appropriately responding to environmental stimuli [4].

As per *Donchin and Cole's Theory of Updating Memory* (1988), P3 is seen as an electro-physiological correlate of a steady revision of representation of an environment in the phase – space of the stochastic trajectory of working memory. P3 reflects neural activities involved in representation changes [5].

P3 latency period has been reported to be related to stimulus evaluation time [6] or the time taken to allocate resources and engage memory updating [7] and the speed of the underlying cognitive processing of the stimulus – locked mental task [8] and lengthens with the difficulty of task and the process of aging [9].

MATERIALS AND METHODS

The present study was carried out in the Department of Physiology in collaboration with the Departments of psychiatry and Pediatrics, SMS Medical

College, Jaipur. 30 children in the age group of 7 to 14 years suffering from ADHD disorder, diagnosed as per DSM V criteria, were included in the study. A control group of 30 children matched for age and sex were recruited for comparative evaluation.

The inclusion criteria for the study adopted were having children having IQ > 70, no chronic medical illness and no previous psychiatric and neurological disorder. Diagnostic and Statistical Manual (DSM V) diagnosed children were recruited in study

Children with anxiety or depression with hearing or vision disorder, lead poisoning were excluded from the study . The family background of children also considered children from broken families inclusive of any abuse also excluded from study.

Procedure

Pseudo randomized sequences consisting of two types of auditory stimuli i.e. a high frequency tone and a low frequency tone were used in the form of an auditory oddball paradigm for recording ERPs. The frequency of high and low tones used was 1200 Hz and 600 Hz respectively. High tone was used as frequent/standard tone (80% probability of presentation) and low tone was used as non-frequent/target tone (20% probability of presentation). Ratio of frequent stimuli and target stimuli was 4:1. The stimulus sequence was presented using a speaker delivering a sound intensity of 60 dB. A variable inter-stimulus interval of 1500 ms (variance of 20) was used with an analysis time of 1000 ms. These binaural auditory stimuli were delivered in a pseudorandom fashion (ensuring no consecutive presentation of two targets and presentation the adequate non target stimuli between targets that varied between two to six). Local peak latency and local peak amplitude of the P300 waveform was then calculated from the obtained average ERP waveform using stipulated time window of this ERP component.

RESULT AND OBSERVATION

Table-1: ERP P 300 Wave Latency

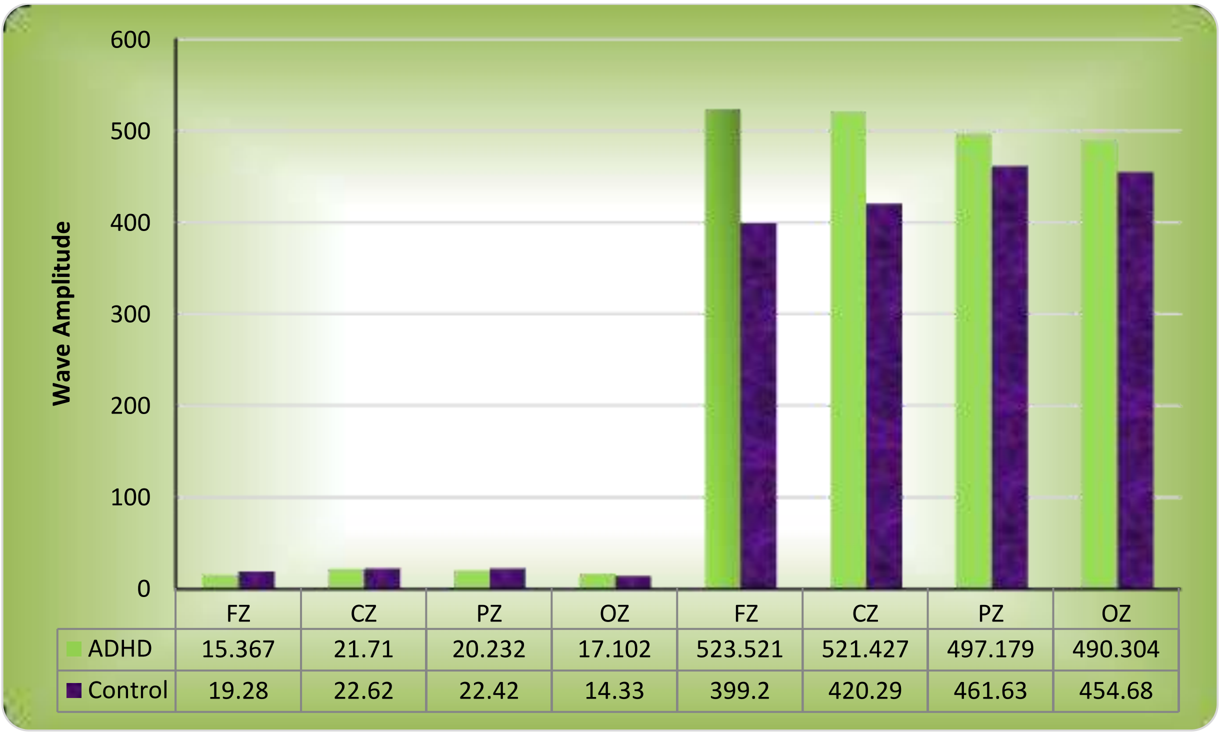
Channel	ADHD			Control			
	N	Mean	SD	N	Mean	SD	P value
FZ	30	523.521	49.151	30	399.20	101.78	**.001S**
CZ	30	521.427	40.462	30	420.29	94.89	**.002S**
PZ	30	497.179	29.994	30	461.63	76.48	.163NS
OZ	30	490.304	31.363	30	454.68	57.92	.073NS

Above table showing the ERP P300 Wave latency in children with ADHD as compare to control .Latency was significantly higher in Fz and Cz mid line electrode site p value was < 0.001 and <0.002 respectively.

Above table showing the ERP P 300 Wave amplitude in ADHD child as compare to control. There was no significant changes are found in both the group.

Table-2: ERP P 300 Wave Amplitude

Channel	ADHD			Control			
	N	Mean	SD	N	Mean	SD	P value
FZ	30	15.367	12.633	30	19.28	9.17	.295NS
CZ	30	21.710	13.165	30	22.62	7.76	.513NS
PZ	30	20.232	12.226	30	22.42	7.86	.431NS
OZ	30	17.102	8.488	30	14.33	6.12	.268NS



Graphical presentation of P 300 Wave Latency and Amplitude

DISCUSSION

In the present research design Event Related Potentials were elicited with an auditory discrimination task (oddball paradigm) by presenting a series of binaural standard/frequent tones (high tone) versus target/non-frequent tones (low tone) in the ratio of 4:1. Active or counting task, the participants were instructed to count the low tones (infrequent target stimulus) quietly in mind while ignoring the high tones (standard/frequent non – target stimulus) and to report the number of low tones to the researcher after procedure.

Loiselle *et al*., in 1980 [10] found decreased P300 amplitudes to attended signals at site Cz in their clinical group. Sunohara *et al*., [11], found that the ADHD group, at baseline, was more impulsive and inattentive than controls and had shorter P200 and N200 latencies and longer P300 latencies. The present study also documented an increase in latency of P 300 wave at Fz and Cz channel (Table-1).

Satterfield *et al*., [12] suggested that the abnormally low P300b amplitude response to attended target stimuli found in ADHD boys may be due in part to insufficiency of the noradrenergic activity of the locus coeruleus (LC), activity that is normally triggered by attended task – relevant or novel stimuli.

Puente *et al*., [13] in a sample of children with attention deficit disorder, found significant prolongation of P300 latency and a significant decrease in P300 amplitude, a finding that has been replicated by the present study, wherein the neural processing time, as manifested by the latency window, is raised (an increase in P300 latency) in ADHD children.

Idiazábal-Alecha [14] conducted the P300 wave assessment using auditory and visual oddball paradigms and documented significantly longer latencies (in milliseconds) and smaller amplitudes (in microvolts) of P300 in ADHD children when compared with that in control healthy children.

CONCLUSION

In this background where an abnormally long latency in milliseconds (and an antecedent low peaking amplitude in microvolts) of P300 wave form is observed in children with attention dysfunction and hyperactivity, it can be extrapolated that the neural network that sub – serves attentional mechanistic underpinnings along the Task – Mediated Network (TMN) and Default Mode Network (DMN) distributed through prefrontal cortex and posterior cingulate cortex and medial prefrontal cortex and angular gyrus [15] respectively has an inherent neurophysiological dysfunction wherein the said neural networks do not get entrained and locked to the stimulus along the space – time axes.

It seems that the common denominator in assessing EEG time series along the Fast Fourier Transform and the ERP protocol underscores the premise of neural dynamics operating in ADHD children that have a tendency to be wayward with an inability to entrain onto impending relevant stimulus.

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