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Computer-Based Attention Training for treating a Child with Attention Deficit/Hyperactivity Disorder: An Adjunct to Pharmacotherapy - A case report

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ABSTRACT

Aim: The current research aims to understand the efficacy of Captain's log, a computerized training programme, on the EEG parameters, and on attention, working memory, processing speed, hyperactivity of the children with ADHD-combined type. **Methods:** A computerized cognitive training programme Captains log Brain Train is used for treating the child. The male child performed cognitive tasks 36 minutes twice a week for 35 sessions that focused on improvement of attention, concentration, processing speed, working memory and impulsivity. Pre- and post- treatment differences on the Evoke Related Potential (ERP), Conners Parent Rating Scale, coding was considered as indices of changes. **Results:** The Scores on Conners Rating Scale revealed a decrease inattention and minimal change in hyperactivity. Electrophysiological testing on Evoke Response Potential (ERP) shows decrease in latency and increase in amplitudes in the few component of ERP. **Conclusion:** The processing speed, visuomotor coordination, sustained attention and working memory improved in the child after cognitive training but the tasks that recruit higher cognitive functioning such as, planning, organizing and conflict monitoring did not show marked improvement.

KEYWORDS: ADHD,Computerized cognitive training programme, Evoke Related Potential

INTRODUCTION

Theoretical and Research Basis for Treatment:

Attention deficit hyperactivity disorder (ADHD) is associated with a deficit in response selection, motor adjustment, behavioral and cognitive impulsivity. Children with ADHD show impairment in target detection and discrimination, with a tendency to commit more errors and show slower and more variable responses[1-3]. Children with ADHD have been reported to have abnormalities in their visual, auditory ERPs [4,5].Event-related brain potentials(ERP) studies have shown abnormally increased latency and decreased amplitude in ADHD children [6]. ERP is claimed to be a useful tool for the investigation of sensory and cognitive processing impairment. [7,8].Low P3 amplitude in ERP is believed to provide an indication of psychophysiological deficits related to behavioral disinhibition [9], failure of behavioral control, CNS hyperexcitability, impairment in engaging in selective attention [10].

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The most common treatment for ADHD is stimulant medication followed by behaviour therapy and cognitive training [11], the earlier researcher agree with Whalen & Hanker (1991) that the benefit of medication is not persistent beyond the treatment phase. Its impact reduces with the termination of medication. An alternative treatment is the computerized cognitive training programme. Captains log Brain Train [12] is one, which has been developed to treat the ADHD with the intention to minimize the side effect of medicine and to hold a persistent impact of training. Kotwal et al.,(1995) observed significant behavioral changes, with enhancement in on-task behaviour and decrease in disruptive behaviour in school after computerized cognitive training programme using Brain Train. Long-term improvement of inattention symptoms with respect to the baseline status has been demonstrated [14] that could indirectly alter academic performance in children with ADHD [15].

The current research aims to understand the impact of Captain's log, a computerized training programme, if any, on the EEG parameters and attention, working memory, processing speed, of the child with ADHD, combined type.

METHOD:

Patient's characteristics and complaints

The child was a 9 year 2 month old male, referred from the Department of the Psychiatric Outpatient Services of R.G. Kar Medical College Hospital, Kolkata, on 9th May, 2015 for the complaints of restlessness, poor scholastic performance, inability to write anything in school, inattentiveness, difficulty in concentrating on one thing for a long time, excessive stubbornness, tendency to disturb other children in school , frequent fighting with friends and impulsivity. The child was diagnosed by a consultant psychiatrist at the hospital and also by a psychologist independently. The case was selected only on the basis of agreement between the psychiatrist and the psychologist, basing their diagnosis on the DSM-V [16] Classification. The written consent was also taken from the parents of the child.

History

The child is the only son of his parents hailing from middle socioeconomic status and lives in a joint family. The child was born of full term cesarean delivery. The current development status is age appropriate. Mode of onset of the disease is insidious, course is continuous and progress is status quo. Medical history reveals he was on inspirol-10mg for 1year.

Assessment

The child and his parents completed following assessment measures. A few tests were administered both as pre- and post test measure-coding (subtest of WISC-IV), Conner's Rating Scale, and electrophysiological measure i.e., ERP.

- **Wechsler Intelligence scale for children-IV [Indian adaptation]** [17] -To measure the IQ WISC –IV was administered to the child and the child is found to be 80, which falls under the "Dull normal category" of intellectual functioning.
- **Devereux Scales of Mental Disorder** [18] -DSMD score reveals that child falls under elevated group on Externalizing disorder that charcterises the child as disobedient, annoying others, inattentive with difficulty in concentration, easily distractible, undercontrolled and restless and. A borderline critical pathology further suggest presence of behavioral disturbances in the child with borderline anxiety, low self concept, tension and worries.
- **Conner's rating scale** [19] - It is a behaviour rating scale that measures variety of behavioral problems. In Conner's rating scale, subject showed very elevated score in the domains of inattention, hyperactivity, oppositional disorder. His score in aggression, learning problem, executive functioning categorized him in elevated group. It is suggestive of attention deficit hyperactive disorder with conduct problems.
- **Electrophysiological measure:**

  The electroencephalogram (EEG) was recorded with Axxonet system technologies machine, 36 channels of which 19 active Ag/AgCl electrodes mounted in an elastic fabric cap following the modified version of the 10-20 system of the American Electroencephalographic Society. Channels were referenced to the left ear [20] .The EEG was sampled at 256 Hz. A Butterworth filter of range 0.05 to 30 Hz is applied and notch filtered at 50 Hz. EEG power was averaged into three regions from individual scalp electrodes (frontal: Fp1, Fp2, F3, F4, F7, F8, Fz), (central: C3, C4, Cz, T3, T4), (posterior : P3, P4, Pz, T5, T6, O1, O2).

  For Event Related Potential, we applied the "2N-Back test" [21] as a visual stimulation. 112 trials were presented for 500ms with a prestimulus of 200ms and interstimulus gap of 4000ms [22]. Latency windows for potentials were designated in the following ranges: 75-150 milliseconds for N1, 120-250 milliseconds for P2, 150-350 milliseconds for N2 and 250-700 milliseconds for P3[7].

Treatment protocol

A computerized Captains log Brain Train programme is used for cognitive training purpose [12]. This system contains five modules and 33 separate cognitive exercises to develop attention, concentration, processing speed, memory and problem solving skills. These exercises are directed towards visual, auditory and combined visual auditory stimulus.

Course of Treatment

The child was on Inspirol 10mg (Methylphenidate) from IPCA Laboratories Ltd. thrice a day for one year duration prior to include him in the Captain Log treatment which was continued while assigned to Captains log Brain Train brain train treatment. He performed cognitive tasks for 36 minutes twice a week for 35 sessions [13] that focused on improvement of attention, concentration, processing speed, working memory and impulsivity skills.

Results of Intervention in comparison with Baseline Status

Table 1. Showing the pre/ post- treatment measures on Conners rating scale and Coding

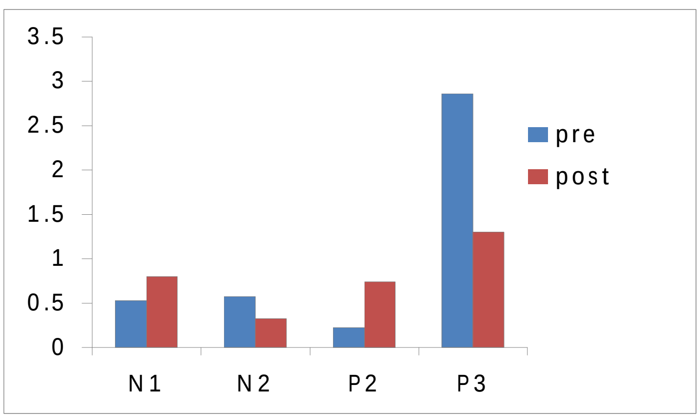
	Before training	Post training
Inattention	84	77
Hyperactivity	71	69
Coding	17	36

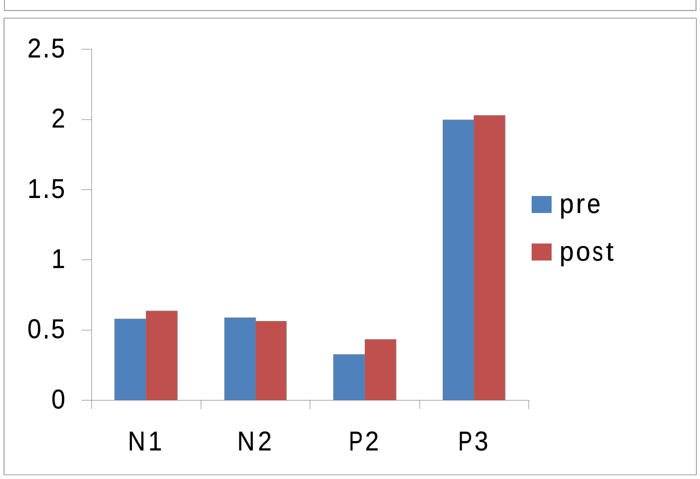
Table2. Showing of the pre and post training Latency(ms) measures of visual ERP components in the child with ADHD

	N1(MS)		N2(MS)		P2(MS)		P3(MS)	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST
FRONTAL	110.47	83.12	208.71	207.6	161.27	200.71	660.15	334.27
CENTRAL	121.1	115.6	300	216.4	211.72	197.66	659.38	572.64
POSTERIOR	95.43	123.57	319.22	196.98	191.94	226.57	620.54	526.77

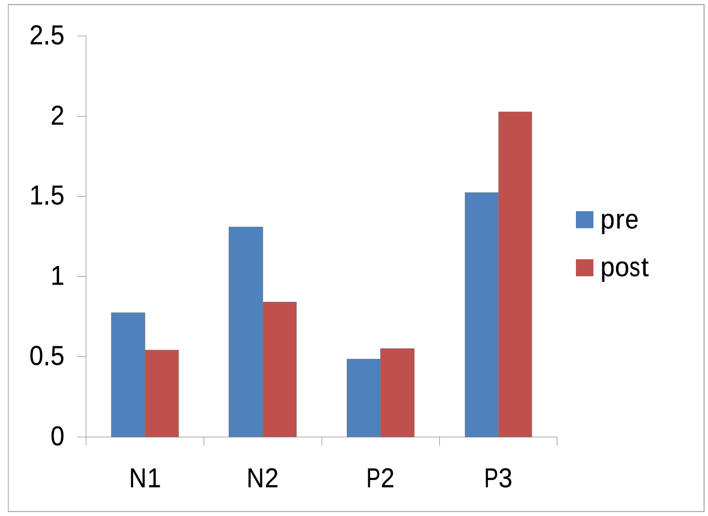
Table 3. Showing of the pre and post training amplitude measures of visual ERP components in the child with ADHD

	N1(µV)		N2(µV)		P2(µV)		P3(µV)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Frontal	0.528	0.798	0.578	0.327	0.224	0.741	2.8	1.3
Central	0.588	0.636	0.588	0.564	0.326	0.434	1.99	2.02
Posterior	0.77	0.54	1.31	0.84	0.48	0.55	1.52	2.03

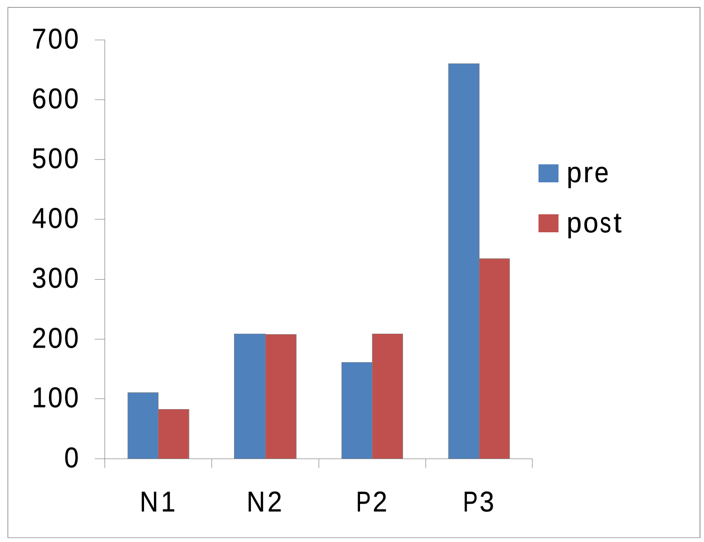


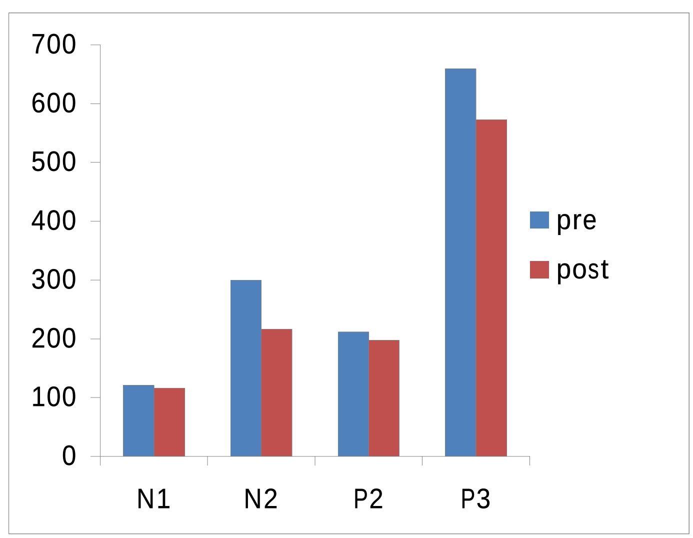


Graph 1& Graph 2: Pre and Post training ERP amplitude measures of the target stimulus in Frontal lobe, Central lobe.

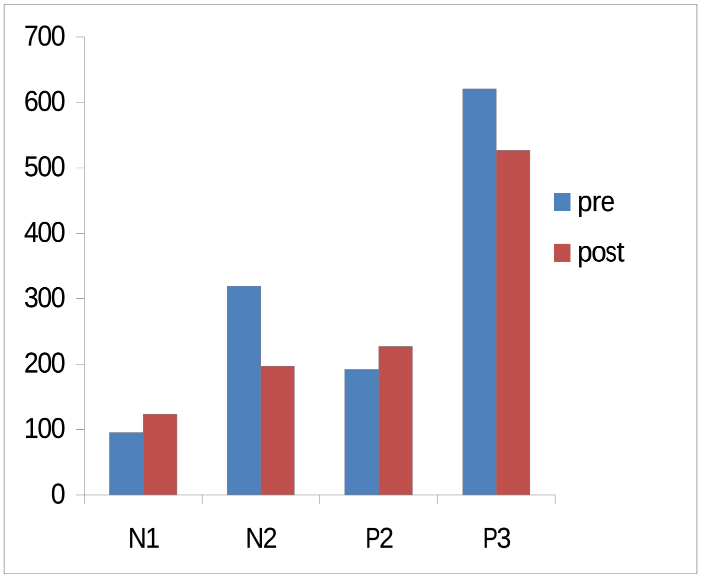


Graph 3: Pre and Post training ERP amplitude measures of the target stimulus in Posterior lobe





Graph 4 & Graph 5: Pre and Post training ERP latency measures of the target stimulus in Frontal lobe and Central lobe



Graph 6: Pre and Post training ERP latency measures of the target stimulus in Posterior lobe

The result of the behavioral measure, electrophysiological and cognitive task before and after cognitive training are elaborated below-

In the Conners rating scale shown as Table.1, T-score in attention subscale decreases from 84 to 77 and in hyperactivity subscale T-score decreases from 71 to 69 after the cognitive training session. In coding test, after the cognitive training a gradual increase in the performance is observed in comparisons to post test measure, the score increases from 17 to 36.

Table 2 shows the latency of the ERP component in frontal, central and posterior region of the brain. The decrease in latency observed post cognitive training in the N1, N2 and mostly in P3(the latency decreases from 660.15ms to 334.27 post cognitive training) in the frontal lobe, in central lobe latency decreases in all the parameters of ERP, in posterior lobe decrease in latency observed in N1, N2, P3 but in P2 latency increases from 191.94ms to 226.57 ms.

Table 3 shows the result of pre and post training session's amplitude measures of the ERP component of the frontal, central and posterior part of the brain. Enhanced amplitude of the target stimulus in ERP is evident in N1, P2 component in the frontal lobe and N1,P2 and P3 component in central region and P2, P3 component in posterior region post cognitive training in comparisons to pretest measure. Decrease in ERP amplitude observed in N2, P3 component in the frontal lobe, N2 in the central part of the brain and N1 amplitude in the posterior part of the brain post cognitive training.

DISCUSSION:

In the Conner's Parent Rating Scale, child shows most improvement in inattention scale [14, 13] and minimal improvement in hyperactivity scale in the post- cognitive training phase.

Digit symbol subtest is an information-processing task. The test requires attention, concentration, visuomotor coordination, and psychomotor speed. The child's score increased from 16 to 37 after cognitive training, improved performance after cognitive training in this domain suggests enhancement in processing speed with an obvious increased efficiency in underlying associated cognitive functions of attention, concentration and visuomotor coordination. Improvement in ERP task with decreased latency in N1, N2, P2 and mostly P3 in frontal, central and posterior lobes after cognitive training corroborates with this findings.

A longer latency in P3 reflects a defect in the cerebral processing of attention that results in slower processing of attention tasks [23]. In our study we found with cognitive training, the P3 latency decreased in the frontal, central and posterior parts of the brain which indicate the improvement in speed of processing of attention tasks [24.] This deep brain stimulation through cognitive training modifies the plasticity in the CNS [25] of the child [26] suggesting enhancement in neural plasticity which is an important factor for adaptation, as it facilitates the function of relevant neural circuitry.

The N1 component, which occurs between 75-150ms is generally thought to represent the initial extraction of information from sensory analysis of the stimulus [27,] or the excitation associated with allocation of a channel for information processing out of the primary cortex [28, 29]. In our study as demonstrated in the Figure.1 it was observed that N1 amplitude in frontal and central lobes of the brain increased after cognitive training indicating the initial extraction of information from sensory analysis of the stimuli has improved in child and the child can sustain the information to perform the task. The ERP findings have also corroborated with the score of inattention domain; both depicted improved attention in child.

The N2 (120-250 ms) amplitude is not changed much after the cognitive training. Though the child can sustain attention and extract information for sensory analysis and makes response selection in N-back task (as ERP task) but unchanged N2 suggests the subject's difficulty in implementation of strategies, organization of material before encoding and evaluation of representations that have been retrieved from long-term memory still remain. This underlying cognitive deficit condition reduces one's capacity for conflict monitoring and efficiency in target detection and discrimination [4] reflected in N-Back task.

The larger P2 amplitude (150-350 ms) in ADHD subjects represents processing of unimportant stimuli [29] resulting in difficulty to perform task efficiently and committing more errors. Larger P2 amplitude observed in this study suggests the child attend to all types of stimuli, regardless of their importance that creates problems with inhibition of processing irrelevant but potentially competing stimuli.[28, 30]

Enhanced P3 amplitude of the target stimulus is observed in the central and posterior part of the brain after cognitive training. As visual stimulus were presented for the ERP task and training was also provided in combined visual and auditory modes it causes enhanced P3 amplitude in central and posterior parts of the brain thereby improving working memory functioning when task was presented visually. Enhanced P3 amplitude is related to working memory functioning [31.]

P3 (250-700 ms) is thought to be generated in the medial cortical or subcortical regions [32.] Lower P3 amplitude is interpreted as disruption in the inhibitory control and CNS hyperexcitability of children with ADHD. No improvement in the P3 amplitude of target stimulus in the frontal lobe is evident at post training phase that indicates minimal improvement in hyperactivity in the child, as prefrontal region is responsible for the inhibition and hyperactivity [33]. This ERP findings corroborates with the Conners rating Scale where not much change is noted in Hyperactivity scale.

Thus, the current research, a case study in particular, demonstrate clearly that the requirement for medications may be reduced in children with AD/HD with logically designed cognitive training avoiding foreseeable side-effects of the currently used drugs although more studies are required.

CONCLUSION:

Processing speed, visuomotor coordination, sustained attention and working memory improved in the male child after cognitive training but higher cognitive functioning such planning, organizing, conflict monitoring and freedom from distractibility has not improved much. Severity of the behaviour problem is an important factor as child falls under highly elevated group in inattention and hyperactivity scale. Few more cognitive training sessions integrating with other behaviour modification programme may be required to improve the cognitive efficacy and quality of life of the child.

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