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Efficacy of Cognitive Retraining Techniques in Children with Attention Deficit Hyperactivity Disorder

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Abstract

Background: Pharmacotherapy using stimulants has emerged as a primary mode of treatment for attention deficit hyperactivity disorder (ADHD). However, these stimulants often do not ameliorate all the problems (especially attentional problems) that these children experience. Considering this, the use of non-pharmacological treatments that are designed to improve attention and other cognitive abilities need to be empirically investigated.
Aim and Objectives: To study the efficacy of cognitive retraining (CR) techniques in management of ADHD.
Materials and Methods: Pre and post-intervention study design was used with 20 children, ages 7 to 11 years, diagnosed with (ADHD). Treatment and wait list control groups (n=10) were matched for age, sex, and medication status. Both groups completed pre- and post-intervention assessment batteries that included psychometric measures of sustained attention, selective attention (Digit Vigilance task), focused attention (Colour Trails Test), divided attention (Triads Test), a measure of academic efficiency (Grade Level Assessment Device, GLAD), and behavioral rating scales (ADHDT). Intervention comprised of 36 hours of cognitive retraining activities aimed to enhance selective, sustained and divided attention. SPSS version17.0 was used for descriptive and analytical statistical analysis.
Results: The mean change from baseline for sustained attention (errors), focused attention and selective attention and was significantly greater in the CR group than in wait list control group ($p<0.05$). The mean change from baseline was significant higher for divided attention in the CR group than in wait list control group ($p<0.01$). Post intervention, the mean academic performance of the subjects of CR group was found to be higher than in the wait list control group.
Conclusion: Cognitive retraining aimed at enhancing attention carries the potential of enhancing attention of children with ADHD along with improving their academic performance. It also reduces the severity of reported behavioral manifestations of inattention–impulsivity (German J Psychiatry 2011; 14(2): 55-59).

Keywords: Cognitive Retraining, ADHD

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Introduction

Neuropsychological interventions involve various direct and indirect therapeutic approaches like neuro-behavioral management, cognitive retraining and others which are comprehensive rehabilitation paradigms involving management of either/both cognitive and behavioral deficits. Behavioral anomalies are largely managed through neurobehavioral interventions that involve identifying the neuropsychological constraints which can interfere with learning and behavior; employ behavioral/ direct interventions to control, modify and eliminate inappropriate or unacceptable behaviors (Wood 1991). Neuropsychological interventions for cognitive deficits generally fall into one of three realms (Mateer, 1996): (a) environmental interventions

that provide contextual support in the area of impaired ability (e.g., audio taping books for individuals with reading disabilities), (b) interventions aimed at compensating for the deficit in ability (e.g., use of memory notebooks or watches with alarms for an individual with memory impairment), and (c) the use of direct interventions aimed at improving the underlying cognitive process and eliminating or reducing the deficit itself. Direct intervention is largely done through cognitive retraining (CR) which seeks to directly improve and/or restore cognitive functions utilizing a variety of pen and paper or computerized tests or games requiring cognitive skills such as attention, planning, problem-solving, and/or memory (Valligan et al., 2006). It is a teaching process that targets areas of neuropsychological functioning involved in learning and basic day to day functioning. Thus, a more comprehensive definition of cognitive retraining can be, "therapeutic interventions involving activities that improve a brain injured person's higher cerebral functioning or help the patient to better understand the nature of those difficulties while teaching him/her methods of compensation" (Bracy, 2003).

A number of CR methods have been utilized, many of which use specially designed computer software, and are called computer assisted cognitive rehabilitation (CACR). The empirical evidence for CACR seems to indicate a potential for improving cognitive functions (Beroll, 1998). The widespread use of computer assisted cognitive retraining procedures is largely because the computers allow accurate timing of stimulus presentation. Further, it is possible to regulate time of stimulus presentation based on individual's performance. However, the drawback of these programs is their rigidity which may be incongruent with patient's need. The floor and ceiling level along with the task content are relatively fixed. Further, the cost of cognitive retraining soft wares is another major limitation. Manualized retraining programs overcome these limitations though at the cost of precision. However, studies have reported no difference in outcome between computer-assisted and manualized cognitive retraining programs (Batchelor et al., 1990). There is substantial evidence supporting the effectiveness of CACR for those suffering from traumatic brain injury, and it is strongly suggested that "micro-based rehabilitation" elicited improvements in the areas of "attention/information processing" and "memory dysfunction", new learning and problem solving skills (Skilbeck 1991). The CACR literature seems to demonstrate the usefulness of these techniques.

Research suggests that children with ADHD have a primary deficit in the ability to sustain attention over time (Douglas 1983; Hooks et al., 1994., Prinz et al., 1984; Seidel et al.1990), selective attention (Ceci, et al., 1984; Landau 1992; Golden 1978; Barkley et al., 1992), divided attention (Heaton et al., 1993). Further, the literature on cognitive retraining strongly purports that cognitive retraining is an effective therapeutic module for enhancing cognitive skills. Considering high cerebral plasticity in children and the relation between cognitive skills and academic performance, if one uses cognitive retraining techniques with them, it is highly likely that these techniques would enhance the cognitive functioning of children and thus, potentially enhance their academic performance. This would further have a profound impact on education. In addition, improved academic performance stemming from an enhanced skill base (e.g., improved attentional skills, improved deductive and inductive reasoning, ability to manipulate numbers and concepts, etc.) rather than from just educational based interventions would appear a more desirable avenue as the child would actually "own" the skills to acquire knowledge and prevent "Matthew effect" (Stanovich 1986).

There are very few studies which have studied the effects of cognitive retraining interventions in children with ADHD (Mateer & Mapou, 1996). These studies have restricted to retraining in one or two domains of attention. There are almost no reported Indian studies which have studied the above effects of manualized CR in ADHD. This study is an attempt in this direction.

The aim of the study was to study the efficacy of cognitive retraining techniques for enhancing attention, academic performance and managing behavioral problems in children with ADHD. The primary objective of the study was to study the efficacy of CR techniques for enhancing attention in children with ADHD. The secondary objectives of the study were to study the impact of CR techniques on academic performance and behavioral problems in children with ADHD.

Methods

Sample

A pre and post experimental design study was carried out with a total sample of 20 children diagnosed with ADHD – Disturbance of activity and attention as per ICD-10-DCR criteria and were matched for their medication status. The twenty children were randomly divided into two groups- Experimental Group (E) with n=10 wait list control group (C) with n=10. These children between ages seven to eleven years were studying in English medium schools in Delhi in Grade 1st to 4th. All children in the sample had average level of intellectual functioning, were attending school regularly and without any study breaks. Children having any physical disability, subnormal level of intellectual functioning, any sensory impairments, children from single parent families or those having any other developmental disorder including learning disability/ any other neurological/ psychiatric/ or any other major medical illness were excluded from the study.

Tools

For assessment of targeted cognitive skills and academic performance at pre and post intervention the following tests were utilized:

- *Grade Level Assessment Device for Children with Learning Problems in Schools* (Narayanan 1993) to assess scholastic performance. The GLAD assesses the level of academic performance in three basic subjects viz. Hindi, English

and Mathematics, in primary school children while systematically making an observation of the processing pattern in the child. The test-retest reliability of GLAD ranges from 0.68 for Grade IV to 0.99 for grade III. Its Criterion validity ranges from 0.74 to 0.89.

- *Colour Trails Test* (D'Elia et al., 1996) was used as a measure of focused attention. It is considered to be free from language effects and has two parts- Part 1 that requires sustained attention, perceptual tracking and simple sequencing. Part 2 requires mental flexibility in addition to the above. Subject is required to ignore irrelevant numbers while scanning for the number which is next in the series.
- *Digit Vigilance Test* (Lezak 1995) to assess selective and sustained attention. It consists of numbers 1 to 9 randomly ordered and placed in rows on a page (30 digits per row, 50 rows on a page). The subject has to focus on the target digits amongst other distracter digits.
- The *Triads Test* (Rao et al.,2004) combines a verbal triads task (16 triads) with a tactual number identification task. The two tasks differ with reference to the stimulus modality and nature of stimulus processing. The nature of response is similar in that both the tasks require a verbal response therefore enabling the assessment of divided attention.
- *The Attention Deficit/Hyperactivity Disorder Test* (ADHDT) (Gilliam 1995) is a standardized norm referenced test that contributes to the diagnosis of children with ADHD and comprises of three subtests- Hyperactivity, Inattention and impulsivity. It obtains rating about child's behavior from parents and/or teachers.

Intervention techniques

Activities in areas of focused, selective, sustained and divided attention were adapted from various cognitive rehabilitation therapy software programs and used in manualized forms. Activities used for involved both visual and auditory modality and involved various adaptations of cancellation tasks, vigilance tasks, discrimination in the presence of distracters, continuous performance tasks, scanning tasks, and mazes.

Procedure

Children and parents were educated about the nature and procedure of the study. The children were enrolled for the study after obtaining written informed parental consent. All the activities that were to be used in order of administration, including each program's description, material requirements, set up, instructions to students, response inputs, were compiled. The first few sessions were devoted to baseline assessments of children. All the baseline assessments were done individually. After the pre intervention assessments, the participants in the Experimental group, began the retraining sessions, which were to be administered twice a week, over eighteen weeks. Of these 36 sessions, 15 were individual sessions while 21 were group sessions. Each session lasted for one hour. Unlike cognitive retraining with brain injured patients, the students were moved on to the next lesson regardless of mastery of goals on the lesson. However, high scores obtained by individual students were appreciated during sessions where participants could see them as reinforcement. After the completion of the 36-lesson program, all the tests were re-administered.

Statistical Analysis

The analysis of primary and secondary efficacy measures was conducted on the data thus collected following the above design and procedure. The primary efficacy measure for the study was Digit Vigilance Test. The data were analyzed using SPSS version 17.0. Initially, the Kolmogorov-Smirnov (K-S) test was applied to check if the data met the assumption of normal distribution. The K-S z values for all the domains were found to range between o.78 to 0.99 indicating that our sample met the criteria of normal distribution. However, considering the small sample size, non-parametric tests were used- Mann-Whitney U Test to compare the performance of two groups (Experimental and Control Group) and Wilcoxon Signed Rank Test to compare the performance of experimental group in the pre and post intervention conditions.

Table 1. Pre and Post-Intervention Comparison of Cognitive Skills for Two Groups (E, experimental group; C, wait list control group)

Assessed Domains	Pre Intervention			Post Intervention		
	Mean		z	Mean		z
	E	C		E	C	
Attention (Time Taken)	9.7	8.7	0.395	5.2	7.2	1.68
Attention (Error Score)	28.2	29.6	0.245	13.0	25.0	-3.18**
Selective Attention	5.2	5.9	0.901	7.6	4.2	1.99*
Focused Attention	41.0	43.1	0.340	65.0	41.0	2.01*
Divided Attention	32.0	30.9	0.211	58.0	34.0	-2.86*
Hindi	60.8	63.4	0.151	71.0	63.0	-2.16*
English	63.2	64.2	0.458	75.6	67.6	-2.18*
Mathematics	52.8	55.8	0.601	69.4	59.1	2.29 *
Inattention	15.7	14.7	0.631	8.4	13.8	3.15*
Impulsivity	14.4	15.1	0.390	11.6	13.9	1.86
Hyperactivity	13.7	12.9	0.725	10.9	11.0	0.98
ADHDT score	128	126	0.913	108.3	116.0	1.06

* p<0.05, ** p<0.01

Results

The mean age of the experimental group was 9.2 years (SD 0.68) and for the wait list control group it was 8.9years (S.D 0.97). The mean number of educational years for the experimental group was 5.2 years (SD= 0.86) and of the wait list control group was 5.6years (S.D 0.78). Table 1 shows the comparison of cognitive skills and academic performance for the two groups (control and experimental group) in both the conditions. Table 2 shows the pre-post intervention comparison of cognitive skills and academic performance in the experimental group.

From Table 1 it is seen that in the pre intervention condition the experimental and wait list control group did not differ significantly on any of the assessed cognitive domains (obtained z scores are below the critical z value). However, in the post intervention condition both the groups differed significantly on all the assessed cognitive, academic and behavioral domains. Further, the study of the mean scores reveals that the experimental group performed better on all the targeted cognitive skills in post intervention condition. Table 2, shows the z values obtained using the Wilcoxon Signed Rank Test for the pre post intervention comparison of cognitive skills for the experimental group. It is observed from Table 2 that there is significant difference in the pre-post intervention scores on all the assessed cognitive domains. The academic performance of children- both pre and post intervention and the z-values thus obtained by their comparison are also shown in Table 1 and 2. The obtained z-values (Table 1) for pre intervention condition for the two groups were found to be non-significant for all the three school subjects.. However, in the post intervention condition, there was a significant difference in the academic performance of the experimental group as compared to wait list control group (Table 1) and also significant enhancement in academic performance of experimental group was observed after the intervention (Table 2).

Table 2. Post Intervention Comparison of Cognitive Skills for Experimental Group

Cognitive Skills	Pre Mean	Post Mean	z
Attention (Time Taken)	9.7	5.2	-1.84
Attention (Error Score)	28.2	13.0	-1.98*
Selective Attention	5.2	7.6	-1.965*
Focused Attention	41.0	65.0	2.870*
Divided Attention	32.0	58.0	2.093*
Hindi	60.8	71.0	-2.94*
English	63.2	75.6	-2.81*
Mathematics	52.8	69.4	-3.15*
Inattention	15.7	8.4	1.99 *
Impulsivity	14.4	11.6	1.07
Hyperactivity	13.7	10.9	0.98
ADHDT Score	128.0	108.3	1.97*

* p<0.05, ** p<0.01

Discussion

Neuropsychological intervention through Cognitive Retraining techniques (CRT) have been reported to produce improvements in cognitive functioning of patients of traumatic brain injury (Tam et al., 2003), schizophrenia (Bell et al.,2009), epilepsy (Gupta & Naroem, 2003), substance abuse (Mathai et al., 1999), learning disability (Malhotra et al.,2009). The present study was the first of its kind in India in which efficacy of CRT on attention of children with ADHD and its impact on school performance were assessed.

In the recent years, children with ADHD have been reported to be having various neuropsychological deficits including primary deficit in the ability to sustain attention over time (Hooks et al.,1994; Prinz et al., 1984; Seidel, et al.,1990), selective attention (Ceci, et al., 1984 ; Landau 1992; Golden 1978; Barkley et al.,1992), divided attention (Heaton,1993). Hence, probably by targeting these domains of attention which form the basic building blocks of school performance, one can enhance the scholastic performance of these children and can also prevent Matthew effect (Stanovich, 1986).

In this study, subjects were given 36 sessions of manualized CR over a period of 18 weeks. This manualized CR module developed for the study largely included activities for the various sub domains of cognitive skill of attention- selective, sustained, focused, divided attention. Based on Piaget's Cognitive Development Theory these activities with graded difficulty level were included and were associated with all the three levels: concrete, semiconcrete and abstract. Overall, these results suggest that a direct treatment approach such as that utilized in the materials can be effective for improving performance on several psychometric measures of sustained, selective, and higher levels of attention. Improvements were also noted in the treatment group on a measure of academic efficiency and in a trend toward a significant improvement in parents' ratings of inattentive–impulsive behaviors. The findings lend support to the notion that systematic practice on attention demanding tasks can result in improved attentional performance.

As seen from results section, in the pre intervention condition, the two groups of children- Experimental and wait list control group did not differ significantly on any of the assessed domains of attention, academic performance on three school subjects and parental reporting of ADHD symptoms; thus, indicating that both the study groups were matched for the measures under study. From Table 1, it is further observed that post-intervention, there were statistically significant differences on the various assessed domains of attention and academic performance along with behavioral domains. With respect to various components of attention, there is a significant reduction in the time taken to complete the task and a significant reduction in the number of errors committed. It was also observed that there was a reduction in both the number of omissions (indicative of visual scanning)as well as commissions(indicator of response inhibition).Thus, with retraining both visual scanning and response inhibition improved. Bracy et al. (1999) used CACR for training attentional, executive, visuospatial and problem solving skills in 12to 14 year old children and reported a significant increase in intellectual functioning(p<.01).Also,

Navarro et al. (2003) reported significant improvement in attention after 10 training sessions by using Computer Assisted Instruction (CAI) for enhancing attention in elementary school children.

Although minimal enhancement has been observed in these components of attention of the wait list control group(Table 1), the enhancement is not statistically significant Since, no significant gains were observed in the group unexposed to the intervention, it can be concluded that the noted significant gains were probably largely due to the intervention given and not other extraneous variables.

Further, in the post-intervention condition, there have been significant improvements in children's performance on the three assessed academic subjects. It is known that academic performance is directly related to cognitive skills, children in the intervention group showed enhancement in their academic performance also.

Improvements in performance on the DVT and the academic efficiency measures (GLAD) reveal that children made gains in their ability to sustain attention which was the primary efficacy measure of the study.

As with other treatment-oriented investigations, the cause of these changes is not definite. One possibility is that the observed improvements reflected an improvement in underlying attentional capacity. Such changes have been hypothesized in other studies based on treatment-related electrophysiological changes. Alternatively, positive changes may be based on the learning of a strategy for regulating attention and arousal. This would be consistent with the work of Reid & Borkowski (1987) with impulsive children, suggesting that attention could be brought under some degree of voluntary control by self-instructional procedures.

The minimal increases from baseline in the mean scores of assessed domains of wait list control group could be probably because although this group was not provided with any CR intervention, children were provided medication in which the parents may have anticipated that they were working on improving their ability to pay attention. It is likely that some combination of these factors has resulted in the improvement seen in the control group.

Although the results of this intervention appear positive, this study has several limitations, including limited measures of generalizability, and the lack of a longer term follow-up. The fact that children in the study improved on psychometric measures of attention (which were different from the training materials) and on an academic task suggests that the gains seen on intervention activities generalized to other tasks. In addition, the reported trend for more attentive and less impulsive behavior in the treated group noted by the parents also suggests some generalization of treatment gains. A longer term follow up is required to determine if is these gains are only time limited or whether they represent an enduring change in underlying ability.

Conclusion

Manualized cognitive retraining over thirty six hours can help to partially remediate cognitive deficits in children with ADHD and improve their scholastic performance. The findings have implications for future educational curricula aiming at improved academic performance stemming from an enhanced skill base rather than from just educational based interventions.

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