Impact of Neuro-feedback Intervention on Children with Attention Problems

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One of the major problems with children in primary school is lack of attention and concentration in academics. Neurofeedback intervention has proved to be effective in enhancing attention in children with ADHD. The present study attempted to find out the effectiveness of neurofeedback in improving attention and concentration in children with non-clinical problems of attention and concentration and the transfer of the impact on academic performance and attention related behaviour. Children studying in classes III through VII participated in this quasi experiment. A total of 50 children with problems in attention/concentration and 26 children without problem were given neurofeedback intervention for 10 weeks. Attention/concentration & memory, academic performance and attention related behavior were compared before and after intervention. Results indicated significant improvement in all parameters for both the groups. However, the group with problem showed a higher improvement in attention/concentration and memory as well as attention related behaviour compared to their counterparts.

Keywords: Neurofeedback intervention; Attention problem; Academic performance in school children

Attention is defined as 'sustained concentration on a specific stimulus, sensation, idea, thought or activity enabling one to use information-processing systems with limited capacity to handle vast amounts of information available from the sense organs and memory stores' (Colman, 2009). More often than not, wide differences in academic performance are not found to be so much related to IQ or ability as varying levels of attention and concentration which in turn has a significant bearing on memory. Working memory was a better predictor of academic progress than IQ (Alloway, 2009). Researchers have attributed low attention to television watching at early age of one and three years (Christakis, Zimmerman, DiGiuseppe, McCarty, 2004) maternal anxiety (Clavarino, 2010) uninteresting curriculum and boring teaching methods (Rath, Dash & Dash, 1979). Besides this there may be a number of other reasons for lack of attention such as malnutrition (Geller & Ramsey, 1989; Martorell, 1999) emotional disturbance (Bowen & Bowen, 1999; Juvonen, Wang, & Espinoza, 2011) stress (Hariharan, Swain, Chivukula, 2014) or several cognitive and non-cognitive factors (Santosh, 2014) found within and outside the child.

Research in the field of Educational Psychology has come up with a number of intervention strategies involving curricular changes and innovative teaching methods to address attention problems that could have been due to contents and methods of curriculum. However in view of individual reasons for low attention, there is also a need to plan interventions at individual level by training children in improving attention.

Interventions involving a software establishing a unidirectional or bidirectional communication between the brain functioning and the computer known as Neuro-feedback are was found to be useful in improving attention levels of individual children. Several studies have successfully established the positive impact of neuro-feedback for children with attention problems (Arns, de Ridder, Strehl, Breteler, &Coenen, 2009; Drechsler, Straub, Doehnert, Heinrich, Steinhausen, & Brandeis, 2007; Fuchs, Birbaumer, Lutzenberger, Gruzelier, & Kaiser, 2003; Kaiser, & Othmer, 2000; Lévesque, Beauregard, & Mensour, 2006) and neurological attention problem (Gevensleben,

Moll, Rothenberger, Heinrich, 2014; Steiner, N. J., Frenette, Rene, Brennan, Perrin, 2014; Zandi, Firoozabadi, Rostami, 2014).

Neuro-feedback interventions have been found to be successful in problems such as distraction, attention, confusion and withdrawal (Escolano, Aguilar, &Minguez, 2011; Gnecchi, Herrera Garcia, & de Dios Ortiz Alvarado, 2007). This intervention is planned based on individual needs depending upon the nature of problem. Training in regulation of Theta brainwaves was found to help in reducing anxiety, depression daydreaming and distractibility (Beatty, Greenberg, Deibler, O'Hanlon, 1974; Vernon, 2005).

Very often attention problems in children are likely to be associated with distraction. Researchers argued that when one is engaged in an activity that demands attention, the neural activity is reflected in Sensory Motor Rhythm (SMR) and training on SMR using neuro-feedback was found to have positive effect on the regulation of attention (Egner, Tobias & Barry Sterman, 2006; Sterman, M.B. 2005; Thompson & Thompson, 2003). Hence, training in regulating Sensory Motor Rhythm would have a positive impact on enhancing attention and concentration levels. Studies on Theta/SMR intervention for 8-13 year old ADHD children witnessed improvements with 40 sessions of treatment (Perreau-Linck, Lessard, Lévesque & Beauregard, 2010).

Research questions

The present study is an attempt to find out if neuro-feedback could be used as an effective individual intervention for children who have problems with attention. The study also compared the impact on these children with the group of children who had no problem in attention.

Objectives

First, to find out the impact of neuro-feedback focused on Theta/SMR waves as intervention on the attention and memory of school children with attention problems and children without problems. Secondly, to examine if the positive impact of the intervention is

transferred to the academic performance and day to day behaviour.

Hypothesis:

Neuro-feedback will have an equally positive impact on children with problems in attention as well as those without problems in attention.

The positive impact of neuro-feedback intervention will translate to academic performance and day to day attention behaviour of children

Method

Study Design

The study adopted a quasi-experimental design with two groups of children – one group having problems with attention (Group 1) and the second group of children matched with the first group in school, class, age and gender and (Group 2). The intervention was neuro-feedback and dependent variables were attention in children, their academic performance and their day to day attention related behaviour.

Participants

The sample constituted 76 children (50 with attention problem, i.e. Group 1 and 26 without attention problem, i.e. Group 2) studying in Class III through VII, from government, private and corporate schools. The reason for including children from all types of schools is to have a representative sample. The students from class III to VII from five schools which consented to participate in the study were selected for the study.

Inclusion Criteria: The first inclusion criteria was those children whose parents were willing to sign informed consent to have their children participate in the study and the children signing their assent form to participate in the study were only included. The second step in inclusion of children followed a procedure. Research in the past have proved teacher's rating (Lahey, Schaughency, Frame & Strauss, 1985) and parent's ratings (Clavarino, et al., 2010) as valid methods of identifying children with attention problems. So the procedure for inclusion involved teachers' and parents' ratings. The teachers were given the Teacher Nomination & Attention Scale. First the teachers were asked

to identify the children who had problems in attention in the class room setting. After they nominated the children, they were asked to rate these children on 49 item behavioural indicators of low attention on a 4-point scale that rated them on the frequency of problem behaviour. Children whose scores crossed 123 (Indicating a mean rating of more than 2.5 on a four point scale) were included in the first level. The parents of these children were contacted. They were asked to rate their children on 60 item Behavioural Rating Scale (Students' Attention Behavioural Rating Scale for Parents). This is a 4-point scale that rated them on the frequency of attention related behaviour. Those children whose scores crossed 150(Indicating a mean rating of more than 2.5 on a four point scale) were included in the sample in the second level. In the third and final selection of sample, the students whose scores crossed 123 as per teachers' rating and also crossed the cut off of 150 as per parents' rating constituted the study sample. Those students where either the teacher or the parent alone rated high on attention problem were screened out. A total of 50 students where teachers' and parents' ratings coincided in crossing the respective cut off points constituted the final sample of group which is referred as study group /Group 1 hereafter.

The Comparison group was identified from the same schools and classes through Teachers' Nomination. The teachers were asked to nominate the children who according to them showed sustained attention in the work they do and also performed well in their academics. The same procedure adopted for group 1 was followed in getting the teachers' and parents' ratings of the behaviour of these children related to attention. Children whose ratings by the teachers was less than 98(Indicating a mean rating of less than 2 on a 4 point scale) and also parent's rating less than 120(Indicating a mean rating of less than 2 on a 4 point scale) were included in the sample. A total of 26 children constituted the second group referred as comparison group/Group 2 hereafter.

Instruments

The tools used in this study can be classified into (a) Screening Tools (b) Assessment Tools and (c) Neuro-feedback machine

Screening Tools

These tools were specifically developed for the purpose of this study:

Students' Attention Behaviour Rating Scale for Teachers- The tool has two parts. Part 1 relates to teacher nomination. Here the teacher is requested to identify those children from his/her class who he/she thought has problems related to attention. This part required the teacher to provide the personal information of the child such as name, class, and age. Part 2 of this tool is a four point rating scale with 16 positive and 33 negative items related to attention and memory in class room context. The scoring was reversed for the positive items so as to get the total score indicating problem behaviour on attention.

Students' Attention Behaviour Rating Scale for Parents- This tool is a four point rating scale with 60 statements (16 positive and 44 negative statements) related to children's activity level, day to day behaviour related to attention and memory. The ratings for positive items were reversed so that the scale measured problem behaviour in attention.

Assessment Tools

PGI Memory Scale (Clavarino, et al., 2010) was adapted and used to assess the attention and memory of the children. Though this scale is meant for adults with cognitive problems the subscales have been used on children in Indian studies and found to be effective (Vazir, Nagalla, Thangiah, Kamasamudram, &Bhattiprolu, 2005).

The original scale has a correlation of 0.71 with Boston Memory Scale and 0.85 with Wechsler Memory Scale. The test-retest reliability ranged between 0.48 and 0.84 for neurotic and normal group. It is a battery of memory tests consisting of 10 subtests. From these a total of seven tests (Attention and concentration, Delayed recall, Immediate recall, Retention for similar pairs, Retention for dissimilar pairs, Visual retention, and Recognition) were identified for assessment of attention. The sub-scale of Immediate recall consisting of a written paragraph was modified by substituting with the content suitable for children. The administration of the test is simple

and took 15-20 minutes. Scoring of each subtest was done as per the manual.

Neuro-feedback machine- The neuro-feedback machine is a device that combines a video monitor, EEG machine and the display monitor. The EEG machine and display monitor are connected to the computer and the video monitor. The computer has software for video animated picture that would move when the electrical impulses cross the set target. Every time the impulses cross the set level of amplitude, there is movement in the animated picture accompanied by an audio effect. This works as an immediate reinforcer. The number of times the child attains the target within the stipulated time is recorded in the computer along with the graph of electrical impulses. Since the activity involves visual and auditory stimulus the electrical impulses were measured in terms of SMR/Theta Waves from occipital and pre temporal lobes. SMR refers to the frequency band of EEG that ranges between 12-15 Hz. This is associated with a state of alertness and attention combined with calm motor activity.

Procedure

Five schools that agreed to participate in the study and ready to sign informed consent were included in the sample. The 76 children included in the sample following the inclusion criteria were administered the seven subtests on attention and memory on PGI memory scale. On an average it took 15 – 20 minutes to complete the pretest. Weekly intervention schedules were drawn for every child. As per the schedule every child was brought to the neuro-feedback laboratory once a week for ten weeks. They were exposed to 15 minute neuro-feedback intervention individually.

Neuro-feedback Intervention

The intervention consisted of 10 weekly sessions of 15 minutes each where the participating children were trained to enhance Sensory Motor Rhythm from 9μV to 18μV, with an incremental enhancement of 2 points every alternate week. Three electrodes E1, E2 and C were placed in the regions of occipital lobe, pre-temporal lobe and ground positions respectively. The cut-off point of SMR was set at 9μV in the first two sessions. Then onwards the SMR targets increased by two points every alternate week making it 9,11,13,15 & 17 μV for weeks 1, 3, 5, 7, & 9 respectively. The reason for enhancing the target was to gradually increase the attention level of children to have the impact on animation that functioned as reinforce. The children were blind to enhancement in targets. The software of neuro-feedback was so designed that the computer monitor facing towards the participant child displayed a car. The child was instructed to concentrate on the picture with all attention and that the better the concentration the faster would the car move forward.

The electrodes translate the electrical impulses of the brain into SMR amplitudes. Only when the impulses crossed the set target, there was movement of the car with the apt audio accompanying it. This animation acted as an instant reinforcement for the participant for focusing and sustaining the attention on the picture. The target attainment in each session was recorded as frequencies.

Post Intervention Evaluation

The intervention was terminated after the tenth session. On termination of intervention the individual children were administered a post-test with the seven tests of PGI memory scale again. The teachers and parents were also administered the respective children's attention behaviour rating scales. They were asked to rate the children on the basis of the child's behaviour in the past four weeks.

Results

In order to examine the efficacy of the neuro-feedback intervention, the data were analyzed applying 2x2 mixed between within subjects ANOVA. Four separate ANOVAs were carried out to find out the differences between the two groups on Attention and Concentration, Academic performance, Teacher's ratings and Parent's ratings.

The results of ANOVA on Attention and concentration revealed a significant main effect for test, $F(1, 74) = 40.87$, $p<0.01$ indicating that there was a significant change in attention and concentration scores across the two different testing periods i.e before and after neuro-

Table 1. Presents the results of ANOVAs on the four parameters- Attention and Concentration, Academic performance, Teacher's ratings and Parent's ratings.

Variables	Pre-test		Post-test		F(1,74)		
	Group1	Group2	Group1	Group2	Between Subjects	Within Subjects	
	M (SD)	M (SD)	M (SD)	M (SD)	Group	Test	Test X Group
Attention and Concentration	22.68 (12.37)	28.11 (7.76)	33.16 (11.42)	33.31 (9.40)	1.43	40.87**	4.65*
Academic Performance	46.60 (17.92)	68.01 (14.44)	49.26 (16.41)	71.05 (20.54)	29.08**	5.04*	.02
Teachers' Rating	139.54 (16.70)	85.23 (18.56)	120.74 (21.67)	78 (17.56)	141.98**	38.96**	7.70**
Parents' Ratings	150.78 (17.91)	92.65 (15.93)	129.34 (21.10)	88.35 (17.68)	193.61**	21.44**	9.49**

Note: *= p<0.05; **= p<0.01

feedback intervention. The mean score clearly shows that both the groups scored significantly higher in the post-test compared to the pre-test. The mean scores show that Group 1 almost reached the level of Group 2 in their post intervention tests scores. This suggests that the training provided in the intervention helped in strengthening the behaviour of sustaining the focus of attention on a stimulus. It may be mentioned here that the reinforcement consisted of both visual and auditory inputs by the forward movement of the car with the sound of an engine. Thus the children might have got tuned to alertness for auditory stimulus. In the attention test when the digits were verbally presented, children in Group 1 in the post-test scenario were able to sustain their auditory alertness and hence were able to respond by repeating the cue in forward and reverse order. The results indicating a significant interaction effect F(1, 74) = 4.65 p<0.05 suggesting that the intervention was highly effective in case of children with problems in attention and concentration compared to those children who did not have the problem.

In order to measure if the improved attention and concentration translated to academic performance, the marks scored in the examinations immediately preceding and succeeding the neuro-feedback intervention was taken as the index. Results clearly showed a significantly higher marks in the examinations succeeding the intervention as indicated by a significant main effect of test, F(1, 74) = 5.04, p<0.05. Both the groups scored higher in the post-test condition. However, Group 2 scored consistently and significantly higher than their counterparts in both pre and post intervention. The fact that both the groups scored significantly higher in the post intervention test suggests that there could also be a possible effect of natural cognitive development in the children. This is evident in the results revealing a significant main effect of Groups, F(1, 74) = 29.08, p< 0.01. The interaction was not significant. Since both groups showed significant improvement between the pre- and post-tests, the impact of natural development because of age and the subjectivity factor in evaluation of performance in examination cannot be totally ruled out.

An attempt was made to see whether the improvement in attention and academic attainment also extended to concomitant improvement in the attention related behaviour of the children. ANOVAs were done on the parents' and teachers' rating scores on children's attention behaviour. The results on teachers ratings revealed a significant main effect of group, F(1, 74) = 141.98, p < 0.01, test, F(1,74)=38.96, p< 0.001 and interaction, F(1,74)=7.70 p< 0.01. This implies that the two groups significantly differed in their attention behaviour, the two groups showed lesser number of problems in

attention behaviour following the neuro-feedback intervention though the improvement in attention behaviour was more pronounced in case of Group 1. The same trend was observed in parent rated attention behaviour. There was a significant main effect of Group, $F(1,74)=193.61$, $p<0.01$, test, $F(1,74)=21.44$ $p<0.01$ and interaction $F(1,74)=9.49$ $p<0.01$. This indicates that as per parents' ratings, Group 1 showed more problems related to attention behaviour compared to their counterparts. There was a significant improvement in attention behaviour in the post intervention stage for both the groups though the improvement was significantly higher in case of Group 1, i.e. children with problems in attention.

Discussion and Conclusion

The main objective of the present study was to measure the impact of neuro-feedback as intervention for primary school children with problems in attention. The effectiveness of neuro-feedback as intervention for ten weeks proved to be highly significant, particularly for children who manifested problems in attention. The children, after 10 weeks of neuro-feedback intervention, showed marked improvement in their attention. This improvement was further carried over to their academic as well as their day to day behaviour related to attention. The present findings are also supported by studies which showed that there is a specific effect of training when neuro-feedback is given. According to parents' and teachers' ratings, children of the neuro-feedback training group improved more than children who had participated in a group therapy program, particularly in attention and cognition related domains (Bakhshayesh, Hänsch, Wyschkon, Rezai, Esser, 2011); Neuro-feedback effectively reduced inattention symptoms on parent rating scales and reaction time in neuropsychological tests (Leins, Goth, Hinterberger, Klinger, Rump & Strehl, 2007) and Parents and teachers reported significant behavioural and cognitive improvements.

The results very clearly proved that neuro-feedback can be used as an effective intervention for children facing problems with attention in school. Though the studies of the past proved this fact, the sample on which the neuro-feedback administered in majority of researches

was clinical sample consisting of children with ADHD, epilepsy and autism. The substantial contribution of this study is the proved efficacy of neuro-feedback intervention on school children manifesting attention problems in the class room and daily behaviour though not formally diagnosed as ADHD.

The results that showed a relatively higher impact on children with problems in attention compared with the group who did not have attention problem indicates that the use of intervention should exercise professional discretion preceded by appropriate screening and diagnosis.

The impact on academic performance and attention behaviour is very encouraging in the sense the study proved the applied value of the intervention. When interventions such as remedial teaching and head-start programmes fail to bring the desirable results, individualized interventions like neuro-feedback may be of great value for improving the academic performance as well as behavioural change in children.

The question whether it would prove detrimental to those with healthy attention and opens the scope for further research. Yet another question to be answered is the sustainability of the impact. Further studies need to be designed to test the short term and long term impact of the intervention to gain insight into the frequency and periodicity with which the child should be administered it for optimizing the impact.

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