

**Effect of Neurofeedback as Therapeutic Intervention for  
Students of Primary School with  
Problems in Attention and Concentration**  
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*Summary*

Primary Education is a fundamental right. Protection of this right goes beyond enrolling children in schools, and extends to ensuring optimal learning of children in schools. This crucial aspect is not receiving its due weightage. As a consequence children have been found to suffer cumulative cognitive deficit resulting in underachievement. Children's nonperformance and failure are often attributed to low attention and concentration in them. Past research has suggested curricular reforms, innovative methods and remedial teaching to combat this problem. However, it is time that this problem of attention deficit in primary school stage is directly attacked through intervention that targets attention levels in individual children. The present research seeks to study such an effect, viz. the impact of neurofeedback on attention and concentration in primary school children.

Attention and concentration are the two essential prerequisites for learning, memory and performance. Very often, the low performance of children is found to be not so much because of absence of potentiality but because of problems related to attention and concentration. In such cases, if the attention factor is ensured, their memory and

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performance will automatically show an improvement. By not targeting to enhance the attention and concentration, the children tend to be stuck with persistent non-learning resulting in repeated under performance in their academics.

Neurofeedback (NFB) is one such method which was used to improve the attention of children with disorders like Attention Deficit Hyperactivity Disorder (ADHD). Around the year 1970 it was discovered that it is possible to recondition and retrain brainwave patterns with a technique that was later called 'neurofeedback'. Neurotherapy, neurobiofeedback or EEG biofeedback - is a type of biofeedback that uses real time displays of electroencephalography to illustrate brain activity, often with a goal of controlling central nervous system activity. Research findings suggest that NFB works with data from inside the brain, whereby it can facilitate changes in the brain wave patterns and regional cerebral blood flow (Demos, 2005). Feedback is given via auditory or graphic signals or both each time the brain is operating more efficiently. NFB is supposed to strengthen neural pathways while increasing mental endurance and flexibility, which makes it similar to a comprehensive exercise program. This is a way for people, including children, to learn about what is happening inside their own brains as their state of mind or awareness changes. It provides a tool for the person to learn how to re-regulate fuzzy distracted thinking and to be able to get on-task with sustained concentration and attention. The processes involved in this kind of feedback can be described by the principles of operant conditioning. When brain activity changes in the direction desired by the training, a 'reward' feedback is given to the individual, e.g., a change in pitch of a tone or a certain type of movement of a character in a video game. This simple reinforcement teaches the brain how to prolong healthy brain wave patterns. Within a few sessions trainees often gain a heightened awareness of mental drifting. Gradually most trainees learn to pay attention for longer periods of time, even during boring tasks in the classroom

or at work (Denws, 2005). For the perception of children, NFB is like a video game where they can bring movement and sound in the picture that appears on the computer screen. This movement will happen only when the attention level reaches a set target. The movement of the picture works as a good incentive for the child to enhance the attention span. Thus, the technique, in a way is like taking advantage of children's attraction for video games and utilizing it to enhance their attention.

The human brain has five brain waves that are linked to certain performance tasks, i.e. concentration or focus. One particular brain wave is the beta wave and its subtype SMR wave, which allows for concentration or focus. Alpha waves measure and reflect relaxation activity. Theta waves are dominant when a child has ADHD due to lack of allocation of attentional resources to a particular task. Finally, the delta waves reflect when the brain is experiencing deep sleep. The basic goal of NFB is to train the subject to decrease their slow wave activity and/or increase their fast wave EEG activity, often using behavioral principles, such as operant conditioning (i.e., positive reinforcement) in the process. When the person is producing the desired EEG pattern, the computer will give a positive response or reward, usually in the form of points earned (Loo & Barkley, 2005). The computer detects the EEG information and provides a visual or auditory display of activity in the targeted frequency band(s) or amplitudes. Individuals who have received neurotherapy have reported improvements not only in disorders like ADHD, but also in school or work performance, social relationships, and self-esteem, as well as reduction in irritability and oppositional behaviour.

It is often noticed that the children are branded as troublesome or backward in academics and are subjected to methods of rectifying the same either by measures of over-disciplining which may be punitive or by neglect. Need for creating awareness regarding

scientific methods of conditioning the neuropsychological functioning of the child has to be emphasized. Considering the vast research that demonstrated that NFB was helpful in children with ADHD, the researchers of the present study attempted to see if a similar improvement may be brought through NFB intervention in children who are normal, yet their lack of attention and concentration is often complained about by teachers and parents as compared to the other children. It was also felt that normal children without any reported attention and concentration problems may also be able to benefit out of this training.

Reviews show more than 20 studies conducted on the treatment of ADHD using NFB. All studies consistently show that 70-80% of subjects significantly benefit from the treatment, and sustainability of these benefits is found to be up to 10 years post treatment (Lubar, 1995). Research has also shown that NFB technique has been cited as being effective in other cognitive problems. EEG biofeedback treatment for Attention Deficit Disorders (ADD) with or without hyperactivity and Learning Disabilities has emerged as an important component in enhancing attention, cognitive functioning and behavior as shown in the reports by several researchers in terms of significant increases in IQ scores, grades and educational test scores (Lubar, 1991; Tansey, 1990 & 1991). During the past three decades, a series of case studies and controlled group studies examining the effects of EEG biofeedback have reported improved attention and behavioral control, increased cortical activation on quantitative electroencephalographic examination, and gains on tests of intelligence and academic achievement in response to this type of treatment (Monastra, Lynn, Linden, Lubar, Gruzelier, & Lavaque, 2005).

Reviews of EEG biofeedback studies have generally concluded that preliminary studies of EEG biofeedback are promising, but also pointed to the need for further research with in rigorous scientifically controlled designs (Arnold, 2001; Nash, 2000;

Ramirez, Desantis, & Opler, 2001). It was pointed that many studies of EEG biofeedback treatment with children seem to lack appropriate control conditions and suffer from extremely small sample sizes. It was also noted by critics that out of several studies, only a few studies have addressed the issue of whether improvements are sustained. In spite of the studies showing positive outcome, some critics who challenge NFB focus on the absence of more number of controlled studies and the fact that most existing work is primarily clinical in nature. Though crucial, what is lacking in most studies of EEG biofeedback according to the critics has been the randomized assignment of cases to treatment and no-treatment (or placebo) groups.

The literature review could not locate any study that directly investigated the benefit of NFB for normal children with problems in attention and concentration. The review glaringly points at the fact that NFB is used as an intervention on clinical samples, i.e. subjects who were diagnosed with definite problems such as epilepsy, ADHD, autism etc. Many children who have short span of attention and concentration may not be classified as ADD or ADHD, while they do suffer from inadequacy in attention and concentration. The argument in the context of the present study is when the NFB is found to have a therapeutic effect for severe attention problems such as ADHD, it should prove to have a positive impact on milder forms of attention problems too. The review related to clinical sample is useful in understanding the method, process and impact of NFB, thus helping in identifying the gaps and providing a direction to the present study. The objective of the study was to explore the efficacy of NFB in bringing positive change in the attention, concentration and memory of primary school students.

The study adopted a quasi-experimental design, where the children having problems with attention and concentration were screened and compared with the group of children who did not have any problem in attention and concentration. The sample

consisted of 76 children studying in Class III through VII. Out of this, 50 children belonged to the category having problems in attention and concentration (Group 1), while 26 children were those identified as academically bright with no problems in attention and concentration (Group 2). Both the groups were exposed to ten sessions of NFB therapy at one week interval. Each session lasted for a duration of 15 minutes. The impact of intervention on attention, memory and academic performance was measured. Further, the impact of intervention on their day-to-day behaviour involving attention and concentration was also observed. In Group 1, 42 children were boys and 8 children were girls whereas in Group 2, 19 children were girls and 7 children were boys.

The tools used in this study can be classified into (a) screening tools and (b) assessment tools. Screening tools namely, Students' Attention Behaviour Rating Scale for Teachers and Students' Attention Behaviour Rating Scale for Parents were used to identify the two groups of children. The assessment tools included PGI Memory scale to evaluate the participants on their attention, concentration and memory, and examinations conducted by school to measure the academic performance before and after the intervention, In addition a uniform Scholastic Test was developed and used to measure their academic performance after the intervention.

The final sample was identified on the basis of screening at three levels. At Level 1, the teachers were asked to identify children in their class who manifested problems in focusing and sustaining their attention and concentration in the studies as per their observation and judgment. At Level 2, the children nominated by the teachers were put under Group 1 and the teachers were asked to fill up Students' Attention Behaviour Rating Scale for Teachers, consisting of 49 behavioural indicators of low attention and concentration on a 4-point scale that rated them on the frequency of the problem

behaviour. Those children with total score higher than the cutoff were identified as having problem in attention and concentration. At Level 3, the parents of the children were asked to rate the children on Students' Attention Behaviour Rating Scale for Parents containing 60 behavioural indicators related to problems in attention and concentration. The ratings were added and those children whose scores were above the cutoff were identified as those manifesting problems in attention and concentration as per the parent's observation. Only those children whose parents' ratings corroborated with that of teachers' ratings were included in the final sample belonging to Group 1 i.e. children who had problem in attention and concentration. The teachers were also requested to nominate the children who according to them performed well, were academically bright and showed sustained attention and concentration in the work they do. These children constituted Group 2, i.e. the children with no problem in attention and concentration. It was made sure that the children screened to be included in the sample had no known neurological or psychiatric problems.

For assessment of levels of attention and concentration and memory, PGI memory scale was used. This 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-normal group. It is a battery of memory tests consisting of 10 subtests viz. remote memory, recent memory, mental balance, attention and concentration, delayed recall, immediate recall (sequential reproduction of sentences), retention for similar pairs, retention for dissimilar pairs, visual retention, and recognition. The test takes care to ensure its independence from intelligence. From these ten tests three tests, viz. remote memory, recent memory, and mental balance tests were excluded. Thus, a total of seven subtests are identified for assessment of attention and concentration. The administration of the test is simple and takes between 15-20 minutes.

Informed Consent was obtained from parents for the participation of children in the research project. Children whose parents were willing to send the children for weekly intervention, and only when the management/teachers also consented for sending the students for ten consecutive weeks to the University laboratory, were included in the sample. A school-wise schedule was drawn for conducting the pretest for attention, concentration and memory. The children were administered PGI Memory Scale individually in a separate room earmarked for the purpose. Academic marks preceding the intervention were taken from the school records for each participant.

The NFB intervention consisted of one trial exposure session and ten intervention sessions with a frequency of one session in a week. In the first session the children were familiarized with the laboratory and the machine. The cutoff point of SMR rhythm was set at  $9\mu\text{V}$  in the first two sessions i.e., week one and week two. Then onwards the cutoff point was increased by two points every alternate week. Thus the cutoff point was set at 9, 11, 13, 15 and  $17\mu\text{V}$  for weeks 1, 3, 5, 7 and 9 respectively. The child had to target each level of  $\mu\text{V}$  for the SMR amplitude for two consecutive weeks. That is week 1 and 2 at  $9\mu\text{V}$ , 3 and 4 at  $11\mu\text{V}$ , 5 and 6 at  $13\mu\text{V}$ , 7 and 8 at  $15\mu\text{V}$ , 9 and 10 at  $17\mu\text{V}$ . The child was not told anything about the set target. The child was instructed to look at the video picture on the monitor and he/she was asked to concentrate as much as possible on the picture so that the picture moved. The electrodes translated the electrical impulses of the brain into SMR amplitudes. Only when the impulses crossed that set target fixed by the test administrator, the car on the video monitor moved forward. Thus the child was reinforced for focusing and sustaining the attention on the picture. This constituted the therapeutic intervention that gradually trained the child to focus attention and sustain concentration on a point. Every session lasted for 15 minutes. These 15 minutes were divided into five rounds, each consisting of three minutes. The number of times the child

attained the target in a session reflected in terms of a total score on display monitor. The intervention was terminated after the tenth session. On termination of intervention the children were given a post-assessment of attention and concentration, and memory. This consisted of PGI memory scale, post-intervention examination marks, and teachers' and parents' ratings on student attention behaviour. In addition to this, separate test papers were constructed for each class with the help of the class teachers to measure the scholastic ability after the intervention.

Separate 2 (Groups: Group 1, Group 2) x 2 (Tests: Pre-test, Post-test) mixed between-within subjects ANOVAs were run on SPSS 20.0 in order to find out if there were any significant differences between the two groups in the scores related to attention, memory, academic performance and behavioral ratings, before and after exposing them to the 10-week long NFB intervention sessions at the rate of one 15-minutes session per week. In each case respective *M* and *SD* were computed and wherever required, graphs were also plotted.

Seven subtests of PGI Memory Scale were grouped into two - attention and concentration, and memory. The first subtest measured the attention and concentration whereas a composite score of memory was evolved combining the six other subtests of memory (immediate recall, delayed recall, retention for similar pairs, retention for dissimilar pairs, visual retention, and recognition). An attempt was made to find out if there were any significant differences in the subtest of attention and concentration, and memory of children of Group 1 and Group 2 in their pre- and post-intervention periods.

Academic performance was measured in terms of marks scored in the tests conducted for the children in different subjects. For this purpose the marks obtained by the children in the examination just preceding the onset of intervention and the marks obtained

in the examination just after the termination of intervention were taken as index of their academic performance. A mixed between-within subjects ANOVA is computed for the two groups of children, taking their examination marks before and after the intervention.

The teachers' and parents' rating scales that measured problems in attention and concentration, were administered at the time of screening and re-administered after termination of the NFB intervention. The data was analyzed using 2 x 2 mixed between-within subjects ANOVA. Correlation was computed between teachers' and parents' ratings in pre and post-intervention condition.

The processes involved in the NFB intervention were also explained emphasizing on the process of shifts in the levels of attention in ten week intervention, progress across the weeks in the two groups of children, and gain in the level, sustenance or loss across the ten weeks that happened along with progressive increase in difficulty level.

The results highlighted the following.

- The NFB intervention showed significant difference in the composite memory scores between the pre- and post-test condition
- The intervention was found to have a significant impact on attention and concentration of children as indicated by the results of ANOVA
- The result of ANOVA on each subtest clearly indicated a significant mean difference between the pre- and post-test in PGI memory scale
- It was found that there is a significant enhancement in the examination marks of the subjects in the post-intervention condition
- The results further indicated that the intervention had significantly positive impact on the attention behaviour of children. This was evident in the students' attention

behaviour rating by teachers and parents following the intervention as compared to their ratings in the pre-intervention condition.

- It was very clear from the results that the impact of intervention is significantly effective for children who had problems in attention and concentration than those who did not. A clear indication of this was found in the interaction effect on the memory test, examination report as well as ratings by teachers and parents.
- The results indicated that the NFB intervention for ten weeks though could bring significant improvement in the performance of children, it is found to be limited to narrowing down the differences between children with and without problems in attention and concentration, though it could not bring them to the same level. The differences between the two groups were found to exist in both the testing conditions.
- Results revealed that the gain factor as measured by the number of children shifting to a higher level of achievement across ten weeks is found to be consistently higher for the children with problems in attention and concentration.

The study very conclusively found the positive impact of NFB and its effectiveness in enhancing attention and concentration of primary school children. Though the studies of the past proved this fact, the sample on which the NFB was administered in majority of researches were clinical sample consisting of children with ADHD, epilepsy and autism. The contribution of this study is that NFB proves very highly effective on non-clinical normal children who suffer from inadequate attention and concentration not so much because of problem at neurological level but due to a number of psychosocial and environmental factors. About one decade of research in the field of Psychology of Education between 1970s and 80s repeatedly diagnosed cumulative cognitive deficit in children from socially disadvantaged groups. Attention and memory were invariably

included in the list of factors identified as antecedents. The suggested intervention included combination of approaches such as curriculum reform, innovative classroom methods, remedial teaching and nutritional supplementation.

The contemporary challenges of education and mental health are different from what it was in 70s and 80s. With globalization and advanced technology the problems of academic underachievement and attention deficiency is not so much due to under stimulation as in earlier decades, but because of overstimulation leading to distraction and deviation. Hence the approach to intervention has to be more in line of training to focus attention and sustain the focus rather than to provide alternative stimulation which has a powerful attention value. In this context NFB may be identified as an effective tool to train the children to sustain their attention. Further the technology involved is useful in motivating the children for the task because the children are found to be very much familiar with technological devices in everyday life.

The definite indicator that suggests the effectiveness of NFB intervention in addressing the problems in attention and concentration should also be taken as a caution in prescribing or administering NFB as intervention. It suggests very clearly that NFB should not be used indiscriminately on children. It may be imperative to ascertain the level of problem not only in prescribing it as an intervention but also in prescribing the frequency and duration of sessions. The question whether it would prove detrimental to those with very healthy attention and concentration opens the scope for further research. A related question to be answered is whether the impact of NFB could be neutral on any sample.

What is very encouraging about the result is that the impact of intervention is just not limited to the tests administered. There is a very clear indication of transfer of effect on academic performance. The children who received intervention not only scored higher

in attention and memory tests but also the improved attention and memory helped them in performing better in their school examinations.

Further, the improved attention was found to be so significant that it could be clearly observed in their day to day behavior. The finding that the impact of NFB brought a positive change in academic performance by also resulting in the desirable behavior modification, points at the power of the intervention. Based on the findings, it may be suggested to reintroduce the appointment of School Counselors. There is a dire need for it, because, without a counselor, the cumulative learning deficit may go unattended. The impact at micro level may be for the child. But at macro level it results in loss of human resource.

However further studies on larger sample, for longer duration, with experimental design are necessary before drawing any definite conclusion. The present study has certain limitations. The finding that the effectiveness is higher in case of children with problems in attention and concentration calls for further research in this area with control group experimental design by applying Solomon four-group design. Such design which includes children with problem in attention and concentration and those without the problem need to be further divided into experimental and control group. Secondly, the present study does not answer the question related to the appropriate and adequate number of intervention sessions that would ensure optimal results. Further, the present study progressively increased the level of difficulty across ten weeks. This led to the problem in determining the norm of SMR amplitude where the neural firing can be optimum. The future studies of Solomon four-group design can also address this concern.

The analysis of the process involved in NFB pointed at a few questions of research interest. One of that is the absence of any definite pattern in terms of progressive increase in target attainment scores. One of the reasons could be shift in difficulty levels. However

the constant significance of individual difference cannot be ignored. Since the study involves the neural functioning, focus on individual differences may be of high relevance in enriching the knowledge related to the impact of NFB. Future research in this area perhaps should include follow up studies on individual children varying in the degrees of attention deficit. The design of the study would have been stronger with equal number of subjects in both the groups. The present study could not control the impact of confounding variables, such as the children's level of IQ and SES. The screening which is based on the concurrence of teacher and parent rating still has an element of subjectivity. Future research may use teachers' and parents' rating as supplement to diagnostic tools that help in placing the participants at various levels of attention deficit.