Chapter 10
Neurofeedback as an Effective Intervention for Academic Performance in Children with Problems in Attention and Concentration

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Attention, Concentration and Academic Performance

Right to education occupies one of the top priorities of developing countries like India. The sanctity of this rests not so much in enrolling all the children in school, but on ensuring that learning takes place in these children in a progressive way that equips them with cognitive skills to match with their developmental stage. Learning calls need to be optimized for developing suitable curriculum and methods on the one hand and proper training and remedial programmes to cater to the deficits in developmental needs on the other. Attention and concentration are the two essential prerequisites for learning, memory and academic performance. Attention refers to the active processing of specific information present in our environment. It is a cognitive process of directing and maintaining awareness of stimuli identified by the senses toward response choice and decision-making. Concentration, on the other hand, refers to the cognitive process of selectively paying attention to one thing and to sustain it for a period of time.

In school, every class is likely to have children who suffer academic failure or underachievement. It is reported that around 20% school children have scholastic backwardness (Karande and Kulkarni 2005). These children's inability to recall learned information is often misjudged and criticized as their disinterest, stubbornness, indifference, non-cooperation or callous attitude. While these reasons cannot be totally ruled out, it could also be because of problems in functioning of pre-frontal cortex caused by trauma (Hariharan et al. 2014). The causes for underperformance may be many ranging from sheer lack of interest to attention deficit or structural changes in the brain. However, as pointed out by Hariharan et al. (2014), demands of schools on children are based on the broad averages of expected abilities of children based on developmental stages. Not much consideration is given to individual

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differences in the pace of development. Barring major causes such as problems with pre-frontal lobe functioning and autism in most cases, problems related to academic performance in school children can be traced back to deficiency or insufficiency of attention. Attention and concentration are the essential ingredients in learning. Academic achievement, which is more often than not a testimony of memory and recall abilities, demand attention and concentration of the learners both in the classroom and during practice sessions of homework. Hence, often the 'non-performers and under-performers' are put on remedial coaching that places higher demand on attention in practice sessions and rote learning. In such cases, exposure to the type of remedial coaching mentioned above may prove counter-productive as they demand longer span of attention. This explains why interventions not based on need assessment often meet with failures. In order to avoid that if interventions are preceded by appropriate screening and need-based planning, the probability of positive and desirable outcomes is increased. For example, in cases where underperformance is attributed to low attention and concentration, if measures are taken to address the attention factor, their memory and performance will automatically show an improvement.

By not targeting to enhance the attention and concentration, children tend to be stuck with persistent non-learning, resulting in repeated under performance. This not only leads to cumulative cognitive deficiency but also impacts the self-esteem and self-efficacy of children. Research studies have demonstrated that having short attention span becomes a block for individuals from effectively or selectively acquiring information. This subsequently results in a lack in competitiveness and the ability to adapt socially. Problems in attention not only affect the academic and cognitive performance, but also manifest in behaviour problems (Ahmed et al. 2007).

The relationship between attention problem and performance has gained the priority of research in the field of developmental psychology and educational psychology for the past several decades. Studies have shown that certain areas of attention dysfunction are correlated with learning problems since attention skills are necessary for accurate perception, storage and retrieval of information. For example, in a study by Accardo et al. (1990), it was seen that in a group of 422 children with attention dysfunction, evidence of learning problems was seen in 73% of them. Another research finding revealed the association between attention problems such as distractibility, low persistence and high activity with grades in reading and also achievement scores in reading and mathematics (Martin and Holbrook 1985).

With the emphasis and insistence on inclusive education, schools are obliged to enroll special children. It is very likely to observe problems indicating suboptimal cognitive functioning among them. Right from the 1960s till late 1990s, even before the policy of inclusive education came into vogue, studies did identify low performance and underachievement among school children that was attributed to problems in attention.

Research shows the prevalence of clinically identifiable attention deficit problems among schoolgoing children which may be categorized under disorders related to cognitive faculties. Research findings indicated that 2–14% children belonging to

school age suffer from Attention Deficit Hyperactive Disorder (ADHD) (Swanson et al. 1998). In a study by Gade (1987) using a sample of 321 schoolgoing children between 5 and 10 years, the prevalence of ADHD was found to be 7.17% when a rating scale was used and 0.94% when clinical interview was used, with an overall prevalence percentage of 8.10. One recent study shows the prevalence to be 11.32% with a higher prevalence among boys than girls. The prevalence was highest in the age group 9 and 10 years (Venkata and Panicker 2013).

Nevertheless, percentage of school children who have problem in attention and concentration that is moderate, and can be rectified with proper intervention, could not be located in the literature. Handling the problem of attention at this level is more productive and cost effective than targeting intervention for a cumulative cognitive deficiency at a later stage. Hence, cognitive intervention at primary school must target children who show symptoms of non-clinical (comparatively low) attention and concentration problems.

Neurofeedback and Its Function

Scientifically, neurofeedback is related to biofeedback, which involves recording and providing feedback on data pertaining to biological functions like heart rate, respiration or skin conduction, to a trainee. But instead of working with these peripheral data, neurofeedback works with data from the brain, whereby it can facilitate changes in the brain wave patterns and regional cerebral blood flow (Demos 2005). When the brain operates in a comparatively efficient pattern, feedback is given via auditory or graphic signals or both. Neurofeedback is supposed to strengthen neural pathways while increasing mental endurance and flexibility, which makes it similar to a comprehensive exercise programme.

This helps the people including children to learn and understand through the feedback what happens in their own brains with a change in their state of mind or awareness. During neurofeedback training, the trainees are provided with the feedback when their cycle of brain waves moves into a more desirable pattern. This feedback enables the persons to learn how to re-regulate their distracted thinking and gain control progressively over their activities and tasks with improved and sustained concentration and attention.

The processes involved in this kind of feedback can be traced back to the late 1960s, when Barry Sterman first described operant conditioning (Gunkelman and Johnstone 2005). In the process of neurofeedback training, when there are desirable brain activity changes, a feedback that is rewarding to the individual is given. If the brain activity changes are in the unintended direction, then the given positive feedback is inhibited or a different feedback is provided. These rewards which provide the required reinforcement can range from a simple change in pitch of a tone to a complex type of movement in a video game. Such reinforcement methods are used to teach the brain how to continue and maintain healthy brain wave patterns. Within a few sessions trainees often gain greater awareness of mental

drifting and insight into their own mental functioning. Gradually, most of the people who are trained learn to sustain attention for greater periods of time, apparently even during boring tasks in the classroom or at work (Demos 2005).

The process of neurofeedback training involves attaching electrodes to the specific regions on the child's head with a conductive gel. These electrodes transmit the electrical information to an instrument which analyses the brainwaves and feeds the information into a computer. These brainwaves are displayed on a computer screen very swiftly after their actual occurrence within a few thousandths of a second. The child watches the monitor of the computer which displays a picture like a moving object or a graph that indicates the extent to which the child produces the brainwave activity in the intended pattern. Reinforcement is given through a visual or auditory signal whenever the desired brain wave frequencies are produced by the child with the help of the software designed for the purpose. Operant conditioning helps in reducing the brain wave frequencies that are in excess, and increasing those with a deficit. The goal for the child throughout this process is to learn to produce the type of brainwaves associated with a more focused and attentive state. Thus the dysfunctional brain patterns are corrected and the desired patterns are improved.

For the perception of children, neurofeedback is like a video game where they can bring movement and sound in the picture that appears initially static on the computer screen. This movement happens only when the attention and concentration level reaches a set target. The movement of the picture works as a positive reinforcement 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 and concentration.

Behavioural Principle in Operation

Five brain wave patterns are discussed with respect to performance tasks associated with concentration or focus. Among these, beta wave is associated with an engaged mind state and its subtype Sensory Motor Rhythm (SMR) waves are associated with concentration or focus. The alpha waves are associated with relaxation activity, theta waves with day dreaming state, and the delta waves with deep sleep experience. Neurofeedback therapy aims to train the subjects to maintain the brain waves associated with the desired mental states displaying calmness, relaxation, alertness, and focus during cognitive tasks. Over the past few decades, such techniques have been developed and described in several research reports (Lubar 1991; Lubar and Lubar 1984; Tansey 1991). Kamiya (1969) popularized neurofeedback in the 1960s by publishing his experiments on alpha brain waves. The classic work of researchers such as Sterman, Lubar and others indicated an enhanced efficacy as a result of beta training which also involved sensorimotor rhythmic Electroencephalogram (EEG) activity (Sterman and Clemente 1962).

As has been described in the preceding section, neurofeedback which applies the behavioural principles such as operant conditioning using positive reinforcement

has been proved to be efficacious to train the subjects in the ability to monitor their slow and fast brain wave activity. Based on these principles, neurofeedback training programmes are designed for alpha wave or theta wave reduction and for increasing SMR or beta waves thus producing the desired EEG pattern. Studies conducted with such programmes have shown favourable results. For example, in a study done by Loo and Barkley (2005), different programmes of training were used to reduce alpha or theta waves and to increase sensory motor rhythm or beta waves. When the trainee produced the required EEG pattern, the computer was programmed to give a positive response or reward which often was in the form of points earned. Many other studies have also shown learning of different EEG parameters through operant principles both in animals as well as humans (Birbaumer 1977, 1984; Birbaumeret al. 1981; Kamiya 1969; Plotkin 1976; Sterman 1977).

Use of Neurofeedback as a Cognitive Intervention

Around 1970 it was discovered that neurofeedback makes it possible to recondition and retrain brainwave patterns. Neuro-biofeedback, also termed as neurotherapy and EEG biofeedback is a type of biofeedback which illustrates the activity of the brain using real time displays of electroencephalography. This is done usually for the purpose of gaining control over central nervous system activity. The work in this field began with enhancing alpha brainwave activity for simple relaxation (Hardt and Kamiya 1977), with attempts to diminish uncontrolled epilepsy (Lubar and Bahler 1976; Seifert and Lubar 1975) and in treating epilepsy (Sterman 2000; Sterman and Friar 1972). Soon, various researchers began using neurofeedback for handling attention and concentration problems in children with ADHD (Fox et al. 2005; Lévesque et al. 2006; Lubar et al. 1995; Monastra et al. 2002). Thus neurofeedback has been used effectively as a cognitive intervention with disorders involving cognitive deficits as indicated by several researches.

The logical explanation for low attention and concentration in classroom-related activities is that for some children these activities (mostly reading and writing) fail to provide any immediate reward. On the contrary, they have the potential power of receiving punishment for any signal of distraction in attention. Such combination of motivation directed by punishment and negative emotion can have a further undesirable impact on attention and concentration. Going by the principle of classical conditioning this negative association with attention can also have the effect of generalization. One way of helping these children is to reverse this process by creating a simulation which allows the children to experience immediate reward for any marginal increase in attention and concentration. Neurofeedback machine enables the children to bring changes in the animation on the computer screen by enhancing their attention, thus providing an automatic self-reinforcement. Repeated experience of this helps as a training packed with positive reinforcement for progressive improvement in attention and concentration. Thus, negative association

with the attention and concentration can be replaced with motivation and self-efficacy which in turn has the power of generalization.

Neurofeedback Intervention for Clinical Sample

Reports of several researches have highlighted the role of neurofeedback in treating Attention Deficit Disorders (ADD) with or without hyperactivity as well as for Learning Disabilities (LD). The EEG biofeedback has been seen to play an important role in improving the attention, cognitive functioning and behaviour as demonstrated by the increase in measures such as IQ scores, grades and educational test scores which is significant (Lubar 1991; Tansey 1990, 1991). It is observed from studies that when neurofeedback training has been used, the conditioned EEG changes that resulted from the training were associated with improvement or normalization of the symptoms of ADHD. It was also reported that the effect of the training has not only been generalized to other facets of life but also sustained thereafter. Studies have shown that these changes have transferred the impact to day-to-day home and school environment even after the treatment is withdrawn (Monastra et al. 2002). Lubar (1991) found that these changes were maintained into adulthood in most treated cases. Researches also pointed to the fact that compared to neurofeedback therapy, no other approach to the treatment of ADHD has been successful in such effects of generalization or maintenance (Pelham et al. 1998; Smith et al. 2006). Multiple advantages of neurofeedback therapy have been reported including improvements in school or work performance, social relationships, self-esteem and plasticity of self-regulatory skills as well as reduction in undesirable patterns of behaviour such as irritability and oppositional behaviour. A review of more than 20 studies using neurofeedback for the treatment of ADHD have shown that 70–80% subjects significantly benefitted which sustained till 10 years after treatment (Lubar 1995). Studies have demonstrated that in addition to IQ scores significant improvements were noticed in classroom performance of children with ADD after neurofeedback training. Distinctly identifiable, EEG differences were noticed after neurofeedback training in children with learning difficulties and attention deficits with or without hyperactivity (Abarbanel 1995; Lubar 1991, 1995; Sterman 1996; Tansey 1990). In a study, a sample of 1089 subjects with attention and behaviour complaints were administered SMR-beta neurofeedback training (Kaiser and Othner 2000). An improvement was reported in areas such as attentiveness, impulse control and response variability after the training, showcasing the importance of neurofeedback training in remediating attentional dysfunction. Mezzacappa and Buckner, (2010) also point to the emerging data suggesting the benefits of interventions designed to improve such skills in both typically developing children and children with impairments. Thus research findings clearly indicate the effectiveness of neurofeedback in bringing positive change in cognitive and behavioural dimensions among children diagnosed with ADHD and LD.

Neurofeedback Intervention for Non-clinical Sample

While the preceding section shows effective results of usage of neurofeedback intervention in children with significant clinical symptoms related to attention, memory and performance, there are also children who have problems with attention, concentration and memory in lower degrees which do not classify them under clinical sample. It is often noticed that children who have problems in sustaining attention and concentration are branded as troublesome or backward in studies and are subjected to methods of rectifying the same either by over-disciplining methods which may be punitive or by neglect. Attention span is related to neurophysiological functioning. Therefore, rather than applying adhoc corrective measures, it is desirable to approach the problem scientifically. For instance, one can contemplate methods of conditioning the neuropsychological functioning of the child.

A careful examination of the research for the past three decades and more shows that several attempts using case study and controlled group studies have been made to examine the effects of EEG biofeedback. Majority of these studies have reported favourable results of this treatment approach. In several studies, quantitative electroencephalographic examination demonstrated improved attention and behavioural control in tests of intelligence and academic achievement (Monastra et al. 2005). Several systematic studies also suggested consistently that neurofeedback training improves attention (Leins et al. 2007), increases IQ scores (Linden et al. 1996) and enhances cognitive performance (Vernon et al. 2003).

Application of Neurofeedback: A Wider Perspective

Contemporary challenges of education and mental health are different from previous decades. With globalization and advanced technology, problems of academic underachievement and attention deficit is not so much due to understimulation as in earlier decades, but because of overstimulation leading to distraction and deviation. Thus the problems are significantly different from what children of 1970s and 80s faced. Hence, the approach to intervention has to be more in line of training to filter attention on selective stimuli, focus and sustain the attention rather than just remedial teaching.

Neurofeedback can be an effective tool for two purposes, i.e., in screening children with problems in attention and concentration as well as in their cognitive training and retraining. Neurofeedback equipment can be used to develop age norms and grade norms of attention and concentration for non-clinical primary school children. Based upon these norms, identification of problems in attention and concentration—the prerequisites for scholastic achievement—may be possible.

The effectiveness of neurofeedback is found in all children with or without developmental psychopathology. Though the studies vary in the methodology in terms of frequency, duration and periodicity, results indicate positive outcome.

Among the healthy children, a single session of neurofeedback training is reported to have resulted in cognitive enhancement (Escolana et al. 2012). Exposure to weekly neurofeedback sessions for seven months is found to be useful in enhancing reading skills and IQ scores in elementary school children having identified learning problems (Orlando and Rivera 2004). Neurofeedback training brings improvement related to symptoms as well as behavioural aspects in children with autism (Jarusiewicz 2002). Significant improvements are also observed in IQ scores following EEG biofeedback in a set of identical twin girls with mild developmental delay and with symptoms suggesting ADHD (Fleischman and Othmer 2006).

The findings of several researches using neurofeedback as an intervention for clinical and non-clinical samples have implications for future educational curricula aiming at improved academic performance. This is possible by identifying the deficits in attention and concentration early enough so that such practical training interventions like neurofeedback are given in addition to educational interventions.

An Empirical Study Using Neurofeedback as an Intervention for Academic Performance in Non-clinical Group of Children with Problems in Attention and Concentration

Considering the vast research which demonstrated that neurofeedback was helpful in children with ADHD and other related clinical problems, the authors conducted a study to measure the effect of neurofeedback as a cognitive intervention in a non-clinical sample. The study attempted to observe if the attention, memory and academic improvement could be brought through neurofeedback intervention in children who were normal. However, their lack of attention and concentration in comparison to other children was often complained by teachers and parents. It was also hypothesized that normal children without any reported attention and concentration problems may also be able to benefit out of this training.

The study adopted a quasi-experimental design, where 50 children studying in Class 3 through 7 having problems with attention and concentration were screened and compared with another group of 26 children who were academically bright with no problems in attention and concentration. The Students' Attention Behavior Rating Scale for Teachers and Children's Attention Behavior Rating Scale for Parents, specifically designed for this study were used as screening instruments to identify the above two groups of children. For the purpose of measuring attention, concentration and memory, PGI Memory Scale (Pershad and Wig 1976) was used, and the examination marks in the pre- and post-intervention phases were taken as measures of academic performance. The intervention consisted of one trial exposure session and ten intervention sessions with a frequency of one session in a week. On termination of intervention, the children were administered a post-test with PGI memory scale and scholastic skills test. The results showed that neurofeedback intervention for ten weeks could bring significant improvement in the academic

performance of children. However, this significant improvement did not equate the academic performance of the children with attention and concentration problem with that of bright children who constituted the comparison group. When it came to directly impact attention and concentration, it was found to be very encouraging because the post intervention scores of children with attention and concentration problems was found to be almost at the same level of comparison group. This could be because the training provided in the intervention that required children to sustain their attention on video pictures providing instant reinforcement (movement of the car in the video screen) helped in strengthening the behaviour of sustaining the focused attention. On the other hand, the significant but limited impact in academic performance may be attributed to the factor related to delayed reinforcement associated with academic performance. Perhaps, a direct positive reinforcement for enhanced academic performance would be helpful in improving their performance, which is comparable with their counterparts in the comparison group.

While the desirable outcome in case of children with problems in attention and memory is considered to be a significant contribution to knowledge, equally or more important is the finding that the intervention did not prove as effective in case of children without problems in attention. In fact, a decline in performance was noticed among them after they crossed the half-way mark. This finding suggests the caution to be exercised in prescribing neurofeedback for children. There may be a number of enthusiastic parents who aspire further excellence in their already 'brilliant' children. They may 'seek' neurofeedback intervention for their children. Similarly, a practitioner who is equipped with the device may feel tempted to use it on children with complaints of performance deficit. Here is where utmost caution needs to be exercised based on the second finding that the intervention proved not effective for the comparison group. Why it was not equally effective on the children without attention problem demands further investigation. It is possible that these children already put their neurocognitive functions to the optimal action, hence the intervention was unable to bring any further improvement that is significant. In such cases, attempts to stretch their attention further should not result in undesirable outcomes. In view of this, screening must be taken up as an essential prerequisite before advocating neurofeedback intervention for any child.

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