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Treating Attention Deficit/Hyperactivity Disorder with Neurofeedback

Attention Deficit/Hyperactivity Disorder (AD/HD) affects approximately 7% to 12% of the child population. The primary symptoms of ADHD are inattentiveness, impulsivity, and hyperactivity, and research now shows that these symptoms are actually secondary outcomes of a neurological disorder (Lubar, Swartwood, Swartwood, & O'Donnell, 1995).

There are a number of difference brainwave frequencies which relate to different states of arousal. These frequencies are presented in Table 1 below. Individuals with AD/HD tend to experience mental wandering, often drifting in their thoughts, and are unable to centralise their attention or grasp information. This occurs during attentional tasks such as reading or listening to a story. During such tasks, individuals *without* AD/HD experience EEG shifts to the beta frequency band (which is associated with attention and memory processes), and an increase in the right frontal region. In comparison, among individuals *with* AD/HD there is evidence of increased theta wave rhythms, which are associated with drowsiness; decreased beta rhythm; and decreased fast sensorimotor rhythm, which is inversely associated with movement (Butnik, 2005; Fox, Tharp, & Fox, 2005; Rojas & Chan, 2005).

Table 1: Brainwave frequencies and states of arousal.

0.5–3 Hz	DELTA	Sleep	Should be low while awake. High delta can interfere with emotional or cognitive processing.
4-7 Hz	THETA	Distracted Daydreaming	Theta is associated with inattentiveness, distractibility, and lack of focus.
8–11 Hz	ALPHA	Spacey Relaxed Inattentive	Alpha is associated with spaciness, lack of motivation, inattentiveness, and depression.
12–15 Hz	SMR	Relaxed attention	More calm; SMR regulates impulsivity and hyperactivity, promotes body awareness, and helps to control anxiety and anger.
15–18 Hz	BETA	Active attention	Focussed; Beta enhances cognitive processing, and improves concentration and attentiveness.
19–35 Hz	HIGH BETA	Anxious Stressed	High beta is associated with a high state of arousal; e.g. excited, scared.

For around 85% to 90% of people with AD/HD, research has found evidence of underactivity over frontal and central midline cortical regions of the brain; it is these regions of the brain that are responsible for attention and behavioural control. It is proposed that Neurofeedback (also known as EEG biofeedback) trains people to increase the level of neuronal activity in these regions of the brain, which then allows them to begin to attend to and maintain behavioural control (Monastra, 2005; Monastra et al., 2005).

Research into this form of AD/HD treatment began to appear in the literature in the mid 1970's, and numerous studies have been conducted since that time (Rossiter & La Vaque, 1995). Most recently, the growing popularity of Neurofeedback has seen its inclusion in books about AD/HD (Hill & Castro, 2002; Sears & Thompson, 1998), and there are currently more than 1500 practitioners using Neurofeedback, with most of these practicing in the United States (Butnik, 2005).

The goal of Neurofeedback is to assist the individual to modify their brainwave activity in order to reduce the primary symptoms of AD/HD. This includes improving attention, reducing impulsivity, and controlling hyperactive behaviours. In addition, Neurofeedback produces long-term effects (Fox et al., 2005).

Neurofeedback teaches the individual to learn how to normalise abnormal EEG frequencies by presenting them visually on a computer screen. By showing the child what concentration looks and feels like in comparison to non-concentration, Neurofeedback increases their awareness of what a normalised EEG pattern feels like (Butnik, 2005).

Psychostimulants such as methylphenidate (Ritalin) have traditionally been a common form of treatment for individuals with AD/HD. Approximately 70-80% of individuals with AD/HD respond to this form of treatment, with improvements in areas such as attention span, impulse control, and reduced motor activity (Rossiter & La Vaque, 1995).

However, a serious limitation of this form of treatment is that it only produces temporary benefits. That is, the improvements in attention, and reductions in impulsivity and hyperactivity disappear once the individual stops taking the medication, and the individual returns to the previous level of deficit (Fox et al., 2005; Rossiter & La Vaque, 1995). There are also significant side effects associated with psychostimulant medication.

In a review of 110 studies, based on more than 4200 children, it was found that the most commonly reported side effects of psychostimulant medication were decreased appetite, insomnia, irritability, weight loss, and abdominal pains (Barkley, 1977). A meta-analysis of research has also found that long-term compliance rates are poor, which also limits the effectiveness of this form of treatment (Rossiter & La Vaque, 1995).

Further, approximately 25% to 40% of AD/HD patients demonstrate either no response or an adverse response to psychostimulant medication (Fox et al., 2005; Monastra et al., 2005). A recent review of 161 randomised controlled trials reports that 25% to 35% of individuals with AD/HD did not significantly reduce in

hyperactivity and impulsivity symptoms after receiving stimulant medication. Between 4% and 10% of these individuals also experience severe side effects (e.g. insomnia, loss of appetite, stomach ache, headache, jitteriness, and increased irritability) (Monastra, 2005).

Since the mid 1970's there has been growing interest in the treatment of AD/HD with Neurofeedback and the research literature in the area is now quite substantial. Among the many published studies, there have been five controlled-group studies published in peer-reviewed journals (Monastra et al., 2005) which are considered instrumental in demonstrating evidence of the efficacy of Neurofeedback in the treatment of AD/HD.

It is important to note that most of the studies in this research area use the Test of Variables of Attention (TOVA) to measure the accuracy and speed of information processing by the brain. Because it is so often utilised in the research described below, it is important to explain its use in more detail. The TOVA belongs to a class of tests commonly referred to as Continuous Performance Tests (CPTs), and is the most widely researched and commonly used CPT available (Greenberg & Waldman, 1993). The TOVA comprises of two tasks designed to assess visual and auditory processing. The visual test involves the computerised presentation of two stimuli in the form of a box at either the top or the bottom of the screen, which are randomly displayed every two seconds. One is identified as a target, which the client should respond to, and the other is a non-target, which the client should ignore.

The auditory test is the same, except that the two stimuli are a high-pitched and low-pitched tone. The TOVA operates in two halves. The first is the Target Infrequent Half, where the infrequent appearance of the target tests the individual's ability to maintain concentration for a relatively boring task, indicating inattention. The second half of the TOVA is the Target Frequent Half, where the frequent appearance of the target tests the individual's ability to inhibit their tendency to press the button incorrectly, indicating impulsivity.

The TOVA measures four characteristics:

- Attention and inattention: responses to the target, either correct or incorrect.
- Impulsivity/disinhibition: responses to the non-target, incorrect only.
- Reaction time: how long the brain takes to respond to the target; individuals with AD/HD are usually slower to respond.
- Variability: the consistency of responses to targets; this usually identifies AD/HD.

We turn now to the first of the rigorous studies identified earlier, conducted by Rossiter & LaVaque (Rossiter & La Vaque, 1995). These researchers compared 20 sessions (3-5 times a week for 45-50 min sessions, which included 30 mins of feedback) of Neurofeedback to psychostimulant medication (methylphenidate or dextroamphetamine) on a continuous performance test, as well as a standardised behavioural rating scale that assessed AD/HD symptoms and other behavioural problems (Monastra et al., 2005). There were 46 participants, all diagnosed with AD/HD, and were aged between 8 and 21 years of age. Parents were given the choice to place their child in either the Neurofeedback or the psychostimulant group. Results showed that those in the Neurofeedback group demonstrated

improvements in all four variables assessed using the Test of Variables of Attention (TOVA); increased attentiveness, reduced impulsivity, increased processing speed, and decreased variability in attention. The children also showed significant reductions on the Hyperactivity, Attention Problems, Externalising Problems, Internalising Problems, and Behaviour Symptoms Index scales of the Behaviour Assessment System for Children (BASC) (Rossiter & La Vaque, 1995). The improvements shown by the TOVA were also recognised by parents, who filled out the parent version of the BASC, showing that there was a correspondence between improvements in behaviour or school performance and improvement in the TOVA.

This suggests that the results of Neurofeedback generalised past the clinic into symptom reduction in the client's daily life (Rossiter & La Vaque, 1995). There was no significant difference between the percentages of patients who showed improvements in each group (Neurofeedback = 83%; psychostimulants = 87%), or in the degree of improvements (efficacy) shown (Monastra et al., 2005; Rossiter & La Vaque, 1995), which suggests that Neurofeedback is as effective a treatment as psychostimulant medication.

In 2004, Rossiter (Rossiter, 2004) replicated the previous study with more participants (N=62), a sample which included adults, and improved statistical analysis. Again, both groups showed statistically and clinically significant improvements (84% of participants) on the TOVA (attention, impulse control, processing speed, and variability in response time). The Neurofeedback group also showed clinically and statistically significant improvements on behavioural measures (BASC and Brown Attention Deficit Disorder Scales) (Rossiter, 2004). It was concluded that Neurofeedback "produced patient outcomes equivalent to those obtained with stimulant drugs" (Rossiter, 2004).

The second controlled-group study was conducted by Linden and colleagues (Linden, Habib, & Radojevic, 1996). Eighteen children aged between 5 and 15 years, who were diagnosed with AD/HD, were randomly assigned to either a waiting list control group (no psychological treatment or medication) or a Neurofeedback group (conducted over 6 months, with 40 lots of 45-minute sessions) (Monastra et al., 2005). Each group had 9 participants; 6 with AD/HD, and 3 with AD/HD as well as a learning disorder (Monastra, 2005). None of the participants were taking medication for AD/HD, or were involved in any other treatments, such as counselling or tutoring (Linden et al., 1996). Results showed that those in the Neurofeedback group experience an average increase in intelligence of 9 points more than the control group (as measured by the Kaufman Brief Intelligence Scale), and a reduction in inattention symptoms as rated by parents (IOWA-Conners Behavior Rating Scale) (Linden et al., 1996; Monastra et al., 2005).

The third controlled-group study, conducted by Carmody and colleagues (Carmody, Radvanski, Wadhwani, Sabo, & Vergara, 2001), was conducted in a school setting. It consisted of 16 children aged between 8 to 10 years, who were randomised to either a waiting list control group or a Neurofeedback group. Half of the children in each group were diagnosed with AD/HD and half were not. The Neurofeedback group completed 3 to 4 sessions each week, with a total of 36 to 48 sessions over a 6-month period (Carmody et al., 2001; Monastra et al., 2005). Results showed that AD/HD children treated with Neurofeedback had reduced

impulsivity (as measured by the TOVA) and higher attentiveness (rated by teachers on the School Version of the Attention Deficit Disorder Evaluation Scale; ADDES) (Carmody et al., 2001; Monastra et al., 2005).

The fourth controlled-group study was conducted by Fuchs and colleagues (Fuchs, Birbaumer, Lutzenberger, Gruzelier, & Kaiser, 2003). The study involved 34 children aged between 8 and 12 years of age, and compared Neurofeedback (30 to 60 minute sessions, 3 times a week for 12 weeks) to psychostimulant medication (Monastra et al., 2005). The Neurofeedback participants did not receive any psychostimulant medication for the duration of the study. Both the Neurofeedback and the Ritalin treatment groups demonstrated significant improvements in all four scales of the TOVA, as well as improvements on the d2 Attention Endurance Test accuracy and speed scores and on the composite total score, demonstrating that the children were able to work on a larger number of items while making fewer mistakes after treatment.

Both interventions also led to improvements on the IOWA-Conners Behaviour Rating Scale; both teachers and parents rate the occurrence of AD/HD-related behaviours as significantly reduced post-treatment. Importantly, the degree of improvement in Neurofeedback participants was comparable to that of the Ritalin group (Butnik, 2005; Monastra et al., 2005).

The final controlled-group study was conducted by Monastra and colleagues (Monastra, Monastra, & George, 2002). This study compared Neurofeedback (weekly sessions of 45 to 50 minutes) to psychostimulant medication (Ritalin, with an average dose of 25mg, with a range of 15-45mg per day) (Monastra et al., 2002). There were 100 participants, aged between 6 and 19 years of age. All participants received a treatment program which incorporated stimulant medication, a 10-week parenting program with individualised parent counselling if needed, and academic support at school. In addition, one of the groups received Neurofeedback training, while one did not.

The Neurofeedback portion of the program continued until the patient could demonstrate a reduced level of cortical slowing (theta activity) that was within one standard deviation of age peers and they could maintain this level of arousal for three sessions. This took an average of 43 sessions, with a range of 34 to 50 sessions; all participants reached this goal (Monastra et al., 2005; Monastra et al., 2002). One year after the initial evaluation, the children were re-evaluated. Firstly, they were evaluated while continuing to take Ritalin. Then, medication was discontinued for 1 week and they were tested again (Monastra et al., 2005). Significant improvement was found in both groups while taking medication. After the 1 week “wash-out”, though, relapse was noted on the TOVA in those who had not received Neurofeedback, and they also had no sustained improvement on the Quantitative electroencephalograph (QEEG) measure, which is a biological measure of cortical arousal. Those who completed Neurofeedback demonstrated sustained improvement on the TOVA and behavioural measures, and maintained QEEG gains even after 1 week without medication (Monastra et al., 2005). In addition, those parents who were using the strategies taught in parenting program had children who showed less attentional and behavioural control problems at home (Monastra et al., 2005) than those who did not use the strategies taught.

A systematic 2-year follow-up of the above study was conducted. Eighty-six (43 Neurofeedback and 43 non-Neurofeedback) participants were re-evaluated six, twelve, and twenty-four months after the conclusion of the first year of treatment (Monastra, 2005). Those participants who did not receive Neurofeedback continued to demonstrate positive responses to behavioural ratings whilst on medication; however, relapse occurred in each participant when tested without medication at one year, eighteen months, two years, and three years after the initial evaluation (Monastra, 2005).

Thus, the reduction of AD/HD symptoms experienced due to three years of pharmacological treatment had disappeared within one week of discontinuation of medication. Neurofeedback participants, on the other hand, continued demonstrating significant and sustained gains on the TOVA and behavioural ratings throughout the 3-year period, even following the discontinuation of psychostimulant medication (Monastra, 2005). At the conclusion of the study, 80% of Neurofeedback patients had decreased their daily dosage of Ritalin by at least 50%. None of the patients in the non-Neurofeedback group were able to reduce their dosage (Monastra, 2005).

In addition, the behaviour ratings of the non-Neurofeedback children, as reported by parents and teachers, remained in the clinical range, while a significant number of Neurofeedback children were now rated in the normal range. The TOVA scores of non-Neurofeedback children fell back into the clinical range following 1 week without medication, while the TOVA scores of Neurofeedback children remained in the normal range following 1 week without medication (Butnik, 2005). On the ADDES (parent and teacher observations), standard scores below 7 are considered to be in the impaired range. After 1 year, the non-Neurofeedback group's means were still below 7, but the Neurofeedback group had sustained improvement, with means now above 7 (Monastra et al., 2002). Participants in this study benefited from a multimodal treatment model which included Neurofeedback, in addition to parent counselling and psychostimulant medication (Monastra et al., 2002). Importantly, the study permitted an understanding of how quickly symptom relapse occurs once psychostimulant medication is discontinued, even after three years of use, and the markedly contrasting results obtained when Neurofeedback training is utilised.

A number of other studies, while not controlled-group studies, also provide interesting results that are clinically relevant. Some examples of these have been conducted by Patrick (Patrick, 1996), Pop-Jordanova and colleagues (Pop-Jordanova, Markovska-Simoska, & Zorcec, 2005), Kropotov and colleagues (Kropotov et al., 2005), and Thompson and Thompson (Thompson & Thompson, 1998).

The first randomised, controlled, double-blind study was conducted in 2004 (deBeus, Ball, deBeus, & Herrington, 2004). It involved compared Neurofeedback to a "pretend" biofeedback, where rewards were provided randomly rather than being based on the individual's brainwave activity. Importantly, because neither therapist nor client knew which treatment condition they were in, this study removes the possibility of positive effects being attributed to client expectations or therapist bias. Those participants receiving Neurofeedback experienced "significantly less hyperactivity at home and school, improved attention at home,

less anxiety, less depression and fewer complaints of minor physical problems at home, better adaptability to change, improved ability to work with others, and improved peer interactions, organisational skills, study habits, and a better attitude toward school" (Monastra, 2005). Neurofeedback participants also had significantly better scores on computerised tests of attention than the "sham" group. Most significantly, there were significant improvements in cortical arousal (reduced theta, increased beta or SMR) in the Neurofeedback group, but not in the "sham" group. (Monastra, 2005)

One study (Keller, 2001) studied participants with attentional deficits stemming from moderate closed head injuries. Patients in the Neurofeedback treatment condition improved significantly more than participants in the no treatment control condition on tests of attention (Keller, 2001).

A large trial was conducted by Kaiser and Othmer (Kaiser & Othmer, 2000), in which 1089 participants (726 children and 363 adults) from 32 different clinical settings received Neurofeedback training. None of the participants were receiving stimulant or antidepressant medication (Kaiser & Othmer, 2000). Neurofeedback training produced significant improvements in attentiveness, impulse control, and response time variability. Interestingly, the greatest improvements were observed when the baseline test scores (TOVA) were poorer (Kaiser & Othmer, 2000). Eighty-five percent of participants showed significant improvement in one or more measures of the TOVA, and 68% showed significant improvement in two or more measures (Kaiser & Othmer, 2000). An important strength of this study is that it is highly representative of the actual clinical population, as participants were samples from 32 clinics in the United States, with varying severity (Kaiser & Othmer, 2000).

In conclusion, around 75% of people in each of the published studies evaluating Neurofeedback as a treatment for AD/HD reported significant clinical improvement (Monastra et al., 2005). Additionally, Neurofeedback is the first treatment for AD/HD which significantly reduces and in some cases normalises the core symptoms of AD/HD; inattention, impulsivity, and hyperactivity (Monastra et al., 2005). Further, improvement generalises outside the treatment setting to home, school, and work environments. Whereas the positive effects of psychostimulant medication such as Ritalin quickly wear off once treatment ceases, those completing Neurofeedback maintain their positive improvements into adulthood once treatment has been withdrawn. It is important to note that no other form of treatment for AD/HD has been able to demonstrate such long-term and wide-spread improvements (Loo & Barkley, 2005).

Psychologists, medical practitioners, parents, teachers, and the wider community have not yet embraced the considerable benefits of Neurofeedback. This is largely due to the fact that Neurofeedback remains relatively unknown and is criticised by those without knowledge of how it works. However, there are now Neurofeedback clinics all over the world, in countries such as the United States, Australia, the United Kingdom, Germany, and the Netherlands, to name a few. For an extensive list of clinics, visit www.eegspectrum.com. In an important step forward, in the last few years Neurofeedback has begun to be recognised by university research groups, with the authors of the Fuchs and colleagues (2003) paper conducting the study from universities in Germany and Italy. In addition, studies on Neurofeedback have begun to appear in peer-reviewed journals, such

as Butnik's (2005) study, published in the Journal of Clinical Psychology. As this review of the literature demonstrates, there is now significant empirical evidence to suggest that Neurofeedback should be taken seriously as a treatment for Attention Deficit/Hyperactivity Disorder, and the research literature is finally beginning to respond to this evidence. It becomes important now for medical practitioners and other professionals to take a look at the evidence presented here and consider Neurofeedback as a possible treatment option for children with Attention Deficit/Hyperactivity Disorder.

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