Electroencephalograph Biofeedback: A Form of Treatment for Attention Deficit Hyperactivity Disorder

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Running Head: EEG BIOFEEDBACK

Electroencephalograph Biofeedback:
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Lisa Gustas
Honors Thesis
This thesis for honors recognition has been approved for the Department of Psychology by:

Ann Perkins Ph.D., Director Date

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Murphy Fox, Reader Date
Abstract

This paper examines the effects of electroencephalograph (EEG) biofeedback as a treatment for Attention Deficit Hyperactivity Disorder (ADHD). It starts with a definition of Attention Deficit Disorder (ADD) and Attention Deficit Hyperactivity Disorder (ADHD), and the diagnostic criteria for the disorders. The paper then discusses EEG biofeedback as a treatment of ADHD, how it developed, and examples of successful treatments. Data is presented and discussed from the pretests, middle tests, and posttests of a juvenile male, as well as a group of children, who received EEG biofeedback treatment for ADHD. Improvements in behavior resulted from the treatment sessions. Results were discussed in relation to the effectiveness of this treatment.
EEG Biofeedback: a Treatment for ADHD

ADD (attention deficit disorder) and ADHD (attention deficit hyperactivity disorder) are two common disorders afflicting many children and adults and can severely hinder a person’s ability to concentrate in numerous arenas of life. For many years researchers and scientists have worked to find an affective treatment which would allow people diagnosed with ADD or ADHD to function in a more socially appropriate manner. The most commonly used treatment, thus far, has been the use of pharmaceutical drugs such as Ritalin. While this drug may treat the symptoms for a certain period of time, it by no means offers a permanent cure. In addition, Ritalin has to be administered regularly, several times a day, in order to maintain effect. Tolerance is often a concern because the more the drug is administered, the higher the dosage has to be in order to remain effective.

Over the past two decades a new form of treatment has been tested for effectiveness. The technique for administering this treatment has also been modified. This cutting edge treatment, EEG biofeedback, also known as neurofeedback, is an alternative treatment for parents and children who do not want to use pharmaceuticals to treat the disorder. EEG biofeedback offers a treatment of the symptoms, and possibly even a long-term cure. There are none of the side effects of pharmaceuticals and no concern for tolerance. The treatment is given in a series of 40 sessions over the course of six weeks. After that, there is usually no need for continued therapy. There have been many successful patients who no longer rely on drugs. Although drugs have been somewhat successful in treating ADHD, EEG Biofeedback may be a more effective treatment because it trains the patient with ADHD to control their own behavior rather
than relying on an exogenous chemical for their concentration. This paper describes how ADD and ADHD are diagnosed and how EEG biofeedback works. In addition, there will be a case study discussion, followed by a more in-depth study, and detailed description of various tests used to determine the effectiveness of EEG biofeedback.

What is ADHD?

**Characterizing and Diagnosing ADHD**

Attention Deficit Disorder may present itself with or without the component of hyperactivity. This paper will focus on, Attention Deficit Hyperactivity Disorder. Another common name for ADHD is Hyperkinetic Disorder (HKD). The DSM-IV identifies the same 18 symptoms for both ADHD as well as HKD (Swanson, Castellanos, Murias, LaHoste, & Kenney, 1998). Swanson et al. (1998) described that the diagnoses of ADHD “are based on subjective reports of developmental in appropriate behaviors within three symptom domains- inattention, impulsivity, and hyperactivity- with the onset of symptoms before 7 years of age and functional impairment across at least two settings (e.g. home, school, playground, etc.)” (p. 263). In the DSM-IV the three domains of inattention, impulsivity, and hyperactivity are now combined into two domains of inattention and hyperactivity/impulsivity for the appropriate diagnosis of ADHD. Table 1 describes the criteria for diagnosing ADHD as reprinted by Koziol (1993).
Table 1: Criteria for Diagnosis of Attention Deficit Hyperactivity Disorder

**Note:** Consider a criterion met only if the behavior is considerably more frequent than that of most people of the same mental age.

(A) A disturbance of at least six months during which at least eight of the following are present:

1. Often fidgets with hands or feet or squirms in seat (in adolescents, may be limited to subjective feelings of restlessness)
2. Has difficulty remaining seated when required to do so
3. Is easily distracted by extraneous stimuli
4. Has difficulty awaiting turn in games or group situations
5. Often blurts out answers to questions before they have been completed
6. Has difficulty following through on instructions from others (not due to oppositional behavior or failure of comprehension), e.g., fails to finish chores
7. Has difficulty sustaining attention in tasks or play activities
8. Often shifts from one uncompleted activity to another
9. Has difficulty playing quietly
10. Often talks excessively
11. Often interrupts or intrudes on others, e.g., butts into other children’s games
12. Often does not seem to listen to what is being said to him or her
13. Often loses things necessary for tasks or activities at school or at home (e.g., toys, pencils, books, assignments)
14. Often engages in physically dangerous activities without considering possible consequences (not for purpose of thrill-seeking), e.g., runs into street without looking

**Note:** The above items are listed in descending order of discriminating power based on data from a national field trial of the DSM-III-R criteria for Disruptive Behavior Disorders

(B) Onset before the age of seven.

(C) Does not meet the criteria for a Pervasive Developmental Disorder.

**Criteria for severity of Attention-deficit Hyperactivity Disorder:**

**Mild:** Few, if any, symptoms, in excess of those required to make the diagnosis and only minimal or no impairment in school and social functioning.

**Moderate:** Symptoms or functional impairments intermediate between “mild” and “severe.”

**Severe:** Many symptoms in excess of those required to make the diagnosis and significant and pervasive impairment in functioning at home and school with peers.

The symptoms ADHD children exhibit contain an inability to continue sustained behaviors; they have a difficult time staying on task (Koziol, 1993). According to Koziol (1993) "they are unable to maintain appropriate levels of behavioral persistence across varied tasks and situations. Attention is underfocused and the resultant behaviors are inadequately maintained" (p. 6). Clinically, ADHD is characterized by exhibiting impulsivity, decreased attention span, and for some even increased motor activity.

According to Lazzaro et al. (1998), there are a number of characteristics of ADHD that are age specific. He states that whereas young children show signs of gross hyperactivity and motor activity, in older children and adolescents the hyperactivity has decreased but instead manifests itself more internally as feelings of restlessness. However, impulsivity and inattention remain in older children and adolescence.

ADHD is found in nearly 2 million children in the United States, 3-6% of the entire child population (Ballard et al., 1997). Because the DSM III-R has such a broad diagnostic criteria, it has resulted in an over diagnosis of children with ADHD (Mann, Lubar, Zimmerman, Miller, & Muenchen, 1991). This makes it necessary to perform many tests to determine the subjects do in fact have ADHD before doing any studies. In addition, boys are more likely to present the symptoms of ADHD than girls are. Girls symptoms are more likely to center in the inattentive domain while boys symptoms center in the hyperactivity/impulsivity domain (Archibald, 1998). The reason for boys showing signs of ADHD more often then girls could be explained by differential socialization. For example, boys are taught to play more actively (horseplay), while girls are taught to play more passively and quietly. This may also be explained by the biological differences in the brains of boys and girls.
ADHD seems to present itself within different generations of the same family. Heredity is a factor in this biological disorder and can be intensified by social influences (Ballard et al., 1997). Some of the extreme social influences, which appear to play a role, include all types of abuse—physical, emotional, and sexual. According to Ballard et al. (1997) the symptoms that present themselves are all prefrontal brain functions including the child’s ability to self-regulate impulse behavior, maintain concentration, and delay gratification. This is evidence that ADHD may be a cause of certain physiological abnormalities in the brain.

Physiological Factors of ADHD

According to studies cited in Ballard et al. (1997), widespread brain dysfunction has been connected to ADHD. Recent studies have suggested that children with ADHD have impaired functioning in the cortical area, related to learning and thinking, and subcortical area, involved in sending messages to the processing and memory parts of the brain. In particular, the areas which are effected are the frontal and motor cortex, which play a role in impulsivity, motor activity and inattention, as well as the prefrontal cortex, which specializes in representative functions such as spatial representations and representations of rewards or motivators. Several other research groups have also reported that children with ADHD have a smaller frontal lobe and basal ganglia. These areas of the brain contain the neuroanatomical networks responsible for executive control and alerting (Swanson et al., 1998). Thus, abnormalities of these areas would show up in the behavioral functions of remaining alert, concentrating, and in control, without impulsive behaviors.
In addition, Ballard et al. (1997) also cited a study that have found increased slow-wave activity in the frontal regions upon analysis of electroencephalograms (EEGs) of ADHD children. According to Lazzaro et al. (1998), this could be interpreted as evidence of a delay in brain maturation of children with ADHD as well as a decrease in beta activity, which would be reflected in cortical hypoarousal. Mann et al. (1991) reported that topographic eletroencephalography studies confirmed previous studies that found an excess of theta activity and lack of alpha attention activity in children with attention disorders not related to another conduct disorder. This suggests that in children with ADHD there is underarousal of the neocortex. In the study performed by Mann et al. (1991) using topographic electroencephalography, children with ADHD increases in theta activity in frontal and central locations and decreased beta activity in the posterior and temporal locations. The differences in this brain wave activity, from the baseline activity, was much greater in the children with ADHD, compared to a control group, during times of performing cognitive tasks such as drawing and reading. In other words, during the times requiring concentration and focusing, there were increases in theta activity and a lack of beta activity in children with ADHD. These findings were supported by Lazzaro et al. (1998) who measured the EEG activity of adolescents with ADHD in a condition of rest with their eyes open. They found increased anterior theta activity with reduced posterior beta activity when compared to a control group. The results of this study demonstrate that there is a continuation in the delayed maturation of the brains of adolescents with ADHD.

Theta brain waves, which are found in excess in frontal regions of children with ADHD, are described as slow wave activity and have been linked to reduced metabolism
as well as blood flow (Fried, 1993). A study cited by Lazzaro et al. (1998) found that there was a lesser amount of metabolism occurring in the frontal lobe of ADHD when compared to a control group. He also cited a PET study that found a reduced amount of glucose metabolism in the left anterior frontal lobe of adolescents with ADHD when compared to a control group. These could all be reasons behind some of the brain dysfunctions found in children with ADHD. This knowledge from the studies of the EEGs of ADHD children leads to the ways in which we can use the alternative EEG treatment to lessen the effects of ADHD.

EEG Biofeedback Treatment

Basically, EEG Biofeedback as a treatment for ADHD is training the child with ADHD to “increase the type of brain-wave activity associated with sustained attention [alpha and beta waves] and to decrease the type of activity associated with daydreaming and distraction [theta waves]” (Goldstein and Ingersoll, 1993). EEG biofeedback treatment is used to improve attention while decreasing impulsivity and hyperactivity. The patient of EEG biofeedback is attached to an EEG machine that measures different involuntary bodily functions, such as the electrical activity in the brain, and in turn provides this information to the patient by first feeding it into a computer and then changing it into a signal such as a tone or light. The patient uses this information to gain control over brain-wave activity (Goldstein and Ingersoll, 1993). Reinforcement is used when the child appropriately increases the Beta-wave activity and decreases the theta-wave activity. The EEG training usually consists of 40-80 sessions, of forty or more minutes, 2 to 3 times a week. EEG training is sometimes accompanied by academic tutoring (Goldstein and Ingersoll, 1993).
History of EEG Biofeedback

Robbins (1998) wrote a historical review of biofeedback that indicated Barry Sterman, Ph.D. who did research with cats, founded EEG biofeedback in the 1970's. It was found that cats could be trained to control their brain waves in a study Sterman conducted, funded by the National Institutes of Health. According to Robbins (1998) "he then discovered that when he exposed those trained cats to toxic vapors that usually induce epileptic seizures, they had far fewer seizures than untrained cats" (p 44). Monkeys were used to replicate the same experiment. Using deep brain probes they found that physiological changes took place in neurons following the training. Sterman then conducted research on the most severe kind of epilepsy, refractory epilepsy, in humans. He was able to reduce the seizures by 60% in 60% of his patients. Joel Lubar was one of Sterman's researchers who did further EEG biofeedback research with ADD after he observed a decrease in hyperactivity of patients, treated for epilepsy, following the treatment. (Robbins, 1998)

Joel F. Lubar is the main player in the development of a successful technique in administering EEG treatment for ADHD. Lubar (1991) states one reason for helping to develop EEG biofeedback as a treatment for ADHD is because it's a problem that continues into adulthood. It is beneficial and important to help children with ADHD learn to gain control over their disorder in order to be the highest functioning adults they can.

Lubar (1991) relates that as early as 1938 researchers presented evidence of EEG abnormalities, specifically slowing in the EEG, of children with MBD (minimal brain dysfunction); MBD would later be divided into several different disorders such as
EEG Biofeedback 11

hyperkinetic disorder, learning disabilities, disorders of conduct, and disorders of attention. It is important to determine which disorder category a child falls into before treating them because these children will respond differently to EEG biofeedback treatment (Lubar, 1991). Lubar (1991) explains that children with pure ADHD respond positively to EEG biofeedback treatment as well as hyperkinetic children who have shown to respond well to stimulant medication; however, children with learning disabilities may not benefit as much from EEG biofeedback treatment.

According to Lubar (1991), in the early 1970's a hypothesis was formed by a group of researchers that children with hyperkinesis appeared to behave in a manner as if they were experiencing decreased sensory arousal, meaning that their sensory information did not have the reinforcement value that it should. These children would run around in a sort of frenzy trying to seek out sensory stimulation until they became so exhausted they would fall asleep. (p. 206) Lubar (1991) states that the dysfunction of these children would be reflected in disinhibition of the prefrontal lobes. By the 1970’s it was shown that stimulants would have the effect, on the hyperkinetic children, of becoming less hyperkinetic and showing improved concentration in the classroom (Lubar, 1991). Lubar (1991) felt there was a very simple explanation for why the hyperkinetic children act as they do. In another study he found that at rest, a person’s EEG activity is primarily in the alpha and theta range. Then, when this person becomes excited, the activity switches to the beta range above 14 Hz. In the early 1970’s, Lubar (1991) formed a hypothesis “that children with hyperactivity, especially where there was an attention deficit, might be less able to produce beta activity above 14 Hz, and
would be experiencing excessive slow activity primarily in the theta region of 4-8 Hz” (p. 207).

Early Successes with EEG Biofeedback Treatment

In one of his first experiments with biofeedback in 1976, Lubar (1991) and a colleague successfully trained an eight-year-old hyperkinetic child to produce sensorimotor rhythm (SMR), which helps inhibit motor activity, and inhibits theta wave activity. In order to prove that it was the treatment that was helping the child improve and not some outside influences, Lubar (1991) and his colleague reversed their treatment, after the initial treatment, so they were training the child to inhibit SMR and increase theta activity. Over the 35 sessions, the child regressed back to his initial levels of SMR and theta activity as well as a decreased school performance. Then they switched the child back to the initial treatment of increased SMR and inhibited theta activity for 28 sessions. The child did this successfully and once again improved in his school performance, which continued without medication. The child’s school performance proceeded to improve following the treatment and showed continued improvement when they did a follow up several years later. This study was groundbreaking in the development of EEG biofeedback as a treatment for ADHD. Linden, Habib, & Radojevic (1996) stated that “although this study was descriptive in nature and had a limited sample size and absence of appropriate control groups, it promoted the initial rationale and basic methodology for exploring EEG biofeedback as a potential treatment modality for ADD and LD children” (pg. 37). More recent studies continued to demonstrate the effectiveness of EEG biofeedback treatment.
Throughout the late 70s and early 80s, Lubar (1991) collected data on many patients and found that “not only did they learn to better control hyperkinetic behaviors with subsequent reduction of stimulant medications in many cases, but they also improved markedly in their ability to focus and concentrate. Many earned improved grades following SMR and beta training with theta and EMG inhibition” (p. 209). Other researchers have also seen the benefits of EEG biofeedback treatment for helping children with various disorders. For example, Michael Tansey and his colleagues have published a series of articles where they used SMR and beta training to help children with learning disabilities and hyperactivity (Lubar, 1991). Lubar gave us a specific history of the development of EEG biofeedback treatment, but it is also important to look at more current studies and developments.

Current Developments and Improvements in EEG Biofeedback Treatment

Although EEG biofeedback is still in the experimental stages, it appears that this form of treatment shows much promise for an alternative, and possibly even more effective, treatment for ADHD. Lubar (1991) feels the positive effects of EEG biofeedback are permanent if they are combined with continued academic training. The effects will become self-reinforcing as the child builds on the skills they have learned and subsequently continues to do better. Lubar (1997) explains that in assessments that occurred in patients ten years after the initial treatment, the greatest improvements seem to have occurred in the categories of overall attitude, general behavior, improved grades related to getting work done, and general relationships. According to Lubar (1997), “for
many of these individuals who are now adults, a much better overall adjustment occurred in the home and school settings and in the work place as well” (p. 123).

A follow up study by Tansey (1993) showed that a boy who received EEG biofeedback treatment at the age of 10 continued to show the positive benefits of the treatment ten years after it was administered. Initially the 10-year-old boy received 30 sessions of EEG biofeedback training. Before training he had been in a special education class since the second grade and had fallen a year behind in school. By his eighth training session he was showing so much improvement that he was moved into a normal fourth grade class. He was medication free and no longer hyperactive. He showed normal functioning within a classroom setting with improved grades over a two-year period. Ten years after the treatment “this young man continues to succeed academically and personally as he did all through grade school, junior high and high school, was voted to a position of honor and responsibility in high school, and has currently earned a 2.50 grade point average last semester in college” (p. 36-37).

Other researchers that have continued with their own studies of the effectiveness of EEG biofeedback treatment for children with ADHD tend to agree that previous studies were beneficial in clarifying some of the mechanisms underlying ADD and ADHD, and have showed much promise for the benefits of continued development of EEG biofeedback treatment. However, according to Linden et al. (1996) “all the previous studies of EEG biofeedback treatment lack appropriate control groups, the use of standard protocols for training, and evaluation of EEG biofeedback as an independent treatment component. Finally, the majority of previous research suffers from small sample sizes.” (p. 38-39)
Because of the perceived lack of organization, small sample sizes, and lack of control, Linden et al. (1996) undertook a larger controlled study of the effects of EEG biofeedback treatment on children with ADHD, as well as some with LD. The objectives of their study was to compare the results of the EEG biofeedback treatment of children with ADHD and LD with a control group which received no treatment, control the amount of sessions, and to use the methodology gained from previous research to administer and measure the treatment in a similar manner. They used eighteen children all with ADD/ADHD; six also had been diagnosed with LD. They used a variety of tools to measure the subjects pre and post treatment including a family history, parent and teacher behavior rating scales, a family interview, a developmental history, and intelligence and achievement tests. The subjects were randomly divided into two groups, one undergoing 40 sessions of the EEG biofeedback treatment and the other receiving no treatment. None of the subjects were taking any medications or participating in other treatment for the duration of the study.

According to Linden et al. (1996) the first subject group attended sessions two days a week, after school or on the weekends. The sessions were 45 minutes long, broken down into three 10 minute sessions; one consisted of attending to auditory and visual feedback with eyes open, the other was a biofeedback session during a reading task, and the last biofeedback session was during an auditory task. The children were to become aware of their own brainwave activity and develop strategies to achieve the most reinforcement. The treatment attempted to decrease theta activity and increase beta activity on the EEG. Reinforcement in the form of tones and beeps for auditory stimulation and points, graphs, or movements on a game for visual stimulation were
given when the subject was able to make the beta amplitude go above its threshold while making the theta amplitude and EMG (muscle artifact) go below its threshold. At the end of each training session the subjects were given small rewards, like stickers or baseball cards, depending on the performance, effort, and cooperation.

The results of the study by Linden et al. (1996) showed an average increase of nine points in IQ for the group that received the biofeedback treatment over the control. The inattentive behaviors for the treatment group decreased at posttreatment. There were no significant differences in the defiant/aggressive behaviors at posttreatment. While the hyperactive behaviors were not statistically different for either group, the group that received the treatment had reduced their hyperactive behaviors to below the cutoff for a finding of hyperactivity in the child's behavior. The results of this study were consistent with those of previous studies and also seemed to have successfully demonstrated an improved methodology by using a control group, larger sample size, and a consistent number of treatment sessions for all the subjects receiving it. More controlled studies with larger sample sizes will be necessary before the benefits of EEG biofeedback treatment will be truly validated by the medical community.

Another study conducted by Cartozzo, Jacobs, & Gevirtz (1995) showed similar results to the Linden et al. (1996) study. In the Cartozzo et al. (1995) study it was hypothesized that the ADHD subjects who were treated with EEG biofeedback treatment would increase their SMR amplitudes and decrease their theta amplitudes in comparison to their own pretreatment baselines and control group, as well as show an increase in attention span and a decrease in hyperactivity when compared to a control group. 15 male subjects who had been diagnosed with ADHD were used. The subjects were
pretested drug-free. These subjects were then divided into two groups, eight who received the EEG biofeedback treatment while the other seven were the control group. The feedback of this study consisted of a Pac-Man video game “which encoded the feedback signal in terms of its brightness and velocity through a maze” (Othmer, Kaiser & Othmer, 1995). 30 sessions were given twice weekly. The sessions were 45 minutes long with an object of the subjects decreasing their theta amplitude and increasing their SMR amplitude. According to Cartozzo et al. (1995) “a token economy served as reinforcement for on task behavior” (p. 22). The control group played the conventional Pac-Man video game manually for 45 minutes for 30 sessions during the study. At the end of the 30 sessions, both groups were tested.

The results of this study showed that the treatment group showed a decrease in their theta amplitude as a result of the treatment and the control group showed an increase in their theta amplitude. There were no significant changes in the SMR for either group. T.O.V.A. and WISC-R subtests showed a significant increase in attention span for the treatment group but not for the control group. However, there was also improved attention and a decrease in hyperactivity in the control group. This study helps to give evidence that “lowering theta amplitude increases arousal and the capacity to sustain attention.” (Cartozzo et al., 1995, p. 23) According to Othmer et al. (1995), improvement in the scores of the study by Cartozzo et al. (1995) “can be interpreted in terms of improvement in the continuity of mental processing, in working memory, and in the ability to sustain attentional focus.” This study was criticized by Othmer et al. (1995) for using a single protocol that allowed some children to improve while others would not.
A paper published by Lubar (1997) attempted to explain some of the neocortical dynamics behind neurofeedback and how “the relationship between the cortex, thalamus, and brain stem are influenced by neurofeedback” and determine the different EEG frequencies (p. 111-112). Lubar (1997) explains that the different EEG frequencies are determined by the different resonant loops that occur within the cortex. He explained that pacemaker cells in the thalamus determine these EEG frequencies. There are different inhibitory and excitatory interactions between the cells of the cortex as well as the cortex and thalamus which “allow the loops to operate and provide the basis for learning” (Lubar, 1997). Lubar (1997) suggests that neurofeedback can interact with and modify these loops and thus modify learning as well as manage different neurologically based disorders, such as ADHD. (p. 111)

Lubar (1997) provides two theories to explain how EEG arises. One suggests that the EEG frequencies arise from intracortical loops and that 97% of the brain’s activity that is recorded as EEG originates within the cortex. However, it is also known that the cortex is affected by pacemaker cells found in the thalamus. When “these pacemakers fire they produce rhythms that we pick up as the EEG on the surface” (Lubar, 1997, p. 114). Lubar (1997) clarifies that the cortex operates in terms of three different kinds of resonance loops that can operate on their own or be driven by the thalamic pacemakers. The local resonance loops, which occur between columns of cells close together, are responsible for very high frequency EEG, such as gamma. The regional resonance loops, which occur between columns of cells that are a little further apart, are responsible for the EEG frequencies of alpha and some beta activity, which are the frequencies that are being increased during EEG biofeedback treatment of children with ADHD. The global
resonance loops, which occur between widely separated areas such as the frontal-occipital regions or frontal-parietal regions, are responsible for the frequencies in the delta and theta range, which are the frequencies that are being decreased during EEG biofeedback treatment of children with ADHD. Lubar (1997) expresses that the firing rate of the thalamic pacemakers, which produce the different brain rhythms, can change and activate changes in the cortical loops as a result of neurofeedback and learning. In other words, neurofeedback can change the intrinsic firing pattern of the pacemaker cells on the cortical loops, which may manifest itself in a change in behavior such as reduced hyperactivity and increased attention span.

Lubar (1997) suggests another effect of neurofeedback. He explains that neurofeedback could possibly alter the effects of different neuromodulators, such as serotonin, acetylcholine, norepinephrine, and dopamine, and thus alter the relationship between the different resonant loops and the levels of these neuromodulators. Increases in serotonin cause hypercoupling, which effect the global resonance loops that control theta and delta activity. In addition, increases in dopamine, norepinephrine, and acetylcholine produce hypocoupling, which affect the regional and local loops, which are responsible for the higher EEG frequencies such as alpha, beta, and gamma. Excessive hypercoupling leads to decreased attention and inadequate functioning while hypocoupling may be very important for increased attention and complex mental activity (Lubar, 1997). Because of this phenomena Lubar (1997) suggests that “we employ neurofeedback to train people to produce activity in this range that may be associated with better learning and better attentive mechanisms” (p. 118). Lubar (1997) concludes his article by pointing out that more studies need to be done to determine the effects of
neurofeedback on cerebral metabolism. He proposes that if neurofeedback can be proven to alter cerebral metabolism then all the tables will turn and it will become the main treatment for attention disorders whereas all other treatments and approaches, including medications, will become the alternative.

Two Current Studies Analyzed for this Paper

A thorough review of EEG biofeedback implicated a need for more data and research, which could be done locally, to demonstrate the beneficial effects of EEG biofeedback treatment. Therefore, two separate studies were conducted, using data from the pre and post testing of the treatment sessions, on children being treated for ADHD with EEG biofeedback at St. Peter’s Hospital in Helena, MT. The first study is data collected from one boy being treated for ADHD. The second study is more extensive and uses data collected from five children being treated for ADHD in order to determine the effectiveness of EEG biofeedback. It is important to note that the child used in the individual case is also a subject in the second study. This was necessary due to a lack of subjects available who had finished all their treatment sessions.

Study 1: Efficacy of EEG Biofeedback Treatment in an Individual Case

Methods. Data were collected from an 8-year-old boy with ADHD who had participated in 40 sessions of EEG Biofeedback. Data collected included results from a series of tests given before treatment, in the middle of the treatment (after 20 sessions), and at the end of treatment (after 40 sessions). Tests to be given at each of the 3 different treatment intervals are as follow: Attention Deficit Disorders (ADD) Evaluation Scale-
home and school versions, ADHD Rating Scale IV- home and school versions, Child
Behavior Checklist for boys ages 4 to 18- administered to parent and teacher, Wide
Range Assessment of Memory and Learning (WRAML), WISC-R Digit Span, Electric
Finger Tapping Test, and Grooved pegboard test. The results of these tests according to
the interval given can be found on Table 2. This thesis evaluates results from: ADHD
Rating Scale IV- home version, ADD Evaluation Scale- home version, Child Behavior
Checklist (CBCL)- home version, WRAML, and WISC-R Digit Span.

Results. **ADHD Rating Scale IV- Home Version** test consists of 18 characteristics
similar to those described in the criteria of diagnosing ADHD in the DSM-III. The
characteristics are ranked into categories regarding how often they occur; never or rarely
(0), sometimes (1), often (2), or very often (3). During pre-testing of the patient, all 18
characteristics were described by the parents as happening often or very often, giving a
total score of 40. After 20 sessions of the EEG biofeedback treatment, all but one of the
characteristics still persisted, but none fell into the very often category; all were in the
sometimes or often categories giving a total score of 22. The results remained the same
after another 20 sessions of treatment or after a total of 40 sessions (Table 3). The mean
score and standard deviation for this test were not available. See figure 1 for a graph of
the results over time.
Table 2: Test Results Before, After 20 Sessions, and At the End of Treatment

<table>
<thead>
<tr>
<th>Tests</th>
<th>Pre-treatment</th>
<th>Middle of Treatment (20 sessions)</th>
<th>Post-treatment (40 sessions)</th>
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</thead>
<tbody>
<tr>
<td>ADD Evaluation Scale- School:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattentive</td>
<td>9</td>
<td>7</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>Impulsive</td>
<td>10</td>
<td>7</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>Hyperactive</td>
<td>10</td>
<td>7</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>ADHD Rating Scale IV- Home</td>
<td>40</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>ADHD Rating Scale IV- School</td>
<td></td>
<td>34</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>ADD Evaluation Scale- Home:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattentive</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Hyperactive-Impulsive</td>
<td>6</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>CBCL/4-18- Problem Scales (Home):</td>
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<td></td>
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<tr>
<td>T score- Withdrawn</td>
<td>79</td>
<td>67</td>
<td>67</td>
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<tr>
<td>T score- Somatic Complaints</td>
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<td></td>
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<tr>
<td>T score- Anxious/Depressed</td>
<td>64</td>
<td>58</td>
<td>53</td>
</tr>
<tr>
<td>T score- Social Problems</td>
<td>80</td>
<td>73</td>
<td>68</td>
</tr>
<tr>
<td>T score- Thought Problems</td>
<td>70</td>
<td>70</td>
<td>73</td>
</tr>
<tr>
<td>T score- Attention Problems</td>
<td>86</td>
<td>67</td>
<td>69</td>
</tr>
<tr>
<td>T score- Delinquent Behavior</td>
<td>59</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>T score- Aggressive Behavior</td>
<td>82</td>
<td>69</td>
<td>69</td>
</tr>
<tr>
<td>TRF- Problem Scales (School):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T score- Withdrawn</td>
<td>51</td>
<td>51</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Somatic Complaints</td>
<td></td>
<td>64</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Anxious/Depressed</td>
<td>51</td>
<td>50</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Social Problems</td>
<td>57</td>
<td>59</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Thought Problems</td>
<td>75</td>
<td>75</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Attention Problems</td>
<td>70</td>
<td>64</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Delinquent Behavior</td>
<td>60</td>
<td>57</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>T score- Aggressive Behavior</td>
<td>61</td>
<td>52</td>
<td>(unavailable- summer)</td>
</tr>
<tr>
<td>WRAML- Examiner Form</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal Memory Index (Sum)</td>
<td>20</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Story Memory</td>
<td>11</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Sentence Memory</td>
<td>5</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Number/Letter</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Visual Memory Index (Sum)</td>
<td>14</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Picture Memory</td>
<td>8</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Design Memory</td>
<td>5</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Finger Windows</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Learning Index (Sum)</td>
<td>18</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Verbal Learning</td>
<td>16</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Sound Symbol</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Visual Learning</td>
<td>13</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Electric Finger Tapping Test:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Hand</td>
<td>21.3</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>Left Hand</td>
<td>20.3</td>
<td>26.67</td>
<td>34.5</td>
</tr>
<tr>
<td>WISC-R Digit Span</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
ADD Evaluation Scale - Home Version-- According to McCamey (1995) the ADD Evaluation Scale was designed for gathering information from the child’s primary settings, such as home and school, in order to help diagnosis ADD/ADHD. The people who are given these tests should be people familiar with the child's behavior patterns, such as a parent, teacher, counselor, etc. These people must observe the child on a regular basis. The parents were chosen to be given this test. The results of the test over time are depicted in figure 2.

The standard scores were found by adding all raw scores from the subscales under the categories of Inattentive and Hyperactive/Impulsive. The standard scores have a mean of 10 with a standard deviation of 3. Scores of 7-13 are considered average while
scores of 6 or below and 13 or above are atypical. A score of more than one standard deviation below the mean indicates the behavior demonstrated was “far more inappropriate than the majority of an extremely heterogeneous population of students who represent a racially, ethnically, intellectually, and socioeconomically divergent group” (McCarnery, 1995, p. 33).

Table 4: ADD Evaluation

<table>
<thead>
<tr>
<th>Scale-Home:</th>
<th>Pre-treatment (0 sessions)</th>
<th>Middle of Treatment (20 sessions)</th>
<th>Post-treatment (40 sessions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattentive</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Hyperactive-Impulsive</td>
<td>6</td>
<td>4</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 2

ADD Evaluation Scale-Home

Child Behavior Checklist (4-18)-Home Version measures eight different problem behaviors and scales these behaviors into a normal and atypical range. The eight problem behaviors measured include: withdrawn, somatic complaints, anxious/depressed, social problems, thought problems, attention problems, delinquent problems, and aggressive
problems. T-scores were used to scale the test. According to Janda (1998), the mean of the T-score is 50 with a standard deviation of 10. According to the CBCL a T-score more than 2 standard deviations from the mean (a score of 70 or more) is considered atypical while anything below 70 is within the normal range. The categories that the patient was in the atypical range before treatment include withdrawn, social problems, attention problems, and aggressive behavior; he was borderline on thought problems. After 20 sessions, he had shown to fall into the normal range of all the problem categories except the social problems and was again borderline on the thought problems. After 40 sessions of treatment he was in the normal range with all problem categories except the thought problems. A complete graph of these categories over time follows in figure 3.

Table 5: CBCL/4-18- Problem Scales (Home):

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-treatment (0 sessions)</th>
<th>Middle of Treatment (20 sessions)</th>
<th>Post-treatment (40 sessions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdrawn</td>
<td>79</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>Anxious/Depressed</td>
<td>64</td>
<td>58</td>
<td>53</td>
</tr>
<tr>
<td>Social Problems</td>
<td>80</td>
<td>73</td>
<td>68</td>
</tr>
<tr>
<td>Thought Problems</td>
<td>70</td>
<td>70</td>
<td>73</td>
</tr>
<tr>
<td>Attention Problems</td>
<td>86</td>
<td>67</td>
<td>69</td>
</tr>
<tr>
<td>Delinquent Behavior</td>
<td>59</td>
<td>63</td>
<td>63</td>
</tr>
<tr>
<td>Aggressive Behavior</td>
<td>82</td>
<td>69</td>
<td>69</td>
</tr>
</tbody>
</table>
WRAML subtests work much like the WISC-R subtests in that they have a mean of 10 with a standard deviation of 3. The Visual Memory Index showed the lowest category of scores by this patient and remained that way all through treatment; although they did improve greatly by the end of treatment with little or no improvement in the other two major categories, Verbal Memory Index, and Learning Index. Table 6 and figure 4 show the sums of the Verbal Memory Index, Visual Memory Index, and Learning Index over the time span of the treatment.
Table 6: WRAML- Examiner Form:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-treatment (0 sessions)</th>
<th>Middle of Treatment (20 sessions)</th>
<th>Post-treatment (40 sessions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal Memory Index (Sum)</td>
<td>20</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Story Memory</td>
<td>11</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Sentence Memory</td>
<td>5</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Number/Letter</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Visual Memory Index (Sum)</td>
<td>14</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Picture Memory</td>
<td>8</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Design Memory</td>
<td>5</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Finger Windows</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Learning Index (Sum)</td>
<td>18</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Verbal Learning</td>
<td>16</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Sound Symbol</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Visual Learning</td>
<td>13</td>
<td>15</td>
<td>11</td>
</tr>
</tbody>
</table>

Figure 4

![WRAML Graph](image-url)
**WISC-R Digit Span** is a subtest of the WISC-R intelligence test. It has a mean of 10 and a standard deviation of 3. This patient falls below the mean but is not considered statistically significant. A graph of the results over the span of the sessions follows.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-treatment (0 sessions)</th>
<th>Middle of Treatment (20 sessions)</th>
<th>Post-treatment (40 sessions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digit Span</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 5

**Discussion.** With only one subject for this study, it is impossible to do any sort of statistical analysis. For this patient however, the ADHD Rating Scale IV- Home version test does show a dramatic and persistent decline in the characteristic behaviors of ADHD after receiving the EEG biofeedback treatment. This drop in the ADHD characteristics could be caused by the EEG biofeedback treatment, which indicates it worked for this patient. According to the CBCL/4-18- Problem Scales (Home) test, the treatment appears
to have been a success. The patient went from being in the atypical range, for all characteristics but two, before the treatment to being within the normal range, in all but one category, by the end of the treatment. The WRAML test showed that the Visual Memory Index had the most improvement throughout the treatment sessions. This could be interpreted to imply that visual memory skills were most influenced by the Attention Deficit Disorder and that is why they improved the most throughout the treatment sessions. WISC-R Digit Span test showed the least improvement over the time span of the treatment sessions, it even declined which could be related to testing error so it may actually have remained consistent throughout the treatment.

Although there was only a slight change in the numbers for the different tests throughout the duration of the treatment sessions, it appears that the EEG biofeedback treatment was a success in helping this patient elevate the effects of the Attention Deficit Hyperactivity Disorder. It is hard to tell by just looking at numbers how much the treatment may have helped the home and school life of the patient. That is why further interviews, after the cessation of the treatments, are suggested in order to assess the full effects of the treatment. Such interviews may help the technicians and researchers obtain suggestions on how to improve the treatment and continue developing better techniques for administration.

Study 2: A Study of ADHD patients receiving EEG Biofeedback Treatment

Methods. In a personal interview, Bernadette Pedersen, the technician trained to administer the EEG treatment, described the protocol administered to the five subjects in study 2. The type of treatment used is called Beta SMR training. This trains the child to
let go of everything and relax while maintaining a concentrated and alert state. The sessions run 30-45 minutes in length. This treatment is very similar to what was previously described in this paper. The child is hooked up to three electrodes, one on the surface of the head exterior to the right temporal lobe and one electrode on each ear, while they are seated in a reclining chair in front of a computer screen. The technician monitors the brainwaves from another computer monitor behind the patient. The purpose of the treatment is to encourage Beta waves ranging from 12-18 Hz. and discourage theta waves (4-7 Hz.) and high beta waves (20-30 Hz.).

The treatment is performed in the form of an island computer game. It appears that the patient is traveling in a boat, facing the wake in the water with a green bar in front. There are also two colored boxes in each corner at the bottom of the screen; one is purple and the other yellow. The green bar in front of the wake represents the beta waves ranging from 15-18 Hz. and will increase in size, across the screen, as the child increases the amount of these brain waves. The yellow box in the bottom right-hand corner represents the amount of muscle tension. The purple box at the left-hand corner of the bottom of the screen represents theta waves and will decrease in size as the child decreases these brain waves. The child scores points as they increase beta waves and decrease theta waves.

The computer feeds back visual, auditory, and tactile reinforcements. The auditory reinforcements are in the form of beeps after each point is earned. Visual reinforcements are in the form of dashes forming on the wake, birds flying in the sky, and after earning 500 points the volcano, in the background, explodes with balloons. Tactile reinforcement is given through a cushion attached to the computer that vibrates after a set
number of points. The child can hold this in their lab or lean against it in the chair. In addition, the technician, Bernadette, also gives pennies for scoring lots of points and beeps. After the child has earned $.25 they can buy a toy from her.

In addition to the highway game there is also a highway game they use where a comet flies through the sky after the child has earned 500 points. There is also a Pac-Man and simple bar game with just the colored boxes representing the different types of brain waves. These are just some examples of how this treatment is currently being used.

Results. The complete results of the treatment for these five subjects can be found on table 8. Two sets of t-tests were used to evaluate the subjects test results: one set of t-tests for the results between pre-testing and testing in the middle of the treatment (after 20 sessions), and the other set of t-tests between testing in the middle of the treatment and post-testing (after 40 sessions). The t-tests were run for each test and their sub-tests, if there was one.

The t-tests for the first set of results (0-20 sessions), except the WRAML test, only included the first, third, fourth and fifth subjects. The second subject did not have a complete set of pre-testing scores. The WRAML t-tests (for 0-20 sessions) included the first, second, fourth, and fifth subjects only because the third subject did not have pre-test results. There were four t-tests that were significant for the 0-20 session t-tests. The inattentive sub-test of the ADD Evaluation Scale- school had a t statistic of 9 (P < .003). The ADHD Rating Scale IV-Home had a t statistic of 3.239 (P < .048). The attention problems sub-test of the CBCL/4-18 (Home) had a t statistic of 5.513 (P< .012). The aggressive behavior sub-test of the CBCL/4-18 (Home) had a t statistic of 3.489 (P < .04).
Table 8: Test Results of EEG Biofeedback Study

<table>
<thead>
<tr>
<th>Test</th>
<th>Pre-Treatment</th>
<th>Middle of Treatment</th>
<th>Post-Treatment</th>
<th>(40+ sessions)</th>
<th>(20 sessions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WRAI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WISC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GROB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results:

- Indicates patient had received more than 40 sessions at time tests tabulated.
T-tests for the second set of results (20-40 sessions) were only evaluated on the second, third, and fourth subjects for the school scales and on the first, second, and fifth subjects for the home scales. The WRAML t-tests used all five subjects. The reason for this difficulty is the first subject was on summer break during the completion of the 40 sessions so the school was not able to do the scales. The parents of the third and fourth subjects did not fill out the scales for post-treatment (40 sessions). The fifth subject did not get his school scales filled out for post-treatment because his teacher was on maternity leave. There was only one t-test that was significant for the 20-40 sessions t-tests. The test that was significant was the visual memory index with a t-score of -3.06 (P < .038).

Discussion. This study was full of problems; the main problem being that not all the rating scales for each subject was available for all three treatment points. Instead of being a study of five subjects it ended up being a study of three or four subjects on most of the levels of behavior scales. It was hard to control for the environment in which the subjects received the treatment because the treatment is so individually oriented. A more extensive study, in which there were more subjects and the parents and teachers were more willing to carry out their part by filling out the scales each time they were given, would be more helpful.

The subjects of this study did show significant improvement over the first 20 sessions on the behavior scales that depict one of the most distinguishing characteristic of ADHD- attention. They improved significantly on their attention at home, and overall, as well as their inattentive behaviors at school and aggression. After the next 20 sessions, the subjects did not show any additional significant improvements, except on the visual
memory index. The reason for lack of additional improvement could simply be do to error in the study or because fewer subjects were used when doing the statistical analysis. This lack of improvement could also demonstrate that most of the learning took place during the first 20 sessions and these skills were then being reinforced and fine-tuned over the next 20 sessions. The fact that the visual memory index was the only scale that had significantly improved between 20 and 40 sessions could be because the treatment was mostly visual.

EEG Biofeedback Treatment vs. Drug Treatment

The results from the previous two studies, although limited, support the findings of Lubar, and other researchers, that EEG treatment is a beneficial alternative to drug therapy. There are some researchers and doctors who would say that EEG biofeedback treatment is not a proven method for treatment. Rather, drug treatments, particularly Ritalin, still offer the best results when treating ADHD. However, in the words of Linden (1996), “the use of stimulant medications such as methylphenidate (Ritalin) is the most common treatment for ADD even though its effects are temporary (e.g., the half-life of Ritalin is approximately four hours). Furthermore, numerous side effects of Ritalin, such as loss of appetite, inhibited growth, insomnia, depression, and motor tics are common” (p. 36). Although stimulants, such as Ritalin have been useful in improving attention span, hyperactivity, and academic performance of children with ADHD, it is not the best answer for treating ADHD. It is effective only if you want a few hours of reduced hyperactivity, but it offers no long-term results. EEG biofeedback treatment, on the other hand, has been shown over and over to offer permanent, long-
lasting results after only a few sessions lasting a few weeks with no need for further medication.

If parents considering using a drug therapy program, they must first be warned of the numerous side effects of stimulant drugs and then decide if their child’s health and well-being is worth the risk. According to Sood, Wood, Ellis, Burns, & Singh (1993) some of the short term side effects of stimulant medication include insomnia, decreased appetite, and decreased body weight. These side effects are possible using moderate and even low doses of a stimulant drug. Other side effects may include nervousness, hypersensitivity, anorexia, dizziness, nausea, drowsiness, blood pressure changes, tachycardia (fast heart beat), and cardiac arrhythmias (Bawden, 1993). 33% of children treated with stimulant drugs for ADHD have been shown to suffer from headaches and stomach upsets; another 1% suffer from tics and if the tics preexist before medication, it can be made worse by stimulant drugs (Sood et al., 1993). In addition, rebound of the behaviors present before the stimulant medication was administered has occurred in some children (Sood et al., 1993). According to Bawden (1993), “there may be effects on the child’s self-esteem or self image from chronically taking medication” (p. 61). Perhaps one of the most serious long-term side effects that have been found is the stunting of growth; however, there appears to be a compensatory growth spurt which occurs after the medication is terminated so the final height of the child is not effected (Sood et al., 1993). Even though the child may reach their full height after they are taken off the medication, they still have to live with the effects of the disorder. Ultimately, the parent must decide if the temporary results of the medication are worth their child suffering through all these side effects.
A study conducted by Potashkin & Beckles (1990) compared the use of Ritalin to treat children with ADHD to the use of a biofeedback-assisted relaxation program to see which yielded the most improvement. A control group of children who received sessions of personal contact and attention was also used. The study, which took place over a six week period, consisted of 18 male subjects, between the ages of 10 and 13, divided into three groups of six. One group received the Ritalin treatment, another received the biofeedback treatment in 10 half-hour sessions over the six week period, and the third group was the control group who were seen for 10 half-hour sessions over the six week period. All subjects were pretested on an electromyograph to measure their levels of tenseness as well as given three different rating scales to measure the levels of ADHD. The Ritalin group was seen by a physician and prescribed the appropriate doses. The biofeedback group was taught a relaxation procedure to do using the biofeedback machine and also given a relaxation exercise to do outside the biofeedback treatments. The control group spent their sessions with a research assistant playing games that allowed for the subjects to show gradual mastery of the games. After the six week study the subjects were again tested on the EMG and using the different rating scales.

(Potashkin & Beckles, 1990,)

According to Potashkin & Beckles (1990), the results of the study showed that “only the biofeedback group improved significantly from pretest to the end of the study on the EMG measure” (p.309). Potashkin & Beckles (1990) reported that all three groups showed improvement on one of the rating scales but more subjects in the biofeedback group were able to reduce their hyperactivity to within the normal range (p.310). “The muscle tension levels of hyperactive children are higher than those found in normal
children" (Potashkin & Beckles, 1990). After the study, it was found that only the biofeedback group was able to sit still without the level of muscle tension found in the other two groups (Potashkin & Beckles, 1990). Furthermore, Potashkin & Beckles (1990) found that the muscle tension of the Ritalin group was the same as it was at pre-testing. The control group was also unable to relax and reduce muscle tension suggesting that the personal attention had no effect on relaxation. This study shows evidence that the effects of a biofeedback treatment can offer better results than a drug treatment program.

Educating parents about the alternatives to treatment, rather than just immediately placing the child on a drug therapy program, is the responsibility of the doctors. Often parents may decide that they do not want their children to become dependent on drugs at such an early age and don’t want them to experience the side effects of the drug therapy programs. Some parents may prefer EEG biofeedback and are more willing to try a new, promising and effective treatment. Although EEG biofeedback requires more time to complete, it offers longer lasting results and more importantly, no side effects. Parents who are willing to try a new approach that may help their child become as functional a person as possible will choose EEG biofeedback treatment. However, parents who are not as willing to experiment with different approaches will rely on what is easiest and most convenient by using drug therapy.

Other Uses of EEG Biofeedback Treatment

So far, EEG biofeedback has only been discussed as a treatment for ADHD. However, the applications of EEG biofeedback are virtually endless. According to
Robbins (1998), other applications of EEG biofeedback include epilepsy, closed head injuries, substance abuse, post-traumatic-stress-disorder, sleep disorders, Tourette’s syndrome, autism, depression, PMS, teeth grinding, migraines, insomnia, strokes, menopause, chronic pain, and others. The applications that have received the most attention so far include epilepsy, ADD, and closed head injuries where a number of studies have been done to show that EEG biofeedback is an effective treatment for each of these medical problems (Robbins, 1998). According to Robbins (1998), “the treatment of epilepsy is the most established of the protocols for neurofeedback” (p. 44). He indicates that there has also been further research that showed positive results in EEG biofeedback helping Tourette’s syndrome and post-traumatic-stress-disorder. In addition, individual case studies have been done on numerous other applications which show positive results; however, no major control studies have been done on them.

Much clinical work has been done in using EEG biofeedback to help treat brain injuries. There is clinical evidence accumulating that demonstrates “the effectiveness of EEG biofeedback training as an adjunct modality for remediating the symptoms of minor closed head injury (EEG Spectrum, Nov. 1995). The symptoms of head injury include short-term memory loss, mood swings and irritability, headaches, confusion, blurred vision, and nausea. There is no drug treatment for head injuries and recovery generally takes place on its own within two years of the injury. (Robbins, 1998) The November issue of EEG Spectrum states, “we have been able to restore to productive life a number of individuals who had been totally disabled for a number of years due to head injury. The training is not always that effective. However, essentially everyone who undertakes the training for head injury derives significant benefit.” They indicate that the training
EEG Biofeedback requires at least ten sessions, possibly taking anywhere from 24 to more than 100 sessions to get a significant recovery, and the gains made appear to hold in the long term (EEG Spectrum, Nov. 1995). Robbins (1998) described a three-year study that consisted of 60 head injury patients who had shown no improvement after the two-year recovery period. They were able to teach 80% of the patients to do the biofeedback treatments. Of these there was a 75% reduction in their symptoms.

In addition to the applications for EEG biofeedback discussed, there have also been studies done on the effects of biofeedback treatment on Generalized Anxiety Disorder (GAD). In a study by Rice, Blanchard, and Purcell (1993), they sought out to test three hypotheses by using five groups of patients with GAD, or at least half of the symptoms of GAD. The first group consisted of nine subjects receiving frontal EMG biofeedback. The second group consisted of nine subjects receiving EEG alpha biofeedback to increase alpha in EEG. The third group consisted of nine subjects receiving EEG alpha suppression biofeedback. The fourth group was a placebo control group, consisting of nine subjects, which were taught meditation techniques to relax. Finally, the fifth group consisted of nine wait-listed subjects. The three hypotheses tested included:

1. All treated groups will show more reduction in self-reported anxiety and physiological arousal than the waiting list controls.
2. The three biofeedback groups will show more reduction in anxiety and physiological arousal than the pseudomeditation group.
3. The frontal EMG biofeedback group will show more reduction in physiological arousal than the two alpha biofeedback groups; however, the
three biofeedback groups will not differ in reduction of self-reported anxiety.

(Rice et al., 1993, p. 94)

The results of this study are not statistically significant between the treatment groups; however, all treated groups seemed to show improvement on the self-report and symptom checklist measures. Rice et al. (1993) stated that “one could interpret these results as showing that whatever one does to individuals with GAD, if it is a credible treatment (or ritual), they will report being less anxious after it has been completed and these results persist at least for six weeks” (p. 103). Although the data for this study were not what the researchers had hoped for, it does demonstrate that EEG biofeedback works for treating GAD.

All the applications for EEG biofeedback treatment discussed in this section are just as useful as the treatment for ADHD. The wide variety of ways EEG biofeedback can be used shows what an effective and useful tool it is. Hospitals and clinics would only have to pay for one set of EEG equipment in order to treat a wide variety of patients.

Conclusion

The effects of the onset of ADD or ADHD at a young age can greatly interfere with the educational and social development of a child. If not treated when young, the child can grow into an adult with more severe and dysfunctional problems. EEG biofeedback treatment appears to offer better and more permanent effects than the traditional drug therapies. EEG biofeedback has no side effects and it is a short-term treatment; it can be given over a relatively short period of time and have long-term effects. There is no need to make sure the next dose is given on time. Training the
patient to self-regulate their brain activity can give them more of a sense of control over their disorder and life, and can therefore be reinforcing. EEG biofeedback treatment also offers an alternative to parents who don’t like the idea of their child depending on a chemical drug for the rest of their lives in order to remain functional.

The testing and experimentation necessary to make EEG biofeedback acceptable as a form of treatment in the medical community are still unfinished. Many refinements on techniques must be made. There are many political obstacles to overcome before it becomes widespread. The data from the case presented in this paper may be one example. Even though the overall improvement of the patient was not dramatic, there was improvement and this may be enough to mend the anxiety of a couple of parents and teachers. It is also hard to say what impact the improvement of a few numbers may have on people’s lives. These data were also inconclusive since a full range of scores from both the home and school setting was not available. The five subject study showed some significant improvements in the attention of the subjects over the first 20 sessions. However, this improvement appeared to level out over the next 20 sessions. The future of EEG biofeedback holds many exciting changes. The day will come when all the testing and controlled studies are done and doctors, counselors, and psychologists will wonder why they ever doubted its effects.
References


