Neurofeedback Treatment of Two Children with Learning, Attention, Mood, Social, and Developmental Deficits

Edward H. Jacobs, PhD

ABSTRACT. *Background.* Neurofeedback is biofeedback training of EEG activity through an operant conditioning process by which the individual is trained to increase or inhibit the brain's production of electrical activity in specific frequency ranges. Studies have demonstrated efficacy with a variety of disorders, including attention deficit hyperactivity disorder (ADHD), learning problems, and autistic features. This paper describes the application of neurofeedback in a clinical setting with two complex children who manifested multiple diagnoses, including learning disabilities (LD), ADHD, social deficits, mood disorders, and pervasive developmental disorder (PDD). Both boys had adjusted poorly to school, family, and peers.

Methods. Subjects were referred to the author's clinical practice. They received individualized protocols based on their symptoms and functional impairments. They were administered semi-weekly 20-minute sessions of one-channel neurofeedback training for approximately six months. In both cases symptoms were identified and tracked with a parent rating scale and one case, with the Symptom Assessment–45 Questionnaire (SA-45) also.

Edward H. Jacobs is affiliated with Edward Jacobs, PhD and Associates.

Address correspondence to: Edward H. Jacobs, 12 Parmenter Road, Londonderry, NH 03053 (E-mail: EHJPsych@aol.com).

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Results. Each boy improved in all tracked symptoms without adverse effects. One improved on most measures of the SA-45 with no deterioration on any measure. Functional improvements in academic functioning, home behavior, and peer relationships were indicated.

Conclusions. Neurofeedback was a successful treatment for these two multi-symptomatic and diagnosed boys, whose improvements surpassed the gains made with previous therapies. The advantages of neurofeedback include the relative absence of observable adverse effects, the lack of reliance on medication with its possible side effects and noncompliance, and the possibility of long-term gains without continued intervention.

KEYWORDS. Neurofeedback, ADHD, learning disabilities, mood disorders, social deficits, autism

BACKGROUND

Neurofeedback seems to help the central nervous system more adaptively regulate its states of arousal, alertness, and emotional control (Othmer, Othmer, & Kaiser, 1999). Several clinical and experimental studies have found that training individuals to increase or inhibit their brain electrical activity in certain frequency ranges over different brain sites have been effective in decreasing the symptoms of attention deficit hyperactivity disorder (ADHD; Linden, Habib, & Radojevic, 1996; Lubar, 1991; Lubar & Lubar, 1984; Nash, 2000; Othmer, Othmer, & Marks, 1992; Tansey, 1990). Long-term improvement was shown in one study with children with ADHD (Monastra, Monastra, & George, 2002) and in independent 10-year follow-ups with 52 ADD/ADHD cases (Lubar, 1995). With learning disabilities and learning performance, neurofeedback has resulted in improvements in performance on tasks assessing visual-motor integration, reading, arithmetic, and spelling (Fenger, 1995), semantic working memory (Vernon et al., 1993), arithmetic performance (Cunningham & Murphy, 1981; Murphy, Darwin, & Murphy, 1977), reading comprehension (Nall, 1973), and creative thinking (Whisenant & Murphy, 1977). Positive outcomes with symptoms of autism have also been reported (Jarusiewicz, 2002; Sichel, Fehmi, & Goldstein, 1995). Several studies have demonstrated effectiveness with different types of affective disorder (Moore, 2000; Rosenfeld, 2000).

This paper describes the outcome of neurofeedback treatment with two complex patients who manifested symptoms of ADHD, learning disabilities, mood disorders, and social deficits. One of the patients also had symptoms of autism.

METHOD

The two subjects were patients in the outpatient psychological services practice of the author. (The case studies included contain composite information and changes in identifying information to protect the privacy of the patients.) One was a 15-year-old boy who was diagnosed with ADHD, PDD, bipolar disorder, and learning disabilities. The other was a ten-year-old boy with ADHD and a nonverbal learning disability. They had been referred to the author by professionals in the community. The author had had previous contact with one patient (the 15-year-old male) because of a psychological testing evaluation he had completed on him three years earlier.

The subjects participated in neurofeedback training based on the procedures developed by Othmer, Othmer, and Kaiser (1999). These procedures involved monitoring and influencing three brainwave frequency ranges simultaneously, with rewards based on the amplitude of brainwave activity being inhibited or below threshold approximately 10 to 20% of the time in two frequency ranges (the inhibit bands), and being above threshold in one frequency range approximately 60 to 80% of the time (the reward band). The frequency ranges were measured in hertz (Hz).

The electrode placements, the reward and inhibit bands, and the frequency of rewards administered were individualized for each subject, depending on their clinical picture. The equipment used was a two-computer system supplied by NeuroCybernetics, Inc. (Canoga Park, CA) using NeuroCybernetics software versions 3.10 or 3.13f with a single-channel setup. Three electrodes were used in each training session; the skin sites were cleaned with an alcohol prep pad, and the electrodes connected to the skin with conductive paste. Electrodes were placed on sites on the scalp and the earlobes according to the international 10-20 system of identification. Training sites were either unipolar (e.g., C4 with reference to the same side earlobe and ground to the contralateral earlobe), or bipolar (e.g., T3-T4, with the ground placed on the earlobe contralateral to the primary training site, which in this case was T3).

For both subjects, target problems were identified by a parent and monitored each session on a problem tracking form. For the adolescent

patient, pre- and post-symptom assessments were made using the Symptom Assessment–45 Questionnaire (SA-45; Strategic Advantage, Inc., 1966). Problems for both subjects were monitored during each session on a chart that was a modification of the Neurofeedback Progress Chart, which was developed by Matthew Fleischman, PhD in his clinical practice solely for the gathering of clinical information (this chart has not been normed and there are no reliability or validity data available). The parent, in consultation with the child, identified one or more problems on the chart that were targeted for improvement through neurofeedback training. The parent then rated the severity of each problem on a 0 to 4 scale, on the right hand side of the chart, with the following values assigned to the ratings: 0 = not at all; 1 = just a little; 2 = some; 3 = pretty much; and 4 = very much. The ratings were provided at the beginning of each training session. A consecutive list was on the left hand side of the chart. The session number was entered on each line along with the date of the training session and the training protocols used (the sites of the electrode placements, the inhibit and reward frequencies). The chart was organized in such a way that each session's problem ratings were set alongside–directly to the right–of the training protocol from the previous session, thereby giving information about how the subject had functioned since the last training session, in order to assess whether there might be a correlation between specific training protocols and problem severity.

The SA-45 is a brief, validated measure of psychiatric symptomatology. It uses a self-report format for 45 symptoms that are clustered into nine symptom domains. The symptoms are each rated on a five point severity scale. There is a Global Severity Index (GSI), which assesses the general severity of symptomatology by factoring in the number of symptoms and their degrees of severity, and a Positive Symptom Total (PST), which assesses general severity by the number of symptoms reported as being present to any degree. The nine symptom domains are anxiety, depression, obsessive-compulsive, somatization, phobic anxiety, hostility, interpersonal sensitivity, paranoid ideation, and psychoticism.

Normative data were reported on the SA-45 by Davison et al. (1997). Reliability data established the internal consistency of the scales with Cronbach's (1951) alpha coefficients of .71 or greater, and with non-inpatient adolescent test/retest reliabilities ranging from .58 to .85. Validity data indicated interscale correlation coefficients ranging from .42 to .79 for the adolescent sample and sensitivity and specificity values of .57 to .68 for adolescent males. Cluster analyses found a 71% hit rate for adolescent patients and a 96% hit rate for male patients. Concurrent

validity was established with the SCL-90 (Derogatis, Lipman, & Covi, 1973), from which the SA-45 was derived, with correlation between the scales and indices for the two measures established at .95 or higher for all scales except one, which was .88 to .90. Content validity for the individual items to the scales to which they belong was established as higher than .50.

Case One

JK was a 15-year-old high school freshman who was diagnosed with attention deficit hyperactivity disorder, combined type (ADHD), pervasive developmental disorder, not otherwise specified (PDD), bipolar disorder, and learning disabilities in reading, math, spelling, written expression, active working memory, visual-spatial memory, and processing speed. All of the diagnoses, except bipolar disorder, were made by the author as the result of a psychological assessment and testing evaluation conducted three years prior to the training. The diagnosis of bipolar disorder was made by a psychiatrist two years prior to the training. All diagnoses were made using DSM-IV criteria (American Psychiatric Association, 1994).

At the time of his referral for neurofeedback, JK was attending a specialized high school for students with emotional handicaps. He had recently been discharged from his second psychiatric hospitalization after a stay of about six weeks. His hospitalizations followed intensification of suicidal threats and gestures, homicidal ideation, and bizarre and illogical thinking.

JK's speech was atypical, starting when he first began to put words together. His syntax, prosody, and choice of words had a formal, intellectualized, and pedantic quality, as if he were talking *at* you, rather than *with* you. The content of his speech often included themes of violence and destruction and, as he grew older, the more personal, crude, and bizarre the content became.

Minor frustrations at home or at school were often met with expressed wishes to dismember the object of his frustration, as well as subjecting them to other horrific tortures, or committing acts of violence on large groups of people or humanity in general. JK would act in aberrant, provocative and attention getting ways in public, often provoking glances or comments from strangers, to which he replied with some crude or threatening comment. He had been expelled from three summer camps, twice after he had physically attacked other children in dangerous ways, and once after being badly beaten up by a peer. In all of these incidents, JK had failed to adequately read social situations to understand when to back off

and not provoke violence or be provoked himself. He seemed to lack the ability to understand the feelings or needs of others, or the benefits of mutual cooperation. JK was largely cut off from human contact outside his family and his school day. He would spend hours on his computer playing fantasy-oriented games. To limit his time on the computer his parents found that they had to engage in extensive and intensive negotiating.

JK had manifested problems learning to read since the first grade. He reversed letters and had difficulty decoding the sounds of letters. He had always found reading to be boring and tedious. His school performance was very inconsistent, as his ability to complete his school work and home work were at the mercy of his impulsivity. His behavior had been disruptive to his learning and to the classroom environment since the first grade. He often blurted out irrelevant and inappropriate comments, daydreamed, or argued with the teachers about minor points. JK's mother, a professional woman, despaired, with a great deal of guilt that she was unable to feel empathy for her son, enjoy his company, or to relax when she was in his presence.

JK was taking the following psychotropic medications: Trileptal (oxcarbazepine), Seroquel (quetiapine), Effexor (venlafaxine), and Strattera (atomoxepine). He had formerly been prescribed stimulant medication, which made him more agitated and resulted in tics and headaches. He had been on medication and in psychotherapy for several years and, in spite of these measures was still having great difficulty functioning at school, at home, and in the community.

At the beginning of treatment JK had been in individual psychotherapy with another psychologist. After five neurofeedback sessions, JK's parents requested that the author begin to see JK in therapy contemporaneous with the neurofeedback training, in order to provide more integration and consistency in JK's treatment. The author saw JK in biweekly individual therapy sessions for the duration of the neurofeedback training. The therapy was cognitive-behavioral in nature, and focused on developing rational interpretations of interpersonal events, anger management, conflict resolution with parents and peers, and the separation of reality from fantasy. JK was seen in 40 neurofeedback training sessions for 20 minutes each, meeting one or two times per week. JK and his mother identified the target problems listed in Table 1 on the problem tracking chart. His mother's pre- and post-neurofeedback ratings on the 0 to 4 scale are indicated in Table 1.

On the SA-45, all pre-treatment measures indicated significant clinical impairment, at or above the 93 percentile (T-score $\geqslant$ 65), except for one measure, which had a T-score of 64. The T-scores for pre- and post-neurofeedback treatment measures are indicated in Table 2:

TABLE 1. Pre- and Post-Treatment Parent Ratings of Target Symptoms in the Neurofeedback Treatment of a 15-Year-Old Boy. (Values Assigned to the Ratings: 0 = Not at all; 1 = Just a little; 2 = Some; 3 = Pretty much; and 4 = Very much)

Problem	Pre-Treatment	Post-Treatment
Poor social skills	4	1
Difficulty focusing/low energy	4	1
Poor organizational abilities	4	2
LDs in reading, math, spelling, writing	4	2
Verbally impulsive/anger	4	1

TABLE 2. Pre- and Post-SA-45 Ratings, Differences, and Differences Required for Statistical Significance in the Neurofeedback Treatment of a 15-Year-Old Boy

SA-45 Measure	Pre-Treatment	Post-Treatment	Difference	Difference Required for Significance in Adolescents ($p < .05$)
Global Severity Index	72	62	10	10.92
Positive symptom total	74	64	10	10.62
Anxiety	75	62	13*	11.20
Depression	72	62	10*	7.93
Obsessive-Compulsivity	71	63	8	11.64
Somatization	70	63	7	14.91
Phobic anxiety	72	63	9*	6.51
Hostility	65	57	8	11.75
Interpersonal sensitivity	76	63	13*	8.70
Paranoid ideation	64	63	1	11.14
Psychoticism	65	49	16*	5.65

*$p < .05$.

JK was treated with the protocols presented in Table 3. All protocols, except where indicated, used inhibits of 2-7 Hz and 22-30 Hz. Right hemispheric training was emphasized in order to lower JK's overall arousal level, effect greater emotional calming, decrease his preoccupations and ruminations, and improve his processing of social stimulation. A 12-15 Hz reward band was used as a starting point, and then lower frequencies were tried in an attempt to enhance emotional calming. However, lower reward band frequencies resulted in fatigue, which impaired JK's ability to remain alert during the treatment, and caused him to feel

TABLE 3. Electrode Placements and Reward Frequencies in the Neurofeedback Treatment of a 15-Year-Old Boy

Session Number	Protocol 1 Electrode Placement	Reward Frequency Range (in Hz)	Protocol 2 Electrode Placement	Reward Frequency Range (in Hz)	Protocol 3 Electrode Placement	Reward Frequency Range (in Hz)
1	C4-A2	12-15	C4-A2	10-13		
2	C4-A2	12-15	C4-A2	10-13	C4-A2	8-11
3-13	T3-T4	12-15	P3-P4	11-14		
14-40	T3-T4	12-15				

sedated for hours afterward. A beneficial effect was noted by the patient and his mother without the sedating effects when training at 12-15 Hz.

Although JK experienced much better control over his anxiety, his irritability, and his social misperceptions with right-sided training, he still had significant problems with his emotional stability much of the time. Therefore, bipolar temporal lobe training was implemented to improve his emotional stability, and to lessen his tendency to become overaroused on the one hand and depressed and underaroused on the other. During the course of the training, JK's mother reported that he had always had difficulty settling down at night to go to sleep and sleeping through the night. Parietal training was introduced to help with general physical calming and sleep regulation.

Case One Results

Throughout the treatment, the target problems were rated by JK's mother prior to each session. All five of the problems were rated with a 4, as occurring "very much" of the time, before treatment. Following treatment, "poor social skills," "difficulty focusing/low energy," and "verbally impulsive/anger" were rated with a 1, as occurring "just a little" of the time; and "poor organizational abilities," and "LDs in reading, math, spelling, writing" were rated with a 2, as occurring "some" of the time. The end results are reported in Table 1, but throughout the treatment, the ratings reflected a slow but fairly steady improvement.

On the SA-45 five of the nine clinical scales showed significant improvement; the other four scales showed symptom improvement but below statistical significance. The two global indices showed symptom improvement just below statistical significance. The five scales on which the ratings showed statistically significant improvement were anxiety, depression, phobic anxiety, interpersonal sensitivity, and psychoticism.

Every one of the scales dropped below a T-score of 65, indicating that JK's symptoms no longer placed him among the upper 7% of the population in his impairment, which would be an indication of severe pathology.

By the end of treatment, JK's parents were reporting that he was a more cooperative and respectful member of the family. He was controlling his emotional reactions, tolerating frustration better, and respecting the feelings of others; violent themes were greatly reduced in JK's speech. His mother felt that she finally had a son with whom she could relate and with whom she could share pleasurable activities and interactions; JK had successfully transitioned out of the special school which he had been attending and into the public high school in his community. He was showing more initiative in completing his schoolwork, was cooperating with his teachers and his aide, and there had been no angry or aggressive peer interactions in four months. JK's teachers reported that he was focusing well in class, not blurting out comments, and taking notes. His mother no longer felt that she had to be home full time to manage their crisis-ridden life, and took steps to reestablish her professional career, which had been on hold for several years.

By the end of treatment, JK was reporting that he was enjoying learning in school for the first time in his life, seeing school as an enjoyable and safe place. He was taking an active interest in his brother and, instead of finding him annoying and fighting with him or antagonizing him, was taking walks with him, playing card games with him, and tolerating his idiosyncrasies. JK was tolerating his parents' inability to cater to his wishes at all times, and was negotiating alternatives, such as agreeing to have his wishes granted at future times when his parents were better able to accommodate him. He had developed a satisfying long-distance e-mail and telephone relationship with a girl his age which had lasted a year by the end of treatment and was enjoying interacting with his peers in school, and tolerating those who annoyed him without engaging them in provocative interactions.

This 15-year-old boy, with ADHD, PDD, bipolar disorder, and learning disabilities, was treated with 40 neurofeedback sessions. Improvement was noted in JK's functioning by all measures used: the problem tracking form, the symptom inventory, and verbal reports of both JK and his parents. This was the first such improvement in JK's functioning despite years of medication and psychotherapy.

On the problem tracking form, all five problems were rated at the highest degree of severity (4) prior to neurofeedback treatment. At the end of treatment, all problems were rated as just a little (1) or some (2), indicating a high degree of improvement in all problems for which the parents

sought treatment. These problems had been at the highest degree of severity for many years and, in fact, had often been even more severe than they were at the start of treatment, with JK's history of suicidal gestures, suicidal and homicidal threats, hospitalizations, removals from schools and camps, and aggressive and poorly controlled behaviors and fantasies.

On the SA-45 every measure was rated as moving in the direction of improvement and all fell below a commonly accepted indicator of clinical impairment (T-score of 65), whereas all but one scale was at or above that level prior to treatment. Symptoms of anxiety, depression, phobias, interpersonal sensitivity, and psychosis showed statistically significant improvement. On the more global indicators of pathology (GSI and PST), improvement was just below statistical significance. The most dramatic improvement was on the psychoticism scale, which indicated that JK was no longer manifesting behaviors that indicated significantly or persistently disordered, illogical, bizarre or fantasy-driven thinking. The decrease in the hostility scale indicated that he was no longer expressing hostile thoughts, intentions, or actions to a significant degree. The other subscales indicated greatly reduced anxiety and depression, somaticizing symptoms, preoccupations, fearfulness and suspiciousness, along with an improved ability to engage in emotionally meaningful and reciprocal interactions with others.

JK's and his parents' comments reflected a greatly improved quality of life for the family. Daily life was no longer filled with tension and anticipation of what could go wrong at any moment when the ordinary, minor annoyances of daily living would explode into an unmanageable situation. All family members felt a greater sense of peace and harmony at home.

Case Two

Luke was a 10-year-old boy with a confusing array of symptoms that made diagnosis difficult. Neuropsychological testing conducted one year prior to the neurofeedback training indicated left hemispheric deficits and ADHD (a diagnosis made according to DSM-IV criteria). However, Luke had severe social, organizational and spatial deficits as well, which suggested right hemispheric involvement and a nonverbal learning disability. His avoidance of social interaction had also resulted in the additional diagnosis of anxiety disorder (according to DSM-IV criteria) through the same evaluation.

Luke had few friends. He rarely initiated social interaction. Luke typically withdrew and was almost mute in social situations. He seemed so

overwhelmed with the stimulation that he appeared to "shut down." He was often bullied on the playground, where he preferred to isolate himself rather than engage the other children. Luke was also very sensitive to loud noises or to voices with a raised pitch, and would often cover his ears when someone was speaking. He often did not respond when spoken to in such situations. Attempts to engage him were met with no response, no eye contact, and no acknowledgement of the other person. His parents often had to cue him repeatedly in order to get a mumbled verbal response out of him. Luke had difficulty getting out of bed and going through his morning routine without constant cueing by his parents. He often appeared to be "tuned out" and the teacher was never sure if Luke was paying attention. At times Luke would fidget in his seat, or talk non-stop in a pressured, anxious manner.

Luke had been in weekly psychotherapy, which alternated between individual and family therapy, with the same therapist for one year prior to the neurofeedback training. He was still experiencing the deficits stated above and he was not on medication. The problems Luke's parents identified and their pre- and post-treatment ratings on the 0-4 scale are presented in Table 4.

Luke was treated with the protocols presented in Table 5. All protocols, except where indicated, used inhibits of 2-7 Hz and 22-30 Hz. Right hemispheric training was emphasized initially in order to improve the processing of social stimulation, to decrease anxiety, and to improve visual-spatial processing. Training began with 12-15 Hz reward, but was gradually lowered to see if there could be greater effects obtained for social processing and anger control. The lower reward frequencies were tolerated without increased fatigue, and were accompanied by gradual improvement in the above-mentioned areas of functioning.

Left and right hemispheric training protocols using only inhibits were introduced because of the high degree of slow wave and fast wave activity

TABLE 4. Pre- and Post-Treatment Parent Ratings of Target Symptoms in the Neurofeedback Treatment of a 10-Year-Old Boy. (Values Assigned to the Ratings: 0 = Not at all; 1 = Just a little; 2 = Some; 3 = Pretty much; and 4 = Very much)

Problem	Pre-Treatment	Post-Treatment
Attention and school performance	4	1
Anger outbursts	3-4	0-1
Listening: needing directions repeated	3-4	1
Tolerance of others	4	1

TABLE 5. Electrode Placements and Reward Frequencies in the Neurofeedback Treatment of a 10-Year-Old-Boy

Session Number	Protocol 1 Electrode Placement	Reward Frequency Range (in Hz)	Protocol 2 Electrode Placement	Reward Frequency Range (in Hz)	Protocol 3 Electrode Placement	Reward Frequency Range (in Hz)
1	C4-A2	12-15				
2	C4-A2	9-12	C4-A2	7-9	C4-A2	6-9
3-8	C4-A2	6-9				
9-11	C3-A1	No reward, inhibits only	C4-A2	No reward, inhibits only		
12	C3-C4	5-8, then 6-9	C3-C4	7-10, then 8-11	C3-C4	9-12
13	C3-C4	7-10				
14	C3-C4	7-10	C3-C4	6-9	C3-C4	5-8
15-34	C3-C4	5-8				
35	C3-C4	5-8	Fp1-Fp2	4-7		
36	C3-C4	5-8	Fp1-Fp2	4-7	Fp1-Fp2	5-8
37	C3-C4	5-8	Fp1-Fp2	5-8	Fp1-Fp2	6-9

noticed in the EEG activity. Focusing on the inhibit frequencies targeted Luke's distractibility and poor listening skills on the one hand, and his social anxiety and intolerance of others on the other hand.

Bipolar central strip placements were added to effect greater improvement in the regulation of anxiety. Prefrontal lobe training was introduced to improve inhibition and executive functions. The specific reward amplitudes were used to affect the maximum degree of calming along with the maximum degree of effect on the other targeted symptoms. Throughout treatment, the target problems were rated by Luke's father prior to each session. The end results are reported in Table 5; throughout the treatment the ratings reflected a slow but steady improvement.

By the completion of treatment Luke's father was reporting that Luke was initiating friendships with boys in his class and Luke's peers were initiating contact with him. Luke was making more eye contact when conversing with others and initiating conversations with his peers during recess. He was more focused in school and at home and showed more cooperation and initiative in his morning routine. His grades in school had improved and his teacher had noticed improved attention to task and improved organizational skills. His father no longer had to repeat himself most of the time when he gave Luke directions.

By the end of treatment Luke was reporting that he had earned an A on a long-term Social Studies project and a grade of A on each specific aspect of the project. He had earned grades of C and B in Social Studies in the past. He had a friend come over to his house each of the last two weekends and he was getting into less trouble for his behavior at home and at church. He was calmer; and he felt pleased and proud of himself for his improvements.

This 10-year-old boy with ADHD, severe social, organizational and visual-spatial deficits, and anxiety was treated with 39 neurofeedback sessions. Improvements were noted on all symptoms. The problem areas of "attention and school performance," "anger outbursts," "listening: needing directions repeated," and "tolerance of others," each of which was initially rated as occurring "pretty much" or "very much" of the time (the two highest ratings on the scale). At the end of treatment these were rated as occurring "not at all" or "just a little." Observational reports from the father indicated improvements in attention, task completion, initiation of social interaction, and social desirability. Luke began neurofeedback treatment with significant deficits in his functioning despite prior psychotherapy and his improvement surpassed any prior treatment efforts.

DISCUSSION

This paper presents a clinical discussion of the neurofeedback treatment of two complex children, one 15-year-old boy and one 10-year-old boy, whose symptoms were similar to those of many children with multiple problems arising in childhood. The 15-year-old had significant impairments in his functioning both at school and at home, which had necessitated psychiatric hospitalizations and placement in a specialized school for children with emotional handicaps. He diagnosed with ADHD, pervasive developmental disorder, bipolar disorder, and learning disabilities in reading, math, spelling, and writing. He received 40 neurofeedback sessions which combined right hemispheric and interhemispheric training. By the end of treatment he was attending the public high school in his community and doing well academically. His emotions and behavior were under good control. His relationships with other family members had become much more harmonious and positive. His violent ideation and inappropriate verbalizations were greatly decreased. The young man who had made a very poor adjustment to school and to home was now making a reasonably good adjustment to both. Improvements were also noted in the areas of his specific learning deficits.

The 10-year-old had serious deficits with attention, organization, social functioning, and spatial processing as well as anxiety that impaired his functioning at home, at school, and with peers. His diagnoses included ADHD, nonverbal learning disability, and anxiety disorder. He received 39 neurofeedback training sessions utilizing right hemispheric, left hemispheric, and interhemispheric protocols. He showed improvements in his social interaction, social acceptability, control over anger, attention to task at school and at home, and ability to interact with others without undue stress. His grades in school had improved. His functioning at school, at home, and with peers had substantially improved, and both he and his father expressed great satisfaction with the changes.

Both boys had received years of prior treatment which included medication for one and psychotherapy for both. Despite these efforts, both boys began neurofeedback with significant and debilitating deficits and adjustment problems in all areas of functioning, and showed substantial improvements in their adjustment and their functioning following neurofeedback treatment. It is also significant that improvements were attained without any reported adverse side effects in either child.

Since research has not always found a clear relationship between neurofeedback training and long-term measurable changes in the EEG, and since most patients present to mental health professionals for treatment based on self-defined functional deficits, the decision to assess improvement in both of these patients based on functional improvements defined by their parents and corroborated by the children was deemed to be justified and sufficient. Neurofeedback training resulted in positive and substantial symptom reduction in these two children with multiple disabilities.

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