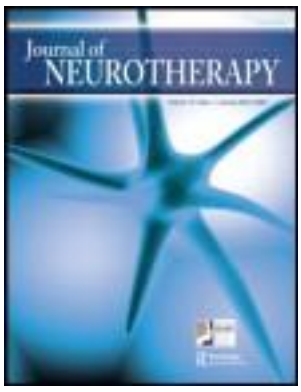

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EEG Neurofeedback Treatment of Patients with Down Syndrome

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EEG Neurofeedback Treatment of Patients with Down Syndrome

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ABSTRACT. *Introduction*: Down syndrome is the most common identifiable cause of intellectual disability, accounting for almost one third of cases and approximately 1 in 800 births. Neurofeedback (NF) is an operant conditioning method for retraining brain wave (EEG) patterns. An increasing number of clinicians use operant conditioning of EEG activity as a method of helping children with Attention Deficit Hyperactivity and Generalized Learning Disability (ADHD/ADD or GLDO). Some Down syndrome children display symptoms of ADHD/ADD, GLDO or both. We believed that NF may have potential in helping children with Down syndrome.

Methodology: Eight children with Down Syndrome (ages 6-14) were evaluated through questionnaire, parent interview, and pre- and post-treatment quantitative EEG's. All eight children were seen by the first author and by the special educator at the baseline, and at the 20th, 40th and 60th treatment sessions. Pre-treatment QEEGs were analyzed using the NxLink normative database and generally showed excess delta and theta EEG patterns. None of the subjects were able to speak more than one word sentences and they had very limited vocabulary (between 5-10 words). They usually pointed a finger to communicate and were not able to engage in basic conversation. All children displayed very poor attention and concentration, poor memory, impulsivity, behavior problems, in some cases balance problems. The purpose of this preliminary study was to evaluate whether QEEG guided, bipolar montage NF training is effective in developing speech, improving attention and concentration, improving learning, decreasing behavioral problems or impulsivity, and alleviating balance problems in Down Syndrome children. All subjects were medication-free during treatment. NF training was conducted using Lexicor Biolex software with electrode placement guided by QEEG findings, seeking to normalize abnormal QEEG patterns. Training continued until the subjects demonstrated improvement and there were significant improvements in the reports of parents, or until a total of 60 treatment sessions were provided. Scores derived from a combination of questionnaire and parental ratings were obtained pre- and post-treatment in the areas of memory, speech and language, attention, behavior, and balance.

Results. One subject dropped out after eight sessions. All seven children who completed NF training showed significant ($p < .02$) improvement in all areas evaluated based on the questionnaire and parent interviewing, and changes were found in QEEGs. Further study with a control group and additional outcome measures is warranted. doi:10.1300/J184v11n01_07

KEYWORDS. Down syndrome, quantitative EEG, neurofeedback, EEG biofeedback

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INTRODUCTION

Down Syndrome is a disability that was first described one hundred and thirty-five years ago. It is the most common identifiable cause of intellectual disability, accounting for almost one third of cases (Wishart, 1993). It occurs equally in all races with an overall incidence of approximately 1 in 800 births (Regezi, 1989). Neurofeedback (NF) is an operant conditioning method for retraining electroencephalographic (EEG) patterns. An increasing number of clinicians use operant conditioning of EEG activity as a method of helping children with Attention Deficit Hyperactivity and Generalized Learning Disability (ADHD/ADD or GLDO) (Lubar, 1985; Lubar & Lubar, 1984). Some of the children with Down Syndrome may have ADHD/ADD or GLDO symptoms, or both. The authors believed that NF might be successfully applied to improve symptoms in children with Down Syndrome.

Characteristics. The characteristics associated with Down Syndrome are many and varied. The physical traits that have been characterized as most common include low muscle tone, flat facial profile, depressed nasal bridge and small nose, upward slant to the eyes, an enlargement of the tongue in relation to size of the mouth, and an abnormal shape of the ear (National Down Syndrome Society, 2001). Children with Down Syndrome are also at greater risk of developing medical health problems (Wishart, 1993). Intellectual changes are also present and researchers have stated that most people with Down Syndrome display some level of intellectual disability ranging from mild to severe, although the mean level of disability remains mild to moderate (National Down Syndrome Society (NDSS), 2001; Wishart, 2001; 1993).

Teaching Strategies: The Most Important One May Be Neurofeedback. Individuals with Down Syndrome differ in their abilities and their interests, and, therefore, it is clear that teaching or learning strategies will vary greatly from one child to the next. The varying abilities within the classroom should not be ignored and it is with the presence of an individualized education plan (IEP) that teachers can maximize such children obtaining an appropriate education. The team, which includes the patient, his/her parents, the classroom teacher, special educator, as well as other professionals that are involved in the child's educational development, put together an education plan. A diet that includes low carbohydrates and high protein is also recommended.

Common difficulties in children with Down Syndrome include attentional and concentration problems, and problems with learning, memory, speech, language, behavior, and physical balance. They have problems focusing on specific stimuli which can have serious and very negative effects on their learning (Biklen, Saha, & Kliewer 1993; NDSS, 2001). Therefore, it is very important to use a variety of strategies to address this problem. The common speech and language problems can include difficulties in expression, articulation, formal or informal social changes, and fluency (Biklen et al., 1993).

Memory Problems. Memory problems present an impairment to some, but not all, forms of learning in children with Down Syndrome (Nadel, 1997). In the past decade research studies have begun to uncover the specific learning defects observed in individuals with Down Syndrome at various ages. Verbal short term memory skills are commonly very poor. Current evidence suggests that forms of learning dependent on the hippocampus, cerebellum and prefrontal cortex may be particularly impaired in Down Syndrome.

Behavioral Profiles. Behavior problems are also common in these children. The problems often include aggression, hyperactivity and excessive noise, and problems complying with rules (Collacott, Cooper, Branford, & McGrother, 1998). It is suggested that neurofeedback can assist in addressing the problems described above.

BACKGROUND AND METHODOLOGY

Traditional methods for assisting Down Syndrome children such as neurocognitive rehabilitation, special education, behavior training, and medication are expensive, time consuming, and of questionable effectiveness with this population. The purpose of this preliminary study was to evaluate whether QEEG-guided neurofeedback training would be effective in

improving speech, attention, concentration, learning skills, and physical balance, and in decreasing behavioral problems and impulsivity in Down Syndrome children.

Individuals with Down Syndrome were recruited, excluding individuals with medical problems. Eight subjects who were medication-free were selected for evaluation. They ranged in age from 6 to 14 years old (mean 9.13 years). The parents of each child were given a questionnaire prepared by the center which included questions about attention, concentration, speech and language capabilities, learning ability, and behaviors. Baseline history interviews on the children were gathered from the parents for 30 minutes and were video recorded. The average attention span of the 8 children with Down Syndrome was 1-3 minutes. The average number of the words in their vocabulary was 5-10. They had severe articulation problems, did not use more than a single word in a sentence, did not obey rules, were stubborn, and had difficulties in remembering the things they learned. The children usually pointed with a finger to communicate and displayed poor attention/concentration, impulsivity, behavior and balance problems. In general they seemed relatively unaware of their surroundings.

A quantitative EEG was done on all subjects at baseline and at the end of neurofeedback treatment, and the data was processed with the Nx Link database (John et al., 1989). Almost all of the subjects were found to have an excess of delta and theta activity, and excessive or deficient beta activity, over some area of the cortex. Based upon the findings of the QEEG analysis and the clinical judgment of the first author all 8 children were classified as having a global learning disability and 3 of the children also met criteria for a diagnosis of attention deficit and hyperactivity disorder. These 3 children met an average of 8 of the DSM-IV ADD/ADHD diagnostic criteria for inattention, and 6 symptoms for ADHD (4 for hyperactivity, and 2 for impulsiveness). Pre-treatment and post-treatment questionnaire and parental ratings were combined to form a single score in categories for problems with speech and language, attention, memory, behavior, and physical balance. Scores in each of these categories were then analyzed using Wilcoxon Signed Rank tests.

All subjects were seen by the first author and by the special education teacher at baseline evaluation, and after 20, 40, and 60 sessions of neurofeedback. Neurofeedback training was guided by the findings of the QEEG and consisted of 30 minute training sessions conducted twice a day, six days a week. Neurofeedback training was done with Lexicor equipment using Biolex software, utilizing a bipolar montage. Neurofeedback training continued until the subjects demonstrated improvement and significant improvements in the reports of parents, or until a total of 60 treatment sessions. However, one subject dropped out of treatment after only 8 sessions. Suggestions were also made for diet and structured parenting skills. Comparisons was made between the questionnaires given to the parents of the 7 children, the parents' video recording reports, the special educator's evaluation, and first author's symptom checklist from the baseline evaluation and following 60 neurofeedback sessions. QEEG results were also evaluated pre- and post-treatment.

The initial QEEG evaluation on the first child revealed excess delta and theta absolute power Z-scores over the cortex and some coherence abnormalities in different frequency bands. Neurofeedback training was done in the first patient with a bipolar (sequential) montage at F7-T5, P3-T5, P4-T6, CZ-C3, F8-T6 electrode sites while inhibiting 0-8 Hz. Training was also done at Cz-C4, inhibiting 4-8 Hz and reinforcing 12-15 Hz. Even though absolute power Z-scores were not significantly abnormal on the QEEGs for the other 6 children at F7-T5, F8-T6, Cz-C4, and Cz-C3, when examined in the Biolex neurofeedback software there appeared to be abnormalities. Therefore, these subjects also received the same training as the first patient at these sites. When called for, interhemispheric coherence training was also done.

RESULTS

Generally the children needed somewhere between 20-40 sessions of neurofeedback before changes started to become obvious. However, all 7 children who remained in neurofeedback showed significant improvement in

their condition as measured on questionnaires and through parental interviews. Initially the children were unable to read or perform math, but following treatment they were beginning to demonstrate some ability to read, to count, and to do simple addition. While initially unable to write, they could now write their names and some meaningful sentences.

Improvements in speech and language abilities over the course of treatment are summarized in Table 1. The children showed improvement in articulation and could engage in more meaningful conversations. Instead of one word interactions, they were able to verbalize 4-5 meaningful words in a sentence. It can be seen that working vocabulary noticeably improved, increasing from an initial vocabulary of 5-10 words to 40-50 words.

Changes in memory are summarized in Table 2. Short term memory and memory for previously learned material appeared to improve as displayed in tests of letter span, word span, and digit span. Attention and concentration were noticeably enhanced following neurofeedback. Before treatment the children were not able to follow conversations with other people and they seemed to be lacking in awareness of their surroundings. This improved following neurofeedback. Instead of only being able to focus for 3-5 minutes, children could concentrate for up to one hour in some cases. Two Down Syndrome children transferred to a regular school after treatment and their new teacher reported that their attention and concentration was actually better than that of their peers. In general the children appeared more able to think and attend, enabling them to have enhanced capacity to learn.

Improvements were also seen in coordination, balance and behavioral control. Prior to treatment the children typically demonstrated a mild form of ataxic walk and were unable to run. Following neurofeedback they were now able to walk more normally and run. Their behavior was less impulsive, more controlled, mature, and they were more obedient to rules.

Figure 1 displays the pre- and post-treatment changes in the QEEG of one of the Down Syndrome children who was treated. Prior to neurofeedback the child showed a global excess in absolute power delta and theta. However, following treatment there is a very obvious reduction in absolute power in both delta and theta. It is also apparent that relative power theta was significantly reduced following neurofeedback, with some degree of movement toward normalization in relative power alpha and an increase in relative power beta. All

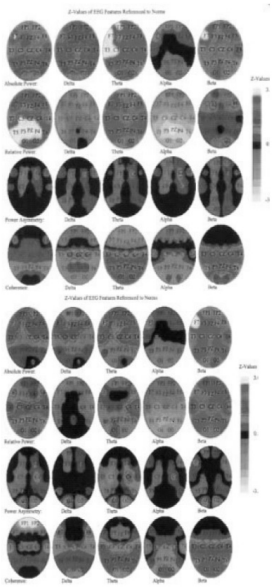
TABLE 1. Speech and Language Activity at Baseline and Post-Treatment

BASELINE	**DURING & POST- TREATMENT**
Verbal Communication	**Verbal Communication**
Number of words: 1	Number of words: 2-5 words
Rules for syntax: None	Rules for syntax: Somewhat present
Words in the memory: 5-10	Words in the memory: 40-50
Pluralization, tense changes: None	Pluralization, tense changes: Somewhat present
Nonverbal Communication	**Nonverbal Communication**
No facial expression	Smile, grimace, and wink appropriately
No gestures except finger pointing	Waving and pointing develop
No squeezing hand	Squeezing hand
Touch present	Touch present
Not actively listening, thinking and sorting out of speech	Somewhat actively listening, thinking and sorting out of speech

TABLE 2. Memory (Registration & Recall) Level at Baseline and Following Neurofeedback Treatment

Baseline	Following Neurofeedback
Short-term memory: Name three objects in 1 s each, then repeat them. Unable to remember the names immediately or after 5 min.	Short-term memory: Named three objects and remembered at least two objects 5 min later.
Unable to do letter span, digit span, or word span.	Able to do all three tasks.
Long-term memory: Unable to remember what was learned in the past.	Mothers report recall of much previously learned material, such as information learned at school 2-3 years prior.

FIGURE 1. Baseline QEEG and Post-Neurofeedback Treatment QEEG



QEEGs showed improvements following treatment.

At the completion of neurofeedback treatment all 7 children showed considerably improved functioning. Table 3 summarizes the combined parent ratings and questionnaire data that were collected at baseline and at the completion of treatment and statistically analyzes the results. These ratings were compiled for problems in the areas of speech and language, attention, memory, behavior, and physical balance. It can be seen that significant improvements ($p < .02$) were noted in all areas. These findings are displayed graphically in Figure 2.

DISCUSSION AND CONCLUSIONS

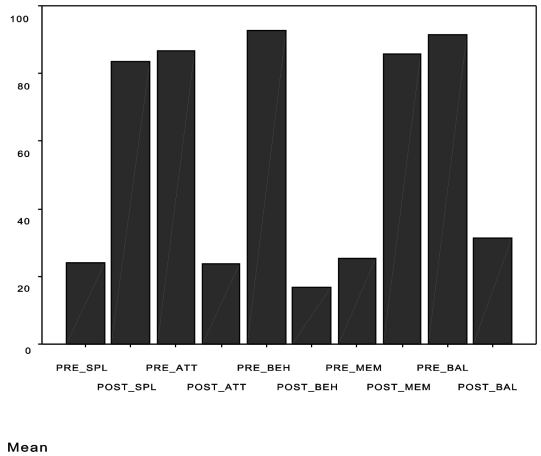
In this uncontrolled open trial of bipolar (sequential) montage neurofeedback training, the 7 subjects with Down Syndrome who remained in treatment experienced substantial and relatively rapid symptomatic improvement. The initial evaluations examining the EEG in bipolar (sequential) placements and analyzed as QEEGs suggested that the children had excess delta and theta activity in at least some parts of the brain. Following neurofeedback to decrease the amplitudes in these frequency bands (and later to increase SMR and beta activity, and seek to normalize coherence patterns), attentional difficulties, speech problems, memory, learning and behavioral problems, and balance all appeared improved. Changes in these areas were all significant ($p < .025$). This uncontrolled case series suggests that neurofeedback can improve symptoms associated with ADD/ADHD and learning disability in Down's children. These changes can impact their capacity to learn and what they are able to accomplish in life. Some children were able to leave special education classes and be integrated into regular classrooms.

Many teachers, special educators, parents, and therapists may underestimate the potentials of Down Syndrome children. Neurofeedback seems to have potential to assist such children to attain a higher level of functioning. This case series has demonstrated that children with Down Syndrome seem capable of obtaining improvements in cognitive and behavioral functioning through the use of neurofeedback.

TABLE 3. Pre- and Post-Treatment Ratings on Speech/Language, Attention, Memory, Behavior, and Physical Balance with Wilcoxon Signed Rank Test Results (7 subjects)

		Mean	Std Dev.	p value
Speech/Language	Pre	24.2	8.2	.016
	Post	83.5	6.9	
Attention	Pre	86.7	7.7	.017
	Post	23.8	6,5	
Memory	Pre	92.9	7.5	.016
	Post	16.7	6.8	
Behavior	Pre	25.4	8.4	.017
	Post	85.7	8.4	
Physical Balance	Pre	91.4	10.7	.014
	Post	31.4	10.7	

FIGURE 2. Pre- and Post-Treatment Changes in Ratings of Speech & Language, Attentional Problems, Behavioral Problems, and Physical Balance



REFERENCES

Biklen, D., Saha, N., & Kliewer, C. (1993). The communication portfolio. *Facilitated Communication Digest, 2*, 15.

Collacott, R. A., Cooper, S. A., Branford, D., & McGrother, C. (1998). Behavior phenotype for Down's Syndrome. *British Journal of Psychiatry, 172*, 85-89.

John, E., Prichep, L., Ahn, K., Kaye, H., Brown, D., Easton, P., Karmel, B., Toro, A. & Thatcher, R. (1989). *Neurometric evaluation of brain function in normal and learning disabled children.* Ann Arbor, MI: University of Michigan Press.

Lubar, J. F. (1985). Changing EEG activity through biofeedback applications for the diagnosis and treatment of learning disabled children. *Theory into Practice, 24*, 106-111.

Lubar, J. O., & Lubar, J. F. (1984). Electroencephalographic biofeedback of SMR and beta for treatment of attention deficit disorders in a clinical setting. *Biofeedback & Self-Regulation, 9*, 1-23.

Nadel, L. (1997). Learning and memory in Down's Syndrome. World Down Syndrome Conference, Unpublished Poster session, Madrid.

National Down Syndrome Society (2001). About Down Syndrome. Internet article: *www.ndss.org/aboutds/educational/educational.html*

Regezi, J., & Sciubba, J. (Eds.) (1989). *Oral pathology: Clinical pathologic correlations* Philadelphia: W.B. Saunders.

Wishart, J. G. (1993). The development of learning difficulties in children with Down's syndrome. *Journal of Intellectual Disability Research, 37*, 389-403.

Wishart, J. G. (2001). Cognitive development in young children with Down syndrome: Developmental strengths, developmental weaknesses. Research Foundation and Research Center. *dsrf.org/inform/index.cfm?FUSEACTION = dsp_articletitle ID = 32*

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