Using SharperBrain, A Computer-Assisted Program, to Treat Attention Deficit Disorders & Learning Disabilities: A Review of 3 Case Studies

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Abstract
The question of whether or not attention deficit disorders can be remedied, has received attention from many researchers. Treating children and adolescents with stimulants (usually Ritalin), has proven to be helpful but is limited by side effect and tolerance. The introduction of Neurofeedback, has offered new hope for parents wanting to help resolve the attentional problems of their children without the use of medication. Neurofeedback research has shown that training brainwave patterns can remedy attentional difficulties associated with AD/HD and learning disabilities. SharperBrain was developed to help those wanting to improve their cognitive function, without the need for EEG instrumentation. It has proven, in a clinical setting, to help in enhancing various cognitive skills associated with attention and memory.

Introduction
The use of computer-assisted programs in the treatment of cognitive deficits is not new. Many previous studies have shown the benefits of such cognitive training for treating attention deficit, with or without hyperactive disorder (AD/HD) or learning disabilities (LD).

The National Institutes of Health Consensus Development Conference Statement (1998) confirmed that "Computer-assisted strategies have been used to improve specific neuropsychological processes, predominantly attention, memory, and executive skills. Both randomized controlled studies and case reports have documented the success of these interventions using intermediate outcome measures."

This paper will review some of the studies done on the use of neurofeedback to treat AD/HD and LD, explain the principles behind SharperBrain, compare it to traditional neurofeedback modalities, and conclude with a case series description.

Use of Neurofeedback in Treating Attentional Difficulties

Neurofeedback, which is a form of biofeedback, has been used for over 20 years to treat concentration related difficulties associated with AD/HD and LD. In general, Neurofeedback is a modality that uses an EEG recording system along with training software to enhance brainwave activity that is instrumental for improving concentration.

The premise behind neurofeedback is related to earlier findings that established that individuals with poor concentration lack sufficient levels of Beta 1 (this band is also commonly termed SMR, for sensory/motor rhythms) brainwaves to sustain attention. The findings also showed that these individuals exhibit excessive amounts of slow brain wave activity, especially Theta waves (Lubar, 1984, 1976; Tansey 1991, 1985). In these studies, treatment modalities focused on enhancing the SMR/theta ratio, demonstrated the effectiveness of Neurofeedback in treating children with attention deficits and learning disabilities, which usually resulted in improved school performance and behavior control. During Neurofeedback sessions, the person wishing to enhance concentration uses feedback coming through an EEG machine to enhance SMR and decrease Theta. After a certain amount of training, typically between 40 and 60 sessions, the individual is able to produce more SMR at will.

Neurofeedback treatment can also result insignificant improvement of intellectual functioning, as measured by increases in IQ scores (Linden, Habib & Radojevic, 1996). Such improvement is most likely the result of the treatment’s positive impact on the person's ability to concentrate.

More recently, Monastra (2002) found that neurofeedback has proven to be successful in long-term improvement of AD/HD symptoms. In this study, 100 children, aged six to nineteen years, diagnosed with AD/HD were monitored for one year. All children received parental counseling, academic support, and Ritalin. Half of the children also received Neurofeedback training. After 12 months, all children showed improvement in their attention. However, childrdren who stopped taking Ritalin and did not train with Neurofeedback, lost the gains they had achieved, whereas those who also received brain wave training, kept their gains even after they stopped using Ritalin.

SharperBrain

SharperBrain was developed for the purpose of enabling individuals suffering from cognitive impairment to train using an IBM-compatible computer, either at home or in a clinical setting. The program was originally designed to enhance three levels of attention:

Calm: Allows the mind to relax and get ready for different mental tasks. In terms of brain activity, this is equivalent to an Alpha state. (8-11Hz)

Focused: Enables attention to a specific task, while offsetting distractions. This is equivalent to a Beta 1 state. (12-15Hz)

Alert: Allows fast response and higher levels of alertness. This is equivalent to Beta 2 state. (16-19Hz)

SharperBrain addresses the major difficulties of ADHD symptoms, which includes impulsivity, distractibility and hyperactivity. SharperBrain was developed under the microscope of EEG instrumentation, and has proven to enhance the above-mentioned states during practice. With continued practice, learning appears to consolidate and generalize to other areas of cognitive performance. The program has 36 regular levels and 18 advanced levels (currently available only in the professional version of the program). These different levels enable individuals to achieve measurable enhancement of a variety of cognitive skill and to be able to apply this skills on a consistent basis, whenever required. It also enables quick shifts from one state of attention to another, at will.

The program trains an individual to develop the different cognitive skills associated with attention. Initial focus is placed on visual/motor integration. According to Fenger (1998), this type of training can enhance achievement in reading, spelling and arithmetic. SharperBrain emphasizes both auditory and visual processing. In addition, it trains users to improve concept comprehension, working memory, selective attention, divided attention, attention duration, sensory/motor coordination, visual processing, auditory processing, audio/visual coordination, and speed of processing.

Training procedures are practiced in slow and fast modes, and then repeated while audio/visual distractions are presented at the background.

Feedback to the user and facilitator is provided through a scoring system, which indicates change on a per-level, as well as accumulated progress.

Differences between SharperBrain and Neurofeedback

Neurofeedback works predominately on enhancing Beta 1 (SMR) brainwaves, while inhibiting slow brain activities, usually Theta waves. SharperBrain, on the other hand, not only enhances Beta 1, but also reinforces Beta 2, an important part of the brainwave spectrum necessary for enhanced alertness, when faster reactions are required. In addition, the program enables users to practice the lows and highs of each band and trains them to quickly shift from one band to another (Alpha, Beta 1, Beta 2), thus developing better attentional flexibility.

Unlike neurofeedback, which must be administered in a clinical setting, SharperBrain can be used without professional supervision, as augmentation of neurocognitive training or as standalone treatment. The software saves the results of progress achieved at home on a floppy disk, which can then be uploaded by a professional supervising the program. These progress reports of cognitive skills training indicate not only general progress but also areas of difficulties.

In contrast with SharperBrain, which targets specific cognitive skills, neurofeedback focuses predominantly on improving sustained attention. However, other elements of attention, such as selective attention, orienting of attention, and executive attention, are not directly reinforced. These states of attention are critical in developing the well-rounded cognitive skills essential to listening, reading, learning, problem solving, following instructions and interacting responsibly in various settings (Posner & Peterson 1990).

Locality of treatment is another difference between neurofeedback and SharperBrain. Most neurofeedback protocols focus on the Cz point on the top of the head; some protocols involve other locations. In contrast, SharperBrain's protocol is not localized. By establishing the challenge in terms of task and desired outcome and presenting a method to accomplish that outcome, the program trains the regions of the brain associated with the specific cognitive task. EEG monitoring has measured increased levels of Beta 1 (SMR) activity at Cz for subjects using the SharperBrain program to practice a state of focus equivalent to reading or listening. Higher levels of Beta 2 were recorded when a more alert state was reinforced. Such an alert state is associated with faster processing and improved mental performance in general (Bellenkes, Wickens, and Kramer 1997). Basic relaxation associated with Alpha waves was measured when patients stopped practicing and performed diaphragmatic breathing for a few seconds.

A final difference has to do with training under distractions. During neurofeedback sessions, the practice environment is usually quiet; it does not accurately emulate common learning environments, such as a classroom. SharperBrain trains users, during the final 12 levels of the program, to repeat cognitive challenges against visual and auditory distractions. This form of training has shown marked improvement in students' ability to concentrate in the classroom, where background stimuli are usually present.

Comparison summary

Neurofeedback protocols focus primarily on developing sustained attention and have to be administered in a clinical setting, whereas SharperBrain incorporates training for more specific cognitive skills, and can be practiced both in a clinical setting as well as at home.

The Neural Basis for Treatment with SharperBrain

The adverse relationship between attention deficits and brain wave structures is well established in literature. Winkler, Dixon, and Parker (1970) discovered that children suffering from both academic and behavioral problems exhibited excessive Theta (4-7Hz) brain waves. Lubar, Bianchini, Calhoun, Lambert, Brody, and Shabsin (1985) observed that children with learning disabilities exhibited more slow brainwave activity than did controls and were able to predict which individuals could be diagnosed with learning disabilities solely on the basis of their brainwave patterns (Lubar et al).

The prefrontal cortex acts as the control center for working memory, cognition, executive control, and attention (Miller & Cohen 2001, Castellanos 1997). Studies have shown increased blood flow in these regions during the performance of cognitive tasks (Javier Villanueva-Meyer et al). Individuals with attention deficit typically demonstrate hypoperfusion and low metabolic activity in the prefrontal lobes.

At the Advanced Cognitive Enhancement clinic in Toronto, Passive Infrared Hemoencephalography (pIR HEG) technology has been used to further test the effectiveness of SharperBrain. pIRHEG is a form of neurofeedback that uses signals based on thermal output caused by changes in blood flow and cellular metabolism, instead of the electrical activity used by traditional neurofeedback instrumentation. This relatively new technology enables measurement of vascular changes at the frontal lobes by measuring changes in infrared temperatures (Toomim & Carmen 1999).

Patients at the beginning of their treatment for attention deficits and for memory decline were connected to this form of EEG. An infrared sensor was attached to the forehead and connected to a control system that displayed the temperature using an LED. In the beginning, subjects were instructed to play a computer game (pinball) for 10 minutes. After a short break, they were prompted to use the SharperBrain program. Measurements demonstrated more significant elevation in frontal-lobe temperature, indicating improved circulation in that area. This rise in frontal infrared output is regarded as an indication of better frontal-lobe engagement. Similar results were recorded even when the order of activity was reversed (SharperBrain first, pinball game second). With continued practice, patients were able to elevate temperature level and maintain it effortlessly. In this “Focus Zone,” the ability to sustain attention seems to extend beyond the practice session. Over time, this form of conditioning facilitates a natural ability to maintain prolonged attention when required.

It is, therefore, hypothesized that SharperBrain can effectively engage different regions of the frontal lobes-for instance, the superior medial, left dorsolateral, right dorsolateral, and more (Stuss, Binss, Murphy & Alexander 2002)-to enable improved ability to perform executive functions and various cognitive tasks. The use of SharperBrain also indicates better task switching, which is associated with improved coordination of executive functions (Kramer, Hahn, & Gopher 1999). More research is currently being conducted to provide empirical evidence to support this hypothesis.

Case study #1 Mathew, a 12-year-old boy diagnosed with ADHD, had been taking Ritalin for two years. He stopped taking medication upon his parents decision, just before starting the program.

The scores in this program represent the accuracy and speed of responses to the different cognitive tasks. During the initial evaluation, Mathew demonstrated a high incidence of commission (typical of ADHD, this is an error made because the individual reacts when reaction is not called for). His average score on the first 12 levels of the program was 59%. But his score on the combined visual/auditory levels alone was 42%. This discrepancy is usually a strong indication of difficulties in auditory processing.

After three sessions, Mathew reported improvement in his concentration and retention ability, and halfway through the program, his parents noted marked improvement in his impulsivity and listening skills. During the training period, he wrote a few exams in school and reported that his mark in math improved from B minus to B plus and in English, from C to B plus.

The goal was to bring his average to the mid 80s, which is the desired score for individuals with attentional difficulties. With practice, he was able to reduce the rate of commissions, and his average eventually progressed to 79%. However, at that point treatment was terminated because Mathew moved out of town.

Case study #2 Kevin was a second-year university student. He was referred by his mother because of depression associated with learning difficulties. She reported that Kevin had exhibited attentional problems since grade school, but he was not assessed and diagnosed with ADD and LD until he was in high school. Kevin also reported periods of depression in high school, for which he was never treated. He had trouble focusing on his studies or reading for extended periods, and he noted that he would "tune out" during lectures. He was taking no medication.

Kevin was treated for a period of 16 weeks and received 14 treatments altogether. Treatment consisted of cognitive/behavioral therapy for his mood swings, as well as training with the SharperBrain program. His average starting score on all 36 levels was 52%. Special difficulties were noted on levels that required divided attention.

Shortly after completing 14 sessions, he wrote his second-semester exams. His overall average rose from 64% to 76%. He reported being able to focus on reading material for longer periods of time. His ability to tune out distractions, which was strongly emphasized during the program, also improved. After the twelfth session, his 36-level average had risen to 81%.

When the school year was over, Kevin decided to take a break; he never returned for further training. Three months after the treatment ended, he reported that his motivation and self-confidence had improved. He estimated that his overall concentration was improved by 75%, and he felt he did not need more work.

Case study #3 Amanda, a ten-year-old fourth-grade student, was diagnosed with ADD about a year prior to starting the program. She did not take any medication for her condition. Her parents reported that she daydreamed frequently, could not concentrate in class and required more time to complete her homework than they thought was reasonable.

Amanda did well on the first three levels of SharperBrain (average score 78%) but had difficulties on the next levels, which required divided attention (54%) and combined auditory/visual processing (48%). She also scored very low on levels that incorporate distractions (42% average).

Amanda's case was remarkable, because after only four sessions her 36-level average rose from 52% to 72%. She reported being able to pay better attention to the teacher, and her mother confirmed that she required less time and less help to prepare homework. We cannot explain this rapid improvement. However, we believe that Amanda was able to quickly figure out the connection between the goals of the program and their application to her studies. She had 8 sessions in total, with an average score of 78% during the last session.

Other cases The SharperBrain program has been tested on a broad spectrum of concentration and memory impairments, such as those associated with stroke, closed-head and traumatic brain injuries, as well as on cognitive decline associated with aging. In most cases, marked improvement has been recorded in terms of long-term and working memory and the ability to sustain attention and to multitask. A recent follow-up on the first three cases to train on SharperBrain confirmed that, after nearly three years, these individuals retained most of the benefits gained from the program.

Summary

SharperBrain has proven to be effective in treating a variety of cognitive deficits for both children and adults. The program may prove to be an effective tool for helping individuals that suffer from attention deficit and cognitive impairment, used in a clinical setting, a classroom, or at home. Presently, there are two versions of the program: one for home use and one for use by professionals. The professional version allows more flexibility in the design of outcomes and incorporates 18 advanced levels.

Quantitative studies are being designed to further establish the efficacy of the program for children with AD/HD and LD. Additional studies to evaluate the efficacy of the program for the head/brain injury population are also being planned for the near future.

References

Bellenkes, A.H., Wickens, C.D., and Kramer, A.F. (1997). Visual scanning and pilot expertise: The role of attentional flexibility and mental model development. Aviation*, Space and Environmental Medicine*, 48(7), 569-579.)

Castellanos (1997). Toward a pathophysiology of attention-deficit/hyperactivity disorder. *Clinical Pediatrics, 381.* <*http://intramural.nimh.nih.gov/chp/articles/adhd/castellanos97a.pdf*>

Fenger T.N. (1995). Visual-Motor Integration and its Relation to EEG Neurofeedback Brain Wave Patterns, Reading, Spelling, and Arithmetic Achievement in Attention Deficit Disorders and Learning Disabled Students. Presentation at 1995 Society for the Study of Neuronal Regulation, Scottsdale, AZ.

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Cerebral Blood Flow During A Mental Activation Task

Kramer, A. F., Hahn, S., & Gopher, D. (1999). Coordinative executive processes during Task Switching. *Acta Psychologica*. 101, 339-378.

Linden, M., Habib, T., Radojevic, V. (1996). A controlled study of the effects of EEG biofeedback on cognition and behavior of children with attention deficit disorder and learning disabilities. *Biofeedback & Self-Regulation, 21*(1), 35-49.

Lubar, J.O., Bianchini, K., Calhoun, W., Lambert, E., Brody, Z. and Shabsin, H. (1985). Spectral analysis of EEG differences between children with and without learning disabilities. *Journal of Learning Disabilities, 18*, p. 403-408.

Lubar, J.F., Shouse, M.N. (1976a). EEG and behavioral changes in a hyperkinetic child concurrent with training of the sensorimotor rhythm (SMR): A preliminary report. *Biofeedback and Self Regulation, 3*, p. 295-306.

Lubar, J.O., Lubar, J.F (1984) Electroencephalographic biofeedback and SMR and beta for treatment of attention deficit disorder. *Biofeedback and Self Regulation. 9* (1) p. 1-23.

Miller K.E., Cohen D.J. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience, 24,* p.167-202.

Monastra, V. J., Monastra D., George, S (2002). The effects of stimulant therapy, EEG Biofeedback, and parenting style on the primary symptoms of attention deficit hyperactivity disorder. *Applied Psychophysiology and Biofeedback, 27* (4), p. FFF.

Posner, I.M., & Peterson, E.S. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* p. 25-42.

Stuss, D.T., Binss, M.A., Murphy, K.J., & Alexander M.P. (2002) Dissociations within the anterior attentional system: Effects of task complexity and irrelevant information on reaction-time speed and accuracy. *Neuropsychology, 16* (4), p. FFF

Tansey, M. A. (1985). Brainwave signatures -An index reflective of the brain's functional neuroanatomy: Further findings on the effect of EEG sensorimotor rhythm biofeedback training on the neurologic precursors of learning disabilities. *International Journal of Psychophysiology, 3,* p. 85-89.

Tansey, M. A. (1991). Wechsler (WISC-R) changes following treatment of learning disabilities via EEG biofeedback in a private practice setting. *Australian Journal of Psychology, 43,* p. 147-153.

Winkler, A., Dixon, J., & Parker, J. (1970). Brain function in problem children and controls: Psychometric, neurological, electroencephalogic comparisons*. American Journal of Psychiatrv, 127,* p. 94-105.