

EEG Biofeedback for Attention Deficit Disorder

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Background

During the last 20 years, EEG biofeedback has emerged as a viable method for treating a variety of conditions, by allowing the brain to learn how to alter particular rhythms and to control the relationships between them. Early work in the 1960's and 1970's led primarily to a generalized "relaxation" model for alpha biofeedback, which was associated with meditation and related practices. However, through systematic research into the structure of brain rhythms associated with various activities and conditions, it has been discovered that EEG biofeedback can be an important tool that can lead a subject (or patient) to develop the ability to control specific brain activity by developing the ability to differentially control various frequency components.

The origins of EEG biofeedback for ADD/ADHD are found in neurodiagnostic work that was pioneered by Jasper and Knott, but was not fully pursued until the 1970's. In particular, Satterfield et. al. (1973) developed the hypothesis that hyperkinetic children have a problem with reticular activation, resulting in a low level of arousal, so that these children are easily habituated to sensory stimulation. This explained the positive effects of amphetamine sulfate originally obtained by Bradley (1937). Based on this work, Lubar suggested that children with hyperactivity, particular where there was an attention deficit, might be less able to produce beta activity above 14 Hz, and would experience excessive slow activity in the theta region of 4-8 Hz. This was based on the idea that these children are less able to shift from the resting dominant alpha/theta pattern, to produce the normal shift to beta that occurs when one becomes excited.

At the same time, M.B. Sterman had begun to use training of the sensorimotor rhythm (SMR) for the management of seizures. In working with Dr. Sterman, Dr. Lubar observed that some of the seizure patients were high school or college students who experienced increased attentiveness, focus, and concentration as a result of the EEG training. In 1976, Lubar and Shuse published a case study demonstrating EEG and behavioral changes in an 8 year old hyperkinetic child following SMR training (reinforcement was blocked when 4-7 Hz theta was also present). During this training, SMR increased threefold, spontaneous EMG reduced by 50%, and a variety of classroom measures of attention and sustained school work improved. A blind reversal of the reinforcement protocol caused the child's EEG to regress to the previous levels, with a concomittant deterioration of school performance.

More extensive studies (Shouse & Lubar, 1978, 1979, Lubar, 1977) followed, employing more children with the same paradigm. These blind crossover studies provided clear evidence that the EEG training was a useful modality for working with the hyperkinetic disorder. After completing these controlled studies, Lubar began to use EEG biofeedback training with hyperkinetic children, as well as patients with seizure disorders. He observed that children with attentive difficulties and problems in reading or spelling, who were not hyperkinetic, exhibited excessive 4-8 Hz theta, plus were deficient in beta production. He developed a paradigm that involved training of SMR initially, and beta (16-20 Hz) activity at a later stage. In both cases, theta was inhibited.

A case study of 6 such patients showed that SMR training followed by beta training with theta inhibition produced significant and sustained improvements in school performance and psychometric measures. Letter grades improved, and learning curves showed significant improvements in both SMR and beta production, with attendant decreases in theta. Since 1980, the Southeastern Biofeedback Institute has treated over 250 children diagnosed with ADD, with and without hyperactivity.

Gains can be permanent, particularly if the biofeedback skills are combined with academic training and incorporated into the classroom setting. Children can build on what they have achieved, and continue to do better.

Technical Issues

Distinctive features of modern EEG biofeedback include the use of more than one frequency band, the combination of reinforcement with discouragement of individual bands, and the critical adjustment of training thresholds. The most common protocol used for the treatment of ADD is to encourage the 12-15Hz band, ("high alpha," "low beta," or "SMR"), and to discourage the theta band, generally from 4-8 Hz. Before training is applied, a baseline EEG is taken. In contrast to conventional 20-minute, multichannel EEG workup, this baseline may consist of a brief monitoring of one or two sites, with the possibility of one or two simple instructions, or a comparison of resting EEG with that when the subject is thinking or speaking. In addition, the therapist may interview the subject, and observe short-term variations in EEG components, as the subject responds. During this assessment, real-time display of EEG frequencies is desirable. This may be achieved either with a concurrent spectral (FFT) display, or with the use of digital filters, so that each frequency band occupies its own waveform display channel.

Two methods are available for the measurement and display of EEG frequency bands: Spectral display, generally using the Fast Fourier Transform (FFT), and digital filtering, which provides a real-time waveform display limited to the frequencies of interest. It is generally accepted that the use of digital filtering is superior, in that it provides a more rapid indication of changes. If the feedback is to be useful to the patient, it must provide a rapid and accurate indication of the frequency content of the EEG. Generally, a response time of 250 milliseconds is considered the maximum tolerable, and response within one or two cycles of the pertinent rhythm is preferred. In the case of a 15 Hz rhythm, this would be 1/15 second, or approximately 75 milliseconds.

The thresholds used to set reward criteria for both the encouragement of the fast alpha, and the discouragement of theta, must be constantly monitored by the therapist, and may need to be adjusted on an as-needed basis. If rewards are too frequent, little discrimination is possible, and learning cannot occur. If rewards are too rare, the patient has little opportunity to experience the mental state that is being sought, and feedback is, again, not efficacious. In addition, as training progresses, the size of the EEG components can change, as much as 50% over a period of minutes, so that adjustments must be made, to keep the training effective. As a result, EEG biofeedback requires a well-trained therapist, and careful attention to the progress of the patient.

Since only one channel can be practically trained at any time, issues of localization, and of hemispheric specificity arise. For example, Carter and Russell (1981) have reported larger increases in verbal IQ with left hemispheric training, and larger increases in performance IQ with right hemisphere training.

Clinical Issues

The following table summarizes the clinical experience with EEG biofeedback in the treatment of ADD and related disorders:

“pure” ADHD	generally respond extremely well
Hyperkinesis	may respond well, may also require medication, especially initially
Specific Learning Disabilities	little benefit as a primary modality; may be adjunctive technique
Conduct Disorder	minimal role

Table 1 - Role of EEG Biofeedback in treating Behavioral/Learning Disorders

Several realities come into play in the addition of EEG biofeedback to the existing treatment regime for ADD and related disorders. One is the need to carefully select candidates who will be able to sit for the required number, and duration of, treatment sessions. Sessions typically last 30 minutes, and a minimum of 10-20 sessions are required before noticeable changes occur. A typical regimen of 40 and 60 sessions is often necessary for significant and lasting changes to occur.

Another issue is the difference in treatment time, and cost, for this modality. EEG biofeedback is a time-consuming and slow process, compared with treatment with drugs. In addition, it is currently not one of the more profitable clinical enterprises, due to the relatively low rate of reimbursement. Therefore, some centers discourage the use of this method, and the discouragement may be aggressive, making it extremely difficult, or impossible, to establish or maintain clinical programs. Finally, there is a considerable effort on the part of drug companies, and their supporters, to discourage this approach, since it threatens the sale of ritalin. Overt “negative advertising” campaigns have been carried out, and there are some very outspoken critics of this method.

Criticism of EEG biofeedback is not without substance, however. As with any new treatment, caution must be exercised in the selection of the candidate treatment population. Overzealous practitioners who recommend the method without regard for the patient’s specifics run the risk of engendering enthusiasm even when the treatment is inappropriate. If the treatment is presented as an alternative to medication or other approaches, unnecessary and potentially harmful confusion may result.

EEG biofeedback should be considered as another tool in a comprehensive plan for the treatment of ADD/ADHD, and its use should be carefully planned, with consideration of each individual’s situation and needs.

Overall Issues

The exact nature of ADD/ADHD is still not entirely clear. For one thing, the disorder can result from a variety of causes, including congenital, environmental, and episodal circumstances. Moreover, since a considerable fraction of the population (5% to 15%) is estimated to have this disorder, one may immediately question whether it is a disorder at all, or whether it is more accurately viewed as a condition that lies on one end of a continuous spectrum. In other words, rather than saying that 5% to 15% of the population “has ADD,” it may be more appropriate to say that 5% to 15% of the population exhibits extreme signs of a condition and behavior pattern that we all have, to a greater or lesser extent.

The importance of this distinction is that it leads to a very different approach to treatment. Rather than trying to eradicate the “disease” with medication or therapy, it makes more sense to “reduce” or “temper” the undesirable behaviors, and to help the patient to learn more appropriate ways of using the brain. Rather than labeling the individual as defective or diseased, we simply recognize that they are at the end of a continuum of a condition that we all have, and that it is simply desirable to help them move more toward the center. The other important effect of this point of view is the recognition that even individuals who do not “have ADD/ADHD” may benefit from EEG biofeedback and related practices, since to condition the brain into a healthier, more productive state is also of benefit to those who do not have a clinically recognizable degree of the disorder.

One point of view is that the “condition” of ADD/ADHD is simply the expression of a normal “hunter/gatherer” mode of behavior, which may be thought of as the opposite of a “sedentary/agrarian” mode of behavior. Since we all have both of these behavioral modes in our ancestral makeup, it is normal to expect them to be expressed, to a greater or lesser degree. The issue becomes one of learning to express the appropriate behavior at the appropriate time, not to eradicate the behavior.

A recent distinction is that what is being taught is flexibility, and appropriateness of mental modes, rather than an absolute conditioning to encourage or discourage a particular state. The child learns to recognize when the brain is in a particular state, and learns to move into a more appropriate state, at an appropriate time. To quote one recent participant, “I can’t say exactly what it is, but I know when I’m doing it right.”

Effects of EEG biofeedback are found to be lasting, and carry on outside of the biofeedback setting, and to last after the biofeedback treatment period is passed. The child is able to recall and use the mental techniques even when the biofeedback equipment is not present. Moreover, the mental skills that develop are lasting, and can remain with the child after the biofeedback treatment program has been discontinued.

New Horizons

New methods are being explored, that address some of the limitations of EEG biofeedback. One is the use of light and/or sound to stimulate, or “entrain,” the brain to produce desired rhythms. While it is likely that such photic or sonic stimulation cannot in itself produce lasting changes, it appears that this is a valuable means of teaching the patient what the subjective correlates of the desired states are, and this appears to accelerate biofeedback training. It has been estimated that, with light/sound stimulation, the typical requirement of 40-60 biofeedback sessions may be reduced to 20-40 sessions, to produce the same, lasting changes in EEG rhythms.

Other methods use different feedback modalities, such as vibrotactile stimulation, or photic driving used as a biofeedback mechanism. One benefit is that the patient can work with eyes closed, which seems to make it easier to produce certain desired states, especially when the desired states are inconsistent with the task of being alert, and attending to a graphical, visual, display.

Yet another approach is to integrate the EEG biofeedback with other tasks, especially tasks that also use the computer. For example, EEG biofeedback can be performed simultaneous with computer-based attention training programs, or something as simple as using a word processor. Also, the biofeedback can be coupled with the other programs, so that information can flow to

and from the task program, providing new methods of giving the feedback to the user. For example, one new approach is to control the level of difficulty of a video game, using EEG (Pope & Bogart, 1996). Thus, when the user is in a desired state, the computer game can become more easy to control. This teaches the user to approach the task with a different type of mental state, thus providing practical, task-oriented training.

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