

Applicability of brain wave biofeedback to substance use disorder in adolescents

(This article has been lightly edited by David Dubin, MD to make it more accessible to a general public.)

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Brain wave biofeedback (sometimes called neurofeedback or neurotherapy) has been studied as a method for treatment of addictive disorders in adults over the past 15 years or so, with a slowly accumulating body of evidence supporting its use in different circumstances.

Although neurofeedback is an attractive technique for treating addictive disorders because it is medication free and compatible with other therapies, it also appeals to persons interested in alternative treatments. It has applicability in difficult-to-treat groups, such as stimulant abusers [3], [4], [5], incarcerated felons [6], and chronic treatment-resistant alcoholics [7], [8]. Most authors describe enduring effects, and in the case of addictions treatment, long-term follow-ups have been done.

Brain wave biofeedback techniques for **psychoactive substance use disorder (PSUD)** may be of special interest for adolescent medicine because of the high comorbidity of PSUD and attention deficit hyperactivity disorder (ADHD) in adolescents [9]. The techniques that are described in this article that combine classic ADHD neurofeedback approaches with addiction neurofeedback approaches hold special interest for adolescents with PSUD. They are medication free and minimize opportunities for medication abuse, by inappropriate self-overdose and by trading medication for other substances.

Hyperactive ADHD is clinically significant because it is an antecedent for PSUD, conduct disorder, and antisocial personality disorder [10], [11], [12]. Neurofeedback techniques may have special applicability in attempting to treat the constellation of conduct disorder, non-alcohol PSUD, and ADHD in teens who are already abusing stimulants. The author reported on the high incidence of childhood ADHD in a sample of adults with chronic PSUD and found that childhood ADHD status in this population predicted adult stimulant abuse [13]. This research sample supports other literature that finds significant over-representation of adults and adolescents with co-morbid ADHD and PSUD and among children with ADHD who develop PSUD over time [14], [15], [16].

Brain wave biofeedback techniques used in addictions

Most addiction protocols involve the use of **alpha-theta biofeedback**. Alpha-theta feedback training was first used and described by Green et al [17] in 1975 at the

Menninger Clinic. This method was based on Green's observations of single-lead EEG during meditative states in practiced meditators. When the separate and independent auditory feedback of alpha and theta signal was given to subjects in eyes-closed seated or semi-recumbent relaxed condition, states of profound relaxation and reverie were reported to occur. Whereas the EEG changes produced are similar to stage 1 sleep [18], the subjects were maintained in a relaxed yet focused condition, subjectively similar to a hypnotic trance with reverie and a sense of timelessness.

Alpha-theta brain wave biofeedback was seen as useful in augmenting psychotherapy and individual insight by Green and colleagues. It could be seen as a use of brain wave signal feedback to enable a subject to maintain a particular state of consciousness similar to a meditative or hypnotic relaxed state over a 30- or 40-minute feedback session.

The first studies of alpha-theta biofeedback for addictions focused on augmenting therapy experience in alcoholics engaged in psychotherapy and 12-step model programs in a Veterans Administration hospital setting. Daily 20-minute alpha-theta EEG biofeedback sessions (integrated with EMG biofeedback and temperature control biofeedback) were done over 6 weeks and resulted in free, loose associations, heightened sensitivity, and increased suggestibility [22]. Patients discussed their insights and experiences associated with biofeedback in therapy groups several times a week, which augmented expressive psychotherapy. Twemlow and Bowen [23] found that “religiousness” as a predictor of “self-actualization” may have increased as a result of imagery experienced in theta states. This was seen as positive to the program goal of augmenting Alcoholics Anonymous as a recovery philosophy.

In another uncontrolled study at **Topeka Veterans Administration hospital**, 21 alcoholics participated [24], [25]. These initial studies advanced the use of biofeedback-induced theta states in promoting insight and attitude change in alcoholics, with the assumptions that biofeedback-induced theta states are associated with heightened awareness and suggestibility and that this heightened awareness and suggestibility would enhance recovery.

Peniston and Kulkosky [8], [26] reported a randomized and controlled study of adult chronic treatment resistant alcoholics treated with alpha-theta EEG biofeedback. Compared with a traditionally treated alcoholic control group ($n = 10$) and nonalcoholic controls ($n = 10$), alcoholics who received brain wave and temperature biofeedback ($n = 10$) showed significant improvements in Beck Depression Inventory scores compared with the control groups. Control subjects who received standard treatment alone showed increased levels of circulating beta endorphin, an index of stress, whereas the brain wave biofeedback group did not. Thirteen-month follow-up data indicated significantly more sustained prevention of relapse and substantial changes in personality test results in the experimental group compared with the controls.

Subsequent studies of Peniston's Protocol in adult alcoholics showed similar positive changes in personality testing and long-term abstinence and remission of comorbid depression [29] and long-term abstinence and decreased re-arrest rates in probationers [7]. A critical analysis of the Peniston Protocol is discussed at length in a previous review [1].

In a large randomized study of alpha-theta training for addiction in the **Kansas Prison System** using group training equipment, little difference was shown between two groups (alpha-theta training plus standard rehabilitation treatment versus standard rehabilitation treatment alone) at 2-year outcome [6]. When results were analyzed for age, race, and drug of choice, however, neurofeedback emerged as a more efficacious treatment for younger and non-white and non-stimulant-abusing participants. The alpha-theta protocol was not effective for cocaine abusers, whereas modifications that incorporate beta training before alpha-theta have been effective with cocaine abusers.

Scott and Kaiser [3], [30] described combining a protocol for attentional training (beta or sensorimotor rhythm augmentation with theta suppression) with the Peniston Protocol (alpha-theta training) in a population of subjects with mixed substance abuse rich in stimulant abusers. Their study group was substantially different than that reported in either the Peniston or replication studies, in that 97% of the subjects were mixed substance abusers with only 6% having alcohol as a drug of choice. One hundred twenty-seven inpatient drug program subjects were randomized to condition, and follow-up was conducted at 1 year. The experimental group received a 40-session biofeedback protocol in addition to the standard residential treatment, the control group received standard treatment alone. Subjects were tested and controlled for the presence of attentional and cognitive deficits, personality states, and traits.

Experimental subjects demonstrated $P < 0.005$ level significant changes beyond the control subjects in five of the ten scales of the Minnesota Multiphasic Personality Inventory (MMPI)-2. Subjects in the experimental group also were more likely to stay in treatment longer and were more likely to complete treatment compared with the control group. Finally, the 1-year sustained abstinence levels were significantly higher for the experimental group compared with the control group.

The approach of beta training before alpha-theta training has been applied successfully in a treatment program aimed at homeless crack cocaine abusers, with impressive results [5]. In a non-controlled open trial, 270 male addicts received 30 sessions of a modified protocol of beta training before alpha-theta training. One-year follow-up of 94 treatment completers indicated that 95.7% of subjects are maintaining a regular residence, 93.6% are employed or in school or training, and 88.3% have had no subsequent arrests. Self-report depression scores dropped by 50% and self-report anxiety scores dropped by 66%. Of the 270 subjects, 53.2% reported no alcohol or drug use 12 months after biofeedback, and 23.4% used drugs or alcohol one to three times after their stay. The remaining 23.4% reported using drugs or alcohol more than 20 times over the year. Urinalysis results corroborated self-reports of drug use. This was a substantial improvement from the expected 30% or less expected recovery in this group, typical of the outcome before the introduction of brain wave training at the study facility.

After the introduction of neurofeedback to the mission regimen, length of stay tripled, beginning at 30 days on average and culminating at 100 days after the addition of neurotherapy. Similarly, before neurotherapy, the mission was “graduating” 12 men per year from their drug treatment program, which has increased to an average of 12 graduates per month.

Applicability of neurotherapy for psychoactive substance use disorder to adolescents

All of the work presented thus far has been concerned with adults. Although little work is available on the prevention and treatment of PSUD in adolescents and children using neurotherapy, there is no reason to suspect that the applicability of the approaches used in adults would not be applicable in adolescents with PSUD.

There have been several reports of brain wave biofeedback used to treat **co- Untreated ADHD**, especially with hyperactivity and conduct disorder in boys, is a risk factor for PSUD [10], [11], [12]. Brain wave biofeedback treatment of ADHD may be important in prevention for children and adolescents at risk for developing PSUD. Stimulant medication treatment of ADHD in children has been shown to not increase subsequent PSUD [48]. Stimulant therapy protected patients who are medicated for ADHD against substance use disorder, which occurred at rates that were three to four times greater among people with untreated ADHD [49]. It may be possible that brain wave biofeedback therapy of childhood ADHD also is associated with a decrease in later life PSUD.

Brain wave biofeedback of ADHD in children and adolescents recently was reviewed extensively [50], [51]. To date, four controlled group studies [52], [53], [54], [55] have been reported in peer-reviewed journals. Each of these studies sought to examine the effects of EEG biofeedback in the treatment of patients diagnosed with ADHD while attempting to control for certain factors (eg, age, intelligence, severity of symptoms before initiating treatment). Maturation effects also were controlled in each of these studies, and comparisons with stimulant medication were included in three of the four studies to control for placebo and trend effects. To date there have been no reported studies of the effect of neurofeedback treatment on prevention of PSUD.

EEG biofeedback of ADHD may be medication free or combined with medication adjunctively. EEG biofeedback may be a preferred approach for child and adolescent ADHD if medication abuse is suspected, if side effects of medication are not tolerated, or if medication is not fully effective. It also may be the choice of patients and therapists who prefer non-medication treatments. Side effects commonly associated with medication (eg, growth retardation) have not been reported with brain wave biofeedback.

Summary

Neurotherapy treatment for addictions holds promise as a treatment modality for adolescents and is attractive as a medication-free, neurophysiologic, and self-actualizing treatment for a substance-based, brain-impaired, and self-defeating disorder. It may have special applicability to treatment-resistant adolescent substance abusers who have attention and conduct problems and to adolescents who abuse stimulants.

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