IPA
International Journal of Psychology
Vol. 5, No. 2, Summer & Fall 2011
PP. 93-114

Iranian **P**sychological
Association

Evaluation of Alpha/Theta Neurofeedback Composed with Scott and Kaiser Protocol as a Treatment for Substance Use Disorders

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The use of neurofeedback as an operant conditioning paradigm has revealed that participants are able to gain some control over particular aspects of their electroencephalogram (EEG). Based on the association between alpha (8–13 Hz) and theta (4–8 Hz) with a hypnogogic state, and beta (15-18 Hz) and/or SMR (12-15 Hz) augmentation and theta (4–7 Hz) and high beta (22-30Hz) suppression with attention processing and relaxation, we investigated the possibility of training addicted individuals in order to enhance their mental health and thus increase the frequency of individuals with prognosis of substance use disorder, in comparison with a control group. Thirty-four males (age: 28.25 ± 3.12 years) diagnosed with Substance Use Disorder (opium addicted) were randomly assigned to Neurofeedback (NF) group (N=16) and control group (N = 18). Participants were assessed prior and subsequent to the training process on two tests of Rap Dip™ InstaTest and the Depression Anxiety Stress scale (Lovibond & Lovibond, 1995). The results of analysis of variance with repeated measures showed that, after twenty sessions of neurofeedback, the treatment group exhibited a significant and clear improvement in depression and anxiety, but there were no significant differences between the two groups in terms of stress variables. Also, negative rate in urinalysis results in treatment group were higher than those for the control group (43.8% vs. 22.2%). However, this difference between neurofeedback and control group was not significant (chi-square= 1.79, P=0.18). This study suggests that SUD individuals can learn to improve their depression and anxiety and to a lesser extent to withdraw from substance use.

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We discuss possible mechanisms that could mediate such effects and indicate a number of directions for future research.

***Keywords*:** EEG biofeedback, neurofeedback, alpha/theta protocol, sensorimotor rhythm, addiction

Substance use disorders (SUD) include disorders related to taking of a drug of abuse (including opium), and represent the most common psychiatric conditions (APA, 2000) resulting in serious impairments in cognition and behavior. The SUD commonly referred to as ‘‘drug addiction’’ is characterized by physiological dependence accompanied by the withdrawal syndrome on discontinuance of the drug use, psychological dependence with craving, the pathological motivational state that leads to the active drug seeking behavior, and tolerance, expressed in the escalation of the dose needed to achieve a desired euphoric state. Drug addiction is a chronic, relapsing mental disease that results from the prolonged effects of drugs on the brain (Dackis and O'Brain, 2001; Volkow, Fowler & Wang, 2003, 2004).

Drug addiction can take control of the brain and behavior by activating and reinforcing behavioral patterns that are excessively directed to compulsive drug use (Di Chiara, 1999; Gerdeman, Partridge, Lupica & Lovinger, 2003). In 2002, it was estimated from the Substance Abuse and Mental Health Service Administration (SAMHSA, 2004) that 22 million Americans have a substance abuse or dependence disorder. The prevalence rates for opiates consumption vary between 0.1% and 2% for the total global population, with the highest annual prevalence rates defined as exceeding one percent of the population above the age of 15 years reported in Asian countries, such as the Islamic Republic of Iran (Hillebrand & Monterio, 2001). In Iran, the number of substance users is estimated between 1.8 and 3.3 million, and the number of intravenous drug users is between 200,000 and 300,000, of whom 1841 are estimated to be suffering from HIV infection. About 74.8 % of all those suffering from HIV infection are intravenous drug users (Bashardoost and Tirani, 2005). In recent decades, HIV infection has increasingly become a global

phenomenon (Mooney, Knox & Schacht, 2006). Many patients seeking treatment for addiction have multiple drug dependencies and psychiatric comorbidities (Volkow and Li, 2005), such as anxiety disorder and bipolar or major affective disorder (Sokhadze, Cannon and Trudeau, 2008).

Furthermore, acute and chronic drug abuse results in significant alteration of the brain activity detectable with quantitative electroencephalography (qEEG) methods. Neurofeedback training (NFT) as an operant conditioning method to control oneself's brain activity has been shown to be an appropriate way to control or change these oscillations (Zoefel, Huster & Herrmann, 2011). The treatment of addictive disorders by electroencephalographic (EEG) biofeedback (or neurofeedback, as it is often called) was first popularized by the work of Eugene Peniston (Peniston and Kulkosky, 1989, 1990, 1991) and became popularly known as the Peniston Protocol (Demos, 2005). This approach employed independent auditory feedback such as waves gently crashing on the beach or a babbling brook. This feedback includes two slow brain wave frequencies, alpha (8–13 Hz) and theta (4–8 Hz) in an eye-closed condition to produce a hypnogogic state. The efficacy of alpha-theta EEG biofeedback may lie in its ability to allow participants to deal with anxiety and anxiety-eliciting situations, which are particularly evident during the initial phases of recovery. The patient was taught prior to neurofeedback to success imagery (being sober, refusing offers of drug, living confidently, and happy) as they drifted down into an alpha-theta state. Repeated sessions reportedly resulted in long-term abstinence and changes in personality and mental health. Given that the method seemed to work well for alcoholics, it has been tried in participants with cannabis dependence and stimulant dependence.

Peniston and Saxby (1995) reported on 14 chronically alcohol dependent and depressed outpatients using this same protocol of alpha-theta brainwave biofeedback. Following treatment, subjects showed substantial decreases in depression and psychopathology as measured by standard instruments. Twenty-one month follow-up data indicated

sustained abstinence from alcohol confirmed by collateral report. These male and female outpatients received 20 40-min sessions of feedback. Bodenhamer-Davis and Calloway (2004) reported a clinical trial with 16 chemically dependent outpatients, 10 of whom were probationers classified as high risk for re-arrest. Participants completed an average of 31 alpha/theta biofeedback sessions. Psychometrics demonstrated improvements in personality and mood. Follow-up at 74–98 months indicated 81.3% of the treatment subjects were abstinent. Re-arrest rates and probation revocations for the probation treatment group were lower than those for a probation comparison group (40% vs. 79%).

Fahrion (1995) gave a preliminary report (n=119) on a large randomized study of alpha-theta training for addiction in the Kansas Prison System using group-training equipment. A report of the completed study (n=520) (Fahrion, 2002) showed little difference between the two groups overall at 2-year outcome. But, when results were analyzed for age, race and drug of choice, neurofeedback emerged as a more efficacious treatment for younger and non-white and non-stimulant abusing participants. Interestingly, this protocol was not effective for cocaine abusers. But, alpha/theta protocol limited success in the work of Scott and Kaiser (Scott and Kaiser, 1998; Scott, Kaiser, Othmer & Sideroff, 2002; Scott, Kaiser, Othmer & Sideroff, 2005). They described combining a protocol for attention training (beta and/or SMR augmentation with theta suppression) with the Peniston protocol (alpha-theta training) in a population of subjects with mixed substance abuse, rich in stimulant abusers. The beta protocol is similar to that used in ADHD (Kaiser and Othmer, 2000) and was used until measures of attention normalized, and then the standard Peniston protocol without temperature training was applied (Scott et al., 2002). The study group is substantially different from that reported in either the Peniston or replication studies. The rationale is based in part on reports of substantial alteration of qEEG seen in stimulant abusers associated with early treatment failure (Prichep, Alper, Kowalik & Rosenthal, 1996; Prichep, Alper, Sverdlov, Kowalik, John, Merkin, Tom

& Rosenthal, 2002) likely associated with marked frontal neurotoxicity and alterations in dopamine receptor mechanisms (Alper, 1999). Additionally, preexisting ADHD is associated with stimulant preference in adult substance abusers, and is independent of stimulant associated qEEG changes. These findings of chronic EEG abnormality and high incidence of preexisting ADHD in stimulant abusers suggest that they may be less able to engage in the hypnogogic and auto-suggestive Peniston protocol (Trudeau, Thuras & Stockley, 1999). This approach has become known widely as the Scott–Kaiser modification (of the Peniston Protocol).

A subsequent published paper (Scott et al., 2005) reported on an expanded series of 121 inpatient drug program subjects randomized to condition, followed up at 1 year. Subjects were tested and controlled for the presence of attention and cognitive deficits, personality states and traits. The experimental group showed normalization of attention variables following the SMR-Beta portion of the neurofeedback, while the control group showed no improvement. Experimental subjects demonstrated significant changes (p.05) beyond the control subjects on 5 of the 10 scales of the MMPI-2. Participants in the experimental group were also more likely to stay in treatment longer and more likely to complete treatment as compared to the control group. Finally, the one-year sustained abstinence levels were significantly higher for the experimental group as compared to the control group.

The approach of beta training in conjunction with alpha-theta training has been applied successfully in a treatment program aimed at homeless crack cocaine abusers in Houston, as reported by Burkett et al., (2003), with impressive results. Two hundred and seventy (270) male addicts received 30 sessions of a protocol similar to the Scott Kaiser modification. One-year follow-up evaluations of 94 treatment completers indicated that 95.7% of subjects were maintaining a regular residence; 93.6% were employed/in school or training, and 88.3% had no subsequent arrests. Self-report depression scores dropped by 50% and self-report anxiety scores by 66%. Furthermore, 53.2% reported no alcohol or drug use 12 months after

biofeedback, and 23.4% used drugs or alcohol only one to three times after their stay. This was a substantial improvement from the expected 30% or less expected recovery in this group. The remaining 23.4% reported using drugs or alcohol more than 20 times over the year. Urinalysis results corroborated self-reports of drug use. The treatment program saw substantial changes in length of stay and completion. After the introduction of the 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. In a later study the authors reported follow-up results on 87 subjects after completion of neurofeedback training (Burkett, Cummins, Dickson & Skolnick, 2005). The follow-up measures of drug screens, length of residence, and self-reported depression scores showed significant improvement. Sokhadze et al., (2008) in review of EEG Biofeedback as a Treatment for Substance Use Disorders based on published clinical studies and employing efficacy criteria adapted by the Association for Applied Psychophysiology and Biofeedback and the International Society for Neurofeedback and Research, concluded that alpha theta training—either alone for alcoholism or in combination with beta training for stimulant and mixed substance abuse and combined with residential treatment programs, is probably efficacious.

The present study aimed firstly to look for mental health change in the drug-addicted population, in order to examine how alpha/theta training composed with Scott and Kaiser Protocol might enhance mental health in individuals with substance use disorder. The Depression Anxiety and Stress Scale was the mental health scale chosen for this study (Lovibond & Lovibond, 1995). This scale consists of the three subscales of Depression, Anxiety and Stress. It was hypothesized that alpha/theta neurofeedback composed with Scott and Kaiser Protocol would reduce Depression, Anxiety and Stress.

The present study aimed secondly to explore the effects of neurofeedback on a Rap Dip™ Insta Test which leads to negative or positive urinalysis results.

Method

Participants

Thirty-four addicted-males, aged 22–36 years with a mean age of 28.25 that conferred to Ardabil's rehabilitations centers at June to July 2011 participated in this study. Participants were randomly assigned to either the neurofeedback group (16 experimental participants) or the control group (18 control participants). All participants met the Diagnostic and Statistical Manual of Mental Disorders, 4th ed; Text Revision, (DSM-IV-TR). Criteria for Substance Use Disorders based on clinical interviews and Rap Dip™ Insta Test (American Psychiatric Association., 2000).

Participants were provided informed consent before participating in this experiment, approved by the UCLA Human Participants Protection Committee.

Apparatus and Feedback Contingencies

A commercially available Neurocybernetics (Encino, CA) EEG Biofeedback System (software version 3.02) was used for the training. A ProComp differential amplifier (Thought Technology Ltd., Montreal, Quebec) acquired signal at 256 Hz sampling rate (granting a resolution of <0.01 Hz), and the signal was amplified by a gain of 10.000. Impedance was kept below 10 K*Ä*. The signal was A/D converted and bandfiltered, low-passing only 0–30 Hz activity, and further digital band-pass filtering resulted in the extraction of the bands to be used in the feedback task (alpha: 8–12 Hz; theta: 4–8 Hz) and (beta (15-18 Hz) and/or SMR (12-15 Hz) augmentation and theta (4–7 Hz) suppression) with a smoothing time constant of 0.5 s. The filters had unity gain for the pass-bands, and 3 dB (0.5 amplitude) points were at pass-band§1 Hz. Artifact rejection thresholds were set closely around the raw (0–30 Hz) EEG trace for each subject individually so as to suspend feedback during gross EEG fluctuations caused by motor activity. Relative increases in alpha activity were represented by a background sound resembling a "babbling brook"

with activity exceeding preset thresholds additionally eliciting a high gong sound. Relative theta band increases were represented by an "ocean waves" background sound, with temporary suprathreshold activity additionally eliciting a low pitch gong sound.

Prior and supsequent the sessions, subjective measures indicating subjective assessment of state were taken from the participants via the Depression Anxiety Stress scales (DASS) (Lovibond & Lovibond, 1995) and Rap Dip™ Insta Test.

The Depression Anxiety Stress Scales (DASS). This brief questionnaire consisted of 21 items of mental health that coded into three scales of anxiety, depression, and stress. The psychometric properties of the Depression Anxiety Stress Scales (DASS) were evaluated in a normal sample of N= 717 who were also administered the Beck Depression Inventory (BDI) and the Beck Anxiety Inventory (BAI). The DASS was shown to possess satisfactory psychometric properties, and the factor structure was substantiated both by exploratory and confirmatory factor analysis. In comparison to the BDI and BAI, the DASS scales showed greater separation in factor loadings. The DASS Anxiety scale correlated 0.81 with the BAI, and the DASS Depression scale correlated 0.74 with the BDI. Factor analyses suggested that the BDI differs from the DASS Depression scale primarily in that the BDI includes items such as weight loss, insomnia, somatic preoccupation and irritability, which fail to discriminate between depression and other affective states. The factor structure of the combined BDI and BAI items was virtually identical to that reported by Beck for a sample of diagnosed depressed and anxious patients, supporting the view that these clinical states are more severe expressions of the same states that may be discerned in normal. Nieuwenhuijsen et al., (2003) in studies showed that internal consistency of the DASS subscales was high, with Cronbach's alphas of 0.94, 0.88, and 0.93 for depression, anxiety, and stress, respectively. Factor analysis revealed a three factor solution, which corresponded well with the three

subscales of the DASS. Construct validity was further supported by moderately high correlations of the DASS with indices of convergent validity (0.65 and 0.75), and lower correlations of the DASS with indices of divergent validity (range -0.22 to 0.07). Support for criterion validity was provided by a statistically significant difference in DASS scores between two diagnostic groups. In the present study, internal consistency of the DASS subscales was high, with Cronbach's alphas of 0.90, 0.82, and 0.90 for depression, anxiety, and stress respectively.

Rap Dip™ Insta Test. One-step BUP Rap Dip™ Insta Test is an immune chromatography based one step in vitro test. It is designed for qualitative determination of the major metabolite of buprenorphine, buprenorphine-3-β-d-glucoronide, in human urine specimens at cut-off level of 10 ng/ml (Baselt, 2000). Buprenorphine resembles morphine structurally but has a longer duration of action than morphine and can be administrated sublingually as an analgesic. In October 2002, FDA approved the use of a buprenorphine mono therapy product, Subutex, and a buprenorphine/naloxone combination product, Suboxone, for the treatment of opioid addiction. Subutex and Suboxone are the first narcotic drugs available under the US Drug Act (DATA) of 2003 for the treatment of opiate dependence that can be prescribed in the US in a physician's work place. Buprenorphine is metabolized primarily by n-dealkylation to form glucuronide-buprenorphine and glucuronide-norbuprenorphine. The Cortez One Step BUP Rap Dip™ Insta Test is based on the principle of specific immunochemical reaction between antibodies and antigens to analyze particular compounds in human urine specimen. When drug is present in the urine specimen, it competes with drug conjugate for the limited amount of antibody-dye conjugate. When the amount of drug is equal or more than the cut-off, 10 ng/ml, it will prevent the binding of drug conjugate to the antibody. Therefore, a positive urine specimen will not show a colored band on the test line zone, indicating a positive result, while the presence of a colored band indicates a negative result. The Cortez Drugs of Abuse Test provides a built-in process control with a

different antigen/antibody reaction at the control region. This control line should always appear regardless of the presence of the drug or metabolite. If the control line does not appear, the test device should be discarded and the obtained result is invalid. The presence of this control band in the control region serve as 1) verification that sufficient volume is added, 2) that proper flow is obtained (Fischer et al, 1999).

Procedure

The general rationale of the study and particularly the a/t protocol rationale and feedback contingencies were explained to the participants prior to the study. The participants were also informed that they would be randomly assigned to either a treatment or a control group.

In Phase I, experimental participants underwent 10 sessions of Beta-SMR EEG biofeedback in which operant conditioning was used to augment either 15 to 18 Hz (Beta) or 12 to 15 Hz (SMR) EEG activity. At the same time, training attenuated elevated activity in the 2 to 7 Hz (Theta) and 22 to 30 Hz (High beta) ranges. Active bipolar electrode placement was at C3-FPZ for Beta and at C4-PZ for SMR, based on the International 10-20 system of electrode placement (Jasper, 1958). The starting protocol consisted of Beta training 50% of the time and SMR training 50% of the time. After 10 Beta-SMR EEG biofeedback sessions, participants initiate Phase II.

During Phase II, participants underwent 10 sessions of alpha-theta training. The frequency range for alpha was 8 to 11 Hz and for theta it was 5 to 8 Hz. The initial sessions were used to train down alpha levels that were above 12 □V (peak to peak)**,** while augmenting theta, until there was "crossover". This was defined as the point at which the alpha amplitude drops below the level of theta. Each alpha-theta session began with the subject sitting in a comfortable declining chair with eyes closed. The active electrode was placed at Pz with a left-ear reference (A1). The right earlobe was connected to circuit ground. Two distinct tones were

employed for alpha and theta reinforcement, with the higher pitched sound used to index the higher-frequency alpha band.

At the start of each session, participants were instructed to relax very deeply in order to achieve an increase in the amount of theta sound representation, while avoid falling asleep. Then, the technician spent 3 to 5 minutes reading a script of guided imagery to the experimental subjects that dealt with identified essential elements of maintaining abstinence. These included ongoing regular attendance at 12-step meetings; weekly meetings with a sponsor, expanding the individuals identified comfort zones, and mental exercises dealing with cue extinction and relapse rejection.

After the guided imagery, it was made clear to the subjects that the objective of the training did not involve explicit rehearsal of the script during the EEG biofeedback. Initial alpha and theta thresholds were based on prefeedback baseline measure taken during a 2-min period of behavioral stillness with eyes closed at the beginning of each session in a way to grant suprathreshold activity about 50% of the time for both bands.

Participants reporting previous meditative practices were asked not to use them during the training, since meditation has been observed to override alpha-theta reinforcement effects. Following the alpha-theta training, clients were given the opportunity to process their experience.

When it appeared that sleep might be occurring during training, participants were told prior to their next session to move a limb if they heard the technician say either, "Right foot, left foot, right hand, or left hand". At points where the subject's delta activity (2 to 5Hz EEG) started to elevate, as well as at their highest amplitudes, (indications of sleep onset) the limb commands were given to determine responsiveness. The delta amplitude value at which the subject transitioned to nonresponsiveness was documented. Subsequently, during sessions where delta was elevating toward non-responsiveness levels, the feedback sounds were inhibited in order to discourage the sleep transition. On occasions, when any technical problems were encountered, or if a participant reported

to have fallen asleep during a session, the session was considered invalid and would be rescheduled.

Sessions were administered 3-4 times a week at approximately identical time of day (50 min) for each participant, until the required ten sessions of valid data were collected. The control group received medicine treatment time equivalent to these biofeedback sessions. At approximately 5 weeks after conclusion of the data collection, the participants were presented preliminary results of the study.

Statistical Evaluation

All strategy questionnaire data were normally distributed. The Barlett Test showed homogenous variances. Parametric procedures, analysis of variance with repeated measures were employed. The data were assessed separately for the first and the last sessions. The significance level was set at <0.05.

Results

Results of Analysis of variance with repeated measures concerning the depression revealed significant group by time interactions in an ANOVA ($F_{(1, 32)} = 18.91$). Also, direct group comparison revealed significant group by time interactions for the anxiety in an ANOVA ($F_{(1, 32)} = 4.83$). But, No significant group by time interactions were found for ANOVA in the stress subscale (Table 1).

Table 1

Depression, Anxiety and Stress in the Pre-and Post-Measurement, Comparing Neurofeedback versus Control Group

Variabl	group	Pre-test	Post-test	$F_{(1,32)}$			ES	
		M(sd)	M(sd)	Group	Time	Interaction	Neurofeedback	Control
Depression	Exp.	16.56(1.96)	14.18(2.58)	.71	33.27***	18.91***	.66	.12
	control	16.11(1.84)	15.77(1.86)					
Anxiety	Exp.	14.93(2.43)	14.12(1.82)	.06	10.91**	4.83*	.50	.08
	control	4.50(1.09)	14.27(1.01)					
Stress	Exp.	15.75(1.61)	15.62(1.58)	1.86	3.28	.48	.12	.05
	control	15.11(0.96)	15.05(0.93)					

*P<0.05 **P<0.01 ***P<0.00

Table 2

Chi-Square Test for the Comparison of Rap Dip™ Insta Test Resulst between Neurofeedback versus Control Group

group	Urinalysis Results		Total	Chi-square	df	Sig.	ES	
	Negative	Positive					Neurofeedback	Control
Experimental	7 (43.8%)	9 (56.2%)	16					
Control	4 (22.2%)	14 (77.8%)	18	1.79	1	.18	.23	.14
total	11 (32.4%)	23 (67.6%)	34					

Result (Table 2) revealed that Rap Dip™ Insta Test was negative in 43.8% of participants in experimental group that were under medicine and neurofeedback simultaneous. While, Rap Dip™ Insta Test's results in control group that only was under medicine treatment was 22.2%. However, this difference between neurofeedback and control group was not significant (Chi-square=1.79, P≤0.05).

Discussion

Mental health

Sessions of neurofeedback produced, on the average, greater improvements in the depression and anxiety groups than the control group. These changes were most notable in the subscale depression with participants having neurofeedback feeling less depression after feedback than the control group. Furthermore, participants in the experimental group reported feeling less anxiety with no significant change on the stress subscale. This finding provides strong evidence to suggest that alpha/theta neurofeedback composed with Scott and Kaiser Protocol is a mood-enhancing procedure.

This study showed that neurofeedback does not have any effect on stress. The reason lies in the fact that stress is a clue that environmental factors (external factors) induce it. Therefore, stress reduction was common to the range of interventions applied, including mental skills training, deep relaxation, the Alexander Technique and the control or elimination of the environmental factors. This problem is wholly consistent with the evidence of Egner and Gruzelier (2003, 2004).

In conclusion, the results of this study were in line with the findings of Peniston, & Saxby (1995), Lawrence (2002), Masterpasqua & Healey (2003), Burkett et al. (2003), Frederick et al. (2004), Scott et al. (2005), Hammond (2005), Sokhadze, Stewart, & Hollifield (2007). Those studies showed that neurofeedback sessions effect on psychological statue and calmness of patients with substance use disorder.

Withdrawal

Negative rate in urinalysis results in treatment group were higher than those for the control group (43.8% vs. 22.2%). However, this difference did not reach significance which lends support to the idea that neurofeedback is moving people towards a change in dependence to opium but that addiction is simply too robust to change quickly within 5 weeks.

This outcome was consistent the findings of Prichep et al. (1996, 2002) and Raymond et al. (2005) but did not support the results of Peniston and Kulkosky (1990), Scott and Kaiser (1998), Scott et al. (2002, 2005), Sokhadze, Cannon, & Trudeau (2008), and Cannon et al. (2008).

There are methodological and theoretical explanations for these results. The methodological reason is the small number of sessions (twenty sessions) used in the present study. Compared with approximately thirty sessions (e.g., Burkett et al., 2003; Bodenhamer-Davis and Calloway, 2004) and 40-50 EEG biofeedback sessions (Scott et al., 2005) used in the afore-mentioned studies. It could be suggested that withdrawal is simply too robust to change over the course of twenty sessions. It is also possible that withdrawal was facilitated by the inclusion of other therapeutic interventions such as those offered by physicians which were intermediating factors in the present study.

The theoretical reason for the discrepancy is that the results of Peniston and Kulkosky (1990), Sokhadze, Cannon, & Trudeau's (2008), and Cannon et al. (2008) were obtained with drug-addicted populations who were only under neurofeedback treatment without the inclusion of physicians interventions. By contrast, the present study used participants who simultaneously underwent neurofeedback and medicine treatments. Also, the control group received medical treatment.

Conclusion

In conclusion, it is suggested that alpha/theta neurofeedback combined with Scott and Kaiser Protocol can improve psychological status in individuals' dependence to Morphine, and thus reduce addiction.

However, these individuals, in addition to the psychological symptoms, suffer from other problems such as family problems (like divorce, family discord, and so on), and comorbid disorders or diseases. Therefore, due to existence of accompanning problems, it is suitable to use neurofeedback in combination with other treatments such as; behavior therapy, family therapy and group therapy.

Moreover, like the other studies, the participants' drop out poses an important limitation to generalization of data as some participants attended the study for only two or three weeks and it can be noted that once the EEG biofeedback was concluded, at week five, the subsequent attrition rates became indistinguishable between the two groups. It may be useful in the future studies to extend the length of the biofeedback training to see its impact on experimental results.

Furthernore, due to the absence of women in this study, gender differences could not be examined.

Effectiveness of neurofeedback on females with substance use disorder and also on injection addicts and comparative multiple treatment studies will enrich the data of this study.

Acknowledgment

The authors would like to thank Ardabil's Rehabilitations Centers for their generous supports and sponsorship of this research.

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Received: 5 / 10/ 2011
Revised : 1 0 / 6 / 2 0 1 2
Accepted: 15 / 6/ 2012