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α-θ Brainwave Training and β-Endorphin Levels in Alcoholics

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An α-θ brainwave biofeedfack training program was applied as a novel treatment technique for chronic alcoholics. Following a temperature biofeedback pretraining phase, experimental subjects completed 15 30-min sessions of α-θ biofeedback training. Compared to a nonalcoholic control group and a traditionally treated alcoholic control group, alcoholics receiving brainwave training (BWT) showed significant increases in percentages of EEG record in α and θ rhythms, and increased α rhythm amplitudes. Alcoholics receiving BWT showed a gradual increase in α and θ brain rhythms across the 15 experimental sessions. These experimentally treated alcoholics showed sharp reductions in self-assessed depression (Beck's Depression Inventory) compared to the control groups. Alcoholics receiving standard medical treatment (abstinence, group psychotherapy, antidepressants) showed a significant elevation in serum β-endorphin levels at the conclusion of the experiment. This neuropeptide is an index of stress and a stimulant of caloric (e.g., ethanol) intake. Application of brainwave treatment, a relaxation therapy, appears to counteract the increase in circulating β-endorphin levels seen in the control group of alcoholics. 13-month follow-up data indicate sustained prevention of relapse in alcoholics that completed α-θ brainwave training.

RECENTLY, investigations have described the electroencephalographic (EEG) features of human alcoholism. Several groups that have studied the sons of alcoholics and chronic alcoholics have demonstrated that even after prolonged abstinence, alcoholics often have lower levels of α waves on background cortical EEGs before ethanol. Further, they are more likely to increase the amount of α waves after alcohol challenge.[1-3] Associated with the poor EEG synchrony exhibited by alcoholics is deficient α activity and decreased amplitudes and increased latencies in some subwaves of event-related potentials.[4-8] These findings suggest that some persons with a predisposition to the development of alcoholism are characterized by deficient α activity compared to controls.[5,9-11] If persons with predisposition to development of alcoholism exhibit deficient α activity while sober, they may be especially vulnerable to alcohol's effects, if drinking enables them to attain a reinforcing psychological state associated with increased α activity.

Major outcome studies that have used specific therapeutic interventions such as controlled drinking, abstinence, compulsory AA attendance, and an active follow-up program yielded results after 2 and 8 years that were no better than those of the natural history of the disorder.[12-14] Considering the overall lack of success of other treatment techniques (i.e., controlled drinking, abstinence, compulsory AA), there is an urgent need for a more efficacious, innovative treatment approach in dealing with alcoholism. Over the past two decades, a variety of techniques subsumable under the global label of relaxation training have been used to treat an exceedingly diverse array of clinical problems, including depression and alcohol abuse.[15-18] The application of relaxation training in the treatment of substance abuse is effective in alleviating anxiety, assessed either in nonstress or stress situations that have been associated with increased drinking of alcohol.[19-24] Using such techniques as systematic desensitization and biofeedback, researchers and therapists have taught voluntary control of a variety of physiological changes including blood pressure, muscle tension, skin temperature, and particular brain-rhythm patterns. However, the empirical efficacy of these techniques, and their long term efficacies, remains equivocal.[25-28]

EEG brainwave α-θ training, a biofeedback technique used to learn control of particular brain-waves, is being increasingly applied for the treatment of a variety of disorders. Many researchers involved in the study of α brainwaves biofeedback training concur on one broad conclusion regarding its character, that a relaxed state is associated with the α rhythm, labeled "enjoyable," "tranquil," "calm," and "serene."[29-31] Much less has been published about the study of the θ rhythm, though it is known that it appears in the brainwaves record of deeper stages of meditation.[32-34] Results of the application of relaxation training techniques to the treatment of alcohol abuse neither clearly support nor disconfirm the efficacy of such techniques.[25-28] It is hypothesized that the EEGs of chronic alcoholics provided prolonged EEG brainwave α-θ training will show reliable elevations of EEG α amplitudes and an increase in the amount of EEG α activity.

Aside from the EEG α deficiencies exhibited by some alcoholics, alterations have been identified in steroid and peptide hormones and biogenic amines.[35,36] However, there is relatively little known about the causes and effects of changes in the levels of humoral factors in alcoholism. It is speculated that changes in EEG may correlate with significant changes in circulating β-endorphin levels.[37] β-

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Endorphin is an endogenous 31-amino acid opioid peptide that functions to regulate bodily responses to stress by controlling responsiveness to pain.[38–42] Since this neuropeptide increases in blood under conditions of stress[41,43,44] a relaxation therapy such as α-θ training may be expected to lower β-endorphin levels. Injection of the opioid β-endorphin potentiates the behavioral effects of ethanol,[45,46] and chronic ethanol treatment lowers plasma and pituitary β-endorphin in rats.[47–49] However, acute ethanol treatment in vivo or in vitro stimulates β-endorphin release.[50,51] Many authors have proposed a link between alcoholism and the activity of endogenous opioids[52–54] and other peptides,[55] but no conclusive evidence of such a link is yet available.

An EEG brainwave α-θ training program was used as an innovative treatment technique for chronic alcoholic patients. The purpose of this initial study was threefold: (*a*) to test the electroencephalographic effects of brainwave α-θ training on chronic alcoholics; (*b*) to determine whether significant changes occur in the blood levels of β-endorphin in fasting human alcoholics after admission or at termination of the EEG brainwave training program, in comparison with matched alcoholic and nonalcoholic controls; and (*c*) to determine the efficiency of EEG brainwave training as indexed by changes in assessed depression, in comparison with the nonalcoholic controls and subjects receiving the traditional medical program (abstinence, psychotherapy, and psychoactive drugs) for the treatment of alcoholism.

SUBJECTS AND METHODS

The sample was composed of 30 subjects who were randomly selected from three different socioeconomic statuses (lower, middle, and upper-middle) of a population from the alcohol treatment unit (n = 20), and the medical center (n = 10). The criteria for selection of the alcoholic group included: (*a*) subjects with alcoholism diagnoses based on DSM-III[56] and clinical records maintained in the medical center; (*b*) subjects' medical records indicate four or more prior hospitalizations for alcohol treatment at various hospitals; (*c*) subjects' medical records indicate 20 or more years of alcoholism; (*d*) subjects with low average and above intelligence quotients (IQs); and (*e*) subjects were not on psychotropic medications for psychiatric problems. These subjects were assigned at random to either the EEG brainwave α-θ training experimental alcoholic group (EXPALC, n = 10), given a modified version of EEG brainwave α-θ training, or to a traditional control alcoholic group (ALCONT, n = 10) that was given daily group therapeutic sessions and lectures. Subjects (ns = 2) in both alcoholic groups received antidepressant medications as determined by the attending physician. A third group (n = 22) was identified as nonalcoholics through records and interviews of a population within the medical center. Ten subjects were assigned randomly to the nonalcoholic control group (NONALC). These control subjects (n = 10) were also given the pre- and post-EEG, α-θ brainwave, depression inventory, and blood sample measures, and were matched with EXPALC and ALCONT subjects on age and social class.

The EXPALC group had a mean alcoholic history (ALC/H) of 22.50 years (standard deviation (SD), of 7.16); a mean number of prior hospitalizations (prior/H) of 5.4 (SD, 1.42); a mean Shipley Institute Scale intelligence quotient (SIS)IQ of 106.80 (SD, 19.60); a mean chronological age (CA) of 49.29 years (SD, 10.57); and a mean social-economic status (SES) of 4.19 (SD, 0.42). The ALCONT group had a mean ALC/H of 21.20 years (SD, 5.95); a mean number of prior/H of 5.40 (SD, 1.42); a mean SIS IQ of 107.09 (SD, 18.65); a mean CA of 49.00 (SD, 10.16); and a mean SES of 4.09 (SD, 0.56). The NONALC group had a mean SIS IQ of 126.44 (SD, 7.98); a mean CA of 44.09 (SD, 12.04); and a mean SES of 3.09 (SD, 0.87).

Social-Economic Status

Hollingshead's[57] Two Factor Index of Social Position was used in this study to assign subjects to one of five distinct social classes. In the aforementioned process the subjects were asked to report on their occupation and education. The two factors employed in the Two Factor Index of Social Position are " . . . (1) the precise occupational role the head of the household performs in the economy, and (2) the amount of formal schooling he has received."[57] Occupation responses were coded into seven categories: (*a*) executives and proprietors of large concerns and major professions; (*b*) managers and proprietors of medium sized concerns and minor professions; (*c*) administrative personnel of large concerns, owners of small businesses and semi-professionals; (*d*) owners of little businesses, clerical and sales workers and technicians; (*e*) skilled workers; (*f*) semiskilled workers; and (*g*) unskilled workers. Seven categories were used to measure educational participation: (*a*) graduate degree; (*b*) standard college or university graduate; (*c*) some college but no degree; (*d*) high school graduation (*e*) some high school, 10–11 years; (*f*) completion of 7-8-9 grade; or (*g*) less than the seventh grade. The individual's rank score on each dimension is multiplied by its respective weight (7 for occupation and 4 for education) and summed to achieve a total score from 11 to 77.

Five classes are created as follows: Class I (11–17); Class II (18–27); Class III (28–43); Class IV (44–60); and Class V (61–77).[58] In general, the lower the point total the higher the social class or status of the subject's family. This schema has been used extensively in other studies.[58,59]

Beck Depression Inventory (BDI)

Each participating subject was asked to respond to a self-report measure designed to assess depression prior to and after completion of treatment. The BDI[60] is designed to assess the severity of a variety of symptoms of depression. Each of 21 items consists of four sentences, and the subject is instructed to choose the one that best describes himself at the present time. Each set of sentences describes symptoms of depression, ranging from normalcy to severe clinically significant symptoms. Each item is scored from 1 to 4, resulting in a range of scores from 21 to 84. Limits of severity are based on mean scores (i.e., normal range below 50, mild to minimal depression 50–59, moderate to marked depression 60–69, severe to extreme depression 70 and over). BDI has been widely used in research studies investigating individual differences in severity of levels of depression.[61–64] Subjects also completed Millon Clinical Multiaxial Inventory (MCMI) and Sixteen Personality Factor (16PF) personality inventories (Peniston and Kulkosky, unpublished observations).

β-Endorphin Levels

Two 5.0-ml blood samples were drawn by venipuncture from members of each group (EXPALC, ALCONT, and NONALC) of patients before and after the brainwave were training (BWT) experiment. Each sample was taken after a 14-h fast, between the hours of 9:00 and 10:00 a.m., when the circadian rhythm of endorphin concentration in plasma was at the medium level in men.[43,44,65] The first blood sample was collected prior to the initial BWT session 1 week after admission and abstinence. For 1 hr prior to each sampling subjects were given a systematic desensitization[21,66] session, i.e. while the patient remained deeply relaxed, he was instructed to imagine various situations or stimuli which normally produced a mild anxiety reaction. The final blood sample was obtained at the end of the BWT experiment, and the patients were again given a systematic desensitization session 1 hr prior to sampling.

Other important variables that may influence the metabolism and secretion of endorphins such as stress[39,41,65] and motoric behavior[67,68] were stabilized by providing a desensitization session 1 hr prior to sampling.

5-ml whole blood samples were collected in 5- or 10-ml vacutainer glass tubes with EDTA 7.2 mg/5 ml as an anticoagulant, and spun in a refrigerated centrifuge for 15 min at 750 × g. The plasma samples were then placed into storage tubes and immediately frozen and stored at −20°C. The specimens were then immersed in liquid nitrogen, packed in dry ice, and shipped by air to Edward Hines VA Medical Center, Endocrinology Laboratory (Hines, IL) to be analyzed. β-Endorphin concentrations were determined from extracted serum samples of blood by radioimmunoassay (Incstar, 46065), at an assay sensitivity of 4.7 pmol/liter.

Medication Consumption

After 1 week of daily practice of α-θ BWT, the drug dosage (tricyclic antidepressants) of BWT subjects ($n = 2$) and ALCONT subjects ($n = 2$) was gradually reduced at their request. During BWT sessions, subjects were monitored by the physicians on the Alcoholic Treatment Unit (ATU) and in the Outpatient Clinic throughout the withdrawal period. The physicians were aware of the treatment groups (EXPALC and ALCONT) and a weekly record was maintained on each patient's medication reductions. If an attempt by the physician to withdraw the subject's initial antidepressant medication resulted in intense depression, the subject was reintroduced to medication.

Electroencephalogram Recording

The Beckman Accutrace TM 200 Autoencephalograph, 16 channel recorder was used to register 60-min EEG recordings before and after the BWT experiment. Prior to the initiation of BWT, all three (EXPALC, ALCONT, and NONALC) groups were administered a pre-EEG assessment, BDI, blood sample extraction and base-rate EEG brainwave measure. Pre-post base-rate measures of α and θ production (percentage of session time in which α and θ was produced) in 5-min intervals were obtained from each subject prior to initial training session and after the last training session. No feedback signals were presented to the subjects during the pre-post base-rate brainwave measurements. The EEG assessments were administered to the subjects during the same hours of the day over a 5-day period. The International 10-20 system for electrode placement was used.[69] Subjects' EEG assessment included the bilateral control (C_3, C_4), parietal (P_3, P_4), and occipital (01, 02), scalp derivations which were referenced against linked ears. All EEG records were visually inspected by two independent raters for artifact (i.e., muscle, EKG, blinking, etc.) detection and EEG synchrony. The raters were unaware of the subject's assignment in the experimental groups. The EEG records from each group (EXPALC, ALCONT, and NONALC) were presented randomly and then rated independently by the two raters. Each rating was based on three levels (central, parietal, and occipital) of scalp region, and laterality (two levels: left and right) of scalp sites. For the purpose of this study, the EEG records were rated on the following distinct EEG markers. The first characteristic was the average α wave frequency (in Hz) and the average amplitude (measured in μV) of α rhythm generated in each EEG record. The second characteristic obtained was the percentage of α frequency waves exhibited. Percentage agreement was obtained by dividing the pre- and post-EEG evaluations between raters by agreements plus disagreements and multiplying by 100. Interraters agreement on the EEG markers ranged from 86 to 100% across all EEG evaluations in which reliability was assessed.

Apparatus

An Autogen 2000 Feedback Thermometer (Autogenic Systems, Inc.) was used to measure the subjects' temperatures and to provide audio feedback. Audio feedback was in the form of a beep tone that rose in pitch as subjects' temperatures increased and that lowered in pitch to corresponding decreases in temperature. The thermometer data was collected in the form of degrees Fahrenheit using an Autogen 5600 Digital Integrator. The integrator supplied a digital record of summated temperature activity, once every 30 sec. The EEG Feedback Monitor (Model E 430) and EEG Timer (ET 330) (RI Company) were used to measure the subjects' brainwave activity and to provide both audio and visual feedback. This EEG Monitor detects information in raw EEG by using three active band-pass filters. α (8–13 Hz), β (13–26 Hz), and θ (4–8 Hz) rhythms are detected by filters with 71 dB per octave attenuation rates. The microprocessor-based Timer accumulated time for a EEG band whenever the signal exceeded the threshold for that band. The audiovisual feedback unit of the instrument contained an individually controlled tone generator. The microvolt levels for each of these band-pass filters were controlled independently, and different individual tones provided audio feedback for the α, β, or θ frequencies. If the brainwave frequency (α, β, or θ) remained above the threshold, a distinct tone was continuously presented. In addition to this audio feedback, a separate set of counters on the EEG Timer was activated by the presence of α, or β, or θ thresholds and thus a calculation of accumulated time was available. At the conclusion of training the EEG Timer also calculated the percentage of time that each band exceeded the threshold, levels.

BWT

All subjects were given a brief introduction to EEG brainwave biofeedback and were told how to interpret the audio feedback (i.e., β, α, θ) sounds. During this initial session the following procedures were implemented. Each subject was seated in a comfortable reclining chair in a sound-proof room and was instructed to sit quietly and relax with eyes closed for 5 min while a base-rate recording was obtained. For biofeedback training purposes, monopolar electrode placements were used to provide a stable high amplitude signal to the instrument input. Earlobes and the area around the inion were cleaned with alcohol prior to attaching the electrode leads. Omni Prep was used as a conduction medium to fill the electrode cups and in the preparation of the electrode scalp site. An occipital (01) electrode was attached approximately 1 cm above and 1 cm left of the inion and help in place by a stretching headband. Two ear-clip electrodes were attached and the active electrode was referenced to the left earlobe (A1), with the ground electrode on the right earlobe (A2). Before recording commenced, electrode impedence was checked and electrodes were reapplied if necessary. β, α, and θ sensitivity threshold settings were adjusted on the feedback monitor for each subject. Prior to recording each individual's initial α and θ base-rate scores, the threshold dials of the feedback monitor were adjusted (aided by the use of a MFE Posi-Traci 1-strip chart recorder) to a point at which the waves characteristic of β, α, and θ registered on the feedback monitor and on the cumulative recording computer-based timer. Because θ was not produced uniformly during the calibration sessions, this procedure could not be used to set a θ threshold. Instead, θ thresholds were arbitrarily set at points 10 μV below those for α because the θ and α thresholds of previous patients who had produced θ during calibration tended to differ by this amount. β (13–26 Hz), α (8–13 Hz), and θ (4–8 Hz) rhythms were defined in terms of time that the input signals exceeded the machine-set thresholds.

Only the EXPALC subjects received eight 30-min sessions of pretraining in temperature biofeedback assisted autogenic training and 15 30-min BWT sessions. During the pretraining sessions, the experimenter (E) attached a temperature thermistor to the tip of the middle finger and middle toe of the subject's dominant hand and foot with micropore tape. The BWT subjects were instructed to sit in a comfortable reclining chair and relax and close their eyes. Then the E introduced the subjects to autogenic training exercises and rhythmic breathing techniques in an effort to induce relaxation of the body and quiet the mind. On the following six or seven sessions, the subjects practiced temperature feedback until the hand and foot could be warmed to more than 95°F and held there over one session. It is speculated that temperature training stimulates the production of the "theta state."[34] Following the tempera-

ture biofeedback pretraining sessions, the experimental subjects completed a total of 15 5-min baseline intervals and 15 30-min BWT sessions. Subjects were seen five times a week (5 days) for a duration of 28 days. Subjects were instructed to close their eyes and construct visualized abstinence/alcohol rejection scenes, and imageries of increased α rhythm amplitude and scenes of the normalization of their personalities. The E instructed the subjects to "sink-down" into θ (reverie) state keeping the mind quiet and alert (but not active), and the body calm. Then, subjects were instructed by the E, to initiate the session with a quiet command, "do it." Prior to the E's exit from the room, the β feedback volume control band was turned off; α and θ feedback volume control bands were adjusted for a comfortable listening level for each subject; and the overhead light was turned off. The E returned to the room 30 min later, E pressed the "stop" button of the computer based timer and gently returned the subjects to a state of awareness. The aforementioned procedures were employed throughout the 15 30-min sessions.

Data collection for this initial study was terminated at the end of the 15th 30-min session. The subjects were readministered the EEG assessment, BDI, blood sample extraction, and base-rate EEG brainwave measures. These data (pre- and postmeasures), in conjunction with the 15 5-min baseline intervals and 30-min BWT sessions, were analyzed with split-plot analyses of variance, followed by Duncan's test, at an α significance level of $p < 0.05$.

The ALCONT and NONALC groups were given only the pre- and post-EEG assessments, BDI, repeated blood sample extractions, and base-rate EEG brainwave measures. Both control groups were instructed not to use any biofeedback relaxation training procedure during the study. The rationale for the subjects' participation in the experiment included statements on the informed consent form that the purpose of the study is to determine if EEG α -θ brainwave training will significantly change β-endorphin levels associated with human alcoholism, and if brainwave training is associated with changes in the α rhythms.

Follow-Up Study

All 20 (EXPALC and ALCONT) alcoholic subjects and their informers (wives, family members, halfway house superiors) were contacted by telephone at monthly intervals for 13 months after completion of treatment. To determine the long-term effects of EEG α-θ brainwave training, subjects and informers were asked to report instances of alcoholic relapse, defined as drinking constantly for a 1-week duration. Data were analyzed with a χ^2 test after application of Yates' correction for continuity, at an α significance level of $p < 0.05$.

RESULTS

β-Endorphin Levels

Table 1 presents mean and standard error (SE) radioimmunoactive β-endorphin levels of extracted serum samples from alcoholic controls (ALCONT, $n = 8$, two samples not obtained), nonalcoholic controls (NONALC, $n = 9$, one sample not obtained), and experimentally treated alcoholics (EXPALC, $n = 9$, one sample not obtained), before and after α-θ brainwave training of the EXPALC group. Analysis revealed a significant main effect of sampling time, $F(1,23) = 6.68$, $p < 0.05$. Duncan's posthoc test indicated a significant increase in β-endorphin level only in the ALCONT group ($p < 0.05$). The mean peptide level in the ALCONT group also was significantly greater than that of the NONALC group at the posttreatment sample ($p < 0.05$). No other significant differences were detected between or within groups ($p > 0.05$).

Table 1. β-Endorphin Levels (pmol/liter) in Alcoholics and Controls before and after α-θ Brainwave Training

Individual values and mean (+ SE) radioimmunoactive β endorphin levels (pmol/liter) in extracted serum samples of alcoholic controls (ALCONT group), nonalcoholic controls (NONALC group), and experimental alcoholics (EXPALC group). Blood samples were taken before initiation of treatment (pre) and at the conclusion of the experiment (post).

Alcoholic controls			Nonalcoholics			Experimental alcoholics		
S	Pre	Post	S	Pre	Post	S	Pre	Post
1	6.3	4.8	11	7.3	7.9	21	4.0	2.8
2	4.0	4.3	12	3.5	3.6	22	5.1	5.9
3	6.9	12.6	13	4.7	5.3	23	8.2	10.9
4			14	7.6	8.5	24	4.9	5.3
5	3.8	5.6	15	5.6	7.1	25	5.0	5.3
6	8.2	11.8	16	3.7	2.7	26	6.0	5.5
7	4.3	5.7	17			27		
8	11.6	12.5	18	4.8	4.6	28	5.0	5.5
9	5.9	6.5	19	2.2	4.3	29	5.6	3.5
10			20	4.3	4.6	30	6.8	7.7
$\bar{X}$	6.375	7.975		4.844	5.400		5.622	5.822
SE	0.923	1.289		0.588	0.664		0.415	0.787

Electroencephalographic Scores

Fig. 1 shows mean (+SE) percentage of brainwaves in the α frequency range, for the ALCONT, NONALC, and EXPALC groups before (pre) and after (pos) treatment. There were significant main effects of group $F(2,27) = 39.40$, $p < 0.05$, and testing time, $F(1,27) = 110.66$, $p < 0.05$, and a significant interaction of group and time, $F(2,27) = 88.61$, $p < 0.05$. There was a significant, nearly 12-fold increase in α waves in the EXPALC group ($p < 0.05$). The mean posttreatment value of the EXPALC group differed from all other means ($p < 0.05$). The latter means did not differ from each other ($p > 0.05$).

Figure 2 shows mean (+SE) percentage of brainwaves in the θ frequency range, for the ALCONT, NONALC, and EXPALC groups before and after treatment. There were significant main effects of group, $F(2,27) = 16.39$, $p < 0.05$, and testing time $F(1,27) = 23.91$, $p < 0.05$, and a significant interaction of group and time, $F(2,27) = 33.96$, $p < 0.05$. There was a significant, nearly 7-fold increase in theta waves in the EXPALC group ($p < 0.05$). Duncan's test revealed significant differences only between the posttreatment mean of the EXPALC group and all other means ($p < 0.05$).

Figure 3 depicts mean (+SE) amplitude (in μV) of α brainwaves for the ALCONT, NONALC, and EXPALC groups at recording coordinates P301 and P402, before and after treatment. Analysis revealed significant main effects of group, $F(2,24) = 10.25$, $p < 0.05$, and testing time, $F(1,24) = 10.31$, $p < 0.05$, and a significant interaction of group and time, $F(2,24) = 6.00$, $p < 0.05$. At both P301 and P402, only the EXPALC group showed significant increases in α wave amplitude ($p < 0.05$). α amplitudes of the EXPALC group nearly doubled across testings, and differed significantly from that of the ALCONT and NONALC groups at the second testing ($p < 0.05$). No other between- or within-groups comparisons were statistically significant ($p > 0.05$).

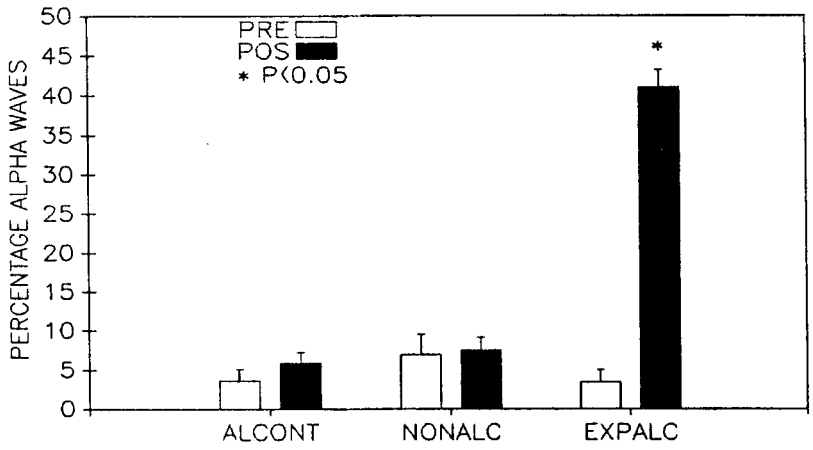

Fig. 1. Mean (+SE) percentage of EEG record in α rhythm frequency range, for the ALCONT, NONALC, and EXPALC groups, before (pre) and after (pos) BWT of the EXPALC group.

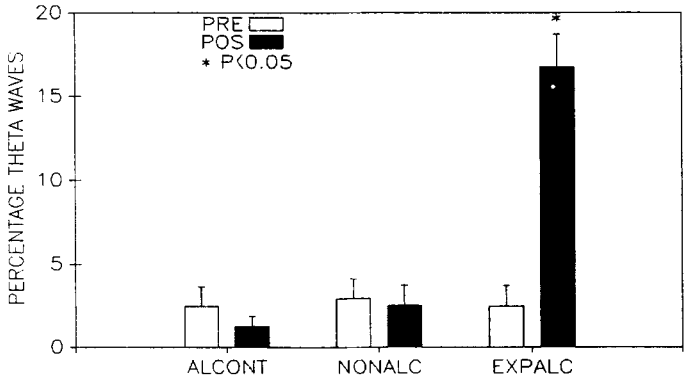

Fig. 2. Mean (+SE) percentage of EEG record in θ rhythm frequency range, for the ALCONT, NONALC, and EXPALC groups before and after BWT of the EXPALC group.

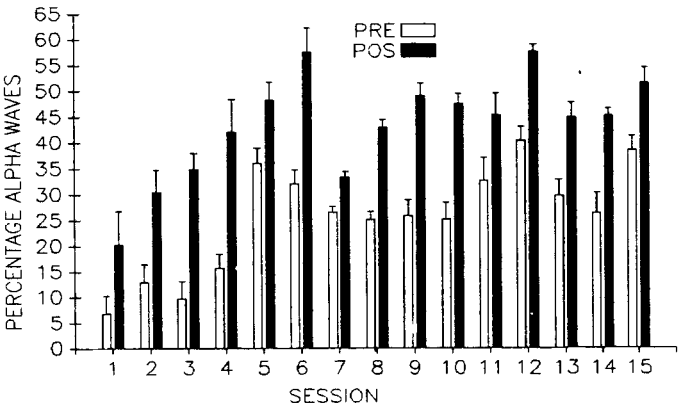

Fig. 4. Mean (+SE) percentage of EEG record in α rhythm frequency range, for the EXPALC group before and after 15 daily BWT sessions.

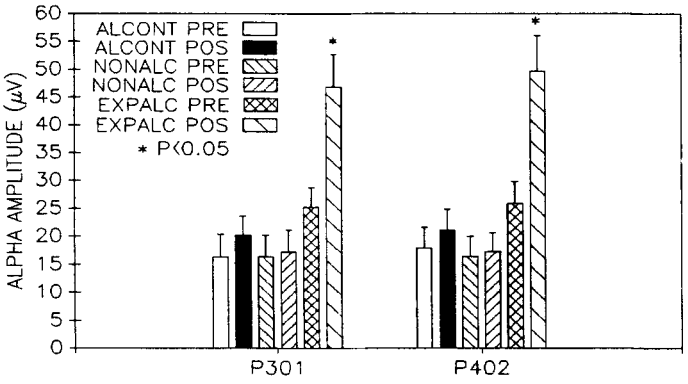

Fig. 3. Mean (+SE) α rhythm amplitude (in μV) of the ALCONT, NONALC, and EXPALC groups, before and after BWT of the EXPALC group, at recording coordinates P301 and P402.

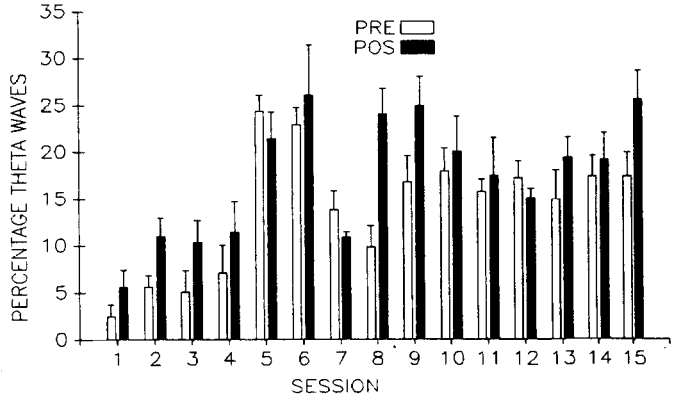

Fig. 5. Mean (+SE) percentage of EEG record in θ rhythm frequency range, for the EXPALC group before and after 15 daily BWT sessions.

Figure 4 shows mean (+SE) percentage of brainwaves in the α frequency range, for the EXPALC group during a 5-min baseline period and during a 30-min biofeedback training period, across 15 sessions. There were significant main effects of testing time, $F(1,9) = 606.05$, $p < 0.05$, and session, $F(14,126) = 12.06$, $p < 0.05$, and a significant interaction of time (pre-post) and session, $F(14,126) = 2.25$, $p < 0.05$. There were significant ($p < 0.05$) increases in percentage of brainwave in α after training in all sessions except the seventh. Baseline (pre) scores increased significantly from the first session on sessions 5–15 ($p < 0.05$). Training (post) scores increased significantly from the first session on sessions 2–15 ($p < 0.05$). Baseline α percentage increased nearly 6-fold across sessions 1–15 and training α percentage increased by a factor of about 2.5 across sessions 1–15.

Figure 5 displays mean (+SE) percentage of brainwaves in the θ frequency range, for the EXPALC group at baseline (pre) and after biofeedback training (post), across 15 sessions. There were significant effects of testing time (pre-post), $F(1,9) = 13.94$, $p < 0.05$, and session, $F(14,126) = 8.66$, $p < 0.05$, and a significant interaction of testing

and sessions, $F(14,126) = 2.14$, $p < 0.05$. There were significant increases in θ waves after training only in sessions 8, 9, and 15 ($p < 0.05$). Baseline scores increased significantly from the first session on sessions 5, 6, 7, 9–15 ($p < 0.05$). Training scores increased significantly from the first session on sessions 5, 6, 8–15 ($p < 0.05$). Baseline θ percentage increased 7-fold across sessions 1–15, and training θ percentage increased by a factor of about 4.6 across sessions 1–15.

Depression Scores

Figure 6 depicts mean (+SE) score on Beck's Depression Inventory (BDI) before and after treatment, for the ALCONT, NONALC, and EXPALC groups. Analysis of variance revealed significant effects of group, $F(2,26) = 12.45$, $p < 0.05$, and testing time, $F(1,26) = 205.0$, $p < 0.05$, and a significant interaction of group and time, $F(2,26) = 222.31$, $p < 0.05$. On the pretest, both groups of alcoholic subjects had higher BDI scores than nonalcoholic controls ($p < 0.05$). However, on the post-test, only the alcoholic controls had higher BDI scores than the NONALC group ($p < 0.05$). Only the EXPALC group showed a significant decrease in BDI scores after treatment ($p < 0.05$). In this group, BDI scores were reduced by half, and did not differ from the NONALC group on the posttest ($p > 0.05$).

Follow-up Reports

Table 2 displays the number of reported instances of alcoholic relapse or maintenance of abstinence in the EXPALC and ALCONT subjects across a 13-month follow-up period. χ^2 analysis of these data indicated a significant difference in incidence of alcoholic relapse in the two groups, $\chi^2 = 5.0$, $df = 1$, $p < 0.05$. Of the 10 chronic alcoholics that participated in the EEG α-θ brainwave training project, only two patients experienced alcoholic relapse after being discharged into their respective communities. In contrast, the alcoholic control patients displayed eight instances of alcoholic relapse and readmission to VA Medical Centers for alcohol dependence treatment.

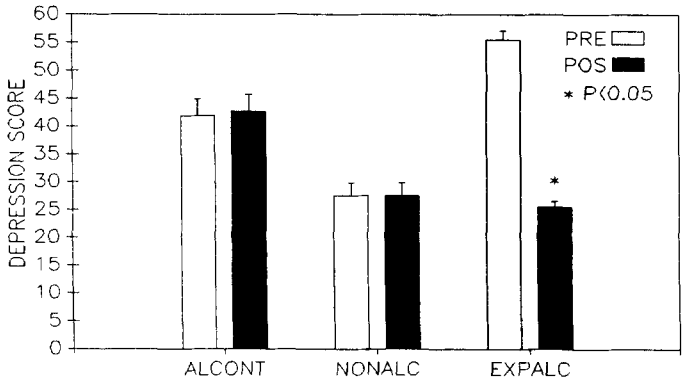

Fig. 6. Mean (+SE) score on Beck's Depressive Inventory, for the ALCONT, NONALC, and EXPALC groups, before and after BWT of the EXPALC group.

Table 2. Reported Instances of Alcoholic Relapse or Continued Abstinence in EXPALC and ALCONT Groups during a 13-Month Follow-up Period

Group	Abstinence	Relapse	Total
EXPALC	8	2	10
ALCONT	2	8	10

DISCUSSION

The results provide clear evidence of the effectiveness of α-θ brainwave training in changing electroencephalographic scores and self-rated depression in alcoholics. Substantial, significant increases of percentages of α and θ brain rhythms and α rhythm amplitude were observed in experimentally treated alcoholics. Depression, as indexed by Beck's Depression Inventory, was significantly reduced to control (nonalcoholic) level after BWT. Time-course analysis of the EEG effects of BWT revealed that increases in α and θ rhythms occurred gradually across the 15 treatment sessions. Baseline α rhythms increased reliably only after 5 sessions, indicating the importance of substantially repeated BWT sessions for the production of durable changes in EEG scores.

In accord with previous studies,[70,71] there were no significant differences in radioimmunoactive β-endorphin levels between abstinent alcoholic subjects and controls at the beginning of treatment. However, the control group of alcoholics that received traditional medical treatment showed a significant increase in β-endorphin levels at the completion of treatment, relative to their initial levels or nonalcoholic control levels. This unexpected result suggests that the standard medical treatment of alcoholism may induce a state of unrelieved stress. Several reviews have summarized the extensive evidence that an increase in β-endorphin levels is a reliable index of severity of stress in the environment.[38–42] The lack of a corresponding increase in β-endorphin in alcoholics receiving BWT further suggests that the deliberate application of relaxation therapies counteracts the stress of abstinence. For example, BWT may relieve the tension and negative self-efficacy reported to be associated with early stages of abstinence.[72–75]

The radioimmunoassay results may provide a neuropeptide-based explanation of the extremely high rate of relapse in alcoholics that receive traditional treatment. Administration of β-endorphin and other opioid peptides has been clearly shown to increase caloric intake in animals and humans.[76–78] An extensive literature confirms that alcohol intake is regulated by the same factors that control food intake.[55] Thus, a neuropeptide that excites energy intake will stimulate ethanol intake, if the caloric consequences of ethanol are familiar. If β-endorphin is elevated in alcoholics, a return to consumption of ethanol calories would be inevitable. Some feature or interaction of relaxation therapies such as autogenic and temperature training, desensitization, and BWT appeared to prevent the relapse to ethanol consumption that may be motivated by elevated endorphinemia.

α-θ brainwave training is also associated with a sharp reduction in self-assessed depression. Results of the BDI are validated by corresponding changes in MCMI and 16 PF scales (Peniston & Kulkosky, unpublished observations). It is not clear whether initial group differences in IQ and/or SES may have contributed to observed depression score differences. No such changes in depression were detected in the traditional alcoholic control group. Relapse of this control group is understandable, in view of the increased blood-indexed stress that is unaccompanied by significant changes in the alcoholic personality. Fundamental changes in blood neurochemistry, brain electrical activity, and personality are produced by BWT, in comparison to the control treatment of alcoholics. However, the mechanism of these therapeutic effects was not addressed in the present experiment. For example, it is possible that some interaction between BWT and the autogenic and temperature training and desensitization sessions contributes to the observed effects. Some feature of the substantially longer exposure of the EXPALC subjects to the relaxation therapies and personnel produced greater relaxation and α and θ brain rhythms than the control alcoholic subjects.

The results of the follow-up study showed that most of the EXPALC patients were maintaining abstinence and preventing alcoholic relapse during this period. Of the two EXPALC subjects that experienced alcoholic relapse over the 13-month follow-up phase, one elected to return to the VA Medical Center for EEG α-θ brainwave "booster" sessions. The informers reported these two EXPALC patients' tolerance for alcohol was significantly reduced, resulting in a psychophysiological reaction of rejection of ethanol exposure. In addition, most (7) of the EXPALC patients have either successfully completed a practical nursing program, or are attending junior college in their communities, or are attending a state training program for certification as alcoholic counselors. These clinical observations lend some support to the hypothesis of these patients undergoing a personality change, as confirmed by BDI results during the experiment. In contrast, the VA medical records indicated that of the 10 ALCONT patients, eight have been readmitted to VAMCS for alcohol dependence treatment and the other two patients were experiencing some uncontrolled drinking episodes during the 13-month follow-up period. These results provided supportive evidence that the EXPALC patients' response to EEG α-θ brainwave training resulted in moderately long-term prevention of alcoholic relapse.

In summary, α-θ brainwave training produces profound increases in α and θ brain rhythms, decreases self-assessed depression, and appears to prevent an elevation of serum β-endorphin levels during the course of treatment of alcoholism. The experimental results and follow-up evidence indicate that this biobehavioral approach to the treatment of chronic alcoholism is a promising alternative to traditional medical treatment of alcoholism. Further study of the mechanism of the therapeutic effect, such as the contribution of placebo or Hawthorne effects, is clearly warranted.

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