Case Study

THE NORMALIZATION OF A PERSONALITY THROUGH NEUROFEEDBACK THERAPY

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ABSTRACT

This is a single case study of the treatment of an alcohol and Xanax dependent patient using the protocol of E. Peniston, and P. Kulkosky[1,2] Neurofeedback Therapy (NT) for alcoholics. Changes are reported in the amplitude of Theta, Alpha, and Beta frequency band waves consistent with stress reduction and "normalization" of the electroencephalogram (EEG). "Normalization" in the patient's personality is demonstrated by pre and post NT assessment with *The Minnesota Multiphasic Personality Inventory-2, The Millon Clinical Multiaxial Inventory, The Beck Depression Inventory* and *The Beck Hopelessness Scale.* The CZ location was utilized as the training site. A one month post-NT four day alcohol binge is reported with the expected severe flu-like symptoms. One month later a booster session was conducted.

KEYWORDS: Neurofeedback, addiction, biofeedback, electroencephalograph, personality

INTRODUCTION

Peniston and Kulkosky[1,2] have demonstrated efficacy of alpha-theta neurofeedback therapy (NT) in the treatment of alcoholics. They report a relatively high rate of abstinence and dramatic shifts of personality in the direction of a more normal personality, as measured by psychometric testing and reports of significant others. Using serum beta-endorphin levels as a biochemical measure of stress, they stated increased levels are positively correlated with stress in humans. The control alcoholics, who received the standard in-patient program without NT, showed significant serum beta-endorphin elevations, while the experimental alcoholics who received NT showed no elevations.

Peniston and Kulkosky[1] developed their novel treatment protocol based on the work of others who had established some evidence that the eyes closed relaxed electroencephalogram (EEG) of some alcoholics shows poorly developed slow wave activity in the theta and alpha frequency bands.[3,4,5,6,7] This would be consistent with a state of chronic hyperarousal for alcoholics in abstinence. In contrast, others have shown that the typical human EEG during eyes closed, relaxed condition is characterized by an increase in alpha (8-12hz) frequency activity with a decrease in beta band (16-20hz) activity.[8] This difference in findings is consistent with alcoholics being in a chronic state of stress.

Several studies indicate that, when alcohol is ingested, there is an increase in slow wave activity in the EEG of alcoholics.[9,10,11,12] Jones and Holmes[5] seem to agree with the proposal that alcoholics are in a chronic state of arousal and that drinking alcohol reduces arousal, which would be consistent with increased slow wave activity upon ingestion of alcohol.

A.P. Byers[13] suggested alcoholics were under stress during withdrawal and early abstinence. Nursing staffs were trained to teach self hypnosis to alcoholic patients to reduce their stress. More recently G. Kutner and R.P. Zahourek[14] have developed a similar program.

S.L. Fahrion, D.E. Walters, L. Coyne and T. Allen,[15] in a controlled single case study of an 18 month abstinent alcoholic, replicated Peniston and Kulkosky's protocol for NT.[1,2] In addition, they monitored hand temperature,

blood pressure and heart rate under laboratory induced stress. The results were comparable to Peniston and Kulkosky's work. They also found the NT resulted in ". . . a more relaxed central nervous system functioning under stress, and/or reduced autonomic activation both during relaxation and under stress." Their work provides more evidence that chronic hyperarousal is a significant contribution to craving and relapse.

The purpose of this study was to further evaluate the protocol of Peniston and Kulkosky[1,2] in a controlled single case study. In this case, the subject had no significant history of abstinence. He was in serious legal difficulties with legal charges pending. He needed to be detoxified from Xanax and alcohol. NT was designed to normalize his personality and to teach him to increase the amplitude of alpha and theta brainwaves. The CZ location was elected because of its easy accessibility. It was thought that the CZ location would be as effective a training site for these purposes as the 01 site previously used. Finally, it was intended to determine if this protocol could be managed in a private group practice with an already established out-patient treatment program for substance abuse.

METHOD

SUBJECT

The subject in this study is a 27 year old Caucasian male. He is a high school graduate and certified in a technical career. It was therefore assumed he was of at least average intelligence. His father and mother were both college graduates. He had a history of psychiatric problems from 9 to 11 years of age. He began to use marijuana in the tenth grade. Before considering NT, he was taking 10 to 16 mg of Xanax each day. Medical care for withdrawal from alcohol and Xanax was carried out for three days in an in-patient medical facility. Prior to admission, he had reduced his Xanax intake to 8.5 mg a day. He had been self-medicating with Xanax to reduce his chronic tension and anxiety as well as to treat his hangovers. At discharge from the hospital, he was taking 25 mg of Doxepin three times a day and 250 mg of Disulfiram once a day, prescribed by the psychiatrist in charge of the detoxification program. On the same day that he was released from the hospital, he

attended his first group therapy session in the out-patient program. His discharge summary from the hospital carried the diagnosis of Alcohol and Xanax Dependence With Major Depression, recurrent. Doxepin and Disulfiram were discontinued by the fourteenth NT session.

Out-patient Program

The patient enrolled in the out-patient program which consists of weekly group and individual psychotherapy, weekly education classes, family counseling as needed, attendance at Alcoholics Anonymous, monitored Disulfiram as needed, and random drug screening. Seventeen days after hospital discharge, the first training session of the Peniston-Kulkosky[1,2] protocol was started. Six sessions of temperature training were completed after which the NT was started. The patient was seen two times a day, five days a week, from the first temperature training session until the thirty-eighth NT session, after which he was seen once a day, concluding treatment at the forty-second NT session. In all, he was seen for 48 individual out-patient sessions, counting the pre-treatment and post-treatment assessment. He participated in six education and six group therapy sessions. The patient signed a treatment program agreement and a consent form for NT.

Pre- and Post-Treatment Personality Assessment

Psychometric assessment was conducted with *The Minnesota Multiphasic Personality Inventory-2* (MMPI-2), *The Millon Clinical Multiaxial Inventory* (MCMI), *The Beck Depression Inventory* (BDI), and *The Beck Hopelessness Scale* (BHS) before and after treatment. Pre-treatment testing was completed three days following hospital discharge. Post-treatment testing was conducted after the completion of the 33 NT sessions. This concluded the training. The additional nine NT sessions were conducted without feedback and for the purpose of weaning from treatment. Weaning from treatment is a gradual decrease in the frequency of sessions with no feedback to foser patient autonomy and self confidence in their self regulation.

Pre- and Post-Treatment Electroencephalogram (EEG) Recordings

Seven days after discharge from the hospital, the baseline EEG was conducted. Relapse behavior was already apparent in that he had self-administered 5 mg of Xanax on the same day the baseline EEG was recorded. This was in addition to the prescribed Doxepin. The baseline EEG may have been affected by these medications. According to C. Miller,[16] Doxepin at 25 mg, three times a day, may have increased the amplitude of both the slow wave and the fast wave activity and may have slowed the alpha frequency at the time the pre-treatment EEG was recorded. In addition he points out, "Benzodiazepines produce dramatic increases of beta activity, maximal over the anterior head region, both in amount and amplitude."[16]

The Neurosearch, 24-channel computerized EEG (Lexicor Medical Technology, Inc., Boulder, CO) was used to record the EEG of the subject before and after NT. In each case, the International 10-20 Montage with linked ears reference was used in all recordings. Electrodes were applied using the electrocap from Electro-cap International, Inc., Eaton, OH. Impedance was judged acceptable when each electrode registered below 5 k ohms. Each was checked separately before the recording. Amplifier gain was set to 32000. High pass filter was set to .5 hz, with low pass filter set to 32 hz. Sampling rate to 128 samples per second per channel.

Frequency analysis was performed using a Fast Fourier Transform (FFT). The same setting and analysis were utilized during the training sessions. Baseline data was collected for each of the following conditions: Eyes open relaxed; Eyes closed relaxed; Reading to self from a newspaper; Drawing Bender Gestalt designs; and Serial 7's backward silently with eyes closed. Artifact removal resulted in a minimum of 44 artifact free epochs (two seconds each) for each condition.

Pre-treatment Thermofeedback Training

Thermofeedback was accomplished using the Autogen 1000b, (Autogenic Systems Inc.). The temperature probe was taped to the index finger of the

right dominant hand with Scotch Brand Hair Set Tape recommended by Autogenic Systems Inc. Temperature was monitored across all NT sessions as well as during the initial feedback sessions. An Integrator (Autogen 5100, Autogenic Systems, Inc) was used to average temperatures across each minute of NT and of the preliminary temperature training. The patient was instructed to develop a strategy for hand warming such as autogenic phrases.[17] Baseline temperature readings may have been affected by the Xanax and Doxepin. Doxepin is a tricyclic antidepressant and is a sympathomimetic and may lower hand temperature, whereas Xanax is a minor tranquilizer and may contribute to increased hand temperature.[18] Each medication may have canceled the effect of the other with respect to vasodilatation.

Visualization Training

Visualization training followed the procedure described by Peniston and Kulkosky.[1,2] The subject was given a form to take home and write out his visualization of: (1) Abstinence in a drinking situation; (2) A normal and happy scene in which alcohol no longer interferes; (3) Alpha wave amplitude getting higher and higher; (4) That part of the brain from which the alpha-theta waves seem to come (hypothalamic-septal circuits); and (5) Seeing one's self with a normal personality (more mellow and relaxed). At the start of each session, these visualizations were read to the subject by the therapist. The patient was then told to take 5 rapid, deep breaths, sink down into a relaxed state keeping the mind alert, but quiet, and the body calm. After this the patient was told "do it." The patient was observed in the relatively quiet, and somewhat darkened, room while each minute of averaged hand temperature was recorded.

Neurofeedback Therapy (NT)

The NT protocol of Peniston and Kulkosky[1,2] was used with the exception that a 5 minute baseline with no feedback was used at the start of each session only for the fourth through the tenth sessions. The last nine sessions of monitored EEG were without feedback. Of these, the last three no-feedback sessions were once a day. The CZ rather than the 01 location was used from

the first through the twenty eighth NT session. The 01 location was used from the twenty ninth NT session through to the last, forty second, session. The Biolex EEG computerized biofeedback program was used (Lexicor Medical Technologies, Inc., Boulder, CO) for the NT. The CZ and the 01 locations were placed according to the International 10-20 Montage. Linked ear reference and one ground electrode attached at the center of the forehead (supplied by the Electro-cap International Inc, Eaton OH) were used. All electrodes were of the same metal and construction. Each session consisted of 30 to 50 minutes, with one exception, (session 29), which was 26.4 minutes long. The average length of a session was 37.9 minutes. Due to patient interest and motivational factors variations in session length were allowed. This was considered a balance between clinical concerns and concern for scientific rigor. All impedances were judged acceptable when they were below 5 k ohms.

Data was collected and stored by way of an IBM compatible computer. Auditory feedback was given if alpha and theta thresholds were reached or exceeded but not if the beta threshold was simultaneously exceeded. Amplitude thresholds for alpha and theta wave band were adjusted to shape the subject's learning to increase amplitude of alpha and theta waves over time. The band waves used were: Delta, 0.0 - 4.0 hz; Theta, 4.0 - 8.0 hz; Alpha, 8.0 - 12.0 hz; SMR, 12.0 - 15.0 hz; Beta, 16.0 - 20.0 hz; EMG, 25.0 - 32.0 hz.

RESULTS

Thermofeedback training began with a baseline of 90.0° Fahrenheit (F), 32.2° Celsius (C), and warming to 92.0° F, 33.3° C, with no feedback during eyes closed relaxed for 30 minutes. Training across the five subsequent sessions lead to the ability to warm to 95.2° F, 35.1° C, and remain above 94.9° F, 34.9° C, for 15 minutes. Hand temperature was monitored across all NT sessions except session two. Temperatures for each minute were averaged. In the temperature training sessions, he averaged 90.5° F, 32.5° C, at the start of each session while ending with a 93.6° F, 35.8° C. The recording of the temperature during temperature training revealed that the subject learned to warm his hands to 95.5° F, 35.2° C. During the NT sessions (with no temperature feedback given), he did not maintain a steady temperature of 95.5° F, 35.2° C. However, he averaged above 94.0° F, 34.4° C, during NT sessions and above 93.5° F, 34.1° C, during the last eight, no-feedback, NT sessions.

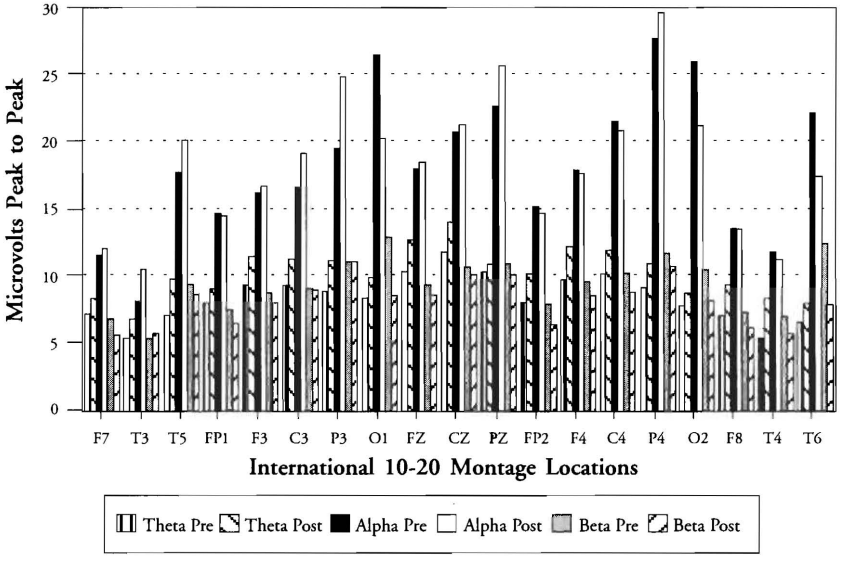

Figure 1. *Comparative increase or decrease in amplitude before and after brain wave neurofeedback therapy, eyes closed, relaxed.*

"Before" and "after" NT amplitudes for theta, alpha, and beta frequency activity are reported in Figure 1 for the 19 locations during eyes closed relaxed condition. Theta average amplitudes are higher after NT at each location. The greatest theta gain is seen at T5. Inspection of the alpha amplitudes will show some are higher after NT and some are lower. Beta amplitudes are lower after NT at all locations except T3 and P3.

Figure 2 shows the percent increase or decrease in amplitude for theta, alpha, and beta waves after NT. The greatest increase in theta is shown at T5. Figure 2 makes it possible to more readily see that the increase in amplitudes of theta occurred across both hemispheres after NT. The greatest increase was at T5 and F8 even though the location used for NT in this study was primarily CZ. It also appears the greatest percent decrease in beta activity after NT was in the right hemisphere.

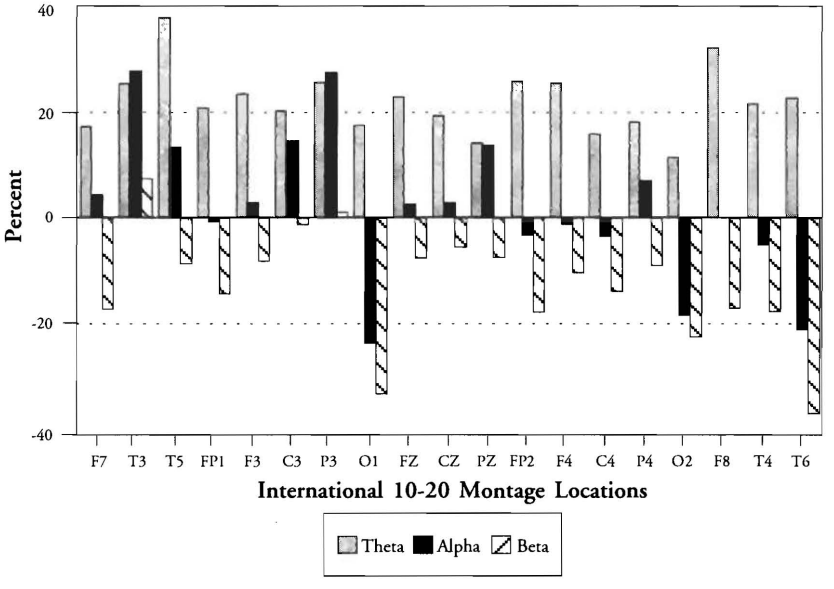

Figure 2. *Percent increase or decrease in microvolts peak to peak between pre and post brain wave neurofeedback therapy, eyes closed, relaxed.*

A learning trend for increased theta amplitudes across NT can be shown by session time-divided history. The Biolex program (Lexicor, cited earlier) computes the average ratio of theta to alpha power (peak to peak) in average microvolts for each training session. It does this by dividing each training session (total time in seconds) into 25 equal units of time. The theta to alpha average ratio is then reported for each time interval (1/25 of total time). When the average of the ratios in each time interval reaches 1.0 or more, theta amplitude has equaled or exceeded alpha amplitude in that time interval.

Figure 3 reports the number of times the average of the ratios for each time interval reach 1.0 or more in each NT session. The closest fit straight line indicates a positive increment in theta amplitude in relation to alpha amplitude. The five minute, no-feedback, sessions prior to commencing with feedback seemed to interfere with the patient's meditation sessions with feedback. This

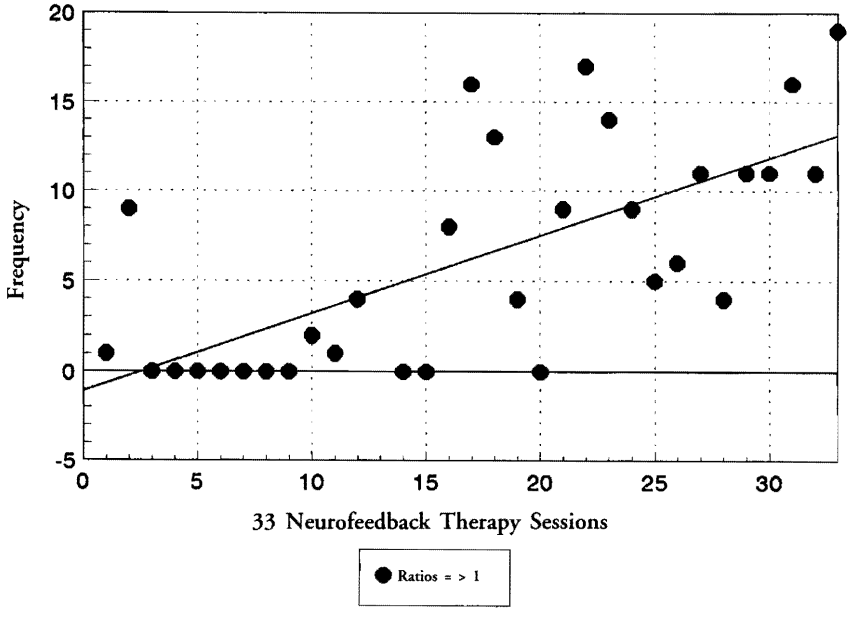

Figure 3. Session time-divided history. Frequency of occurrence of theta to alpha (microvolts peak to peak) with average ratio being equal to or greater than one.

is shown by a lack of change in alpha-theta density in sessions 4 - 10. These 5 minute baseline sessions were discontinued since the first priority was the treatment goal. Session 13 data was lost, consequently is not included in Figure 3.

Figures 4 and 5 offer a way of visually seeing the development of the subject's ability to reach the theta state by a trend graph. The first NT session (Figure 4), epochs 500 - 600 can be seen as lacking in theta exceeding alpha. However, as NT progressed, "cross-over" (Theta exceeding Alpha for a period of time) increasingly occurred as demonstrated in the last session, in epochs 500 - 600. The subject is then presumed to be in the theta state (Figure 5). This is a state of consciousness that is characterized by creativity and the conscious awareness of hypnogogic images.[19] The subject was observed to be relaxed but not asleep. Forgotten memories, especially traumatic ones, may come to awareness.[20] A change in one's perspective of past experiences can take place in the theta state.[19,20]

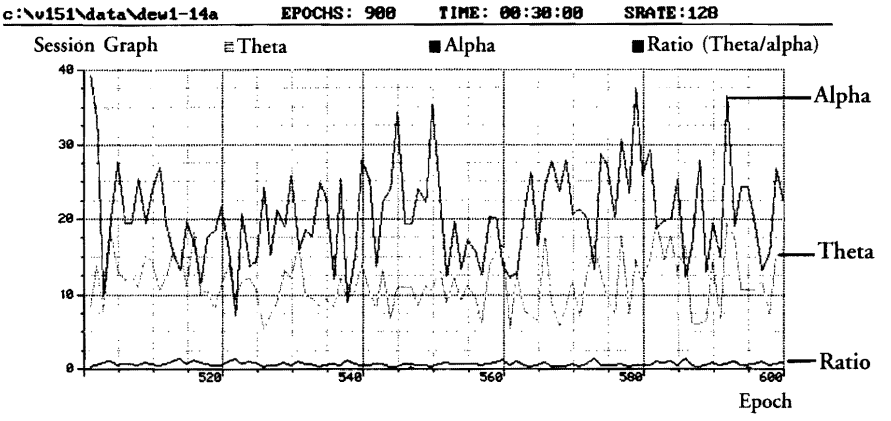

Figure 4. First NT session.

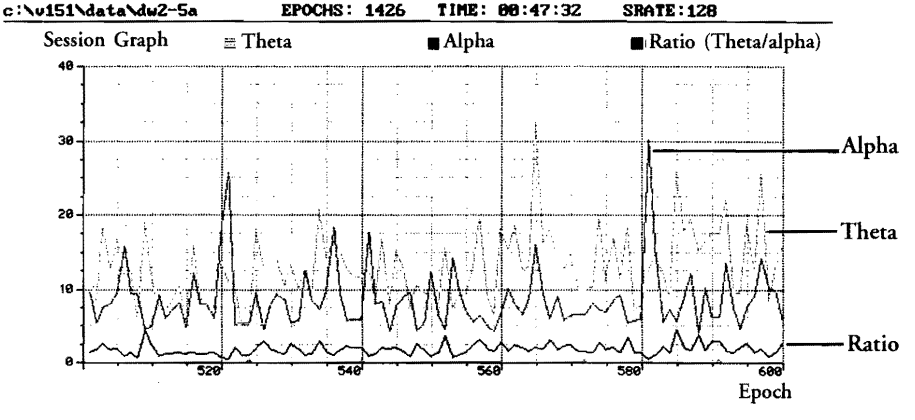

Figure 5. Final NT session.

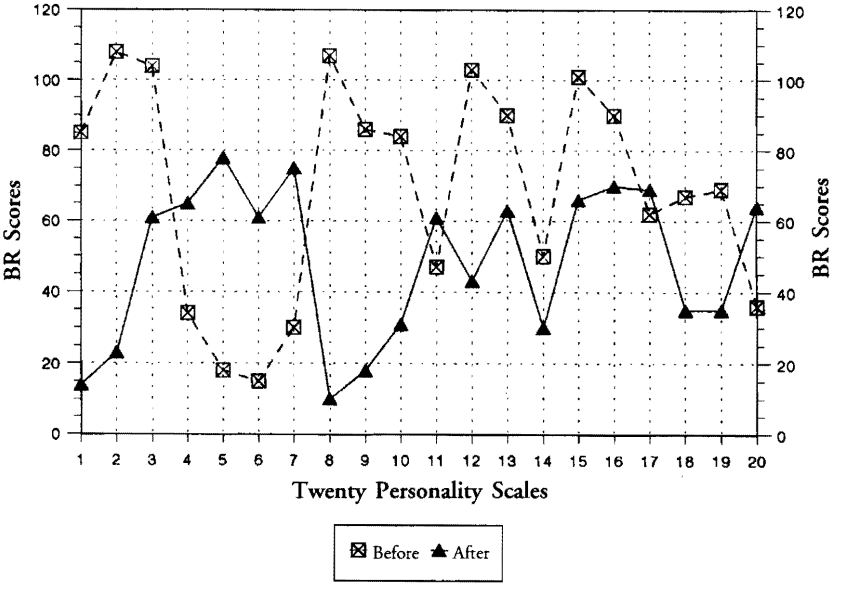

Figure 6. Millon clinical multiaxial inventory results. BR scores before and after neurofeedback therapy.

Figure 6 shows the results of pre and post testing with the MCMI. The pre-treatment profile reveals scales 1, 2, 3, 8, 9, 12, 13, 15, and 16 are above the Base Rate (BR) score of 85. In contrast, the post-treatment profile reveals no BR score above 85. The post-treatment profile is closer to normal even though it suggests the subject may still have some problems to deal with in that scales 5 and 7 reach the BR score of at least 75. Elevations on scales 5 and 7 are often consistent with personality disorders.

The MMPI-2 profile before and after NT is shown in Figure 7. Using the cut-off T-score value of 65, the profile resulting from the subject's responses before NT reveal abnormal scale scores on all scales except L, K, Ma, R, and MAC-R. The profile earned by the subject's responses after NT result in all T-score values falling within the normal range, below T-score 65.

The BDI and BHS scores are reported in Figure 8. Both instruments show a normalization of responses to the items following NT.

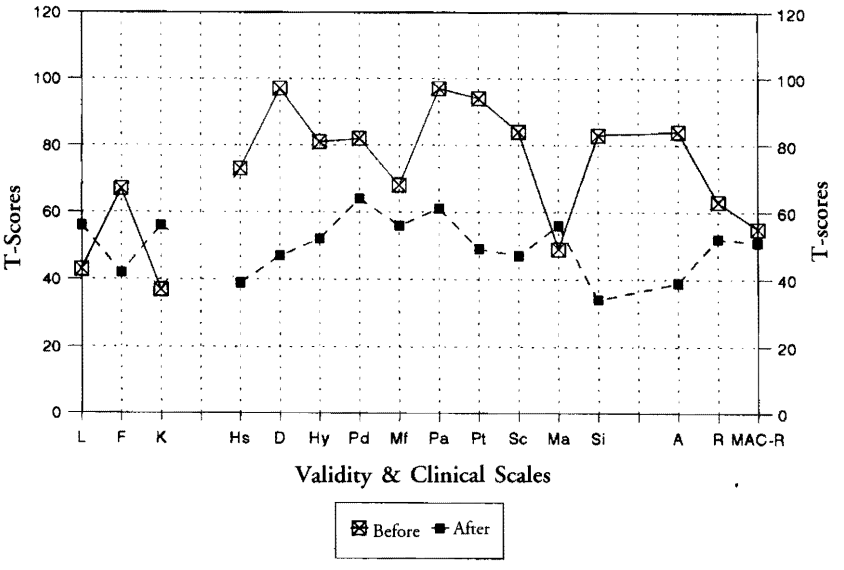

Figure 7. Minnesota multiphasic personality inventory-2. T-scores before and after neurofeedback therapy.

DISCUSSION

Based on the data collected and reported herein, it appears that the Peniston-Kulkosky protocol[1,2] was effective in one month of NT training to teach this substance abuse patient to reduce his amplitude of beta frequency brain waves (16.0-20.0 hz) and increase his amplitude of theta frequency brain waves (4.0-8.0 hz). Training resulted in movement away from the typical EEG pattern of alcoholics, many of whom do not show a well developed pattern of slow wave activity. This study found an increase in resting alpha amplitudes at 10 locations while 5 show a decrease. A study of Figure 2 shows a more wide spread reduction of beta wave activity than could be accounted for by abstinence from Xanax alone. According to Barnhart,[21] the mean elimination half-life of Alprazolam is 15 - 20 hours. The results reported here are consistent with stress reduction and are not likely due to simply discontinuing the Xanax.

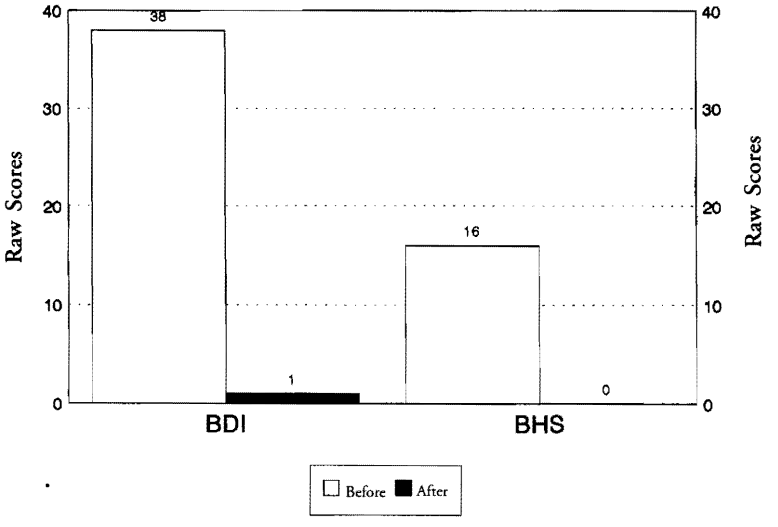

Figure 8. Beck depression inventory and hopelessness scale results.

In addition, it appears this treatment leads to a normalization of the subject's personality as measured by psychological tests. It also appears that the training location at CZ may be just as effective as training at 01. The shift to 01 was done to confirm that similar results were being produced at each location. However, post-treatment EEG evaluation shows a decrease in alpha at 01 with eyes closed relaxed. This was the case even though NT sessions 29-33 resulted in similar increase at 01 to those seen at CZ.

It was found that a 5 minute baseline session prior to each NT session was counter-productive for this subject and may be so for others. Monitoring digital temperature during the NT sessions confirmed that the patient could continue to experience hand warming even though no temperature feedback was offered. It appears that other substance abuse, such as Xanax, in addition to alcohol, is not a contraindication for this protocol.

In a personal communication in 1992, E. Peniston indicated nine of ten experimental subjects were still alive four years after the NT treatment. Eight of

those nine are still sober. It is not known how permanent the changes will be that are reported here in this study. At the booster session, one month after a four day relapse with beer, there was a pattern of alpha/theta cross-over greater than the complete lack of such cross-over prior to treatment. Even if there is a return to EEG base line, one can wonder whether or not the changes in personality and recovery from substance abuse will be maintained. Many more months of follow up will need to be carried out with this one subject to find out. Hopefully, as planned, the follow up can include EEG, psychometric and abstinence data.

The binge undertaken by the subject was reported to be different than binges and withdrawal prior to treatment. As in Peniston's subjects[1,2] this subject reported, "the very worst hangover ever. It lasted longer and was more intense, like a week of withdrawal rather than a couple of days. My poor sleeping pattern was made worse. My head hurt and nerves were on end. I swear I never had such an experience. I realized I really hurt myself. I can't do this. I never thought that way before." Peniston reported in a personal communication in 1992 that the personality continues to mellow and the sickness associated with substance abuse becomes more severe each time. The subject's personality change, as measured by psychological tests, was also confirmed by his parents. They were not specific but reported that "he was very different."

This writer would suggest that perhaps the "normalization" of personality we all know so well that occurs in some alcoholics with five or more years of unbroken sobriety may be accomplishing the same thing as in one month of NT treatment. If that were the case, at the very least, this protocol shortens the time for high risk of relapse and all the attendant threats to health and safety. We can not rule out the possibility that these results could accrue from communicating demand characteristics to the patient, or from the commitment of time and money, as well as intense involvement on a one-to-one level with a therapist. It is also possible that placebo and Hawthorne effect were involved. On the basis of this single case, it is not possible to determine the most important factors contributing to the successful outcome.

The protocol requires two sessions a day, one-hour each, with a minimum of 30 minutes on task for 30 sessions. An alternative might be to use one session

a day with 45 minutes on task. In an out-patient setting, some subjects, though a limited number, have employment conditions that would allow this intense program, but many others do not. To increase the number of patients who can take advantage of this treatment, evening sessions could be utilized with training in groups of five subjects at one time. Research with such arrangements is planned for the future.

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