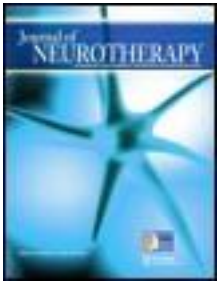

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Comparison of Alpha-Theta, Alpha and EMG Neurofeedback in the Production of Alpha- Theta Crossover and the Occurrence of Visualizations

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Comparison of Alpha-Theta, Alpha and EMG Neurofeedback in the Production of Alpha-Theta Crossover and the Occurrence of Visualizations

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ABSTRACT. *Background:* Alpha-theta biofeedback training has been employed in clinical addictions treatment since the first reports of suc-

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cessful application by Peniston and Kulkosky. Several studies have questioned the theta crossover component of this feedback protocol as necessary to the training condition.

Methods: We observed theta and alpha amplitudes, percentage of theta/alpha crossover, and self-reports of visualization in 191 sessions of three different protocols of brain wave biofeedback. Feedback conditions studied were alpha only, alpha-theta, and a type of EMG training. Subjects with identical electrode placement in all conditions, and not informed as to the nature of the feedback received, were given the same induction and expectations. They were asked to describe imagery occurring during feedback.

Results: Visualization was found to be not exclusive to alpha-theta neurofeedback, but instead was present in all three modes of feedback. In addition, an inverse relationship was found to exist between the degree of theta-greater-than-alpha states and the presence of visual imagery. EMG sessions produced a greater percentage of time in theta/alpha crossover states than alpha training alone, but the differences were small.

Conclusions: Alpha only feedback, EMG feedback and alpha-theta feedback sessions were associated with similar amounts of average theta/alpha ratio and percentage of theta/alpha crossover across sessions. Neither alpha-theta biofeedback nor biofeedback associated theta/alpha ratio increase is specific to the self-reported production of imagery.

KEYWORDS. Biofeedback, EEG, EMG, alpha-theta, alpha, addiction, theta crossover

INTRODUCTION

This study compares the presence of theta-greater-than-alpha brain wave states during alpha-theta, alpha, and EMG biofeedback training sessions in a chemically dependent population. Alpha-theta biofeedback for addictions, first reported by Twemlow and Bowen in 1977, has been described as a promising treatment for addiction (Peniston & Kulkosky, 1989, 1990, and Saxby & Peniston, 1995).

In the Peniston protocol of alpha-theta feedback training, participants first are taught to achieve a relaxed state through skin temperature biofeedback in which they learn to increase their finger temperature with the aid of autogenic phrases. They then are instructed in

brain wave biofeedback, and in an eyes closed and relaxed condition, receive auditory signals from EEG biofeedback apparatus. When alpha (8-12 Hz) brainwaves exceed a preset threshold, a pleasant tone is heard, and by learning to voluntarily produce this tone, the subject becomes progressively relaxed. When theta brainwaves (4-8 Hz) are produced at sufficiently high amplitude, a second tone is heard.

It has been reported that during periods when theta amplitude is elevated in relation to alpha amplitude, the subject becomes deeply relaxed and enters a reverie state characterized by hypnagogic imagery (Green, Green & Walters, 1974) and high suggestibility. Green, Green and Walters (1974) defined hypnagogic imagery as imagery that ''comes suddenly into the mind from some unconscious source.'' The theta component of alpha-theta feedback has been described as essential to the treatment method. ''It is hypothesized that the more the synchronicity and amplitude of theta waves increase, the deeper the patient is able to descend into the reverie (theta) state, which activates anxiety provoking images.''(Peniston, Marriman, Deming, & Kulkosky, 1993). Peniston, who refers to the state in which theta amplitude exceeds alpha amplitude as ''crossover'', has discussed the uniqueness of theta feedback extensively. In alpha-theta neurofeedback, the participant is rewarded for increasing both alpha and theta rhythms. However, at some point, a relatively rapid decrease in alpha amplitude is seen to occur until theta is greater than alpha. The periods of time during which this theta/alpha magnitude relationship is maintained are ''crossover'' periods. ''Crossover'' is thought to represent an event when hypnagogic imagery is most vivid and is described as the ''window of opportunity'' and ''the goal of neurofeedback therapy'' (Peniston, Marriman, Deming, & Kulkosky, 1993). Peniston's initial work focused on increases in theta amplitude over the course of brain wave biofeedback sessions, which he related to decreased depression and therapeutic efficacy (Peniston & Kulkosky, 1989).

However, the hypothesis that theta crossover is an essential part of alpha-theta treatment effect is controversial. Others report substantial imagery and therapy effect with relaxation methods, such as relaxation with suggestion (Lowe, 1999), meditation, and EMG biofeedback (Taub, Steiner, Smith, Weingarten & Walton, 1994). In a critical analysis of the Peniston protocol, Graap and Freides (1998) question whether Peniston's studies support the effect of alpha-theta training, or some other therapeutic intervention altogether. Taub and Rosenfeld (1994)

suggest that alpha-theta is non-specific in the treatment of addiction, and that relaxation achieved in a controlled setting by some other means is just as effective.

We designed a study to test the hypotheses that: (a) crossover states and elevated theta amplitude states occur more commonly in alpha/theta feedback than in another relaxing feedback condition, and (b) theta crossover and elevated theta/alpha amplitude states are associated with self reported visual reverie. We compared the responses of subjects randomized to one of two conditions: alpha-theta feedback, and a type of EMG feedback, under double blind conditions. We wished to control for all other variables, such as subject and therapist expectation, and the effects of the training suggestions and training setting, and blinded both subjects and the counselors who did group therapy after the training sessions to the training condition. We conducted our sessions in groups with a mix of subjects in each training paradigm in the groups to control for inter subject induced expectation. The study was terminated when it was discovered that during the course of this study some subjects had sessions, in which they were inadvertently given alpha feedback alone due to technician error, thus affecting the randomization. However, we were able to collect data regarding ratios of alpha and theta and self-reports of imagery in biofeedback sessions conducted under three conditions (alpha feedback, alpha-theta feedback, and EMG feedback) and report those findings here.

METHODS

Subjects. Participants (n = 35) completed written informed consents approved by the human subjects' committee of the Minneapolis Veterans Affairs Medical Center (VAMC). All participants were male and actively enrolled in residential and outpatient substance abuse programs at the Minneapolis Veterans Home or the Minneapolis VAMC. Their average age was forty-one years and they were abstinent for at least one month at the time of the study. Self reported abstinence was verified by urine drug screen. Prior to the brain wave biofeedback sessions, all subjects had pretreatment skin temperature biofeedback sessions as described by Peniston (Peniston & Kulkosky, 1989, 1990; and Saxby & Peniston, 1995). Although each subject was to receive 20 brain wave sessions, the participants had varying numbers of brain wave training sessions due to drop out. Brain wave treatment sessions

(n = 191: 103 in the alpha/theta condition, 43 in the alpha only condition, and 45 in the EMG condition) were analyzed for theta/alpha ratios and theta/alpha crossover and imagery content as described in the following sections.

Equipment. Brain wave biofeedback was provided with Lexicor NRS-2D acquisition units and 486 computers with Lexicor Biolex version 2.37 software. A sampling rate of 128 Hz with 2-second epochs and a frequency resolution of .50 Hz were used. Digital filters were used with an 8th order filter to define steepness of bands with the following bandwidth selections and band analysis times: theta 4.0-8.0 Hz (500 ms), alpha 8.0-12.0 Hz (250 ms), and EMG 25-32 Hz (79 ms). The NRS-2D is a miniaturized acquisition unit configured to provide a single channel of biofeedback employing a three-lead configuration, using one ear as ground, one as reference, and the site studied as an active electrode (NRS 2-D Users and Biolex Software Manual). All participants had active electrodes attached to international 10-20 site O2. Nuprep skin preparation abrasive gel was used to prepare the scalp and earlobes. The right ear electrode was used as reference; the left ear electrode was used as ground. Ten20 conductive paste was used in the application of electrodes. Prior to the feedback sessions, impedance was checked and connections were adjusted to give readings under 10 K Ohms.

Training parameters. Biolex software allows for configuration of audio feedback conditions by selecting the defined bandwidth, the tone, and the threshold condition for which the tone is heard. The specifics for the three training conditions used are as follows:

Alpha-Theta: Participants received a primary feedback tone when alpha (8-12 Hz) amplitude was above threshold at a target rate of fifty-seventy percent. A secondary feedback tone was given when theta (4-8 Hz) amplitude rose above threshold at a target rate of twenty-forty percent. This was done to approximate the parameters set out by Peniston (Peniston, Marriman, Deming, & Kulkosky 1993).

EMG: EMG was considered to be activity in the twenty-four to thirty Hertz range. A primary feedback tone was given when EMG amplitude was less than threshold at a target rate of fifty percent. When EMG amplitude decreased to a level where it was about one microvolt below threshold a secondary feedback tone was given at a target rate of twenty percent. When EMG amplitude decreased further, to a point where it was about one and one-half microvolts below

threshold, the primary tone shut off while the secondary tone remained. The primary tone was identical to the tone given for alpha feedback and the secondary tone was identical to the tone given for theta feedback in the alpha-theta protocol. This protocol was designed to be indistinguishable from the alpha-theta protocol in terms of amount of feedback tone and effect of relaxation when compared to the alpha-theta tone in experienced subjects (unpublished data).

Alpha: Participants in the alpha group received a primary feedback tone when alpha amplitude was above threshold at a target rate of fifty percent. A second tone was given when alpha increased to a level two or three microvolts above threshold, and a third tone appeared when alpha amplitude increased two or three microvolts more. Whether the second and third tones were set at two- or three-microvolt increments depended upon the magnitude of the monitored signal. If the participant's derived alpha averaged 10 microvolts, the increment would be set at two. If the signal was stronger, say around twenty microvolts, the increment would be three. This protocol, not originally part of the study design, had previously been designed to produce progressive relaxation. As noted, it was inadvertently introduced to some subjects by a technician who selected the ''alpha'' rather than the ''alpha-theta'' template to create individual set up files. The tones were similar in quality, but not identical to the tones in the two designed protocols above.

All thresholds in the study were set individually during the initial training sessions and adjusted periodically to ensure that the participant was receiving defined levels of feedback. For example, if a target feedback level for alpha in a training condition was fifty to seventy percent, then during an ideal session the subject would hear the feedback tone between fifty and seventy percent of the time.

Group sessions and reported visual imagery. Subjects were given biofeedback in groups of two to six. The participants' eyes were closed for the duration of the forty-minute sessions, directly observed by the recording technician who was in the same room with the subject group, and who also directly observed real time EEG on all subjects via monitor. Participants in all conditions were instructed to attempt to keep the feedback tones on as much as possible throughout the sessions. A brief induction script identical to that described by Peniston (Peniston & Kulkosky, 1989) was read aloud at the beginning of each session that encouraged participants to enter a state of relaxation. A

detailed protocol followed during all group sessions is available from the authors on request.

Following the biofeedback sessions, participants completed questionnaires that in an open-ended way asked them to describe their experiences during the session, and also asked them to describe visualizations or other imagery. The questionnaire response was further validated by the technician, who observed, but did not participate in, a fifteen-minute post biofeedback debriefing session conducted by a counselor who was blind to condition. In this group debriefing session, participants were asked to describe their imagery and share their experiences. The random mix of subjects in different training protocols in a group session was done deliberately to assure that cross-referencing influences among the subjects would not bias their expectation of visualization. The presence or absence of visualization was determined by a blind evaluation of the written questionnaire response by a third party, a therapist experienced in alpha-theta brain wave biofeedback, and the results were tabulated as to whether or not visualization occurred for each session studied.

Measurements of theta crossover and theta/alpha ratios. The Biolex program can be configured to record a number of parameters for a training session, including tracking of a set of conditions as the percentage of time they are met across a session, and ratios of conditions being met averaged across a session (NRS 2-D Users and Biolex Software Manual). The percentage of time that theta amplitude was greater than alpha amplitude was measured for each forty-minute biofeedback session and recorded as ''Percentage Crossover.'' The ratio of mean theta amplitude to mean alpha amplitude was recorded as ''T/A Ratio.'' Both ''Percentage Crossover'' and ''T/A Ratio'' were tabulated and reported for each of the 191 feedback sessions studied.

RESULTS

Results are analyzed by session and do not reflect intra or inter subject variables. Tables 1, 2, and 3 show the data from a collection of 191 training sessions. The sessions are unequally distributed among 35 participants. Thirteen were in the alpha-theta group, eleven were in the EMG group, and eleven were in the alpha group. The 191 sessions are from various points in the training process, from the first session through the twentieth. The number of sessions represented in each

TABLE 1. The ratio of theta amplitude to alpha amplitude.

condition	n-sessions	Mean ± SD
Alpha-Theta	106	1.05 ± 0.22
Alpha	43	0.95 ± 0.24
EMG	45	1.09 ± 0.28

TABLE 2. The percentage of time in theta/alpha crossover.

condition	n-sessions	Mean ± SD
Alpha-Theta	89	40.5 ± 22.6%
Alpha	40	32.7 ± 22.0%
EMG	44	43.1 ± 24.5%

TABLE 3. Theta/Alpha ratio and percentage theta/alpha crossover compared to presence or absence of visualization.

Visualization in session?	Mean % T/A crossover ± SD	Mean theta to alpha ratio ± SD
Yes (n = 113)	35.6% ± 22.9%	1.00 ± 0.23
No (n = 41)	41.8% ± 22.0%	1.10 ± 0.27

table differs, as the data available were incomplete. Some sessions were missing either percentage crossover or visualization data.

Hypothesis 1: Do crossover states and elevated theta amplitude states occur more commonly in alpha/theta feedback than in another relaxing feedback condition? Table 1 displays data for theta/alpha ratios. The averaged ratio for alpha training is lower than that of alpha/theta and EMG. The production of high theta amplitude across sessions (relative to alpha amplitude) was evaluated first by a univariate analysis of variance. A significant difference was found between the three subsets [$F(2,188) = 3.52$, $p = .032$]. A post hoc comparison (Tukey) indicated a significant mean difference between theta alpha ratios in the EMG condition as compared to the alpha condition at the .05 level.

Table 2 shows the percentage of time in theta/alpha crossover across the three conditions. Crossover was achieved in these training sessions at similar ratios. Using a univariate analysis of variance, [F (2,170) = 2.39, p = 0.95], no significant difference was demonstrated between the three conditions. In summary, the data do not support the hypothesis that crossover occurs more commonly with alpha/theta feedback than with alpha feedback or with EMG feedback.

Hypothesis 2: Are percentage theta/alpha crossover and elevated theta to alpha ratios associated with self reported visual reverie? Table 3 examines the presence or absence of visual imagery, percentage theta/alpha crossover, and the averaged ratios of theta to alpha amplitude. Data from all three conditions are considered. Visualizations are more common in sessions with fewer crossovers or lower averaged theta/alpha ratios. A univariate analysis of variance for the association of visualization with percentage alpha theta crossover in all sessions does not demonstrate a difference [F (1,137) = 1.95, p = .165]. A univariate analysis of variance for the association of visualization with average theta/alpha ratio in all sessions does demonstrate an unexpected inverse relationship [F (1,152) = 5.56, p = .02]. Self reported visual imagery was found less commonly in sessions with high theta amplitude, contrary to the expectations of Peniston (Peniston, Marriman, Deming, & Kulkosky, 1993).

We also examined whether the presence or absence of visualization was associated with any of the three training conditions. Table 4 gives the data for 154 sessions for which complete data are available regarding the presence or absence of visualization. A Pearson Chi-Square test of the association of visualization with any of the three training conditions was not significant (p = .208). In summary, the hypothesis that visualization is associated with theta/alpha ratios or percentage theta/alpha crossover is not supported. Also, the three training conditions appear similar in their production of visualization.

In addition to analyzing sessions across subjects, we were able to do

TABLE 4. Presence or absence of visualization by type of training.

Visualization present?	EMG	Alpha	Alpha-theta
Yes	27 (77.1%)	23 (62.2%)	63 (76.8%)
No	8 (22.9%)	14 (37.8%)	19 (23.2%)

a limited comparison of sessions within subjects. Table 5 shows the results of the seventh biofeedback session for each of eleven participants for whom complete records of the seventh training session were available. It lists the percentage of time in alpha-theta crossover, the theta/alpha ratio, and whether or not the participant experienced visualizations. Although no statistical analysis is possible, it illustrates that crossover and visualization do occur with any of the three feedback conditions.

DISCUSSION

Our results join those of other authors in support of the interpretation that brain wave parameters of deeply relaxed states, namely theta amplitude greater than alpha amplitude, can be demonstrated without direct theta feedback. We found that participant self-reports of imagery occurred in our series with all three conditions studied and were not necessarily associated with theta/alpha ratio or crossover percentage of time increases. Lowe (1999) has recently reported that she found no significant differences in treatment outcomes between an alpha-theta treated group and a control group that participated in a modified Peniston protocol. On a similar note, Taub has suggested (Taub, Steiner, Smith, Weingarten, & Walton, 1994) that other forms of relaxation therapy, such as meditation or EMG biofeedback may be

TABLE 5. Data from a representative session for individual subjects.

Participant	Condition	% alpha-theta crossover	Theta/Alpha ratio	Visualization?
AT1	Alpha-Theta	56.1	1.2	Yes
AT2	Alpha-Theta	19.5	0.9	Yes
AT3	Alpha-Theta	54.3	1.2	No
AT4	Alpha-Theta	50.0	1.1	Yes
E1	EMG	66.0	1.4	Yes
E2	EMG	3.4	0.6	Yes
E3	EMG	20.2	0.8	Yes
E4	EMG	78.2	1.7	No
A1	Alpha	45.0	1.1	Yes
A2	Alpha	3.5	0.6	No
A3	Alpha	32.7	0.9	Yes

just as effective as alpha-theta brain wave training in addiction. The findings from the study reported here and those cited above support the assertion by Taub and Rosenfeld (1994) that alpha/theta training is not specific or essential to achieving a state of relaxation and visualization, and possible high suggestibility.

Visualization is stressed in the Peniston protocol during post feedback debriefing as essential to the technique, but may be easily influenced by expectations. We were concerned that subjects would be coerced into reporting some type of imagery as expected either by the induction, which instructs them to visualize, or the debriefings where they are asked, ''What did you see?'' or by the questionnaire itself. Because subjects had post-feedback debriefing in groups facilitated by a counselor who was also blind to condition, self-reports of visualization could not be influenced by either counselor or subject expectation of the efficacy of one method over the other. Lowe (1999) also reported that visualization occurred without regard to condition in blinded subjects in a comparison of alpha-theta feedback vs. simple relaxation and suggestion.

In individual training sessions the pattern we noted was that during crossover periods the relationship between alpha and theta magnitudes becomes inverted not because of theta increase, but rather because of a dramatic alpha decrease just prior to the crossover period. This is consistent with the ''alpha dropout'' seen by sleep EEG researchers in the early drowsiness period of stage one sleep (Niedermeyer & Lopes Da Silva, 1993). The absence of marked theta increase we saw may also be of note. From one perspective this is not surprising as the hypnagogic rhythmical theta activity seen in drowsiness in early childhood is rare after the age of 6 years.

This study has several methodological weaknesses. Although the statistics used in the analysis account for the unequal group sizes, the data came about from both a prospective design (alpha/theta vs. EMG) and an unplanned interjection of a third training paradigm (alpha). The study does not account for intra-and inter-subject differences that may have influenced any of the results displayed. Rather than analyzing data by subject, it is analyzed by session.

We used O2 as a training site, although Peniston first described the use of O1 as the training site for alpha-theta feedback, (Peniston & Kulkosky, 1989). One could argue that this difference is not trivial, considering the different roles of the two cerebral hemispheres. In fact,

O2 was chosen in light of: (a) the possibility that the right hemisphere may be more involved in higher visual processing than the left, and (b) the purpose of this training was to engender visualizations. It should also be noted that Peniston later employed both O1 and O2 as training sites when he used Cap-scan equipment (Peniston, Marriman, Deming, & Kulkosky, 1993).

We do not know at what point(s) in the session the participant experienced visualizations. This study only addresses the relationship between the presence of hypnagogic imagery and measures of theta-greater-than-alpha states as averaged over the course of forty-minute sessions. It does not speak to the question of what the ''instantaneous'' theta/alpha ratio generally is during moments when a subject is experiencing hypnagogic imagery. The confusion of terminology regarding the totally subjective experiences of reverie, visualization and imagery makes assessment of an end point difficult, and we simply chose the presence or absence of visualization as an end point. We saw great variability across participants' post-session reports in the intensity and complexity of visualizations. This makes a yes/no evaluation for visualization problematic and may call into question the viability of subsequent data based on the evaluation of whether or not imagery was present in a session. However, since the scorer was unaware of the condition, percentage of crossover, and theta/alpha ratios of the sessions being scored, it seems reasonable to allow that there is some measure of consistency in evaluation across feedback conditions and throughout the distribution of theta/alpha crossover and ratios. We used the approach of having questionnaires regarding visualization evaluated by a therapist blind to the condition to eliminate bias.

Within its methodological limitations, our study shows that uniformly applied biofeedback sessions employing one of three conditions give similar results for both averaged theta/alpha ratios and percentage of time in crossover. Our study also suggests that the occurrence of visualization experiences is independent of: (a) the biofeedback protocol used or (b) averaged measurements of theta relative to alpha amplitude. It also suggests that visual imagery may actually be less likely to occur when subjects are in theta/alpha crossover states. While we do not question the value of relaxation training in addiction treatment, it is clear that those methods other than EEG biofeedback, less expensive and less time consuming may be equally as effective. More clinical trials reporting on comparisons between methods are needed.

REFERENCES

Graap, K. & Freides, D. (1998). Regarding the database for the Peniston alpha-theta EEG biofeedback protocol. *Applied Psychophysiology and Biofeedback 23*, 265-272.

Green, A.M., Green, E.E., & Walters, E.D. (1974). Brainwave training, imagery, creativity and integrative experiences. Paper presented at the Biofeedback Research Society Conference.

Lowe, F. (1999). How essential is the EEG component in the Peniston and Kulkosky protocol? Proceedings AAPB Thirtieth Anniversary Annual Meeting. Victoria, Canada. 92-94.

Niedermeyer, E. (1999). Sleep and the EEG. In E. Niedermeyer & F. Lopes Da Silva (Eds.), *Electroencephalography: basic principles*, *clinical applications*, *and related fields*. 4th Edition. (174-189). Baltimore: Williams and Wilkins.

Niedermeyer, E. (1999). Maturation of the EEG. In E. Niedermeyer & F. Lopes Da Silva (Eds.), *Electroencephalography: basic principles*, *clinical applications*, *and related fields*. 4th Edition. (189-214). Baltimore: Williams and Wilkins.

Passini, F.T., Watson, C.G., Dehnel, L., Herder, J., & Watkins, B. (1977). Alpha wave biofeedback training in alcoholics. *Journal of Clinical Psychology*, *33(1)*, 292-299.

Peniston, E.G. & Kulkosky, P.J. (1989). Alpha-theta brainwave training and beta-endorphin levels in alcoholics. *Alcoholism Clinical Experimental Research*, *13*, 271-279.

Peniston, E.G. & Kulkosky, P.J. (1990). Alcoholic personality and alpha-theta brainwave training. *Medical Psychotherapy*, *2*, 37-55.

Peniston, E.G., & Kulkosky, P.J. (1991). Alpha-theta brain wave neurofeedback for Vietnam veterans with combat related posttraumatic stress disorder. *Medical Psychotherapy*, *4*, 1-14.

Peniston, E.G., Marriman D.A., Deming, W.A., & Kulkosky, P.J. (1993). EEG alpha-theta brain wave synchronization in Vietnam theater veterans with combat related posttraumatic stress disorder and alcohol abuse. *Medical Advances in Medical Psychotherapy*, *6*, 37-50.

Saxby, E. & Peniston, E.G. (1995). Alpha-theta brainwave neurofeedback training: an effective treatment for male and female alcoholics with depressive symptoms. *Journal of Clinical Psychology*, *51(5)*, 685-693.

Taub, E. & Rosenfeld, J.P. (1994). Is alpha/theta training the effective component of the alpha/theta therapy package for the treatment of alcoholism? *Biofeedback*, *22(3)*, 12-14.

Taub, E., Steiner, S.S., Smith, R.B., Weingarten, E.I., & Walton, K.G. (1994). Effectiveness of broad-spectrum approaches to relapse prevention in severe alcoholism: a long-term randomized controlled trial of transcendental meditation, EMG biofeedback, and electronic neurotherapy. *Alcoholism Treatment Quarterly*, *11*, 187-220.

Twemlow, S.W. & Bowen, W.T. (1977). Sociocultural predictors of self-actualization in EEG biofeedback treated alcoholics. *Psychological Reports*, *40*, 591-598.

Watson, C.G., Herder, J., & Passini, F.T. (1978). Alpha wave biofeedback training in alcoholics: an 18-month follow-up. *Journal of Clinical Psychology*, *34(3)*, 765-769.

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