AN ABSTRACT OF THE THESIS OF

Michael Lawrence Reed for the degree of Master of Arts in Interdisciplinary Studies in Psychology, Anthropology, Statistics presented on October 15, 1979.

Title: The Effects of Electromyographic Biofeedback on Test Anxiety and Performance

Redacted for Privacy

Abstract approved: ______ Carol A. Saslow, Ph.D.

The applicability of electromyographic biofeedback toward alleviating test taking anxiety was examined along with the effects of relaxation training on general anxiety, locus of control, test performance, and muscle tension during a test. The Achievement Anxiety Test (AAT) was administered to 271 freshman psychology students. Students whose scores indicated high levels of test anxiety were invited to participate in the study. Twenty-seven volunteers were randomly assigned to three groups. Biofeedback (B) subjects received verbal instructions and muscle tension (EMG) biofeedback. Instruction-control (IC) subjects received verbal relaxation instructions alone. A second control group (C) received no treatment. B and IC subjects received eight half-hour relaxation sessions spread over four weeks. Forehead EMG was monitored during each session.

Several self-report measures were administered to all subjects before and after training. They included the AAT, the State-Trait

Anxiety Inventory (STAI), and the Rotter Locus of Control (I-E) Scale. Additionally, forehead muscle tension data were collected on all subjects while they completed an easy and a hard form of the Raven Progressive Matrices test (presented with ego-involving instructions). Equivalent forms of the tests were used pre and post, and the forms were counterbalanced across subjects.

Analysis of the EMG data collected during relaxation training indicated that B and IC subjects significantly reduced forehead muscle tension but did not differ from each other. EMG biofeedback appears to add little to the effectiveness of brief relaxation instructions and practice. Analysis of anxiety measures indicated that B and IC subjects changed significantly pre to post while C subjects changed very little. No between-group differences were found on any of the measures. On the I-E scale, only IC subjects showed a significant shift toward being more internal, reflecting an increased belief in personal control. The effect of relaxation training on test performance and muscle tension during testing was evaluated with an analysis of variance. Within-group EMG and performance changes were nonsignificant, suggesting there was no generalization of training effects. In addition, EMGs did not differ between Easy and Hard tests, although performance scores indicated there were real differences in test difficulty.

The effects of relaxation training in this study are clearly limited to the reduction of resting forehead muscle tension and self-report anxiety. No training effects were found on test performance or EMG during testing. These results are due either to the methodological limitations of a laboratory testing situation, or that forehead EMG is not as good a measure of anxiety as other researchers have suggested.

The Effects of Electromyographic Biofeedback on Test Anxiety and Performance

by

Michael Lawrence Reed

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Arts in Interdisciplinary Studies

Completed October 15, 1979

Commencement June 1980

APPROVED:

Redacted for Privacy

Professor of Psychology

Redacted for Privacy

Chairman, Department of Psychology

Redacted for Privacy

Dean of Graduate School

Date thesis is presented: October 15, 1979

Typed by Christina Pyle for Michael Lawrence Reed

ACKNOWLEDGMENT

Special thanks to Carol Saslow for the use of laboratory space and equipment and for her continual support and encouragement.

TABLE OF CONTENTS

The Effects of Electromyographic Biofeedback on Test Anxiety and Performance

I. INTRODUCTION

The development of an effective and efficient technique to help alleviate test-taking anxiety would be of considerable value to psychologists and school counselors. A number of studies have indicated that high test anxiety is related to such factors as poor classroom test scores (Alpert and Haber, 1960; Walsh et al, 1968), lower grade point averages (Desiderato and Koskinen, 1969), dropout rate (Spielberger, 1962), and lower performance on achievement and aptitude tests (Sarason, 1961). There is also research suggesting that performance of high test anxious students improves under low stress or non-evaluative testing conditions (Russel and Sarason, 1965).

A number of methods for reducing test anxiety have been developed and applied to student populations. They include such things as systematic desensitization (Quinn, 1968); Garlington and Cotler, 1968); Mitchell and Ng, 1972), modeling (Horne and Matson, 1977), study counseling (Meichenbaum, 1972), autogenic training (Snider and Oetting, 1966), and physical exertion (Driscoll, 1976).[1] There appears to be almost as many ways of treating test anxiety as there are therapeutic philosophies.

Treatment effectiveness has been assessed in a variety of ways. Self-report measures of anxiety are used most often. There are a number of standardized scales specifically designed to measure test anxiety.

---

[1] These and other methods for reducing test anxiety are reviewed more completely in Appendix A.

These include the Achievement Anxiety Test (Alpert and Haber, 1960), the Test Anxiety Scale (Sarason, 1958), and the Suinn Test Anxiety Behavior Scale (Suinn, 1969).

Certain performance measures might also be used. For example, changes in grade point averages, classroom test performance, or performance in a laboratory testing situation might be assessed before and after a given treatment. Laboratory testing situations typically involve the use of ego-involving or threat instructions to simulate an actual test. A laboratory setting has the advantage of maintaining a constant, controlled environment for testing but may be disadvantageous in that it lacks the motivational elements of a real test.

Another method for determining the effects of a given treatment involves monitoring physiological changes in the subject. Early researchers had to rely primarily on self-report and performance measures. Present day researchers have relatively easy access to information about a subject's heart rate, blood pressure, skin temperature, and muscle tension. Positive changes in these measures, either following treatment and/or during a testing situation, may support the efficacy of a particular method for reducing test anxiety. It is unfortunate, however, that few studies measure physiological variables and even fewer have measured them during a testing situation. Given that physiological indices are a valid measure of anxiety, physiological data recorded during testing may add additional information concerning the amount of anxiety being experienced by the subject.

Most methods of reducing test anxiety involve learning deep muscle relaxation. There is a considerable amount of research indicating that when a person learns to relax voluntarily and practices regularly, subjectively experienced anxiety as well as tension and stress-related conditions lessen (Patel, 1977; Reinking and Kohl, 1975; Hutchings and Reinking, 1976; Kotses et al, 1976; Fowler et al, 1976). Several recent studies have applied muscle relaxation training to the problems of test-taking anxiety and other forms of anxiety with varying degrees of success (Raskin et al, 1973; Deffenbacher and Snyder, 1976; Quinn, 1968). A number of researchers have used electromyographic (EMG) biofeedback, also with varying degrees of success, to decrease muscle tension, enhance a person's ability to relax, and decrease anxiety (Budzynski and Stoyva, 1969; Ohno et al, 1978; Kinsman et al, 1975; Hutchings and Reinking, 1976).

However, the exact nature of the relationship between muscle tension and anxiety remains unclear. Malmo and Smith (1955) report elevated forehead muscle tension in anxious subjects and further increases under stress. Similar results are reported by Wolff (1948). A study by Sainsbury and Gibson (1954) suggests forehead EMG changes are correlated with muscle tension elsewhere in the body as well as other indices of autonomic arousal such as heart rate and respiration. And research conducted by Smith (1973) has demonstrated that personality variables, including anxiety, are significantly correlated with levels of forehead muscle tension. This research suggests that if relaxation training reduces forehead muscle tension, it should reduce anxiety as well. It also suggests that relaxed forehead muscles are indicative of general overall relaxation. Alexander (1975) conducted a study designed to test these assumptions.

In Alexander's study, 28 adults were randomly assigned to two groups. One group received relaxation training via forehead EMG feedback; the other was simply asked to relax. Subjects participated in five sessions during which muscle tension in the forehead, forearm, and lower leg was monitored. Subjects were asked to rate their feelings of relaxation on a standard scale following each session. The group receiving EMG feedback was more successful at reducing forehead muscle tension, but both groups reported feelings of relaxation of about the same magnitude. No support was found for the assumption that reductions in forehead EMG lead to similar reductions in other muscles. In addition, no support was found for the assumption that forehead muscle tension reduction is related to or produces general feelings of relaxation. In light of earlier findings, more research in this area is needed.

In addition, it has not yet been conclusively established whether EMG biofeedback adds anything to relaxation programs designed to decrease muscle tension or reduce anxiety. In a recent study by Kappes and Michaud (1978), EMG biofeedback was used in the treatment of 12 test-anxious college females. Six subjects received contingent EMG feedback while the other six received noncontingent feedback. Subjects receiving contingent feedback reported a decrease in test anxiety while those receiving the noncontingent feedback reported an increase. Since the subjects knew when feedback was noncontingent, this was not an appropriate control for establishing the effectiveness of biofeedback in treating test anxiety. An appropriate control group would be one for which expectations of improvement were the same as those for the biofeedback group.

A study by Romano and Cabianca (1978) compared the effectiveness of EMG-assisted systematic desensitization, systematic desensitization alone, and EMG training alone, in the treatment of test anxiety. Test anxiety was assessed by several standardized questionnaires. An anagrams test served as a measure of performance. It was administered in a laboratory setting before and after treatment. After nine training sessions, all three experimental groups significantly reduced their test-taking anxiety in comparison to control subjects; however, there were no significant differences among the experimental groups. In addition, no effects of treatment were found on anagram test performance. The use of EMG feedback appeared to add little to the effects of treatment according to the self-report and performance measures used. Because the use of biofeedback is expensive, in terms of therapist time and equipment, additional, well-controlled, comparative research studies are needed to establish the relative cost effectiveness and value of EMG biofeedback as a method of relaxation.

Another consideration in evaluating a technique for therapeutic effectiveness is whether a given technique, if successful, has desirable or nondesirable side effects for the client. One of these side effects might be changes in the clients' perception of the source of factors controlling their behavior. Rotter (1966) has developed a "Locus of Control" scale for measurement of whether a person tends to attribute reinforcing events to his own efforts or to external sources, such as luck or chance, which are not under his control. Carlson (1977) has found a relationship between locus of control and the effectiveness of EMG biofeedback training in reducing frontalis muscle tension.

Additional research examining the effects of voluntary relaxation training on this aspect of personality is needed.

The present study compared the effectiveness of brief relaxation instructions plus EMG feedback with relaxation instructions alone in reducing forehead muscle tension, self-reported test anxiety, and in altering perceived locus of control. The effects of treatment on test performance were also assessed. This study was similar to previous research except that forehead muscle tension was monitored during testing. In addition, special care was taken to control for the effects of subject expectations and experimenter bias.

II. METHODS

Subjects

Twenty-seven college students (6 males and 21 females) from a freshman Personal Development class volunteered for the study from a sample of 88 high test-anxious students. The mean age of these students was 19.

Sampling Procedure. The Achievement Anxiety Test (AAT) (Alpert and Haber, 1960) was administered to a total of 271 students (128 males and 143 females). Of these, 25 percent of the males and 39 percent of the females were identified as high test anxious by scoring 31 or higher on the Debilitating Test Anxiety Scale of the AAT. High test-anxious subjects were invited to participate in a "program to help reduce test-taking anxiety." Volunteers were assigned at random to one of the following groups: Relaxation instructions with EMG biofeedback (B); Instruction-control (IC), given relaxation instructions alone; or No-treatment control (C).

Apparatus

Forehead electromyographic (EMG) activity was measured in microvolts (rms) with a Cyborg J33 muscle trainer interfaced with a Cyborg BL900 dual processor. EMG activity was integrated for 10-second samples and the average activity recorded from a meter. The EMG trainer produced a series of clicks at a rate proportional to EMG activity. For feedback, the sensitivity of the trainer could be adjusted so that as B subjects became proficient at reducing EMG activity, the threshold for the production of clicks was reduced. Electrodes were attached to the forehead at a standard four-inch spacing with adhesive discs.

Verbal instructions between the experimenter and subjects were reduced to a minimum by using tape-recorded instructions. This was done to control for possible experimenter biasing effects.

All relaxation training was carried out in a shielded room to reduce electrical interference. This room was dimly lit and a recliner chair was provided.

Pre- and Post-Testing Procedures

Self-Report Measures. All subjects met as a group prior to the start of the program to develop a training schedule and fill out the self-report pre-test measures. To avoid attracting subjects who may have had an interest in or bias toward biofeedback and/or relaxation, no mention of the training procedures was made prior to administering the AAT.

The following self-report measures[2] were administered at the beginning and end of the program: the AAT (used for the initial screening of subjects); the Spielberger State-Trait Anxiety Inventory (STAI) (Spielberger et al, 1970); and the Rotter Internal-External Locus of Control (I-E) Scale (Rotter, 1966).

Within the AAT are two separate scales: one measures debilitating (D) test anxiety; and the other, facilitating (F) test anxiety. Alpert and Haber (1960) have used these scales to predict successfully several

[2]See Appendix C.

performance criteria, such as grade-point averages and final examination grade. The D and the F scales combined are significantly better performance predictors than either one alone. The STAI yielded a score for both general (trait) and situation-specific (state) anxiety. Subjects were asked to imagine themselves "in an important testing situation" when responding to the state form of the STAI. Rotter's (1966) Internal-External Locus of Control (I-E) Scale is designed to assess the extent to which a person attributes reinforcing events to his/her own efforts or to luck or chance.

Pre- and post-testing involved the same procedures except for the addition of the AAT to each subject's post-test packet. Self-report post-test data were collected on an individual basis following each subject's tenth session. The order of all pre- and post-test measures was counterbalanced across subjects.

Performance Measures. Performance testing was done on an individual basis during each subject's first and tenth laboratory session. The Standard Progressive Matrices test developed by Raven (1938) was used as a performance measure. The original test consisted of 60 problems spanning a large range of intellectual development. The task is to select a small pattern from a number of possibilities which most logically completes a larger pattern. The large pattern and the number of possible solutions get progressively more complex and harder to complete.

The gradual progression from easy test items to more difficult ones, and the large number of problems, lent the Progressive Matrices nicely to division into equivalent forms for pre- and post-testing. The first half of each form (15 problems) was used as an easy test; the second half of each form became a hard test (also 15 problems). Easy and hard tests were counterbalanced across subjects for pre- and post-testing.

Upon arrival at the laboratory, subjects were informed about the testing that would be taking place and given information about the EMG equipment. Subjects were then led into the testing room and electrodes were attached to the forehead. A tape recording was played which described the nature of the test and the importance of doing well.[3] Subjects were given seven minutes to complete each version of the test. Forehead muscle tension was monitored during testing.

Pre- and post-test procedures were the same except at post-test subjects were asked to stay relaxed during the testing but still do as well as they could on the test.

Relaxation Training

Control subjects were rescheduled following the pre-test to begin their programs four weeks later. They were post-tested at this time and then offered training similar to that received by the B and IC groups. Training was conducted for B and IC subjects during laboratory sessions two and nine. The eight half-hour training sessions were held on an individual basis: two per week for four weeks.

Forehead muscle tension was recorded at the beginning and end of each session (12 10-second integrated samples were taken). Initial readings were recorded before subjects began practicing their respective

[3]See Appendix D.

relaxation procedures. Final EMG readings were recorded at the end of the 20-minute session without disturbing the subject.

Both groups listened to three minutes of taped relaxation instructions[4] at the beginning of the first two sessions. The tape included instructions for an abbreviated form of Progressive Relaxation (Jacobson, 1938) as well as additional instructions to help "deepen" relaxation (i.e., "attend to your breathing"; "repeat the word 'calm' silently to yourself"). In order to minimize subject expectations in the description of the task, such terms as "electrode," "biofeedback," and "experiment" were avoided.

B subjects differed from IC subjects in one way only: they received auditory feedback about the tension of their forehead muscles during each session. Feedback was contingent upon increases in muscle tension. The training instrument was presented simply as "information about how relaxed your forehead muscles are...that may help you in learning to relax." It was small enough that subjects could hold it comfortably on their laps. B subjects were shown how and instructed to adjust the machine when forehead muscle tension dropped below threshold and the signal was no longer heard. They received immediate auditory feedback about their forehead muscle tension, as well as end-of-session information from a dial on the machine about overall changes during each session.

Subjects were not told about the other groups in order to avoid the possibility of creating feelings of having something extra or of missing out on something. At the end of each session, B and IC subjects were

---

[4] See Appendix E.

told that they were progressing as expected and complimented on their progress. All training sessions were held in the afternoon.

III. RESULTS

Analysis of the self-report data proceeded in the following manner. Descriptive statistics were calculated and examined pre and post for anxiety and locus of control scales. Tables 1, 2, and 3 summarize these data, along with raw and percent change values, for each group. As shown in Figure 1, B and IC subjects consistently showed changes in the direction of improvement that were not characteristic of C subjects. The amount of variability within each group remained relatively constant pre to post with the exception of the debilitating (D) scale of the AAT. On this scale, there was approximately twice as much variability at post-test within all groups.

To determine if there were significant differences between groups, one-way analyses of variance (ANOVA) were used. An ANOVA was calculated on raw pre-to-post change scores for each subjective measure. No significant between-group differences were found on any of the scales.

Two-tailed independent _t_-tests on ratio change values were used to determine if treated subjects (B and IC) differed significantly from untreated subjects (C). These results are presented in Table 4. Change scores were used to eliminate the effects of pre-test differences. Ratio change scores were calculated by dividing the change pre to post by the initial scale value. Treated subjects differed significantly from untreated subjects on the facilitating (F) scale of the AAT ($p < .05$) and the state ($p < .05$) and trait ($p < .01$) forms of the STAI. However, no differences were found on the D scale of the AAT or the I-E scale.

Two-tailed _t_-tests for paired data were calculated to examine within-group changes in subjective measures. These statistics are given in Table 5. The pre-to-post test scores of B subjects shifted significantly on both scales of the AAT. Debilitating test anxiety decreased ($p < .05$) and facilitating test anxiety increased ($p < .01$). A significant decrease in reported anxiety as found also on the STAI in both state ($p < .05$) and trait ($p < .01$) scales.

On the STAI, IC subjects showed a significant decrease in both state ($p < .01$) and trait ($p < .05$) anxiety, but no significant pre-to-post difference was found on either scale of the AAT. Because the subscales of the AAT have only a few items, they may be less sensitive to change separately than they would be if combined. To increase the sensitivity of the AAT and get a measure of overall improvement, decreases on the D scale and increases on the F scale were given the same sign and combined. An ANOVA on these combined scores yielded a significant difference between groups ($F(2,24)=2.99$, $p < .10$). When the Least Squares Differences (Snedecor and Cochran, 1967) were calculated between groups, both B and IC groups differed significantly from controls ($p < .05$) but not from each other.

On the I-E scale, only IC subjects changed significantly in the direction of increased internal control ($\underline{t}=1.88$, $p < .10$). This reflects an increased belief in personal control and attribution of reinforcing or positive events to self effort rather than external sources. B and C subjects showed no such shift.

None of the pre-to-post test comparisons on subjective measures were significant for C subjects. Overall, it appears that both B and

IC subjects report experiencing some benefit from their participation in the relaxation program, while C subjects report little or no change following treatment.

An analysis of the EMG data during relaxation training indicated that both the B and IC groups were successful at reducing forehead muscle tension. Means and standard deviations for the initial and final values were calculated from the 12 10-second integrated EMG samples recorded at the beginning and end of each relaxation session. Table 6 presents these data along with the mean difference, ratio change, and calculated _t_-values on between-session (session one to session eight) changes for the relaxation groups. Ratio change scores were calculated in the same manner as before. Both groups show significant drops in initial and final EMG levels across sessions. The groups differed very little with respect to within-group decreases in overall (beginning of session one to end of session eight) EMG activity; B subjects dropped 53 percent while IC subjects dropped 59 percent. Between-group differences were also small and not significant according to a two-tailed independent group's _t_-test on overall percent change scores.

The relationship between overall (from the beginning of relaxation session one to the end of session eight) changes in forehead EMG during relaxation training and changes in self-report measures pre to post was examined using correlations. Table 7 presents the correlation matrix on ratio change data for B and IC groups combined. Both Pearson Product Moment Correlations and Spearman's Rank Order Correlations are given because of the small sample size and high variability of these data. All correlations are small and not significant.

While the subjective measures suggest that relaxation training was effective in reducing test taking anxiety, there were no effects of treatment on test performance or forehead muscle tension during testing. Table 8 presents the results of 3x2x2 nested ANOVA for the number of correct responses on the Progressive Matrices test. There were no significant group differences in number correct and no change pre to post. There was, however, a significant ($F(1,72)=230.4$, $p < .0001$) difference between the easy and hard versions of the test. There were more correct answers on the easy tests than on the hard tests. This suggests that real differences existed in terms of test difficulty. All interactions were small and not significant.

A 3x2x2 nested ANOVA also was used to analyze the time required to complete test data. This is presented in Table 9. Once again, there were no overall group differences, suggesting there was no effect of treatment. A significant ($F(1,72)=935.4$, $p < .0001$) difference between easy and hard versions of the test was found in the amount of time needed to finish. The hard version of the test took longer to complete than the easy version. A significant ($F(1,72)=8.72$, $p < .01$) decrease pre to post in time needed to complete the tests was found also. However, since there was no Group X Pre-Post interaction this effect is probably best attributed to practice and familiarity with the task and not to treatment. All other interactions were small and not significant as well.

The forehead EMG data recorded during testing were analyzed, once again, with a 3x2x2 nested ANOVA. No significant differences were found overall between groups and there was no change pre to post. In addition, no differences were found between the easy and hard testing situations.

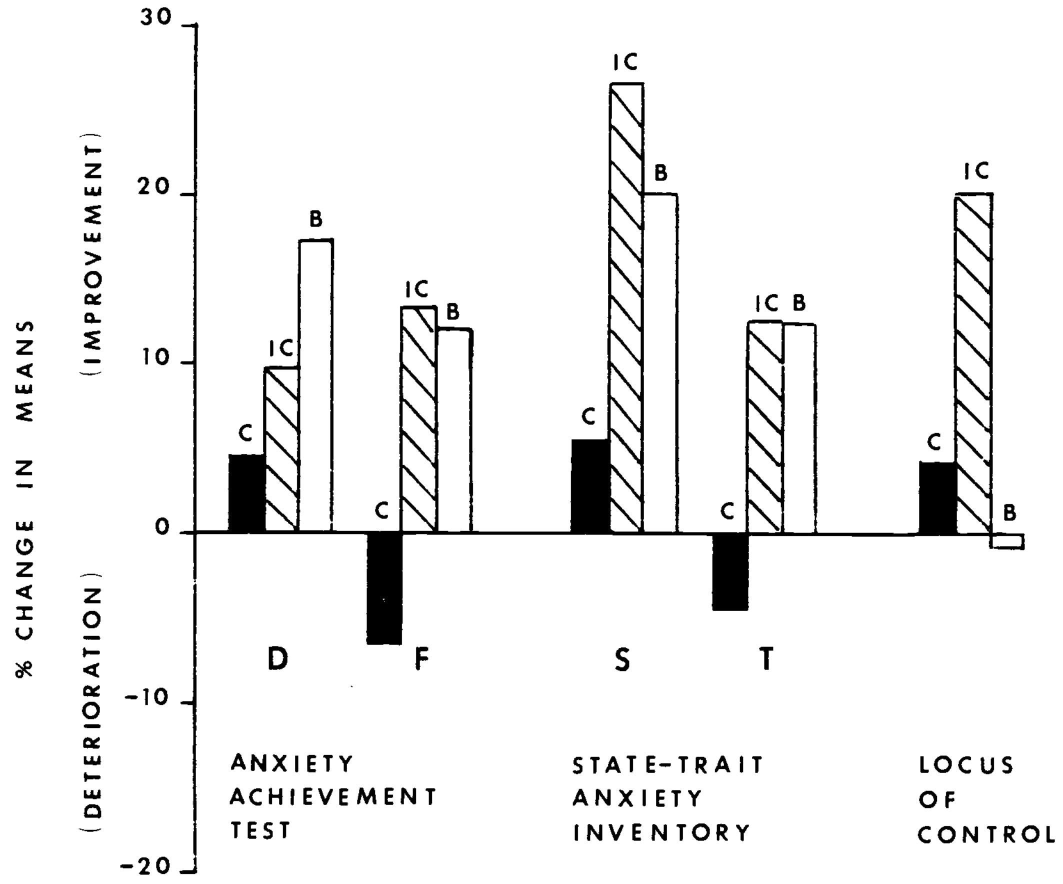


Figure 1. Percent change in group means from pre to post for the different anxiety measures and for locus of control.

TABLE 1

Summary and Change Statistics on Each Subjective Measure for Biofeedback (B) Subjects (N=9)

	AAT (D)	AAT (F)*	STAI (State)	STAI (Trait)	I-E
Pre-Test					
Mean ($\bar{X}$)	35.78	19.22	62.88	45.44	9.66
(SD)	(3.34)	(3.66)	(9.37)	(8.30)	(5.98)
Median	34	19	62	43	11
Range	31-41	15-25	45-76	35-63	2-17
Post-Test					
Mean	28.11	21.67	50.44	39.78	9.78
(SD)	(6.99)	(3.46)	(8.67)	(8.30)	(5.87)
Median	29	21	47	36	10
Range	17-37	18-27	37-58	31-53	2-15
Pre-Post Change					
Mean	6.67	-2.44	11.22	5.67	-.33
(SD)	(7.73)	(1.70)	(14.89)	(8.33)	(4.93)
Median	5	-2	12	4	0
Type of Change					
# Improved	7	8	7	7	4
% Improved	78%	89%	78%	78%	44%
$\bar{X}$ Improvement	9.1	2.8	18.1	8.9	2.5
# Worsened	2	0	2	2	3
% Worsened	22%	0%	22%	22%	33%
$\bar{X}$ Decrement	2.0	-	7.5	5.5	2.3
# No Change	0	1	0	0	2
% No Change	0%	11%	0%	0%	22%

*Increases in facilitating test anxiety are a sign of improvement.

TABLE 2

Summary and Change Statistics on Each Subjective Measure for Instruction-Control (IC) Subjects (N=9)

	AAT (D)	AAT (F)*	STAI (State)	STAI (Trait)	I-E
Pre-Test					
Mean ($\bar{X}$)	34.77	16.67	62.11	41.22	11.11
(SD)	(3.11)	(3.57)	(8.64)	(2.28)	(2.42)
Median	35	17	61	43	5
Range	30-39	11-22	48-74	38-44	6-14
Post-Test					
Mean	31.44	19.11	45.67	36.11	8.89
(SD)	(6.23)	(4.37)	(8.11)	(5.68)	(3.48)
Median	31	19	44	34	10
Range	22-41	14-25	35-57	30-46	2-13
Pre-Post Change					
Mean	3.33	-2.44	16.0	5.11	2.22
(SD)	(6.37)	(4.54)	(10.55)	(5.30)	(3.33)
Median	4	-2	17	9	-5
Type of Change					
# Improved	5	5	9	7	6
% Improved	56%	56%	100%	78%	66%
$\bar{X}$ Improvement	8.0	6.0	16.0	6.6	3.7
# Worsened	2	4	0	2	1
% Worsened	22%	44%	0%	22%	11%
$\bar{X}$ Decrement	5.0	2.0	-	3.5	2.0
# No Change	2	0	0	0	2
% No Change	22%	0%	0%	0%	22%

*Increases in facilitating test anxiety are a sign of improvement.

TABLE 3

Summary and Change Statistics on Each Subjective Measure for Control (C) Subjects (N=9)

	AAT (D)	AAT (F)*	STAI (State)	STAI (Trait)	I-E
Pre-Test					
Mean ($\bar{X}$)	33.78	18.33	62.78	42.89	11.89
(SD)	(1.9)	(4.3)	(7.0)	(7.4)	(3.5)
Median	34	19	64	44	12
Range	31-37	10-24	48-75	35-54	5-17
Post-Test					
Mean	32.22	17.22	59.33	44.89	11.44
(SD)	(6.1)	(4.7)	(11.8)	(8.5)	(5.3)
Median	31	16	62	44	10
Range	25-40	15-25	37-70	31-57	7-18
Pre-Post Change					
Mean	1.56	1.11	3.56	-2.00	0.44
(SD)	(5.3)	(3.5)	(5.7)	(4.0)	(4.2)
Median	2	1	2	-1	1
Type of Change					
# Improved	5	2	7	2	5
% Improved	56%	22%	78%	33%	56%
$\bar{X}$ Improvement	5.6	4.5	5.3	3.5	3.2
# Worsened	3	6	2	6	4
% Worsened	33%	66%	22%	66%	44%
$\bar{X}$ Decrement	4.7	3.2	3.0	4.2	3.8
# No Change	1	1	0	1	0
% No Change	11%	11%	0%	11%	0%

*Increases in facilitating test anxiety are a sign of improvement.

TABLE 4

A Comparison of Treated (B and IC) Subjects to Untreated (C) Subjects, Using Ratio Change Data

Subjective Measure	Treated (N=18) Mean Percent Change	(SD)	Untreated (N=9) Mean Percent Change	(SD)	Two-tailed t-value
AAT (D)	13	(.21)	5	(.16)	1.11
AAT (F)	16	(.24)	-5	(.18)	2.29*
STAI (State)	21	(.19)	6	(1.0)	2.20*
STAI (Trait)	12	(.15)	-5	(.97)	2.90**
I-E	5	(.32)	9	(.31)	-0.31

Critical _t_-values for independent _t_-tests (25 df):

* $p < .05 = 2.06$

** $p < .01 = 2.79$

TABLE 5

Pre- and Post-Test Statistics for Anxiety Measures and Locus of Control (separately for the three groups)

Group	Pre $\bar{X}$	Pre (SD)	Post $\bar{X}$	Post (SD)	t-score	Significance (2-tailed)
	Achievement Anxiety Test - Debilitating					
B	34.8	(3.3)	28.8	(7.0)	2.44	$p < .05$
IC	34.8	(3.1)	31.4	(6.2)	1.48	NS
C	33.8	(1.9)	32.2	(6.1)	0.83	NS
	Achievement Anxiety Test - Facilitating					
B	19.2	(3.7)	21.7	(3.5)	-4.05	$p < .01$
IC	16.7	(3.6)	19.1	(4.4)	-1.52	NS
C	18.3	(4.3)	17.2	(4.7)	0.89	NS
	Anxiety Inventory - State					
B	62.9	(9.4)	50.4	(8.7)	2.52	$p < .05$
IC	62.1	(8.6)	45.7	(8.1)	4.52	$p < .01$
C	62.8	(7.0)	59.3	(11.8)	1.76	NS
	Anxiety Inventory - Trait					
B	45.4	(8.3)	39.8	(8.3)	1.92	$p < .10$
IC	41.2	(2.3)	36.1	(5.7)	2.72	$p < .05$
C	42.9	(7.4)	44.9	(8.5)	-1.38	NS
	Locus of Control					
B	9.7	(5.9)	9.8	(5.9)	-0.13	NS
IC	11.1	(2.4)	8.9	(3.5)	1.88	$p < .10$
C	11.9	(3.5)	11.4	(5.3)	0.30	NS

Note: Because the AAT has fewer items than the STAI, it may be less sensitive to changes. For this reason, the change scores on the D and F scales were combined and a one-way analysis of variance was run. Significant post-test differences among groups were found ($F(2,24)=3.26$, $p < .10$). B and IC groups differed significantly from controls but not from each other.

TABLE 6

Summary and Change Statistics on Forehead EMG (μV rms) for B and IC Subjects at the Beginning (Initial) and End (Final) of Sessions One and Eight

	First Session		Last Session		Between Session Change		
	$\bar{X}$	(SD)	$\bar{X}$	(SD)	Mean Difference	Percent Change	t-score
			Biofeedback (B) Group				
Initial	3.05	(1.70)	2.28	(0.85)	0.77	25%	2.29*
Final	1.93	(1.00)	1.44	(0.69)	0.49	25%	4.23**
Within-Session Change							
Mean Difference	1.12		0.84				
Percent Change	37%		37%				
			Instruction-Control (IC) Group				
Initial	2.87	(1.30)	1.96	(0.23)	0.91	32%	2.22*
Final	1.62	(0.58)	1.17	(0.30)	0.45	27%	2.28*
Within-Session Change							
Mean Difference	1.25		0.79				
Percent Change	43%		40%				

Two-tailed table value with 8

* $p < .10 = 1.86$

** $p < .01 = 2.35$

TABLE 7

Correlation Matrix of Changes in Muscle Tension and Subjective Measures for B and IC Groups Combined (N=18)

	EMG	ATT (D)	ATT (F)	STAI (State)	STAI (Trait)	I-E
EMG	1.0	.27/.34	-.09/-.15	.11/.12	-.02/.07	-.35/-.39
AAT (D)		1.0	-.21/-.15	.36/.35	.12/.05	-.58/-.48
AAT (F)			1.0	.14/.03	-.24/-.23	.09/.04
STAI (State)				1.0	.04/-.08	-.17/-.14
STAI (Trait)					1.0	.44/.43
I-E						1.0

Note: Pearson's Product Moment Correlations are listed first, then Spearman's Rank Order Correlations. Both are given because of the small sample size and high variability of these data.

TABLE 8

Number of Correct Responses (15 possible) for Each Group and Results of 3x2x2 Nested Analysis of Variance (N=9 for each group)

	Pre		Post	
	$\bar{X}$	(SD)	$\bar{X}$	(SD)
B Subjects				
Easy Test	14.7	(0.71)	14.7	(0.50)
Hard Test	10.0	(3.13)	9.6	(2.36)
IC Subjects				
Easy Test	13.8	(0.84)	13.7	(1.74)
Hard Test	8.1	(3.19)	7.9	(3.49)
C Subjects				
Easy Test	14.5	(0.73)	14.0	(1.66)
Hard Test	9.0	(1.33)	10.2	(2.28)

Group Differences: $F(2,24)=2.20$, NS

Task Difficulty: $F(1,72)=230.36$, $p < .0001$

Pre-to-Post Change: $F(1,72)=0.27$, NS

All interactions were small and not significant.

TABLE 9

Time Taken to Complete Test (7 minutes maximum) and Results of 3x2x2 Nested Analysis of Variance (N=9 for each group)

	Pre		Post	
	$\bar{X}$	(SD)	$\bar{X}$	(SD)
B Subjects				
Easy Test	3.1	(1.53)	2.3	(0.07)
Hard Test	6.9	(0.11)	6.8	(0.26)
IC Subjects				
Easy Test	2.8	(0.61)	2.5	(0.66)
Hard Test	6.6	(0.81)	6.4	(0.87)
C Subjects				
Easy Test	2.8	(0.46)	2.2	(0.49)
Hard Test	6.6	(0.80)	6.5	(0.80)

Group Differences: $F(2,24)=0.855$, NS

Task Difficulty: $F(1,72)=935.38$, $p < .0001$

Pre-to-Post Change: $F(1,72)=8.72$, $p < .01$

All interactions were small and not significant.

TABLE 10

Forehead EMG (microvolts, rms) During the Pre- and Post-Test and Results of 3x2x2 Nested Analysis of Variance (N=9 for each group)

	Pre		Post	
	$\bar{X}$	(SD)	$\bar{X}$	(SD)
B Subjects				
Easy Test	2.9	(1.28)	2.6	(2.13)
Hard Test	3.0	(1.43)	2.8	(2.06)
IC Subjects				
Easy Test	3.3	(0.80)	2.8	(0.96)
Hard Test	3.4	(1.22)	3.2	(1.40)
C Subjects				
Easy Test	3.0	(0.74)	2.8	(0.69)
Hard Test	3.0	(0.43)	3.1	(1.78)

Group Differences: $F(2,24)=0.24$, NS

Task Difficulty: $F(1,72)=2.48$, NS

Pre-to-Post Change: $F(1,72)=1.80$, NS

All interactions were small and not significant.

IV. DISCUSSION

Based on the screening for the present study, test-taking anxiety appears to be a common experience among freshman college students. Thirty-two percent of the students sampled (n=271) were experiencing or had experienced debilitating test anxiety at a level where treatment of some kind might be beneficial. Snyder (1976), using the same AAT and the same cutoff, reported only 14 percent of his sample (n=350), from all class levels, as high test anxious. The higher percentage of test-anxious students found in the present study may be the result of testing only freshmen. The proportion of high test-anxious students may decrease with more experiences in college or high test-anxious students may simply leave school. Additional research is needed to find out if and how test-anxious students learn to cope.

If there had been only one self-report dependent measure of anxiety in the present study, the interpretation of results would be much simplier. However, two scales were used, the AAT and the STAI (each with two subscales), with not entirely consistent results. On the AAT only, B subjects showed a significant decrease in debilitating test anxiety from pre to post. The changes for IC and C groups were not significant, but the mean changes for IC subjects were in the desired direction. When an analysis of variance was run for the combined changes on the D and F scales, both groups differed significantly from controls but not from each other. When analyzed this way, the AAT data indicate that IC as well as B subjects experienced an improvement in their feeling about test taking. However, when treated (B and IC) subjects were compared with untreated (C) subjects, differences were found on the F scale (facilitating test anxiety) of the AAT only.

An analysis of the pre-to-post test data from the STAI indicated that both relaxation groups felt significantly less anxious following treatment. For test-taking situations (state anxiety), both B and IC subjects reported significant decreases. The same was true for B and IC subjects with respect to general, or trait, feelings of anxiety. The results of *t*-tests comparing treated subjects with untreated subjects are consistent with this finding.

While the *t*-tests of pre-to-post change and treated versus untreated subjects were consistently significant on the STAI for both B and IC subjects, *t*-tests on the AAT were not. This is confusing because the D scale (debilitating test anxiety) of the AAT and the State scale of the STAI are supposed to be measures of the same thing: how anxious the subject feels during a test. This inconsistency could be a reflection of poor scale reliability or that the AAT is less sensitive to change than the STAI, possibly because it has fewer items. (The AAT has 19 items while the STAI has a total of 40.) The significant result of the analysis of variance for combined D and F scales would support this idea. The means for both groups on the AAT show definite changes toward improvement not characteristic of the controls. But, the relatively small sample size and variability in scores may have obscured changes. The two-fold increase in variability seen in all groups on the AAT-D at post-test could reflect differences in subject's feelings about the efficacy of the relaxation program. It also may be a reflection of poor test-retest reliability. The lack of similar change in the other subjective measures supports the latter suggestion.

The larger number of items on the STAI appear to make it a more reliable measure of anxiety than the AAT, especially with small, highly variable samples. Based on this scale, both conditions--brief relaxation instruction alone and instructions plus EMG feedback--appear to produce significant decreases in subjectively reported levels of general and test-specific anxiety. Studies by Coursey (1975), Alexander (1975), and Reinking and Kohl (1975) using samples not selected for high anxiety also report EMG feedback and relaxation instructions to be similar in their effects on subjective levels of anxiety.

On the I-E scale, IC subjects were the only ones who changed significantly from pre to post. This increase in the attribution of the outcome of reinforcing events to one's own effort rather than luck or chance was not seen in B or C subjects. Additional research will be needed to replicate this finding.[5]

The lack of change of B subjects on the I-E scale is inconsistent with the findings of Stern and Berrenberg (1977). Their study compared the effects of EMG feedback training with false-feedback and no-feedback controls. Following three training sessions, only experimental subjects shifted significantly in the direction of more internal locus of control. Perhaps it is necessary to administer more than three training sessions before meaningful comparisons can be made between groups.

---

[5]A later study by Saslow and Reed (1979b) failed to replicate this finding.

The analysis of data collected during relaxation training indicated both B and IC subjects showed decreases in forehead EMG of about the same magnitude. This was true both within and across training sessions. A _t_-test on overall changes in average forehead EMG indicated there were no differences between groups, despite the very brief instructions given to IC subjects. These results are consistent with those of Cox _et al_ (1975) and Haynes _et al_ (1975), using subjects suffering from muscle tension headaches, and Alexander (1975), using normal subjects. Reinking and Kohl (1975) found EMG feedback added little to the effectiveness of relaxation training using systematic desensitization procedures. In studies reporting the superiority of EMG feedback to other methods of reducing muscle tension, the control of subject expectations and experimental bias may be neglected. In the Kappes and Michaud (1978) study, for example, subjects knew about the other experimental condition. In the study by Coursey (1975), subjects received different instructions.

Forehead muscle tension is assumed by many clinicians and researchers to be a valid measure of anxiety. If this assumption is correct, then changes in self-report anxiety following treatment should correlate strongly with changes in forehead EMG. No such correlations were found in the present study. In addition, the intercorrelations among anxiety scales were small and not significant. This lack of correlation may account for the discrepancy in results between the AAT and the STAI.

Analysis of the testing data indicated there were no effects of relaxation training on performance. On the Progressive Matrices test, subjects in all groups answered significantly more of the easy problems correctly than hard ones, but no group or pre-post differences were found. This is consistent with research by Romano and Cabianca (1978) using a similar research design. Allen (1971, 1973) reports a significant increase in test performance following treatment involving study skills training in addition to relaxation training. It appears that relaxation skills alone are not sufficient for improving test performance. However, it is difficult to interpret both no change in performance and performance improvement. No change could be attributed to failure of the treatment to generalize to a testing situation and/or failure of the laboratory testing situation and instructions to be motivating enough. If test performance does improve, it could be due to factors not related to treatment. For example, at post-test subjects may feel more familiar with the lab setting and lab personnel, more comfortable with the test itself, and/or less threatened by the test instructions.

The analysis of time required to complete the tests indicated that the hard test required significantly more time to complete than the easy test. In addition, a significant decrease in test time was found pre to post. However, the absence of a Group X Pre-Post interaction suggests that this is due to practice and familiarity with the test rather than relaxation training.

Based on the above results, there appear to be real differences between easy and hard versions of the test. Assuming that a more difficult test will increase anxiety in test-anxious students and that forehead muscle tension is a good measure of anxiety, forehead EMG should be sensitive to differences in test difficulty. However, the analysis of forehead EMG data recorded during testing revealed no differences in muscle tension between easy and hard tests. In addition, there were no overall differences between groups and no change in EMG pre to post. This suggests the effects of relaxation training on muscle tension did not generalize to test taking.

An alternative explanation of these findings may be that forehead EMG is not a valid measure of anxiety. The small correlations found between the pre-to-post changes in anxiety and overall change in muscle tension following training support his. Given the extensive validity and reliability data on the AAT and the STAI, it's possible but less likely that these measures are unreliable. As stated before, the correlations between the anxiety measures are also very small.

While these results are consistent with those of Alexander (1975), they are contrary to earlier research. The significant relationship between changes in muscle tension and self-report anxiety reported by Malmo and Smith (1955) and Wolff (1948) may have been due to characteristics of the population sampled. Earlier researchers worked primarily with subjects experiencing tension headaches or excessive anxiety. It seems possible that individuals experiencing these types of problems may be disposed to respond to stress with muscular tension. These same individuals may manifest generalization effects and report feeling of anxiety not characteristic of normal subjects. This suggests that clinicians who continue to rely solely on forehead EMG as a measure of anxiety should keep in mind that the value and accuracy of this measure may differ among individuals.

A methodological limitation, which also may help to explain these results, is the use of a laboratory environment for performance testing.

In spite of the ego-involving instructions that were used for testing, a subject's level of anxiety and degree of motivation may have been considerably less than what would occur in a "real life" test. To determine the extent of this problem, in further research, a simple questionnaire regarding feelings of anxiety experienced during testing might be used. This could be administered before or immediately following testing. Additional measures of arousal such as heart rate, blood pressure, respiration rate, and skin temperature also might be recorded during testing. If forehead muscle tension is found to correlate with these other measures, then its value as a measure of anxiety would be substantiated. If no correlations, or correlations with only some of these measures, were found, then the limitations of forehead EMG would be further realized.

In the present study, great care was taken to ensure that subjects in both experimental groups were treated the same and had the same expectations for improvement. The groups differed only in that B subjects received feedback on the activity in their forehead muscles while the IC subjects did not. The results indicated that, when proper controls were used, EMG feedback added little to the effectiveness of relaxation instructions and practice in decreasing subjective feelings of anxiety, improving test performance, or lowering forehead muscle tension. Relaxation instruction without EMG biofeedback had the desirable side effect of shifting subjects towards a more internal locus of control. While the self-report data indicates that treatment was successful in reducing test anxiety, forehead muscle tension recorded during testing suggests that the effects of relaxation training did not generalize to test taking.

BIBLIOGRAPHY

Alexander, A.B. An experimental test of assumptions relating to the use of electromyographic biofeedback as a general relaxation technique. Psychophysiology, 1975, 12, 656-662.

Allen, G.J. Effectiveness of study counseling and desensitization in alleviating test anxiety in college students. Journal of Abnormal Psychology, 1971, 77, 282-289.

Allen, G.J. Treatment of test anxiety by group-administered and self-administered relaxation and study counseling. Behavior Therapy, 1973, 4, 349-360.

Alpert, R. and Haber, R.N. Anxiety in academic achievement situations. Journal of Abnormal and Social Psychology, 1960, 61, 207-215.

Ballard, P., Doerr, H., and Varni, J. Arrest of a disabling eye disorder using biofeedback. Psychophysiology, 1972, 9, 271.

Bandura, A. Principles of Behavior Modification. New York: Holt, Rinehart and Winston, Inc., 1969.

Barlow, D.H., Argras, W.S., Abel, G.G., Blanchard, E.B., and Young, L.D. Biofeedback and reinforcement to increase heterosexual arousal in homosexuals. Behavior Research and Therapy, 1975, 13, 45-50.

Basmajian, J.V., Kukulka, C.G., Narayan, M.G., and Takebe, K. Biofeedback treatment of footdrop after stroke compared with standard rehabilitation technique: Effects on voluntary control and strength. Archives of Physical Medicine and Rehabilitation, 1975, 56, 231-236.

Beatty, J. Effects of alpha wave abundance and operant training procedures on occipital alpha and beta wave activity. Psychonomic Science, 1971, 23, 197-199.

Bell, I.R. and Schwartz, G.E. Voluntary control and reactivity of human heart rate. Psychophysiology, 1975, 12, 339-348.

Blanchard, E.B. and Haynes, M.R. Biofeedback treatment of a case of Raynaud's disease. Journal of Behavior Therapy and Experimental Psychiatry, 1975, 6, 230-234.

Blanchard, E.B. and Young, L.D. Clinical applications of biofeedback training: a review of evidence. Archives of General Psychiatry, 1974, 30, 573-589.

Blanchard, E.B., Young, L.D., and Haynes, M.R. A simple feedback system for the treatment of elevated blood pressure. Behavior Therapy, 1975, 6, 241-245.

Braud, L.W. The effects of frontal EMG biofeedback and progressive relaxation upon hyperactivity and its behavioral concomitants. Biofeedback and Self-Regulation, 1978, 3, 69-90.

Bronzaft, A.L. and Stuart, I.R. Test anxiety, GSR, and academic achievement. Perceptual and Motor Skills, 1971, 33, 535-538.

Brudny, J., Grynbaum, B., and Korein, J. New therapeutic modality in the treatment of spasmodic torticollis. Archives of Physical Medicine and Rehabilitation, 1973, 54, 575.

Brudny, J., Grynbaum, B.B., and Korein, J. Spasmodic torticollis: treatment by feedback display of the EMG. Archives of Physical Medicine and Rehabilitation, 1974, 55, 403-408.

Brudny, J., Korein, J., Grynbaum, B., Friedman, L., Weinstein, S., Sachs-Frankel, G., and Belandres, P. EMG feedback: Review of treatment of 114 patients. Biofeedback and Self-Control, 1976, 47-66.

Budzynski, T.H. Biofeedback in the treatment of muscle-contraction (tension) headache. Biofeedback and Self-Regulation, 1978, 3, 409-434.

Budzynski, T.H. and Stoyva, J.M. An instrument for producing deep muscle relaxation by means of analog information feedback. Journal of Applied Behavior Analysis, 1969, 2, 213-238.

Budzynski, T.H., Stoyva, J., and Adler, C.S. Feedback-influenced muscle relaxation: Applications to tension headache. Journal of Behavior Therapy and Experimental Psychiatry, 1970, 1, 205-211.

Carlson, J.G. Locus of control and frontalis electromyographic response training. Biofeedback and Self-Regulation, 1977, 2, 56-73.

Cleeland, C.S. Biofeedback and other behavioral techniques in the treatment of disorders of voluntary movement. In J.V. Basmajian (ed.), Biofeedback: Principles and Practice for Clinicians. Baltimore: Williams and Wilkins, 1978.

Coursey, R.D. Electromyograph feedback as a relaxation technique. Journal of Consulting and Clinical Psychology, 1975, 43, 825-234.

Cox, D.J., Freundlich, A., and Meyer, R.G. Differential effectiveness of electromyographic feedback, verbal relaxation instructions and medication placebo. Journal of Consulting and Clinical Psychology, 1975, 43, 892-898.

Davis, M.H., Saunders, D.R., Creer, T.L., and Chai, H. Relaxation training facilitated by biofeedback apparatus as a supplemental treatment in bronchial asthma. Journal of Psychosomatic Research, 1973, 17, 121-128.

Deffenbacher, J.L. and Snyder, A.L. Relaxation as self-control in the treatment of test and other anxieties. Psychological Reports, 1976, 39, 379-385.

Delprato, D.J. and Dekraker, T. Metronome-conditioned hypnotic-relaxation in the treatment of test anxiety. Behavior Therapy, 1976, 7, 379-381.

Dember, F.E., Nairne, F., and Miller, F.J. Further validation of the Alpert-Haber Achievement Anxiety Test. Journal of Abnormal and Social Psychology, 1962, 65, 427-428.

Desiderator, O. and Koskinen, P. Anxiety, study habits and academic achievement. Journal of Counseling Psychology, 1969, 16, 162-165.

Diamond, S., Diamond-Falk, J., and DeVeno, T. Biofeedback in the treatment of vascular headache. Biofeedback and Self-Regulation, 1978, 3, 385-408.

Donner, L. and Guerney, B.G. Automated group desensitization for test anxiety. Behavior Research and Therapy, 1969, 7, 1-13.

Douvan, E. Social status and success strivings. Journal of Abnormal Social Psychology, 1956, 52, 212-223.

Dowley, H. Group implosive therapy in the treatment of test anxiety: A brief report. Behavior Therapy, 1973, 4, 261-263.

Driscoll, R. Anxiety reduction using physical exertion and positive images. The Psychological Record, 1976, 26, 87-94.

Easterbrook, J.A. The effect of emotion on cue utilization and the organization of behavior. Psychological Review, 1959, 66, 41-44.

Elder, S.T. and Eustis, N.K. Instrumental blood pressure conditioning in outpatient hypertensives. Behavioral Research and Therapy, 1975, 13, 185-188.

Engel, B.T. and Melmon, L. Operant conditioning of heart rate in patients with cardiac arrhythmias. Conditioned Reflex, 1968, 3, 130.

Engel, N.P., Nikoomanesh, P., and Schuster, M.M. Operant conditioning of rectosphincteric responses in the treatment of fecal incontinence. New England Journal of Medicine, 1974, 290, 646-649.

Epstein, L.H. and Abel, G.G. Analysis of biofeedback training effects for tension headache patients. Behavior Therapy, 1977, 8, 37-47.

Epstein, L.H., Hersen, M., and Hemphill, D.P. Music feedback in the treatment of tension headache: An experimental case study. Journal of Behavior Therapy and Experimental Psychiatry, 1974, 5, 59-63.

Feldman, G.M. The effect of biofeedback training on respiratory resistance of asthmatic children. Psychosomatic Medicine, 1976, 38, 27-34.

Fernando, C.K. and Basmajian, J.V. Biofeedback in physical medicine and rehabilitation. Biofeedback and Self-Regulation, 1978, 3, 435-455.

Finley, W.W., Niman, C., Standley, J., and Ender, P. Frontal EMG biofeedback training of athetoid cerebral palsy patients: A report of six cases. Biofeedback and Self-Regulation, 1976, 1, 169-182.

Fowler, J.E., Budzynski, T.H., and Vandenberg, R.L. Effects of an EMG biofeedback relaxation program on the control of diabetes. Biofeedback and Self-Regulation, 1976, 1, 105-112.

Friar, L.R. and Beatty, J. Migraine: Management by trained control of vasoconstriction. Journal of Clinical Psychology, 1976, 44, 46-53.

Garlington, W.K. and Cotler, S.B. Systematic desensitization of test anxiety. Behavior Research and Therapy, 1968, 6, 247-256.

Gatchel, R.J. and Proctor, J.D. Effectiveness of voluntary heart rate control in reducing speech anxiety. Journal of Consulting and Clinical Psychology, 1976, 44, 381-389.

Goldfried, M.R. and Trier, C.S. Effectiveness of relaxation as an active coping skill. Journal of Abnormal Psychology, 1974, 83, 348-355.

Graff, R., MacLean, D., and Loving, A. Group reactive inhibition and reciprocal inhibition therapies with highly anxious students. Journal of Counseling Psychology, 1971, 18, 431-436.

Guitar, B. Reduction of stuttering frequency using analogue electromyographic feedback. Journal of Speech and Hearing Research, 1975, 18, 672-685.

Hardt, J.V. and Kamiya, J. Anxiety change through electroencephalographic alpha feedback seen only in high anxiety subjects. Science, 1978, 201, 79-81.

Hardyck, C. and Petrinovich, L. Feedback of speech muscle activity during silent reading. Science, 1966, 54, 1467-1468.

Harleston, B.W. Test anxiety and performance in problem-solving situations. Journal of Personality, 1962, 30, 557-573.

Harris, F.A., Spelman, F.A., and Hymer, J.W. Electronic sensory aids as treatment for cerebral-palsied children. In appropioception: Part II. Physical Therapy, 1974, 54, 354-365.

Haynes, S.N., Griffin, P., Mooney, D., and Parise, M. Electromyographic biofeedback and relaxation instructions in the treatment of muscle contraction headaches. Behavior Therapy, 1975, 6, 672-678(a).

Haynes, S.N., Moseley, D., and McGowan, W.T. Relaxation training and biofeedback in the reduction of frontalis muscle tension. Psychophysiology, 1975, 12, 547-552(b).

Hoon, E.F., Wincze, J.P., and Hoon, P. Sexual arousal in women: A comparison of cognitive and physiological responses by continuous measurement. Archives of Sexual Behavior, 1977, 6, 121-133.

Horne, A.M., and Matson, J.L. A comparison of modeling, desensitization, flooding, study skills, and control groups for reducing test anxiety. Behavior Therapy, 1977, 8, 1-8.

Hume, W.I. Biofeedback. Montreal: Eden Press, 1976.

Hume, W.I. Biofeedback, Vol. 2. Montreal: Eden Press, 1977.

Hutchings, D.F. and Reinking, R.H. Tension headaches: What form of therapy is most effective? Biofeedback and Self-Regulation, 1976, 2, 183-190.

Jacobson, A.M., Hackett, T.P., Surman, O.S., and Silverberg, E.L. Raynaud phenomenon treatment with hypnotic and operant technique. Journal of American Medical Association, 1973, 225, 739-740.

Jacobson, E. Progressive Relaxation. Chicago: University of Chicago Press, 1938 (2nd edition).

Jankel, W.R. Bell's palsy: Muscle re-education by EMG feedback. Archives of Physical Medicine and Rehabilitation, 1978, 59, 240-242.

Javel, A.F. and Denholtz, M.S. Audible GSR feedback and systematic desentization: A case report. Behavior Therapy, 1975, 6, 251-253.

Johnson, S.L. and Sechrest, L. Comparison of desensitization and progressive relaxation in treating test anxiety. Journal of Consulting and Clinical Psychology, 1966, 30, 544-549.

Johnston, R. and Lee, K.H. Myofeedback: A new method of teaching breathing exercises in emphysematous patients. Physical Therapy, 1976, 56, 826-829.

Kamiya, J. Conscious control of brain waves. Psychology Today, 1968, 1, 57-60.

Kappes, B. and Michaud, J. Contingent vs. noncontingent EMG feedback and hand temperature in relation to anxiety and locus of control. Biofeedback and Self-Regulation, 1978, 3, 51-60.

Katahan, M., Strenger, S., and Cherry, N. Group counseling and behavior therapy with test anxious college students. Journal of Consulting Psychology, 1966, 30, 544-549.

Kimmel, H.D. Instrumental conditioning of autonomically mediated behavior. Psychological Bulletin, 1967, 67, 337-345.

Kinsman, R.A., O'Brien, K., Robinson, S., and Staudenmayer, H. Continuous and discrete post trial verbal feedback in frontalis muscle relaxation training. Psychophysiology, 1975, 12, 30-35.

Koenig, K.P. False emotional feedback and the modification of anxiety. Behavior Therapy, 1973, 4, 193-202.

Kondo, C. and Canter, A. True and false electromyographic feedback: Effect on tension headache. Journal of Abnormal Psychology, 1977, 86, 93-95.

Kotses, H., Glaus, K.D., Crawford, P.L., Edwards, J.E., and Scherr, M.S. Operant reduction of frontalis EMG activity in the treatment of asthma in children. Journal of Psychosomatic Research, 1976, 20, 453-459.

Lanyon, R.I., Barrington, C.C., and Newman, A.C. Modification of stuttering through EMG biofeedback: A preliminary study. Behavior Therapy, 1976, 7, 96-103.

LeBoeuf, A. The treatment of severe tremor by electromyogram feedback. Journal of Behavior Therapy and Experimental Psychiatry, 1976, 7, 59-61.

Lemont, J.F. and Sherman, L.J. Group systematic desensitization and group insight therapies for test anxiety. Behavior Therapy, 1971, 4, 511-518.

Lubar, J.F. and Bahler, W.W. Behavioral management of epileptic seizures following EEG biofeedback training of sensorimotor rhythm. Biofeedback and Self-Control, 1976-1977, 457-502.

Malmo, R.B. Anxiety and behavioral arousal. Psychological Review, 1957, 64, 276-287.

Malmo, R.B. and Shagass, C. Anxiety states and muscle tension. Psychosomatic Medicine, 1949, 11, 9.

Malmo, R.B. and Smith, A. Forehead tension and motor irregularities in psychoneurotic patients under stress. Journal of Personality, 1955, 23, 391-406.

Mandler, G. and Sarason, S.B. A study of anxiety and learning. Journal of Abnormal and Social Psychology, 1952, 47, 166-173.

McLean, P.D. and Milne, L.G. Effect of exteroceptive feedback in controlling electrodermal activity in pre-conditioned fears. Perceptual and Motor Skills, 1975, 40, 487-493.

Meichenbaum, D.H. Cognitive modification of test anxious college students. Journal of Consulting and Clinical Psychology, 1972, 39, 370-380.

Melzack, R. and Perry, C. Self regulation of pain: The use of alpha feedback and hypnotic training for the control of chronic pain. Experimental Neurology, 1975, 46, 452-469.

Miller, N.E. and DiCara, L.V. Instrumental learning of heart rate changes in curarized rats. Journal of Comparative and Physiological Psychology, 1967, 63, 12-19.

Miller, N.E. and Dworkin, B.R. Visceral learning: Recent difficulties with curarized rats and significant problems for human research. In P.A. Obrist et al (eds.), Cardiovascular Psychophysiology. Chicago: Aldine, 1974.

Mitchell, K.R. and Ng, K.T. Effects of group counseling and behavior therapy on academic achievement of test-anxious college students. Journal of Counseling Psychology, 1972, 19, 491-497.

Morris, L.W. and Liebert, R.M. Relationship of cognitive and emotional components of test anxiety to physiological arousal and academic performance. Journal of Consulting and Clinical Psychology, 1970, 35, 332-337.

Netsell, R. and Cleeland, C.S. Modification of lip hypertonia in dysarthria using EMG feedback. Journal of Speech and Hearing Disorders, 1973, 38, 131-140.

Norman, R.A. A comparison of systematic desensitization, electromyogram, electroencephalogram, and temperature biofeedback training: To relieve test anxiety in college students. Unpublished doctoral dissertation, East Texas State University, 1976.

Nowliss, D.P. and Kamiya, J. The control of electroencephalographic alpha rhythms through auditory feedback and associated mental activity. Psychophysiology, 1970, 6, 476-484.

Nunes, J.S. and Marks, I.M. Feedback of true heart rate during exposure in vivo. Archives of General Psychiatry, 1976, 33, 1346-1350.

Ohno, Y., Tanaka, Y., Takaya, T., Matsubara, H., Kuriya, N., and Komemushi, S. Biofeedback modification of frontal EMG in normal subjects. Biofeedback and Self-Regulation, 1978, 3, 61-68.

Paskewitz, D.A. and Orne, M.T. Visual effects on alpha feedback training. Science, 1973, 181, 360-363.

Patel, C.H. Biofeedback-aided relaxation and meditation in the management of hypertension. Biofeedback and Self-Regulation, 1977, 2, 1-39.

Patel, C.H. 12-month follow-up of yoga and biofeedback in the management of hypertension. Lancet, 1975, 1, 62-65.

Patel, C.H. Yoga and biofeedback in the management of hypertension. Lancet, 1973, 2, 1053-1055.

Paul, G.L. Outcome of systematic desensitization II: Controlled investigations of individual treatment, technique variations and current status. In C.M. Franks (ed.), Behavior Therapy: Appraisal and Status. New York: McGraw-Hill, 1969, 105-109.

Philips, C. The modification of tension headache pain using EMG biofeedback. Behavior Research and Therapy, 1977, 15, 119-129.

Plotkin, W.B. On the self regulation of the occipital alpha rhythm: Control strategies, states of consciousness, and the role of physiological feedback. Journal of Experimental Psychology, 1976, 105, 66- 9.

Plotkin, W.B., Mazer, C., and Loewy, D. Alpha enhancement and the likelihood of an alpha experience. Psychophysiology, 1976, 13, 466-471.

Quinn, R.M. The desensitization of test anxiety by group and individual treatment. Behavior Research and Therapy, 1968, 15, 572-575.

Raskin, M., Johnson, G., and Rondestvedt, J.W. Chronic anxiety treatment by feedback induced muscle relaxation: A pilot study. Archives of General Psychiatry, 1973, 28, 263-267.

Raven, J.C. Guide to the Standard Progressive Matrices. New York: The Psychological Corporation, 1960.

Redmond, D.P., Gaylor, M.S., McDonald, R.H., and Shapiro, A.P. Blood pressure and heart rate response to verbal instructions and relaxation in hypertension. Psychosomatic Medicine, 1974, 36, 285-297.

Reed, M.L. and Saslow, C.A. The effects of relaxation and EMG biofeedback on test anxiety and performance. Paper presented at Western Psychological Association, San Diego, 1979(b).

Reed, M.L. and Saslow, C.A. The effects of relaxation instructions and EMG biofeedback on test anxiety, general anxiety, and locus of control. In press, _Journal of Clinical Psychology_, 1979(a).

Reinking, R.H. and Kohl, M.L. Effects of various forms of relaxation training on physiological and self-report measures of relaxation. _Journal of Consulting and Clinical Psychology_, 1975, _43_, 595-600.

Rimm, D.C. and Masters, J.C. _Behavior Therapy, Techniques and Empirical Findings_. New York: Academic Press, Inc., 1979.

Romano, J.L. The effects of EMG biofeedback and systematic desensitization on test anxiety reductions. _Dissertation Abstracts International_, 1977, _37_, 3626.

Romano, J.L. and Cabianca, W.A. EMG biofeedback training systematic desensitization for test anxiety reduction. _Journal of Counseling Psychology_, 1978, _25_, 8-13.

Rosen, R.C. Suppression of penile tumescence by instrumental conditioning. _Psychosomatic Medicine_, 1973, _35_, 509-514.

Rotter, J.B. Generalized expectations for internal versus external control of reinforcement. _Psychological Monographs_, 1966, _80_, 212-236.

Russell, R.K., Miller, D.E., and June, L.E. A comparison between group systematic desensitization and cue-controlled relaxation in the treatment of test anxiety. _Behavior Therapy_, 1975, _6_, 1972-177.

Sainsbury, P. and Gibson, J.F. Symptoms of anxiety and tension and the accompanying physiological changes in the muscular system. _Journal of Neurology, Neurosurgery and Psychiatry_, 1954, _17_, 216.

Sarason, I.G. Intellectual and personality correlates of test anxiety. _Journal of Abnormal and Social Psychology_, 1959, _59_, 272-275.

Sarason, I.G. Interrelationships among individual difference variables, behavior in psychotherapy and verbal conditioning. _Journal of Abnormal and Social Psychology_, 1958, _56_, 339-344.

Sarason, I.G. Test anxiety and cognitive modeling. _Journal of Personality and Social Psychology_, 1973, _28_, 58-61.

Sarason, I.G. Test anxiety and intellectual performance of college students. _Journal of Educational Psychology_, 1961, _52_, 201-206.

Sarason, I.G. and Palola, E.G. The relationship of test and general anxiety, difficulty of task, and experimental instructions to performance. Journal of Experimental Psychology, 1960, 59, 185-191.

Sargent, J.D., Green, E.E., and Walters, E.D. Preliminary report on the use of autogenic feedback training in the treatment of migraine and tension headaches. Psychosomatic Medicine, 1973, 35, 129-135.

Saslow, C.A. and Reed, M.L. Contribution of EMG biofeedback to voluntary muscle relaxation: Two experiments. Submitted to Journal of Applied Behavior Analysis, 1979(a).

Saslow, C.A. and Reed, M.L. The effects of autogenic instructions and temperature biofeedback on test anxiety and performance. Manuscript in preparation, 1979(b).

Schandler, S. Use of muscle biofeedback relaxation in the treatment of eczema. Annual Proceedings, Biofeedback Society of America, 1978, 95.

Shoemaker, J.E. and Tasto, D.L. The effects of muscle relaxation on blood pressure of essential hypertensives. Behavior Research and Therapy, 1975, 13, 29-43.

Sirota, A.D., Schwartz, G.E., and Shapiro, D. Voluntary control of human heart rate: Effect on reaction to aversive stimulation. Journal of Abnormal Psychology, 1974, 83, 261-267.

Sittenfield, P., Budzynski, T., and Stoyva, J. Differential shaping of EEG theta rhythms. Biofeedback and Self-Control, 1976-77, 339-406.

Smith, R. Frontalis muscle tension and personality. Psychophysiology, 1973, 10, 311-312.

Snedecor, G.W. and Cochran, W.G. Statistical Methods (sixth edition). Ames: Iowa State University Press, 1967.

Snider, J.G. and Oetting, E.R. Autogenic training and the treatment of examination anxiety in students. Journal of Clinical Psychology, 1966, 22, 111-114.

Snyder, A.L. A comparison of relaxation as self-control and systematic desensitization in the treatment of test anxiety. Unpublished doctoral dissertation, University of Oregon, 1974.

Solberg, W.K. and Rugh, I.D. The use of biofeedback devices in the treatment of bruxism. Journal of Southern California Dental Association, 1972, 40, 852-853.

Sperber, Z. Test anxiety and performance under stress. Journal of Consulting Psychology, 1961, 25, 226-233.

Spielberger, C.D. The effects of manifest anxiety on academic achievement in students. Mental Hygiene, 1962, 46, 420-426.

Spielberger, C.D., Gorsuch, R.L., and Luchene, R.E. The STAI Manual. Palo Alto: Consulting Psychologists Press, Inc., 1970.

Sterman, M.B. Neurophysiologic and clinical studies of sensorimotor EEG biofeedback training: Some effects on epilepsy. Seminars in Psychiatry, 1973, 5, 507-525.

Stern, G.S. and Berrenberg, J.L. Biofeedback training in frontalis muscle relaxation and enhancement of belief in personal control. Biofeedback and Self-Regulation, 1977, 2, 173-182.

Suinn, R.M. The STABS, a measure of test anxiety for behavior therapy. Normative data. Behavior Research and Therapy, 1969, 7, 335-339.

Suinn, R.M. and Richardson, F. Anxiety management training: A non-specific behavior therapy program for anxiety control. Behavior Therapy, 1971, 2, 498-510.

Townsend, R.E., House, J.F., and Addario, D. A comparison of biofeedback mediated relaxation and group therapy in the treatment of chronic anxiety. American Journal of Psychiatry, 1975, 132, 598-601.

Tubbs, W. and Carnahan, C. Clinical biofeedback for primary dysmenorrhea: A pilot study. Biofeedback and Self-Regulation, 1976, 1, 323, (Abstract).

Turin, A. and Johnson, W.G. Biofeedback therapy for migraine headaches. Archives of General Psychiatry, 1976, 33, 517-519.

Wachtel, P.L. Anxiety, attention, and coping with threat. Journal of Abnormal Psychology, 1968, 73, 137-143.

Walsh, D.H. Interactive effects of alpha feedback and instructional set on subjective state. Psychophysiology, 1974, 11, 428-435.

Walsh, R.P., Engbretson, R.O., and O'Brien, B.A. Anxiety and test taking behavior. Journal of Counseling Psychology, 1968, 15, 572-575.

Weiss, T. and Engle, B. Operant conditioning of heart rate in patients with premature ventricular contractions. Psychosomatic Medicine, 1971, 3, 1-25.

Welgen, P.R. Learned control of gastric acid secretions in ulcer patients. Psychosomatic Medicine, 1974, 36, 411-419.

West, C.K., Lee, J.F., and Anderson, T.H. The influence of test anxiety on the selection of relevant from irrelevant information. The Journal of Educational Research, 1969, 63, 51-52.

Whitehead, W.E. Biofeedback in the treatment of gastrointestinal disorders. Biofeedback and Self-Regulation, 1978, 3, 363-374.

Whitehead, W.E., Renault, P.F., and Goldiamond, I. Modification of human gastric acid secretion with operant conditioning procedures. Journal of Applied Behavior Analysis, 1975, 8, 147-156.

Wine, J. Test anxiety and direction of attention. Psychological Bulletin, 1971, 76, 92-104.

Wolff, H.G. Headache. New York: Oxford University Press, 1948 (1st edition).

Wolpe, J. Psychotherapy by Reciprocal Inhibition. Stanford: Stanford University Press, 1958.

Wyler, A.R., Lochard, J.S., Ward, A., and Finch, C.A. Conditional EEG desynchronization and seizure occurrence in patients. Biofeedback and Self-Control, 1976-1977, 503-512.

Zingheim, P.K. and Sandman, C.A. Discriminative control of vaginal vasomotor response. Biofeedback and Self-Regulation, 1978, 3, 29-42.

APPENDICES

APPENDIX A

Literature Review

Test Anxiety and Treatment Strategies: With Special Emphasis on Electromyographic Biofeedback

There is a large body of research dealing with the relationship between anxiety and learning in educational settings. It suggests, in general, that high levels of anxiety are associated with decreases in academic performance. This paper will review the research literature in this area, placing special emphasis on the numerous methods of reducing test taking anxiety. One method in particular, electromyographic (EMG) biofeedback, will be covered in detail.

This paper begins with a brief review of the theory of test anxiety. This is followed by a discussion of the effects of test anxiety on academic performance. The reader will note that the direction of the relationship between anxiety and performance is not always consistent. The third section reviews the numerous methods of reducing test anxiety and the ways in which treatment effectiveness is assessed. The fourth section defines the area of biofeedback and reviews its many applications. Special emphasis is placed on muscle tension, EMG biofeedback, and the relationship between muscle tension and anxiety. Section four and five are related since section five concerns the application of EMG biofeedback to the problems of test anxiety.

Test Anxiety Theory

Mandler and Sarason (1952) were the originators of test anxiety theory. They made several assumptions about the relationship between anxiety and test taking situations. The first of these is that test anxiety is a learned drive that is expressed by a series of task-relevant and/or task-irrelevant behavior. Task-relevant behaviors include attention to the task and recall of the material. Task-irrelevant behaviors include such things as nail biting, daydreaming, pencil tapping, hand rubbing, or any behavior that is incompatible with task-relevant behaviors. Their second assumption was that test taking situations are threatening for many students because evaluation is often associated (or "paired") with negative outcomes. Being faced with negative outcomes may elicit fear, conditioned avoidance, and/or anxiety responses. In accordance with the above assumptions, Mandler and Sarason predicted that high and low test anxious students (at any intellectual level) would differ in their responses to the stress or threat of an examination situation.

Mandler and Sarason went on to find that high and low test anxious students do indeed respond differently during a test. High and low anxious students were divided into two groups based on their responses to a questionnaire concerning anxiety during test taking. Then, while the students completed a standardized intelligence test, raters evaluated the task-relevant and task-irrelevant behaviors of each subject. Low anxious subjects tended to react to the testing situation with increased attention and few task-irrelevant behaviors. And, as predicted, high test anxious subjects exhibited a significantly higher number of task-irrelevant, interfering responses, which the experimenters attributed to expectations of the inability to cope, or fear of failure.

Sarason (1959) suggested two broad categories of responses that interfere with test taking. The first of these, self-rumination or thoughts of failure (i.e., "I know I am going to fail."), may interfere with the orderly recall of test material. Small amounts of anxiety are held to improve performance by increasing motivation and increasing task-relevant responses. Larger amounts of anxiety are said to increase thoughts of failure and strengthen ego-defensive responses, responses characteristic of the self rather than the task at hand. Since ego-defensive responses are self-centered rather than task relevant, they interfere with performance.

The second response category suggested by Sarason was that of accelerated autonomic functioning. For example, increases in heart rate, blood pressure, and muscle tension may be associated with anxiety and may interfere with or improve performance. He went on to find (Sarason and Palola, 1960) along with other researchers (Malmo, 1957) that the relationship between anxiety and performance among test anxious subjects follows an inverted U function. This suggests that physiological overactivity as well as underactivity is associated with decreases in performance.

A review of the literature by Wine (1971) of studies where the instructional conditions presented to subjects were manipulated indicates an interaction between level of test anxiety reported by subjects and the emphasis of the instructions they received prior to a test. High test anxious subjects were found, in general, to do worse following "ego-involving," evaluative, or threat instructions; the reverse was true for low anxious subjects. Following "anonymous" or non-evaluative instructions, high test anxious subjects generally performed better than those reporting low levels of test anxiety. When few or no instructions or neutral instructions were given, high and low test anxious subjects performed about the same.

Easterbrook (1959) suggests that the effects of anxiety on performance may be due to differences in the attentional focus and cue utilization of high and low test anxious individuals. Highly anxious subjects are said to respond to evaluative test situations with self-evaluation, thoughts and expectations of failure, and worry (Morris and Liebert, 1970); thus, they are less likely and possibly even unable to direct their attention to cues relevant to the task of test taking. Studies by West _et al_ (1969) and Wachtel (1968), which examined the nature of the relationship between self-reported anxiety and the extent of cue utilization during an exam, support this notion. Wachtel suggests the attention of an anxious person is directed inward toward his anxiety, leaving less attention available for task-relevant cues.

To summarize, there appears to be two primary elements important for an understanding of anxiety associated test taking situations: The first, physiological arousal or activity, which appears in the form of increased autonomic functioning and task-irrelevant behaviors. The second, attentional distractions and self-verbalizations as expressed in the form of negative thoughts, fear, worry, and expectations of failure. In addition, the relationship between anxiety and performance appears to follow an inverted U function.

Test Anxiety and Performance

Many studies indicate that high levels of test specific anxiety are associated with decreased academic performance. This research is typically correlational in nature and/or relies on self-report measures of anxiety. When considered together, these studies are quite suggestive. However, reducing test anxiety does not, in every case, guarantee an improvement in test performance.

Alpert and Haber (1960), working primarily with college students, report a negative correlation between performance on standardized achievement and aptitude test (i.e., Scholastic Aptitude Test, American College Test) and high levels of test anxiety. This finding was replicated by Dember _et al_ (1962). In comparison to low test anxious students, high test anxious students perform poorly in classroom testing situations (Walsh _et al_, 1968) and have lower grade point averages (Desiderato and Koskinen, 1969). Another study (Speilberger, 1962) reports a significantly higher dropout rate due to academic failure among high test anxious students compared to their low test anxious peers. Given that most of these studies are correlational in nature, it is not safe to attribute poor test performance solely to test anxiety. There is, however, research indicating that performance of high test anxious students improves under low stress or non-evaluative conditions. This was found by Russel and Sarason (1965) for college students in a laboratory test taking situation that involved solving several anagrams.

Unfortunately, the nature of the relationship between anxiety level and performance is obscured when a study by Sperber (1961) is considered. Sperber divided a large sample of Air Force recruits into high and low test anxious groups according to their scores on a subjective anxiety scale. They also were matched for intelligence. Half the recruits in each group then were given a standardized intelligence test under either high or low stress conditions. Results indicated that high test anxious recruits performed significantly better under high stress conditions than did their low anxious matches. Low test anxious students were found to consistently perform better under low stress conditions.

The effects of anxiety on performance in Sperber's study are opposite to the results described above for Russel and Sarason (1965). These differences might be attributable to the fact that laboratory and "real life" testing situations are not equivalent. The recruits in the high stress condition believed the tests were part of the military assessment program and the results would be used to determine future training opportunities. The low stress condition was presented as "experimental" and not part of the regular assessment program. It is also probable that there were motivational differences between recruits and the college students in other studies who knew they were participating in an experiment.

Educational level, intelligence, and social status also might account for the differences between military recruits and college students (especially in 1961 when this study was conducted). College students are characteristically middle-class where there are strong pressures for achievement, academic or otherwise. The military recruits in Sperber's study were typically from working-class families, which, according to Douran (1956), tend to place little emphasis on formal education and are generally skeptical about academic achievement. Differences in the pattern of performance between the two groups could be due to the importance and relative value placed on the testing situation by the recruits and the students.

These studies suggest a complex interaction of anxiety-related, motivational, and task-specific variables. When all these variables are taken into account, predicting whether anxiety will help or hinder test performance becomes quite complex.

In addition to anxiety, another variable related to test performance is subject expectations. Koenig (1973) evaluated the effects on performance of false verbal information about galvanic skin response (GSR), which students in the study believed to be a measure of emotional arousal. Subjects were led to believe that they were experiencing high, medium, or low levels of emotional arousal during a math test. Those who thought they were highly aroused showed a decrement in performance and an increase in self-reported anxiety. Subjects told that their GSR was low showed improved performance and reduced anxiety. GSR information reporting medium arousal led to performance and anxiety levels intermediate between the high and low arousal subjects.

Harleston (1962) found similar effects on performance by giving subjects success or failure information about an initial test, prior to completing a second. Performance on the second test was reduced by a report of failure on the first test and increased by a report of success.

These two studies suggest the importance of controlling subject expectations in evaluating performance or the effects of any therapeutic or treatment program. In the next section, the methods of treating test anxiety will be reviewed. If subject expectations are left uncontrolled, then comparative studies are not very meaningful. A person experiencing test anxiety quite naturally will expect to feel less anxious after participating in a treatment program or meeting with a therapist with the intention of reducing anxiety, especially when compared to untreated control subjects. It seems possible--given the number and variety of techniques reported effective in reducing test anxiety--that changes in self-report, subjective, anxiety measures usually attributed to treatment effectiveness may be simply the result of the subjects' expectations for improvement and being "treated" or attended to.

Methods for Reducing Test Anxiety

In this section, the methods used by therapists and researchers for reducing test anxiety will be reviewed. These techniques are quite numerous and may differ considerably in procedure. Methods for assessing treatment effectiveness will be covered as well. They fall into three main categories: self-report questionnaires or scales, performance measures, and physiological changes.

Assessing the effects of treatment. Self-report measures of anxiety are used most often. Several scales have been developed specifically for measuring test related anxiety. For example, Alpert and Haber (1960) developed a scale called the Achievement Anxiety Test (AAT). It has two subscales. One measures debilitating anxiety or how much anxiety interferes with test taking; the other measures facilitating anxiety or how much anxiety helps with test taking. Other scales include the Suinn Test Anxiety Behavior Scales (STABS) developed by Suinn (1969) and the Test Anxiety Scale (TAS) developed by Sarason (1958). General measures of anxiety also might be used. The State-Trait Anxiety Inventory (STAI) developed by Spielberger (1970) is a commonly used and cited scale.

Changes in various performance measures also might be assessed following treatment for test anxiety. For example, the grade point averages or final exam scores of treated subjects might be compared to those of untreated controls matched for anxiety level. Laboratory testing situations may involve the use of ego-involving or threat instructions to simulate an actual test. Under these conditions, a subject might be given any combination of math problems, anagrams, analogies, or all or part of a standardized intelligence test.

A third, less frequently used method for evaluating treatment efficacy involves monitoring physiological changes in the subject. Recent technological advances make it possible to economically monitor numerous indices of bodily relaxation and arousal. Early studies had to rely primarily on anxiety and performance measures. Present day researchers can have relatively easy access to information about a subject's level of muscle tension, heart rate, blood pressure, respiration rate, skin temperature, skin resistance, and, even, hormone levels in his blood. These measures may be taken before and after treatment, during treatment, before a test or other performance situation, or during a performance situation.

Treating test anxiety. The remainder of this section reviews the various methods used for reducing test anxiety. All of the studies cited report, at the very minimum, significant improvement in subjective anxiety. Since performance measures are recorded less often, they are reported less often as well. Systematic desensitization will be discussed first because it is well researched and frequently used by therapists.

Systematic desensitization was developed by Wolpe (1958) and is one of the most widely used treatment techniques for phobic and anxiety related problems. Systematic desensitization begins with instructions and practice in deep muscle relaxation using a procedure called Progressive Relaxation developed by Jacobson (1938). Progressive Relaxation involves actively tensing and relaxing different muscle groups, one area at a time, to increase the client's awareness of what relaxed muscles feel like.

When muscle relaxation is achieved and can be maintained, the client is instructed to visualize the thing(s) or situation that creates anxiety. This is done in graduated steps following a hierarchy of events developed by the client and therapist. The client begins with aspects of the situation that evoke only small amounts of anxiety and works up to more anxiety provoking situations. For example, the first step in the hierarchy for test anxiety might be visualizing the course instructor announcing a future examination. The last phases, of a sometimes lengthy hierarchy, might involve visualizing approaching the exam room, having the exam passed out, and finally taking the exam. The client progresses gradually through all the steps in the hierarchy while similtaneously experiencing relaxation. The effectiveness of systematic desensitization is grounded in the belief that muscle tension and anxiety are incompatible. Research by Smith (1973) supports this belief.

Systematic desensitization has been used extensively in the traditional one-to-one, client-therapist, situation (Garlington and Cotler, 1968; Johnson and Sechrest, 1966); in groups where several people are treated simultaneously (Katahan et al, 1966; Quinn, 1968); in combination with group counseling (Mitchell and Ng, 1972); and in "automated" form (Donner and Guerney, 1969) where instructions are tape recorded and contact with a therapist is minimal. Improvement in performance measures are found in some of the studies cited above but not found in others. According to Bandura (1969) and Paul (1969), either alone or in combination with other forms of treatment, systematic desensitization is the most effective and empirically grounded treatment for test anxiety available. However, since these studies and the literature reviewed by Bandura and Paul were published, a number of other ways of reducing test anxiety have been tried.

A study by Allen (1971) suggests that reduction in test anxiety does not guarantee improvement in performance for college students with inadequate study skills. When systematic desensitization combined with study skills training was compared to systematic desensitization alone, both groups showed reductions in anxiety but only the study skills group showed improved course averages.

In addition to systematic desensitization, a wide variety of other forms of treatment have been successfully used to reduce test anxiety. Several studies have evaluated the contribution of relaxation (without visualization of anxiety provoking images) to the effectiveness of systematic desensitization (Goldfried and Trier, 1974; Suinn and Richardson, 1971; Garlington and Cotler, 1968). These studies have demonstrated, using Progressive Relaxation or similar verbal instructions, that relaxation training alone is also effective in reducing test anxiety.

Horne and Matson (1977) used a rather unique procedure termed "modeling" to reduce test anxiety. Subjects in this study heard tapes of students role playing a treatment group for reducing test anxiety. Subjects on the recordings expressed a great deal of anxiety in session one and progressively less and less anxiety during the rest of the ten sessions. After the tapes, the counselor selectively reinforced all nonanxious statements and mannerisms. Modeling was found effective in reducing pulse rates taken prior to an exam and improving test scores.

Study counseling alone and in combination with general relaxation was used by Allen (1973). Study counseling subjects were instructed to monitor their study behavior, given ways to improve study efficiency and several specific techniques to help when studying for an examination. Both techniques were significantly more effective than no treatment in reducing self-report anxiety and improving grades.

Meichenbaum (1972) developed and evaluated a procedure called "cognitive modification." Cognitive modification combines insight-oriented therapy (designed to make test anxious persons aware of their anxiety engendering thoughts) with a modified desensitization procedure involving: 1) coping imagery on dealing with anxiety and 2) self-instructional training to attend to the task and not ruminate about oneself. This was found equally effective as systematic desensitization alone and significantly better than control procedures in reducing subjective anxiety and improving performance in an analogue test situation.

In a study by Driscoll (1976), a rather unusual approach to reducing test anxiety was employed. Physical exertion (in the form of running in place) was used to reduce muscle tension and anxiety. Subjects also were asked to imagine themselves in a situation where they commonly enjoyed themselves and felt relaxed, secure, and confident. The presence versus absence of physical exertion was crossed with the presence versus absence of positive images and compared to systematic desensitization and a no-treatment control group. Physical exertion and positive images together were found most effective in reducing self-report test anxiety and improving grade point averages.

Relaxation as self-control is a general relaxation technique developed by Deffenbacher which also has been used to reduce test anxiety. Deffenbacher and Snyder (1976) found that, compared to untreated controls, subjects using these procedures significantly reduced subjective anxiety. Performance measures are not reported.

Russell *et al* (1975) used a procedure similar to relaxation as self-control called Cue-Controlled Relaxation. In this technique, subjects are first trained in progressive muscle relaxation. The relaxed state is then paired with a self-produced cue. For example, the word "calm" or "relax" might be used. Cue-controlled relaxation was found better than no treatment and similar to systematic desensitization in reducing self-report anxiety. However, no differences in grade point averages were found between treated and control groups.

Time and space do not allow a complete review of the literature nor is such review really necessary here. A number of other techniques are found to effectively reduce test anxiety. Briefly, these include such things as flooding (Graff *et al*, 1973), metronome-conditioned hypnotic-relaxation (Delprato and Dekraker, 1976), implosive therapy (Dowley, 1973), insight therapy (Lemont and Sherman, 1971), and autogenic training (Snider and Oetting, 1966). Various forms of biofeedback, a topic to be discussed more completely in a later section, also have been used to reduce test anxiety. Hardt and Kamiya (1978) found reductions of subjective anxiety in high anxious subjects following training and practice with electroencephalographic (EEG) alpha feedback. Similar results are reported by Reed and Saslow (1979a) using electromyographic (EMG) feedback, and by Saslow and Reed (1979b) using temperature feedback.

There appears to be almost as many ways of treating test anxiety as there are therapeutic philosophies. The above studies provide consistent evidence for the efficacy of a wide variety of treatment techniques in terms of self-report measures of anxiety. In general, it appears that multimodel forms of treatment, especially those including study counseling and test taking strategies, are most effective in reducing anxiety and improving performance. At the very least, if a high anxious student could learn to perform at the same level with less anxiety, there would be a gain for the student and treatment could be considered successful.

Methodological problems with performance measures. Performance measures such as course grades and *in vivo* exam scores are often used to evaluate the effects of a given treatment. Overall, the evidence that test performance improves following treatment is inconsistent but positively weighted. However, it is difficult to separate the actual effects of subject expectations resulting from being treated. The importance of subject expectations on performance has been demonstrated by Koenig (1973) and Harleston (1962).

The use of laboratory testing situations insures a constant and controlled environment for assessing performance, but the "real life" anxiety and motivational components may be lacking. A number of studies have evaluated verbal performance (usually via standardized intelligence tests or parts of them) before and after relaxation training or other forms of treatment. Ego-involving or threat instructions are usually given to create feelings of anxiety and increase motivation. An example from Snyder (1974) follows:

> This is a very sensitive test of general intelligence and ability to think in abstract terms. From your performance on this test, we will obtain an IQ score measuring your level of general intellectual ability. You should work as fast as you can.... (p. 83)

It is difficult to interpret both no change in performance and performance improvement. No change could be attributed to failure of the treatment to generalize to a testing situation and/or failure of the laboratory testing situation and instructions to be motivating enough. On the other hand, if performance improves, it may be due to factors not related to treatment. Threat instructions given in in an unfamiliar lab setting with an unfamiliar experimenter while the subject is performing an unfamiliar task may cause anxiety for the subject the first time (pre-test) but be less threatening when repeated (post-test). Changes seen in performance may result simply from the subject feeling more comfortable with the testing environment and less threatened by the instructions. This effect may be compounded by the experimenter (wedded to his particular treatment for test anxiety) who expects better performance at post-test and conveys this expectation (perhaps unconsciously) to the subject.

Advantages of physiological measures. Given the shortcomings of self-report and performance measures in evaluating the effectiveness of treatment, another method may be to approach the problem from the level of the physiology. Physiological measures such as heart rate, blood pressure, muscle tension, skin resistance, and skin temperature can be used as indicators of anxiety and arousal. Reductions in these following treatment may support the efficacy of a particular anxiety reducing technique. Unfortunately, few studies measure physiological variables. And even fewer have measured them during a testing situation.

A study by Horne and Matson (1977) recorded heart rate prior to an actual classroom examination, before and after ten one-hour counseling sessions. Subjects were given systematic desensitization, flooding, counseling, study skills, or no treatment. Modeling and systematic desensitization were found most effective in reducing anxiety and pulse rate. Modeling, systematic desensitization, and study skills were most effective in improving performance.

In another study, Bronzaft and Stuart (1971) measured galvanic skin resistance (GSR) during an actual course examination and while subjects responded to a neutral questionnaire. The examination was found more emotion arousing (created higher mean GSRs) than the neutral questionnaire. In addition, GSR reactivity was significantly correlated ($r = +.46$) with a self-report anxiety scale. No performance data are reported.

Reed and Saslow (1979b) measured forehead muscle tension (EMG) during a laboratory testing situation. Forehead EMG is assumed by many researchers and clinicians to be a viable measure of tension and anxiety. High test anxious subjects were given eight half-hour sessions of relaxation instructions (abbreviated progressive relaxation), relaxation instructions plus EMG biofeedback, or no-treatment. They report no effect of relaxation training on forehead muscle tension recorded during testing. In addition, no-treatment effects were reported for performance measures. There is still some question, however, whether forehead EMG is a reliable measure of general relaxation. The literature in this area will be covered in some detail in a following section.

It appears that physiological indicators of arousal may provide a useful measure of treatment efficacy, especially when used in combination with self-report anxiety scales and performance measures. More comparative studies are needed in this area, using the above cited and other physiological indices. The recent interest in biofeedback procedures and their application to a variety of clinical problems has increased the availability of gadgetry necessary to monitor physiological processes. Future researchers should take advantage of this and include physiological variables in their studies.

An Overview of Biofeedback

The application of EMG biofeedback and relaxation training to the specific problems of test anxiety will be discussed in the next section. First, it is important to define and discuss biofeedback in general terms and review some of the early research in this area. There are numerous recent applications of (or attempts at applying) biofeedback principles and technology. The results of some investigators are quite positive or, at least, promising. Others may be weak or inconclusive.

To do justice to the research in each clinical area and type of biofeedback would require literature reviews dealing specifically with each one separately. One area, the use of EMG biofeedback in relaxation training, will be covered in detail. This research is important because of the supposed relationship between muscle tension and anxiety and because EMG biofeedback recently has been applied to the problem of reducing test anxiety.

Early research in biofeedback. Behavior therapists Rimm and Masters (1979) define biofeedback as follows:

> Biofeedback is the name given to a wide variety of procedures wherein some aspect of an individual's physiological functioning is systematically monitored and fed back to that individual, typically in the form of an auditory or visual signal. The individual's task then is to modify that signal in order to change that physiological function or process in some way. (pp. 448-449)

Biofeedback came into widespread use in the late 1960's. Its credibility and acceptance by clinicians stems from two separate lines of research. The first, studies showing that a number of presumably involunatry responses could be brought under operant control. For example, galvanic skin response (Kimmel, 1967); and in rats, heart rate, blood pressure, and vasoconstriction in the ear (Miller and DiCara, 1967). A later study (Miller and Dworkin, 1974), however, failed to replicate the initial findings in support of visceral learning. The second area, electroencephalographic (EEG) studies, dealt with learning to control brain wave activity. For example, research by Kamiya (1968) and Nowliss and Kamiya (1970) indicated that alpha brain wave activity (associated with "relaxed wakefulness") could be brought under voluntary control in humans. Later researchers failed to replicate these findings as well (Paskewitz and Orne, 1973; Walsh, 1974) and began to question the clinical value of alpha training (Plotkin, 1976).

Despite the failure to replicate some of the initial studies in biofeedback, the earlier findings were exciting and suggestive; suggestive enough that researchers and clinicians began exploring the numerous possibilities for applying biofeedback principles and technology. The intention here is not to review in detail the various applications of biofeedback methodology but simply to point out that there are many.[1] The reader may wish to consult Blanchard and Young (1974) or Hume (1976, 1977) for a more complete review.

Forehead EMG as a measure of anxiety. The first question to be addressed is whether forehead EMG is a valid measure of generalized relaxation and arousal or anxiety. In other words, are increases and decreases in forehead muscle tension associated with increases and decreases in other indices of arousal? (For example, heart rate, blood pressure, respiration rate, muscle tension in muscles besides the forehead, and self-report measures of anxiety.)

Read and Saslow (1976b) were referred to earlier for a study in which forehead EMG was recorded during a laboratory testing situation. Twenty-seven test anxious college students participated in a program to reduce test anxiety. They were randomly assigned to receive forehead EMG biofeedback and relaxation instructions (B), relaxation instructions alone (IC), or no treatment (C). B and IC subjects received eight half-hour sessions spread over four weeks. Pre- and post-training EMGs were collected on all subjects while they filled out a neutral questionnaire and completed an easy and a hard test of reasoning ability

---

[1] Appendix B lists, according to type of biofeedback, some of the physiological responses and/or symptoms which researchers have attempted to manipulate or improve with biofeedback.

(presented with threat or ego-involving instructions). Equivalent forms of the test were used during pre- and post-testing and the forms were counterbalanced across subjects. Self-report measures of anxiety were collected, using standardized scales, at the beginning and end of the program from all subjects. While significant decreases in subjective anxiety were reported for B and IC subjects, no changes in performance were seen pre to post. Forehead muscle tension recorded during testing also changed very little. In addition, no changes were seen in EMG between easy and hard versions of the test or between filling out a neutral questionnaire and taking a test. The authors conclude that changes in subjective anxiety do not appear to reflect changes in muscle tension and that the main effect of relaxation training is on subject attitudes (as reflected in changes in self-report anxiety of B and IC subjects), not performance or physiological measures.

It may be difficult to account for these findings. The possible deficit in motivational and anxiety factors inherent in a laboratory testing situation already have been discussed. This is a possible explanation. Another possibility is that forehead EMG doesn't really measure anxiety. The assumption that it does is the justification many clinicians give for using forehead EMG biofeedback for relaxation training.

Several studies have been conducted to determine the relationship between forehead EMG and anxiety. Early research by Malmo and Shagass (1949) found that the amplitude of action potentials recorded from the neck muscles of patients experiencing anxiety states were significantly higher than healthy controls. In other research (Malmo and Smith, 1955), forehead muscle tension was found elevated in anxious subjects and to increase further under stress. Wolff (1948) also recorded more activity in the electromyograms of the neck and scalp muscles of anxious patients compared to nonanxious normals. A study by Sainsbury and Gibson (1954) suggests changes in forehead EMG are correlated with muscle tension in other areas of the body and with other indices of autonomic arousal such as heart rate. Smith (1973) conducted a study that examined the relationship between muscle tension and various personality traits. Significant correlations were found between resting forehead EMG and trait anxiety ($r = +.529$), external locus of control ($r = +.412$), and neuroticism ($r = +.384$). This research suggests that if relaxation training (EMG biofeedback or some other method) reduces forehead muscle tension, it should reduce anxiety as well, and also that, especially given Sainsbury and Gibson's (1954) study, relaxed forehead muscles are indicative of general overall relaxation. A study conducted by Alexander (1975) was designed specifically to test these assumptions.

In Alexander's study, 28 "normal" adults were randomly assigned to two groups. One group received relaxation training via forehead EMG feedback; the other was simply asked to relax. During the course of five sessions, muscle tension in the forearm and lower leg of each subject was monitored (in addition to the forehead). Subjects also were asked to rate their feelings of relaxation on a standard scale immediately following each session. The results revealed no evidence that lowered forehead EMGs generalize to muscles in untrained sites. The group receiving EMG feedback was more successful at reducing forehead muscle tension, but both groups reported feelings of relaxation of about the same magnitude. No support was found for the assumption that reductions in forehead EMG lead to similar reductions in other muscles in the body. In addition, no support was found for the assumption that forehead EMG reduction is related to or produces general feelings of relaxation.

The results of this study by Alexander are consistent with the conclusions drawn by Reed and Saslow (1979b) but contrary to earlier work relating forehead EMG and anxiety. It is possible that the significant relationship between changes in muscle tension and subjective anxiety reported in previous research was due to the characteristics of the population sampled. Earlier work was limited primarily to subjects' experiencing tension headaches or excessive anxiety. It seems possible that individuals with very high muscle tension levels or those experiencing some tension related pathology (i.e., muscle tension headaches), may be disposed to respond to stress with muscular tension. These same individuals may manifest generalization effects and report feeling of anxiety not characteristic of normal subjects.

To clarify the relationship between forehead muscle tension and anxiety, additional research is needed in which muscle tension is monitored during test taking and physiological measures besides EMG are used as well. Even though the studies in this area are inconclusive, research continues using forehead EMG biofeedback as a general relaxation method. The question to be addressed now is whether biofeedback procedures are any more effective in reducing muscle tension than procedures that rely on verbal instructions alone.

EMG biofeedback versus other methods of relaxation. A number of studies have been conducted that compare EMG biofeedback procedures with false feedback or noncontingent pseudofeedback procedures (Kappes and Michaud, 1978; Kondo and Canter, 1977; Philips, 1977). Subjects usually receive feedback contingent upon changes in muscle activity; with this procedure, feedback and muscle activity are unrelated. Subjects in these studies are typically suffering from muscle tension headaches. Pseudofeedback is used to control for placebo and subject expectation variables that may contribute to the effects of biofeedback. In all such studies, EMG biofeedback is reported superior to noncontingent feedback in lowering forehead muscle tension and reducing headache frequency. It seems likely, however, that subjects could readily determine whether the feedback information they were receiving was or was not accurate. Subjects would have only to tense their forehead muscles several times, either intentionally or by chance. If they tensed their forehead muscles and didn't receive the appropriate feedback from the machine (i.e., an increase in pitch or number of clicks), they might begin to wonder what was happening, get suspicious, or stop trying to relax.

Thus, it appears that noncontingent or pseudofeedback procedures are inadequate control procedures for establishing the superiority of EMG biofeedback to reduce muscle tension. A more appropriate control procedure would be one in which expectations of improvement were the same for all groups. One way to accomplish this might be to give control subjects relaxation instructions of some kind. In this way, all subjects would have similar feelings of success and expectations of improvement. Several studies have done this.

Haynes _et al_ (1975a) used tension headache patients in a study that compared forehead EMG feedback relaxation training with a specially prepared passive relaxation program. After six half-hour sessions spread over three weeks, both groups showed significant reductions in headache activity compared to a no-treatment control group and did not differ from each other. However, no data are presented on the effects of relaxation training in reducing forehead muscle tension.

In a study by Cox _et al_ (1975), muscle tension data are presented. This study (also using tension headache patients) compared subjects receiving EMG feedback, progressive relaxation instruction procedures, or a placebo drug. The two relaxation groups received two sessions per week for four weeks. The drug group received a glucose capsule administered during individual hour-long, weekly sessions. Both biofeedback and verbal instructions were reported significantly better than the placebo control in reducing forehead EMG but not significantly different from each other. The same pattern of results was reported for headache frequency and intensity.

Reinking and Kohl (1975) conducted a study using nonheadache normals. Subjects were divided into five groups which received forehead EMG feedback, progressive relaxation instructions, EMG feedback plus relaxation instructions, EMG feedback plus monetary reward, or were simply told to relax. Self-report measures indicated that all groups reported increased feelings of relaxation. EMG measures suggested that in speed of learning and depth of relaxation EMG feedback groups were superior to the progressive relaxation instruction group. The authors reported a 50 percent reduction in EMG for the relaxation instruction group and a 90 percent reduction for groups using feedback. However, an examination of the data indicates that the biofeedback groups (even though subjects were randomly assigned) began with higher baseline EMGs, thus giving these subjects more room for decreases in EMG. In addition, subjects in the relaxation instruction group may have been overwhelmed by the instructions. They were presented with 12 minutes of taped instructions at the beginning of each session. The tape suggested so many things that possibly it was difficult to remember them all and to relax. Subjects also may have been bored from hearing the same lengthy tape over and over.

In another study (Haynes et al, 1975b), also using nonheadache normals, subjects received forehead EMG feedback, tense-relax progressive relaxation-type instructions, passive relaxation instructions, false feedback, or no treatment. EMG feedback was reported to lower forehead muscle tension better and at a faster rate than any of the other methods or control procedures. However, this was a one-session study. It seems possible that verbal instructions may be found just as effective as EMG feedback in reducing muscle tension if subjects are given more practice.

Saslow and Reed (1979a) report findings from two studies that suggest relaxation instructions are just as effective as biofeedback in reducing forehead EMG. In the first study, college-aged subjects were randomly assigned to receive forehead EMG biofeedback plus abbreviated progressive relaxation instructions (B) or EMG relaxation instructions alone (R). Both groups received four 20-minute relaxation sessions. Instructions and expectations of success were the same for both groups. The groups were kept as similar as possible except that

B subjects received audio feedback about the state of tension in their forehead muscles. At the end of relaxation session one, B subjects showed reductions in EMG significantly greater than R subjects. After four sessions, however, the groups were not significantly different in their ability to reduce forehead muscle tension.

The second study by Saslow and Reed used the same procedures as in the first study except that subjects were selected from a group of high test anxious freshmen and relaxation training continued for eight sessions instead of four. Once again, B and R subjects were significantly different at session one but no differences were found between groups after R subjects received several sessions of practice. The authors concluded that when subjects are given the same relaxation instructions and the same expectations of success, there is no evidence for group differences. They suggest it is extremely important to control for subject expectations and experimenter bias when doing comparative research on the effectiveness of different techniques of voluntary relaxation.

It seems clear that in the long run, after several sessions of practice, EMG biofeedback is not any more effective in reducing forehead muscle tension than simple verbal instructions. It does work a little faster, making it the method of choice for some clinical situations. However, as a method of general relaxation, its value is questionable, especially when biofeedback is expensive in terms of therapist time ($35 to $50 per session) and equipment ($500 to $1,000 to start).

It is of interest to note that researchers using blood pressure feedback report similar findings in terms of the relative value of biofeedback. Redmond et al (1974) found no differences in the ability of moderate hypertensives to reduce blood pressure levels when given a session of verbal feedback compared with simple instructions to reduce blood pressure. This was confirmed by Shoemaker and Tasto (1975) using visual feedback of blood pressure changes. In a group of essential hypertensives, they found relaxation instructions produced a greater decrement in diastolic blood pressure than did biofeedback, and both experimental conditions were associated with larger decreases in blood pressure than a no-feedback control group.

With appropriate controls (i.e., experimenter bias and subject expectations), other types of feedback may be found to have only marginal benefits above and beyond what "verbal" techniques have to offer. The fact remains, however, that the expense and the "mystique" that surrounds biofeedback may be exactly what some individuals require for a treatment to be effective. Some people may believe "if it doesn't cost me lots of money, it probably won't do me any good."

EMG Biofeedback and Test Anxiety

EMG biofeedback appears to add little to the effectiveness of simple verbal relaxation instructions and practice in reducing forehead muscle tension, muscle tension headaches, or general anxiety. The possibility remains, however, that biofeedback procedures may have something more to offer in the reduction of test anxiety. The final section of this paper deals specifically with studies using EMG biofeedback in the treatment of test anxiety.

The research by Reed and Saslow (1979a, 1979b) has already been reviewed in some detail with reference to the validity of forehead EMG as a measure of anxiety. Relaxation instructions alone and relaxation instructions plus EMG feedback resulted in significant decreases in forehead muscle tension and self-reported anxiety, while a no-treatment control group changed very little. In addition, no group differences were found in verbal performance in a laboratory testing situation or in forehead muscle tension recorded during testing.

In other research (Kappes and Michaud, 1978), EMG biofeedback was used in the treatment of 12 test anxious college females. Six subjects received contingent EMG feedback from the forehead, while six received noncontingent feedback. Subjects receiving contingent feedback reported a decrease in test anxiety while those receiving the noncontingent feedback reported an increase. The inadequancy of noncontingent feedback as a control procedure for biofeedback already has been discussed. Once again, a more appropriate control group would be one for which the expectations of improvement were the same as those for the biofeedback group.

Norman (1976) compared the effectiveness of various biofeedback techniques with two types of taped instructions. High test anxious college students (N = 50) were randomly assigned to treatment groups which received: EMG biofeedback, EEG alpha biofeedback, temperature biofeedback, taped systematic desenitization training, or taped progressive relaxation training. Subjects participated in five 50-minute sessions spread over five weeks. Self-report test anxiety data were collected pre and post, using a standardized scale. Analysis of these data indicated that all five treatments were effective in reducing test anxiety. Significant pre-to-post treatment changes were found within groups, but there were no differences between groups. No performance or physiological measures were reported.

A study by Romano and Cabianca (1978) compared the effectiveness of EMG-assisted systematic desensitization, automated systematic desensitization, EMG feedback training alone, and no treatment, in the reduction of test anxiety. An anagrams test administered pre and post in a laboratory setting served as a measure of performance. Test anxiety was assessed by several standardized questionnaires. After nine training sessions, all three experimental groups significantly reduced their test taking anxiety in comparison to control subjects; however, there were no significant differences among the experimental groups. In addition, there were no effects of treatment on anagram test performance. The effect of treatment on forehead EMG is not reported in the published work but is presented by Romano (1977) in his dissertation. No differences in EMG reduction were found between subjects who received EMG feedback and those that did not. The results suggest that taped relaxation procedures are as effective as EMG biofeedback in reducing forehead muscle tension.

The results of these studies indicate that, when proper controls are used, EMG biofeedback adds little to the effectiveness of simple relaxation instructions and practice in decreasing subjective feelings of anxiety or lowering forehead muscle tension. Norman's (1976) study suggests the same may be true for EEG and temperature biofeedback, at least in terms of self-report anxiety. Additional, well controlled research that includes performance and other physiological measures is needed to determine if biofeedback procedures influence other aspects of test anxiety.

APPENDIX B

A Partial List of Physiological Responses and/or Symptoms to Which Researchers Have Attempted to Manipulate or Improve with Biofeedback

Electrodermal (Galvanic Skin Resistance or GSR) Biofeedback

- hypertension	Patel, 1973, 1975, and 1977
- snake phobia	McLean and Milne, 1975
- spider phobia	Javel and Denholtz, 1975

Electroencephalographic (EEG) Biofeedback

- alpha brain wave activity	Plotkin *et al*, 1976 Kamiya, 1968
- beta brain wave activity	Beatty, 1971
- epileptic brain wave activity	Lubar and Bahler, 1976-77 Wyler *et al*, 1976-77 Sterman, 1973
- theta brain wave activity	Sittenfield *et al*, 1976-77
- test anxiety (alpha training)	Hardt and Kamiya, 1978
- unremitting chronic pain (alpha training)	Melzack and Perry, 1975

Electromyographic (EMG or Muscle Tension) BIofeedback

Physical Therapy (Muscle Re-Education)

- Bell's palsy	Jankel, 1978
- blepharospasm (spasms in musculature of eye)	Ballard *et al*, 1972
- cerebral palsy	Finley *et al*, 1976 Harris *et al*, 1974
- literature review	Fernando and Basmajian, 1978
- Parkinsons's disease	Netsel and Cleeland, 1973
- partial paralysis following a stroke	Brudny *et al*, 1976 Basmajian, 1975
- spasmodic torticollis	Cleeland, 1978 Brudny *et al*, 1974 Brudny *et al*, 1973
- tremor	LeBoeuf, 1976

Electromyographic (EMG or Muscle Tension) Biofeedback (continued)

Muscle Relaxation

- anxiety reduction	Reed and Saslow, 1979(a) Townsend *et al*, 1975 Raskin *et al*, 1973
- asthma	Kotses *et al*, 1976 Davis *et al*, 1973
- attention deficits in child (hyperactivity)	Braud, 1978
- dentistry (mouth and jaw muscles)	Solberg and Rugh, 1972
- dermatitis	Schandler, 1978
- diabetes	Fowler *et al*, 1976
- dysmenorrhea (menstrual cramps)	Tubbs and Carnahan, 1976
- emphysema	Johnston and Lee, 1976
- muscle tension headache	Budzynski, 1978 Epstein and Abel, 1977 Cox *et al*, 1975 Haynes *et al*, 1975 Epstein *et al*, 1974
- stuttering	Lanyon *et al*, 1975 Guitar, 1976
- subvocal speech	Hardyck and Petrinovich, 1976

Heart Rate and Blood Pressure Biofeedback

- cardiac arrhythmias	Weiss and Engle, 1971 Engle and Melmon, 1968
- heart rate control	Bell and Schwartz, 1975
- hypertension	Blanchard *et al*, 1975 Elder and Eustis, 1975 Shoemaker and Tasto, 1975
- pain reduction	Sirota *et al*, 1974
- speech anxiety	Gatchel and Proctor, 1976
- Various animal phobias	Nunes and Marks, 1976

Specialized Applications of Biofeedback

- dysmenorrhea	Clayman and Simkins, 1975
- encopresis (fecal incontinence)	Engel *et al*, 1974
- gastrointestinal disorder (in general)	Whitehead, 1978
- homosexuality	Barlow *et al*, 1975

Specialized Applications of Biofeedback (continued)

- penile erection	Rosen, 1973
- respiratory resistance (in asthmatic children)	Feldman, 1976
- stomach acidity	Whitehead *et al*, 1975 Welgan, 1974
- vaginal blood flow	Zingheim and Sandman, 1978 Hoon *et al*, 1977
- visual accommodation	Provine and Enoch, 1975
Temperature or Thermal Biofeedback	
- anxiety reduction	Saslow and Reed, 1979(b)
- dysmenorrhea	Ribbs and Carnahan, 1976
- migraine headache	Diamond *et al*, 1978 Turin and Johnson, 1976 Friar and Beatty, 1976 Sargent *et al*, 1973
- Raynaud's disease	Blanchard and Haynes, 1973 Jacobson *et al*, 1973

NOTE: The results of some investigations are quite positive or, at least, promising. Others may be weak or inconclusive.

APPENDIX C

Alpert-Haber Achievement Anxiety Test

Instructions: The questions are intended to indicate how you feel about taking tests. There are no right or wrong answers to any of the questions.

When answering these questions, simply try to answer the question, "About how often does this happen to me?" Using the scale below, enter in the blank the number that describes you best.

1 means "No," "never," "not at all," etc.
2 means "somewhat," "sometimes," "a little," etc.
3 means "about as often as not," "an average amount," etc.
4 means "usually," "a good deal," "rather often," etc.
5 means "practically always," "entirely," etc.

_____ 1. Nervousness while taking an exam or test hinders me from doing well.

_____ 2. I work most effectively under pressure, as when the task is very important.

_____ 3. In a course where I have been doing poorly, my fear of a bad grade cuts down my efficiency.

_____ 4. When I am poorly prepared for an exam or test, I get upset, and do less well than even my restricted knowledge should allow.

_____ 5. The more important the examination, the less well I seem to do.

_____ 6. While I may (or may not) be nervous before taking an exam, once I start, I seem to forget to be nervous.

_____ 7. During exams or tests, I block on questions to which I know the answers, even though I might remember them as soon as the exam is over.

_____ 8. Nervousness while taking a test helps me do better.

_____ 9. When I start a test, nothing is able to distract me.

_____10. In courses in which the total grade is based mainly on one exam, I seem to do better than other people.

_____11. I find that my mind goes blank at the beginning of an exam, and it takes me a few minutes before I can function.

_____12. I look forward to exams.

_____13. I am so tired from worrying about an exam, that I find I almost don't care how well I do by the time I start the test.

_____14. Time pressure on an exam causes me to do worse than the rest of the group under similar conditions.

_____15. Although "cramming" under pre-examination tension is not effective for most people, I find that if the need arises, I can learn material immediately before an exam, even under considerable pressure, and successfully retain it to use on the exam.

_____16. I enjoy taking a difficult exam more than an easy one.

_____17. I find myself reading exam questions without understanding them, and I must go back over them so that they will make sense.

_____18. The more important the exam or test, the better I seem to do.

_____19. When I don't do well on a difficult item at the beginning of an exam, it tends to upset me so that I block on even easy questions later on.

Rotter Internal-External (I-E)
Locus of Control Scale

ATTITUDES TOWARD LIFE EVENTS

This is a questionnaire to find out the way in which certain important events in our society affect different people. Each item consists of a pair of alternatives lettered a or b. Please select the one statement of each pair *(and only one)* which you more strongly *believe* to be the case as far as you're concerned. Be sure to select the one you actually *believe* to be more true rather than the one you think you should choose or the one you would like to be true. This is a measure of personal belief: obviously there are no right or wrong answers.

Your answers to the items on this inventory are to be recorded on a separate answer sheet which is loosely inserted in the booklet. REMOVE THIS ANSWER SHEET NOW. Print your name and any other information requested by the examiner on the answer sheet, then finish reading these directions. Do not open the booklet until you are told to do so.

Please answer these items *carefully* but do not spend too much time on any one item. Be sure to find an answer for *every* choice. Find the number of the item on the answer sheet and black-in the space under the number 1 or 2 which you choose as the statement more true.

In some instances you may discover that you believe both statements or neither one. In such cases, be sure to select the *one* you more strongly believe to be the case as far as you're concerned. Also try to respond to each item *independently* when making your choice; do not be influenced by your previous choices.

I-E SCALE
Page 2

1. a. Children get into trouble because their parents punish them too much.
   b. The trouble with most children nowadays is that their parents are too easy with them.

2. a. Many of the unhappy things in people's lives are partly due to bad luck.
   b. People's misfortunes result from the mistakes they make.

3. a. One of the major reasons why we have wars is because people don't take enough interest in politics.
   b. There will always be wars, no matter how hard people try to prevent them.

4. a. In the long run people get the respect they deserve in this world.
   b. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries.

5. a. The idea that teachers are unfair to students is nonsense.
   b. Most students don't realize the extent to which their grades are influenced by accidental happenings.

6. a. Without the right breaks one cannot be an effective leader.
   b. Capable people who fail to become leaders have not taken advantage of their opportunities.

7. a. No matter how hard you try some people just don't like you.
   b. People who can't get others to like them don't understand how to get along with others.

8. a. Heredity plays the major role in determining one's personality.
   b. It is one'e experiences in life which determine what they're like.

9. a. I have often found that what is going to happen will happen.
   b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.

10. a. In the case of the well prepared student there is rarely if ever such a thing as an unfair test.
    b. Many times exam questions tend to be so unrelated to course work that studying is really useless.

11. a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.
    b. Getting a good job depends mainly on being in the right place at the right time.

12. a. The average citizen can have an influence in government decisions.
    b. This world is run by the few people in power, and there is not much the little guy can do about it.

13. a. When I make plans, I am almost certain that I can make them work.
    b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.

14. a. There are certain people who are just no good.
    b. There is some good in everybody.

I-E SCALE
Page 3

15. a. In my case getting what I want has little or nothing to do with luck.
    b. Many times we might just as well decide what to do by flipping a coin.

16. a. Who gets to be the boss often depends on who was lucky enough to be in the right place first.
    b. Getting people to do the right thing depends upon ability, luck has little or nothing to do with it.

17. a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.
    b. By taking an active part in political and social affairs the people can control world events.

18. a. Most people don't realize the extent to which their lives are controlled by accidental happenings.
    b. There really is no such thing as "luck".

19. a. One should always be willing to admit mistakes.
    b. It is usually best to cover up one's mistakes.

20. a. It is hard to know whether or not a person really likes you.
    b. How many friends you have depends upon how nice a person you are.

21. a. In the long run the bad things that happen to us are balanced by the good ones.
    b. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three.

22. a. With enough effort we can wipe out political corruption.
    b. It is difficult for people to have much control over the things politicians do in office.

23. a. Sometimes I can't understand how teachers arrive at the grades they give.
    b. There is a direct connection between how hard I study and the grades I get.

24. a. A good leader expects people to decide for themselves what they should do.
    b. A good leader makes it clear to everybody what their jobs are.

25. a. Many times I feel that I have little influence over the things that happen to me.
    b. It is impossible for me to believe that chance or luck plays an important role in my life.

26. a. People are lonely because they don't try to be friendly.
    b. There's not much use in trying to hard to please people, if they like you, they like you.

27. a. There is too much emphasis on athletics in high school.
    b. Team sports are an excellent way to build character.

28. a. What happens to me is my own doing.
    b. Sometimes I feel that I don't have enough control over the direction my life is taking.

29. a. Most of the time I can't understand why politicians behave the way they do.
    b. In the long run the people are responsible for bad government on a national as well as on a local level.

State Anxiety Scale of the State-Trait Anxiety Inventory (STAI)

SELF-EVALUATION QUESTIONNAIRE

Developed by C. D. Spielberger, R. L. Gorsuch and R. Lushene

STAI FORM X-1

NAME ______________________________ DATE ______________

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *feel* right now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	①	②	③	④
2. I feel secure	①	②	③	④
3. I am tense	①	②	③	④
4. I am regretful	①	②	③	④
5. I feel at ease	①	②	③	④
6. I feel upset	①	②	③	④
7. I am presently worrying over possible misfortunes	①	②	③	④
8. I feel rested	①	②	③	④
9. I feel anxious	①	②	③	④
10. I feel comfortable	①	②	③	④
11. I feel self-confident	①	②	③	④
12. I feel nervous	①	②	③	④
13. I am jittery	①	②	③	④
14. I feel "high strung"	①	②	③	④
15. I am relaxed	①	②	③	④
16. I feel content	①	②	③	④
17. I am worried	①	②	③	④
18. I feel over-excited and "rattled"	①	②	③	④
19. I feel joyful	①	②	③	④
20. I feel pleasant	①	②	③	④

Trait Anxiety Scale of the State-Trait Anxiety Inventory (STAI)

SELF-EVALUATION QUESTIONNAIRE

STAI FORM X-2

NAME ______________________________ DATE ______________

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	①	②	③	④
22. I tire quickly	①	②	③	④
23. I feel like crying	①	②	③	④
24. I wish I could be as happy as others seem to be	①	②	③	④
25. I am losing out on things because I can't make up my mind soon enough	①	②	③	④
26. I feel rested	①	②	③	④
27. I am "calm, cool, and collected"	①	②	③	④
28. I feel that difficulties are piling up so that I cannot overcome them	①	②	③	④
29. I worry too much over something that really doesn't matter	①	②	③	④
30. I am happy	①	②	③	④
31. I am inclined to take things hard	①	②	③	④
32. I lack self-confidence	①	②	③	④
33. I feel secure	①	②	③	④
34. I try to avoid facing a crisis or difficulty	①	②	③	④
35. I feel blue	①	②	③	④
36. I am content	①	②	③	④
37. Some unimportant thought runs through my mind and bothers me	①	②	③	④
38. I take disappointments so keenly that I can't put them out of my mind	①	②	③	④
39. I am a steady person	①	②	③	④
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	①	②	③	④

APPENDIX D

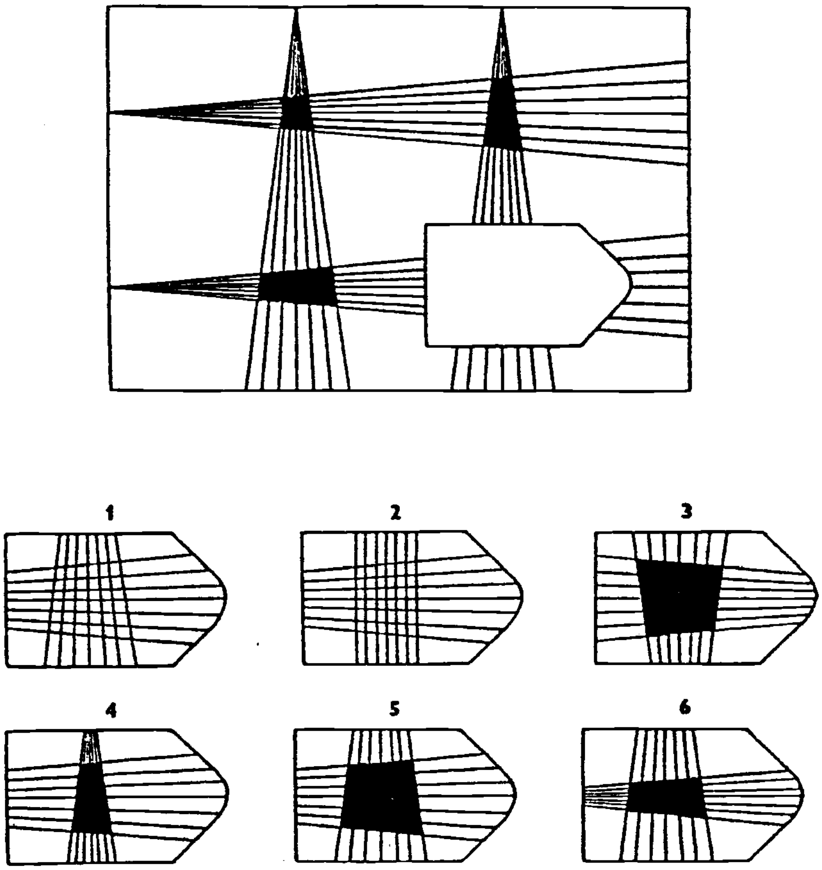
"Ego-Involving" Instruction
Heard By Subjects Prior to Testing

In a few moments you will be taking a short but important test. This is a form of intelligence testing. You will be presented with a pattern that has a missing part. Your task is to choose a pattern from the ones given that best completes the larger pattern. Then, put the number of your choice in the space provided on the answer sheet. This test is in two sections: one easy and one more difficult. You only have seven minutes to complete each section so work as quickly as you can. If you need to draw or write anything, please do it on the answer sheet and not the test booklet.

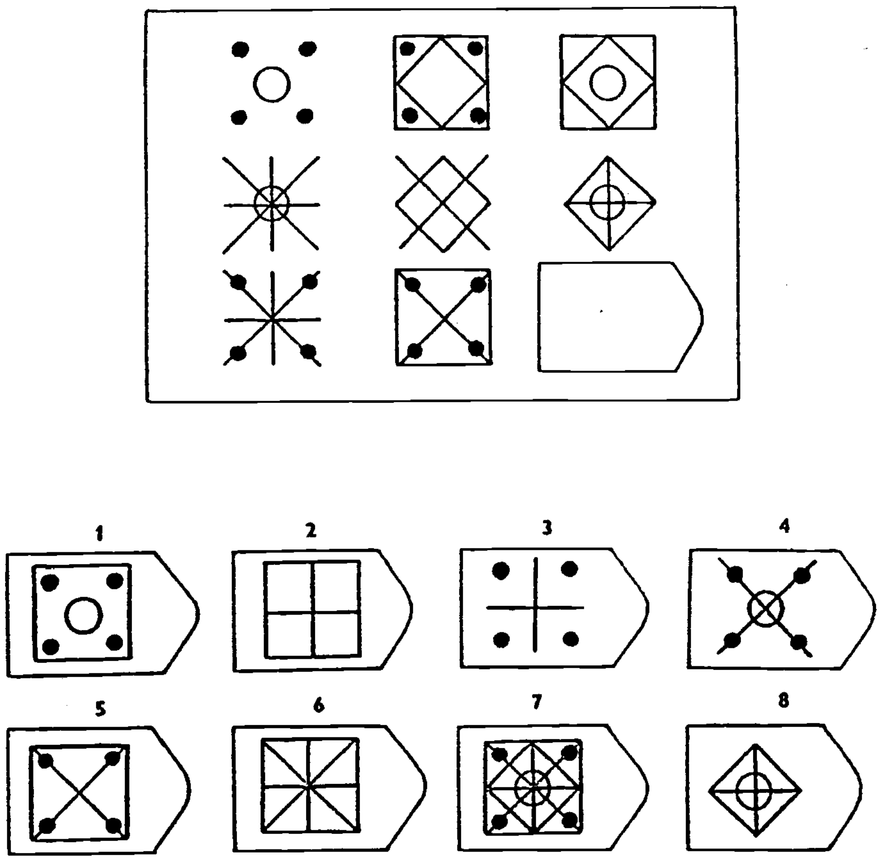
These problems comprise a very sensitive test of general intelligence and ability to think in abstract terms. From your score on this test, we will obtain a measure of your general problem-solving ability. You should work as fast as you can and complete as many of the problems as possible in the time allowed. (At the same time, you should try and maintain the relaxed state you have experienced during the relaxation sessions.) Every one you miss counts against you and lowers your score when it is compared with the scores of other people.

Note: The statement in parentheses was included in post-test instructions only.

Sample Problem - Easy Version of the
Raven Progressive Matrices Test



Sample Problem - Hard Version of the
Raven Progressive Matrices Test



APPENDIX E

Relaxation Instructions

The relaxation technique for this program is comprised of two parts: a period of active relaxation followed by a period of passive relaxation. Individuals may differ in their ability to achieve deep states of relaxation. They may also differ in their ability to use these instructions. You may become very relaxed right away, or it may take two or three sessions. In either case, remember not to worry about whether you are successful in achieving a deep level of relaxation. Maintain a passive attitude and permit relaxation to occur at its own pace. The ability to relax is one skill which is easiest to learn when you remain passive.

Begin by getting as comfortable as you can; remove your shoes and loosen your clothing.

The active relaxation period is termed active because it involves the tensing and relaxing of your muscles. The basic assumption of this technique is that you cannot be fully relaxed unless you are aware of what a relaxed muscle feels like. Awareness of a relaxed muscle state can be enhanced by tensing and relaxing all the muscles in your body, one area at a time.

Begin with the muscles in your feet, then move progressively up through the muscles in your calves, thighs, stomach, chest, hands, arms, and head. You should tense a muscle group, hold the tension and be as aware of it as you can, then release the tension. Take your time; center your awareness on the muscle group you are tensing, remain tense for three or four seconds, and then relax. Be aware each time of the contrast between a tense muscle and a relaxed one.

Once you have completed the active relaxation exercises, concentrate on relaxing completely. You will have the feeling that you are sinking into the chair. Try not to think of other things. It may help to center your attention on your breathing or repeat the word "calm" silently to yourself.

Begin now, actively tensing and relaxing your muscles. After you work through all the muscles in your body, begin the passive relaxation period. Get as deeply relaxed as you can for the remainder of the session. Don't worry about the time; we will let you know when the session is over.