THE CONTRIBUTIONS OF CIRCADIAN RHYTHMS AND

BIOFEEDBACK TRAINING IN LEARNING TO

RELAX AND MINIMIZING TENSION

UNDER STRESS

By

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PREFACE

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CHAPTER I

INTRODUCTION

The meaning of the term biofeedback is quite simple. Biofeedback
is feedback of information to the individual concerning his own biologi-
cal processes. Recent evidence indicates that when a person is provided
with the appropriate information he can learn to control his biological
processes. These increments in self-control have led to considerable
modification in a number of pathological processes.

Biofeedback approaches have had significant initial success in
alleviating tension headaches (Budzynski and Stoyva, 1970), essential
hypertension (Patel and Datey, 1974; Benson, 1974), insomnia (Stoyva and
Budzynski, 1974), stabilization of diabetes (Fowler and Budzynski, 1974),
and epileptic seizures (Finley, 1974, p. 383).

One particular form of biofeedback, electromyographic (EMG) feedback,
which will be used in this study, appears to be very promising. The
abbreviation, EMG, will be used in place of the term, electromyographic,
in the remainder of this paper. The subject receives information from
this type of feedback concerning the level of tension in his skeletal
muscles. The muscle most commonly monitored is the frontalis. One
application using this feedback has been to reduce the level of tension
headaches.

Although results are initially encouraging, more systematic
investigation must be made before judgment can be passed concerning the

efficiency of the biofeedback approach at this time. Miller (1974)

addresses himself to this problem when he writes the following:

> Two of the most urgent current needs in the burgeoning
> new area of biofeedback are for studies of therapeutic effects
> that are far more rigorous than those published to date, and
> for studies of the laws governing this new type of learning
> situation. We need to discover these laws in order to improve
> the efficiency of training (p. xi).

The purpose of this experiment is multiple. The first purpose is

to examine how one parameter, circadian rhythms, may affect biofeedback

training effectiveness. The second purpose is to examine the effective-

ness of biofeedback training itself in relaxation training, and how

effective this training may be during stress situations. Closer scrutiny

of these two purposes can be useful for future studies.

Circadian rhythms refer to changes taking place in an organism

during a 24 hour period. These changes are usually quite regular. Phy-

siologically, a person's body temperature, blood pressure, amino acid

level, hemoglobin, blood sugar level, respiration, and pulse change dur-

ing circadian rhythms. Adrenal hormone and urinary excretion have also

been demonstrated to have circadian fluctuations (Luce, 1970). With such

internal changes taking place, it is reasonable to expect an impact upon

performance.

The hypothesis that performance is affected by the time of day has

been confirmed experimentally when Kleitman (1963) had six subjects per-

form many tasks at different times of the day. These tasks were: card

dealing, card sorting, mirror drawing, nonsense syllable copying, simple

code transcription, multiplication, hand steadiness, and body sway.

Speed and accuracy of performances were at a minimum in the morning and

late at night. Maximum performances occurred in the middle of the day.

The subjects' temperature curves varied directly with their performance

curves except during 1200 and 1800 hours (if one were using a 24 hour clock). During these times, performances declined slightly whereas the subjects' body temperatures were still rising slightly. Some test results concerning hand steadiness and body swaying did match the temperature curves.

In another study Kleitman, Titelbaum, and Deiveson (1938) watched the reaction times of six subjects throughout the day. They found the subjects' performances were frequently related to their body temperature curves. Maximum performances generally occurred when body temperatures peaked. Similarly, low body temperatures were associated with lowered performances. Blake (1967) also found time of day affected level of performance on various tests. Wilkinson (1967) demonstrated circadian rhythm effects on a signal detection task.

These experiments do lend support to the thesis that time of day, or circadian rhythms, does affect performance. Furthermore, body temperature seems to be a possible predictor of performance efficiency.

The use of body temperature as a measure of circadian rhythms is a logical choice for a number of reasons. It is an easy measure to take and is very stable (Luce, 1970, p. 44). Body temperatures have already been used in a number of studies concerning circadian rhythms, some of which have already been reviewed.

Kleitman and Ramsaroop (1948) found distinct individual differences in the pattern of body temperature and of heart rate. The time and the duration of the subject's maximum body temperature, in particular, will vary widely from subject to subject. However, an individual's temperature fluctuations over days tend to be very stable. Generally, an individual's body temperature is low in the early morning hours and begins

to rise at about 0700 hours. The body temperature increases most rapidly in the morning hours and eventually reaches a peak in the afternoon or in the evening hours.

Generally, the high temperature period is associated with muscular tension and with arousal. The low temperature period is usually associated with relaxation of the striate musculature (Luce, 1970, p. 27).

In summary, it appears that high body temperature is associated with peak performance and with increased muscle tonus. Low body temperature is associated with decreased performance and with decreased muscle tonus. In the proposed study, the subject will be given a task to learn: to learn to relax. It is possible to argue that the subject can either learn this task best at peak temperature, when efficiency is also at a peak, or at low temperature, when striated muscles are already more relaxed. One method of testing which condition is more effective is to compare how each subject trained at different times does in a stress testing situation.

This experiment is also designed to test the effectiveness of biofeedback training as compared with controls. Some studies have already been done in this area. Alexander and Hansar (1974) and Coursey and Frankel (1974) found EMG feedback with experimental subjects was more effective in reducing frontalis EMG levels than did relaxation training, but he found passive relaxation was as effective as biofeedback in reducing tension headaches and insomnia. Budzynski and Stoyva (1969) concluded EMG feedback was more effective in teaching relaxation than was irrelevant feedback or no feedback in five training sessions. In a more recent study Budzynski, Stoyva, Adler, and Mullaney (1973) found biofeedback was significantly more effective in reducing EMG levels in training

than was pseudofeedback. There were also significant drops in tension headaches in the biofeedback group as compared to the pseudofeedback group. The subjects in this experiment consisted of 18 people suffering from tension headaches. Cleaves (1970) found EMG biofeedback was significantly more effective in reducing frontalis tension levels than was a combination of Jacobson and Schultz's training procedure in muscle relaxation and with a third group that was told to relax. Cleaves used 76 normal female subjects, and all subjects had only one training session.

It is this experimenter's opinion that too few studies with control groups have been performed to justify the deletion of controls not receiving biofeedback. The studies which have included controls, however, have only compared acquisition rates; this study will monitor how subjects react to and how they recover from a stress situation after training has taken place.

The type of training the control subjects will be receiving is meditation training. Orenstein (1972) attempts to describe meditation as follows:

> The concept, meditation, refers to a set of techniques which are the product of another type of psychology, one that aims at personal rather than intellectual knowledge. As such, the exercises are designed to produce an alteration in consciousness -- a shift away from the active, outward oriented, linear mode and toward the receptive and acquiescent mode. Meditation is a technique for turning down the brilliance of the day (p. 107).

Benson (1974) describes what he feels are the four basic elements of meditation: 1) a constant stimulus; i.e., a secret sound, word, or phrase repeated silently or audibly; 2) a passive attitude -- if distracting thoughts do occur during the repetition, they should be simply disregarded, and the person's attention should be redirected to the technique; 3) a quiet environment, and 4) a decrease in muscular tonus.

Benson states these techniques produce a general relaxation response which consists of a 50-300% increase in skin resistance, lower cortisol levels, decreased metabolism heart rate, lower breathing rates, lower blood pressure, and a drop in muscle tension.

The subjects practicing meditation training were asked to practice for 5-20 minute sessions on their own. Because these sessions were not directly monitored by the experimenter, these subjects will be referred to as a control group rather than as a meditation control. It was felt that the inclusion of subjects who reported they practiced meditation training would be a greater challenge to the biofeedback groups than controls who received no training.

In summary, these points were covered in the introduction: the potential importance of electromyographic biofeedback training and how circadian rhythms may affect biofeedback training itself in relaxation training, and how effective this training may be during stress situations. Relevant research in the areas of biofeedback and circadian rhythms was reviewed, and the type of training (meditation) the controls received was also discussed.

CHAPTER II

METHOD

Subjects

The subjects consisted of 50 male undergraduate student volunteers from introductory psychology courses taught at Oklahoma State University. The subjects were assigned to one of the six groups in the experiment by the use of a random digits table.

Apparatus

An Autogenic Systems 1500 Electromyograph was the feedback device utilized. Its sensitivity was .1 microvolts RMS. Differential input impedance was greater than 100 megohms. The common mode rejection was: minimum - 90 dB (33,000:1), typical - 100 dB (100,000:1). The artifact rejection filters were: 60 Hz powerline, 40 dB (100:1) minimum, ECG - 50 dB/octave below 100 Hz, and radio frequency filters. The standard bandpass used was: 100-200 Hz, high pass - 50 dB/octave, and low pass - 18 dB/octave. The feedback mode used was a standard click feedback. The click rate was proportional to the amplitude of the electrical signal coming from the subject. The logarithmic output in this study was used in conjunction with a Grass Model 7B Polygraph. The amplifier used was a Grass Model 7DAEF. The Chart Drive Model number was H25-60.

Other equipment used in the experiment included: a stopwatch, a clinical oral thermometer, a cassette tape recorder, and two headphone sets.

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Experimental Procedure

The study consisted of six groups of subjects which comprised two control groups and four experimental groups.

Four groups designated as experimental groups received five training sessions before the subjects underwent the testing procedure. There were five subjects in each of the four groups. All subjects in these groups had their oral body temperatures monitored in all of the training sessions. All of these subjects received EMG frontalis biofeedback during these training sessions. The four experimental groups were labeled based on when they were trained and tested, morning or afternoon. Two of the experimental groups received their training during the morning from 0800 to 1230 hours. During the test sessions, one of these two experimental groups was tested in the afternoon between 1500 and 2000 hours, and this group was designated as the M.A.E. Group. The second group was tested in the morning between 0800 and 1300 hours and was designated as the M.M.E. Group. The other two experimental groups received their five training sessions in the afternoon between 1500 and 2000 hours. One of these two groups was tested in the morning between 0900 and 1300 hours; this group was labeled the A.M.E. Group. The second group was tested in the afternoon, and it was assigned the label of the A.A.E. Group.

When it was possible, the experimental subjects were scheduled so that they underwent their training sessions on five consecutive days. The test sessions were scheduled the day after the subjects received their last training sessions; however, these arrangements were not always possible. A number of the experimental subjects took up to two weeks to complete the six sessions.

The two control groups received no biofeedback training; instead, they were asked to practice a form of meditation for five consecutive days for 20 minutes each session. (See the Appendix for the meditation instructions.) These subjects were then scheduled for the test sessions with almost all subjects being able to complete the entire procedure within a two week period. The subjects in one control group were scheduled for the test sessions in the morning hours between 0800 and 1230. The group was labeled the M.C. Group. The second control group underwent the test sessions in the afternoon hours, and this group was designated the A.C. Group.

Morning Training, Morning Test, Experimental Group (A.M.A.M. Group)

All subjects in this experimental group received EMG training in the morning from 0800-1230 hours. The subjects were brought in the experimental room, and the instructions were given as follows:

> Please sit down here. I am going to place three electrodes on your forehead to monitor the level of tension in your forehead muscle. There is no chance for you to receive a shock from these electrodes. I will also clean your forehead with alcohol to insure good contact.

The foreheads of the subjects were then cleaned with alcohol, and the three electrodes were positioned. The two active electrodes were placed one inch above the eyebrows and spaced four inches apart from each other. The third electrode, the ground electrode, was placed in the center of the forehead.

Once the electrodes had been properly placed, subjects were then given a set of headphones, and were instructed how they could use the sound feedback in learning to relax. The instructions were as follows:

> The purpose of this procedure is to teach you biofeedback training so that you can better learn to relax.

> I will know how relaxed you are by monitoring the forehead
> muscle with the electrodes. You will hear a sound through
> these headphones. It will be a crackling sound, and your
> task will be to reduce the rate of the popping sounds. As
> you are reducing this popping noise rate, you are actually
> reducing the level of tension in your forehead muscle --
> the muscle we are monitoring. This session will last for
> 20 minutes. There will be a one minute break every 10
> minutes. Remember to keep your eyes closed, and do not
> talk or move except during the one minute breaks.

At the end of the 20 minute training sessions, the subjects' oral

temperatures were taken twice in succession for two three-minute periods.

The instructions were as follows:

> I am going to take your temperature. Be sure that you
> place the thermometer so that the tip is touching the artery
> under your tongue here. I will take two three-minute read-
> ings.

The subjects returned for four more morning training sessions, and

these sessions followed the procedures just described.

Following the fifth training session, the subjects were administered

a morning test session. Electrodes were attached to the foreheads, but

subjects received no feedback. They were told to sit back and close

their eyes for five minutes. This was the pretest period. The test

period consisted of memorizing 10 paired associate nonsense syllables

picked from Glaze's (1928) list of nonsense syllables. The nonsense

syllables were presented auditorily by means of a cassette tape. All

nonsense syllables had a meaningfulness value of 47-55 on a scale from

0 to 100.

Stimulus terms were chosen in a manner similar to Underwood's (1953)

procedure for producing high similarity. Only three letters were used to

start each of the 10 syllables (two letters started three, and one

started four). Likewise, only three, although different, consonants were

used to end the syllables. In no situation was a vowel, center letter,

used more than three times in a list, and generally, each vowel occurred

only twice. A total of six consonants was used in the 10 stimulus non-

sense syllables. To prevent stimulus generalization no letter used to

start a syllable on the stimulus side was used to start a syllable on

the response side.

The response nonsense syllables were constructed in the manner

described by Underwood for producing low similarity of nonsense syllables.

Low similarity nonsense syllables were those in which no repetition of

consonants occurred. There were 20 consonants making up the 10 items;

no vowel was used more than three times.

The 10 stimulus response pairs were presented aloud in sequence;

the subjects' EMG levels were monitored only during the presentation per-

iod. (During the presentation period, movement artifacts were at a min-

imum.) After hearing all 10 pairs, the subjects were presented the first

stimulus word and were given five seconds to give the appropriate re-

sponse. After five seconds, the next stimulus word was given regardless

if the subjects had responded. This procedure was repeated through the

tenth pair; after a short pause, the procedure was begun anew and sub-

jects had the chance to respond again to the stimuli. The six trials

took 25 minutes to give.

The instructions to the subjects were as follows:

> You will now be given a test which is one measure of
> basic raw intelligence, independent of information you have
> learned in school. Your performance will be compared with
> other students in your own age group.

> You will be presented 10 pairs of nonsense syllables
> in succession. An example of a pair would be XYZ-ZYX.
> After you have had a chance to listen to all 10 pairs, the
> first portion of each pair will be presented with the second
> half of the pair. For instance, if I say XYZ, you would
> respond with ZYX. Your task will be to attain the goal of
> giving the correct response to all 10 stimulus syllables in

one trial. I want you to strive to attain 10 correct responses
in one trial period. Do the best you can as this task is one
measure of your intelligence, but at the same time keep your
eyes closed, and remain as relaxed as possible (by applying
what you have learned in previous sessions). The goal is to
do as well as possible while remaining as relaxed as possible.

The portion of the previous sentence in parentheses was deleted from

the instructions to the control groups, which received no training.

After the testing situation, the subjects were told to relax as

deeply as possible, and recovery rates were then measured. After the

recovery period, subjects were given the information that the test situa-

tion was designed to be very difficult for everyone; and even if people

had perceived the situation as difficult, it was no reason for them to

assume that they had done worse than others. They were also asked not

to discuss this experiment with anyone.

Morning Training, Afternoon Test, Experimental Group (A.M.P.M. Group)

The second experimental group was administered to in the same way

as the M.M.E. Group except that the test session was in the afternoon.

Afternoon Training, Afternoon Test, Experimental Group (P.M.P.M. Group)

The procedure was the same for this group as for the M.M.E. Group

except that the training session and the test session were in the after-

noon.

Afternoon Training, Morning Test, Experimental Group (P.M.A.M. Group)

The procedure for this group was the same as that for the A.A.E.

Group except that the test session was in the morning.

Morning Control Group (C.A.M. Group)

The M.C. Group was given the meditation instructions, as found in the Appendix, and these subjects were told to practice this form of meditation for five 20 minute periods on a daily basis.

When the subjects completed the meditation assignment, they were scheduled for a morning test session. The test session procedure was the same as that described for the experimental groups.

Afternoon Control Group (C.P.M. Group)

The A.C. Group underwent exactly the same procedure as the M.C. Group except these subjects were tested in the afternoon period between 1500 and 2000 hours.

CHAPTER III

ETHICAL CONSIDERATIONS

While reading the instructions prior to the test situation, the experimenter made the statement that, "this is one test of raw intelligence, independent of information you have learned in school." Because the test was designed so that all subjects would make mistakes, most subjects perceived themselves as doing poorly. However, once the test ended, all subjects were told that everyone performed poorly on this test, and that the subjects' perceptions of how poorly they might have done had nothing to do with their intelligence.

Following completion of data collection and analysis, all subjects were sent an outline of the experiment.

CHAPTER IV

DEPENDENT VARIABLES

Muscle Tension

The muscle tension of the subjects was obtained by monitoring the
logarithmic output of the EMG with the Grass Polygraph. A logarithmic
scale, which was calibrated in microvolts, was used to measure the de-
flections of the polygraph stylus. In the training session five readings
were taken, in two second intervals, at the beginning of each minute of
biofeedback training. These five readings were then averaged to produce
a single estimate of the tension levels of the subjects. There were 21
such estimates collected during each training session.

For the test session, EMG readings were taken in the pre-stress
period, the stress period, and the recovery period. In the pre-stress
period and the recovery period measurements were taken in the same manner
as was specified for the training period. The only difference was that
the number of estimates of the subjects' tension levels for the pretest
period and recovery periods was 6 and 10, respectively. Each of the
estimates consisted of a mean score derived from five measures taken in
a 10 second period at two second intervals. In the stress period measures
were taken at five second intervals in the presentation period. The mean
of these measurements was the estimate used for that particular presen-
tation period.

The above measurements were made in microvolts. The experiment was calibrated by sending a signal of known voltage through the polygraph and measuring the degree of deflection of the pen. Calibration signals of .5, .6, .75, .8, .9, 1, 1.25, 1.50, 1.75, 2.00, 2.50, 3.00, 3.50, 4.00, 4.50, 5.00, 6.00, 7.00, 7.50, 8.00, 9.00, 10.00, 12.50, 15.00, 17.50, and 20.00 were used to construct the microvolt scale. Finer discrimination was obtained by mathematically estimating where the midpoints of the above measurements fell.

Oral Temperature

After each session, the subjects' oral temperatures were taken twice in succession, and means of these two readings were used as a measure of their oral temperature.

Performance on the Nonsense Syllable Test

The subjects' performances on the test sessions were measured in terms of the total number of nonsense syllable errors they produced.

CHAPTER V

RESULTS

Training Phase

In the training phase, the afternoon biofeedback group did not reach significantly lower EMG levels than did the subjects in the morning biofeedback group (Table I). The treatment by sessions interaction was, however, significant at the $P < .05$ level (Figure 1). The afternoon biofeedback group in the first session was at a higher level than the morning biofeedback group. However, in the second session the EMG levels of the afternoon group dropped substantially while there was very little change in the morning group. The EMG levels of the afternoon group reamined lower than that of the morning group for the remainder of the sessions.

The sessions factor was also significant at the $P < .05$ level. This was primarily a result of the precipitous drop in EMG levels of the afternoon trained subjects after session number one (Figure 1).

Figure 2 indicated how EMG levels changed over trials ($P < .005$). This change was a result of progressively decreasing EMG levels over trials. The largest decrease occurred between trials one and two. After trial two, the drops were in smaller increments, but these drops continued as the trials progressed.

The correlation that was expected between core body temperature and EMG levels for all trials and sessions did not materialize (Table II).

TABLE I

AOV TRAINING PHASE SUMMARY TABLE WITH TREATMENT
TIME (MORNING VERSUS AFTERNOON BIOFEEDBACK
TRAINING) AS THE INDEPENDENT VARIABLE
AND WITH MICROVOLTS AS THE
DEPENDENT VARIABLE

SOURCE	SS	df	MS	F	P
Total	1439.0749	2099			
Between	444.9680	19			
A (Treatments)	14.1959	1	14.1959	.593	NS
Error (a)	430.7720	18	23.9317		
Within	994.1068	2080			
B (Sessions)	47.8155	4	11.9538	3.260	$< .05$
A x B	39.9593	4	9.9898	2.720	$< .05$
Error (b)	263.9972	72	3.6663		
C (Trials)	109.7184	20	5.4859	20.240	$< .005$
A x C	4.8236	20	.2411	.890	NS
B x C	18.5326	80	.2316	.850	NS
A x B x C	21.4016	80	.2675	.990	NS
Error (c)	487.8799	1800	.2710		
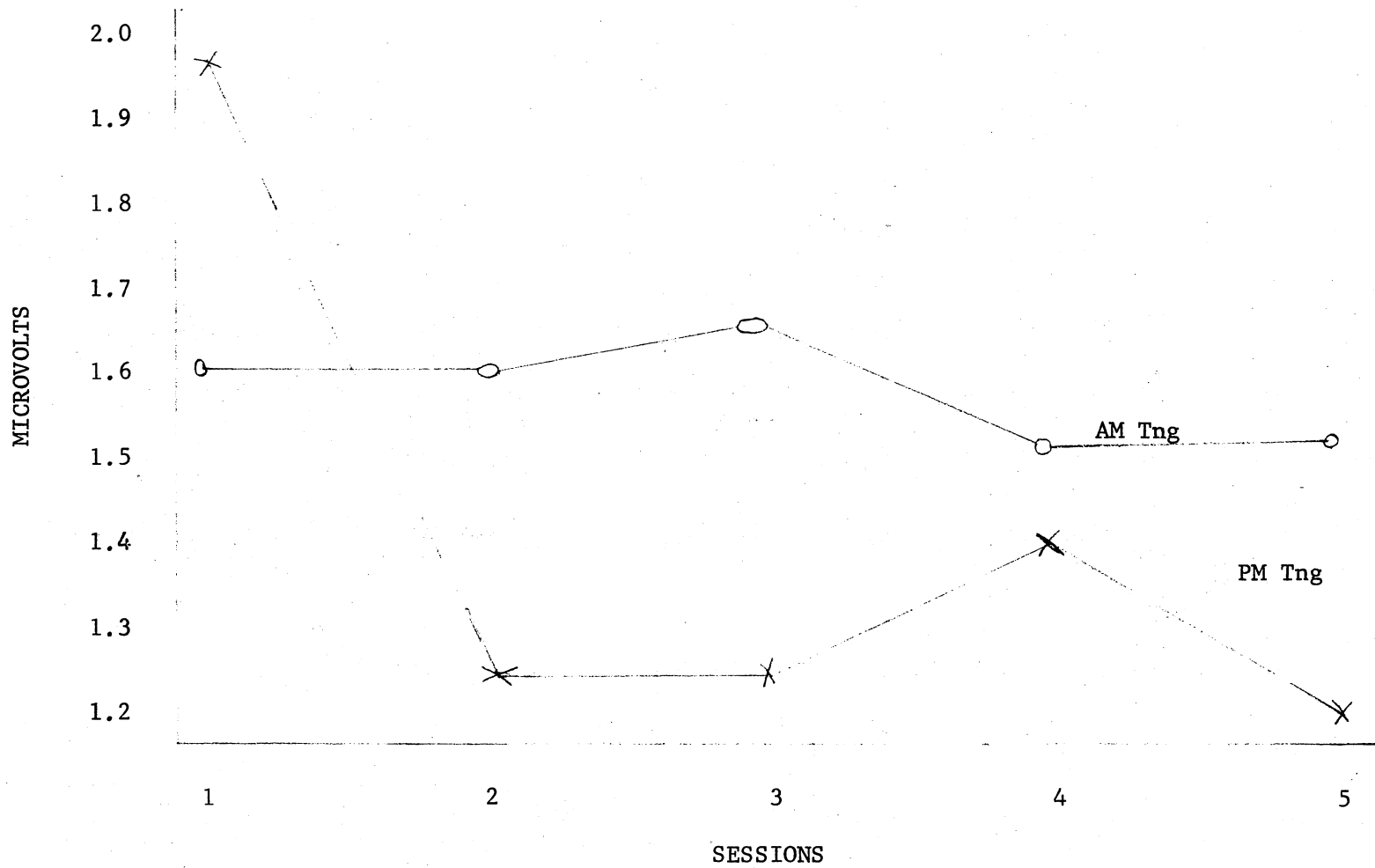
Figure 1. Training Phase-Treatment x Sessions
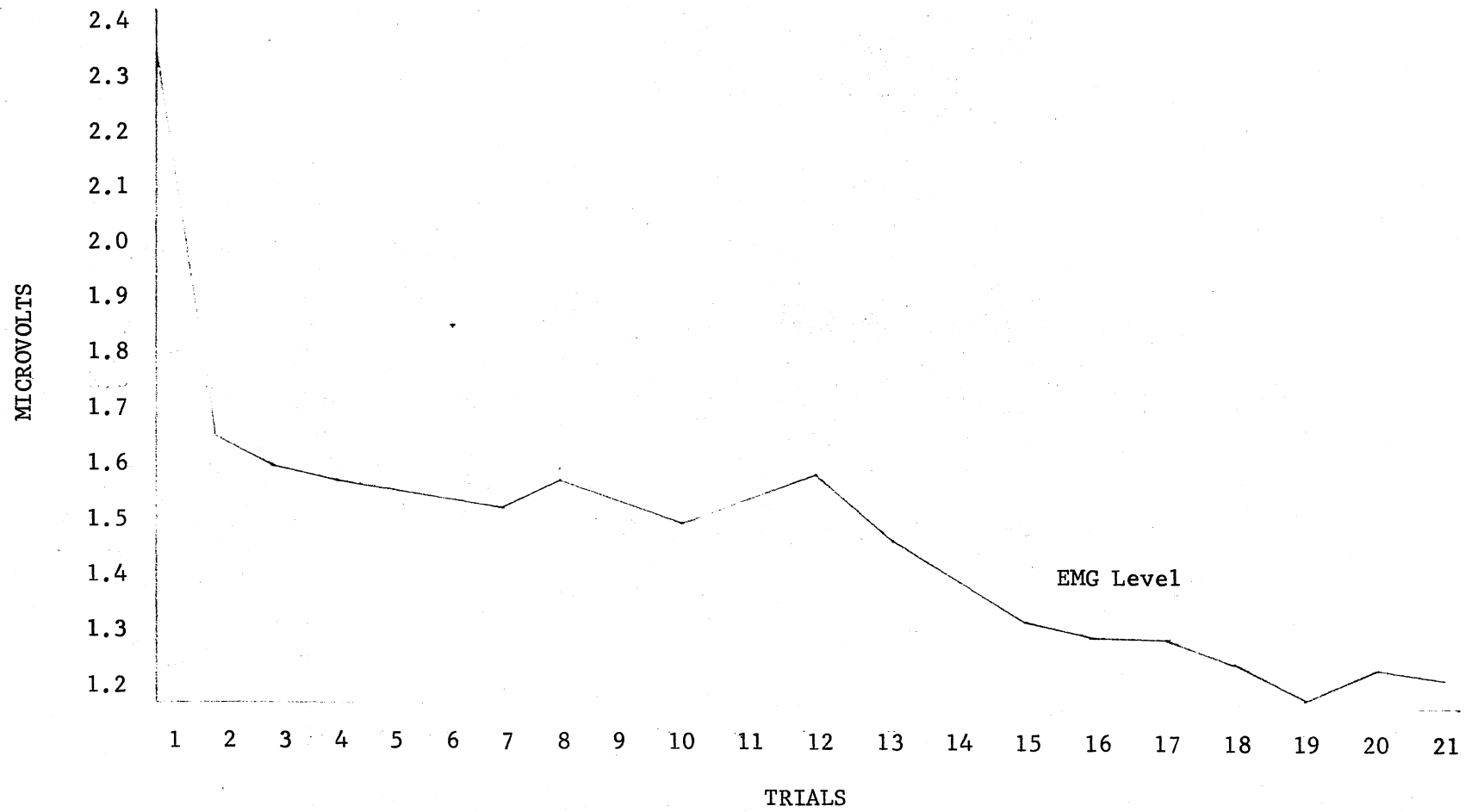
Figure 2. Training Phase-Trials

However, when correlations were computed for trial 1 of session 1, trial 10 of session 3, and trial 21 of session 5, coefficients of +.464 ($<$ .05), -.347 ($<$ .20), and -.415 ($<$ .1), respectively, were found. Figure 3 indicated the progression from a positive correlation to a negative correlation as training progressed.

TABLE II

PEARSON PRODUCT CORRELATION COEFFICIENT SUMMARY
TABLE FOR THE TWO FACTORS: CORE BODY
TEMPERATURE AND FRONTALIS TENSION
LEVELS (UV)

Coefficient	R	t	df	P
Coefficient for 5 sessions	-.0837			NS
Coefficient for trial 1 session 1	+.464	2.22	18	$<$ .05
Coefficient for trial 10 session 3	-.347	1.569	18	$<$ .20
Coefficient for trial 21 session 5	-.4149	1.93	18	$<$ .10

Test Phase

In the pretest period no significant differences were detected among the three treatment groups (see the unequal number of subjects analysis of variance, Table III). There was, however, a significant trials effect ($P < .01$). The significant trials effect was a result of the significant treatment by trials interaction ($P < .05$) illustrated in Figure 4. This interaction was primarily due to the afternoon training
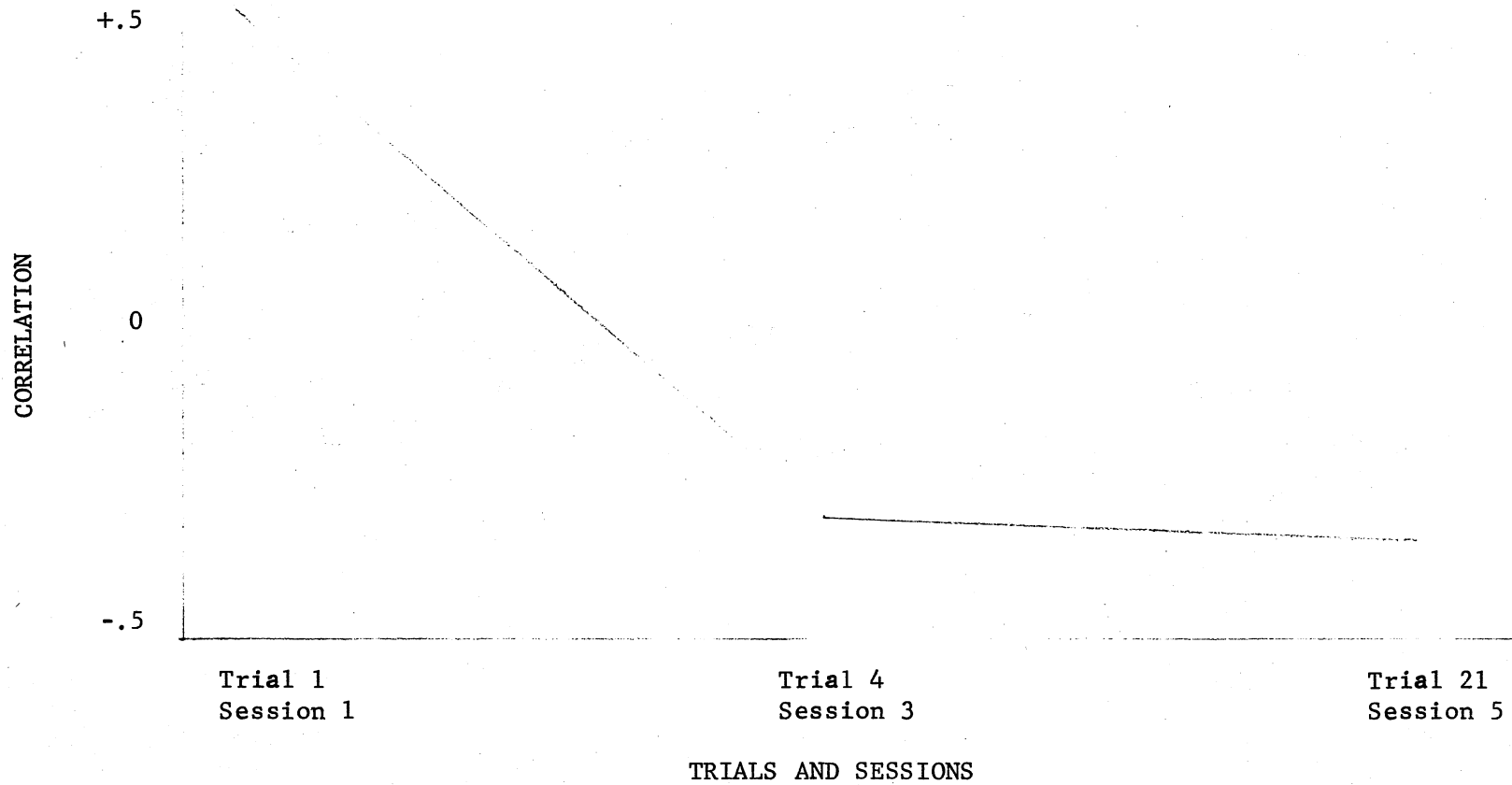
Figure 3.   Training Phase-Correlation Coefficients

TABLE III

AOV SUMMARY TABLE CONCERNING THE INDEPENDENT
VARIABLES TREATMENTS (MORNING VERSUS AFTER-
NOON BIOFEEDBACK VERSUS CONTROLS) AND
TEST TIME (MORNING VERSUS AFTERNOON)
DURING THE PRETEST PERIOD WITH
MICROVOLTS AS THE DEPENDENT
VARIABLE

Source	SS	df	MS	F	P
Total	238.5911	227			
Between	202.4058	37			
A (AM-PM-Controls)	8.0860	2	4.0480	.669	
B (AM Test-PM Test)	2.6276	1	2.6276	.434	
A x B	26.3520	2	13.1760	2.179	< .25
Error (a)	193.9471	32	6.0459		
Within	36.1853	190			
C (Trials)	7.3955	5	1.4791	26.560	< .01
A x C	1.3410	10	.1341	2.409	< .05
B x C	2.2387	5	.4474	8.040	< .01
A x B x C	16.3007	10	1.6300	29.740	< .01
Error (b)	8.9092	160	.5568		
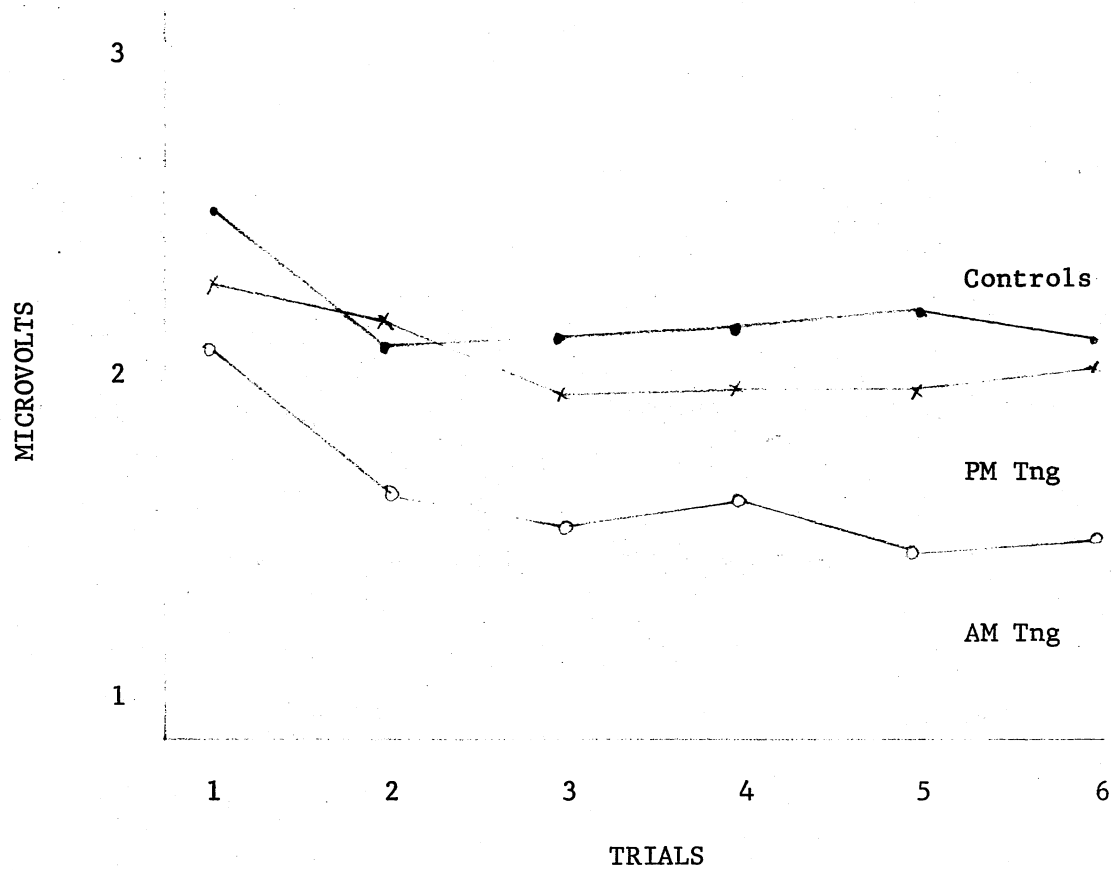
Figure 4.   Pretest-Treatment x Trials

group. On trial two the afternoon training group did not register as large an EMG level drop as the other two groups registered. As a result, the afternoon training group intersected the control group. In addition, by trial six the afternoon training group and the control group converged. A test time x trials effect (P < .01) was found and was illustrated in Figure 5. As trials progressed, these two groups converged producing the interaction. The triple interaction was also significant (P < .01). This interaction effect was illustrated in Figure 6. After an initial drop in EMG levels was registered by all groups, the AM control group and the AMAM groups should increase. The other groups showed little or no increases.

In the test period a planned comparison analysis indicated the mean of the two biofeedback groups was significantly lower (P < .001) than the mean EMG level of the controls (Table IV). Though the treatment factor, in the test period, did not reach significance, an unequal number of subjects analysis of variance indicated there was a significant (P < .01) treatment by trials interaction (Table V). This interaction shown in Figure 7 was a result of: the control groups increasing EMG levels as trials progressed, the temporary increase in trial two of the afternoon trained biofeedback group, and the gradual convergence of the morning and afternoon trained biofeedback groups culminating in the afternoon trained group dropping below the morning group in trial five.

The recovery period of unequal number of subjects analysis of variance (Table VI) pointed to a significant difference (P < .05) among treatment groups. The average of the two experimental groups was significantly lower (P < .001) than the controls (Table VII). In pairwise comparisons of means, both of the experimental groups were significantly
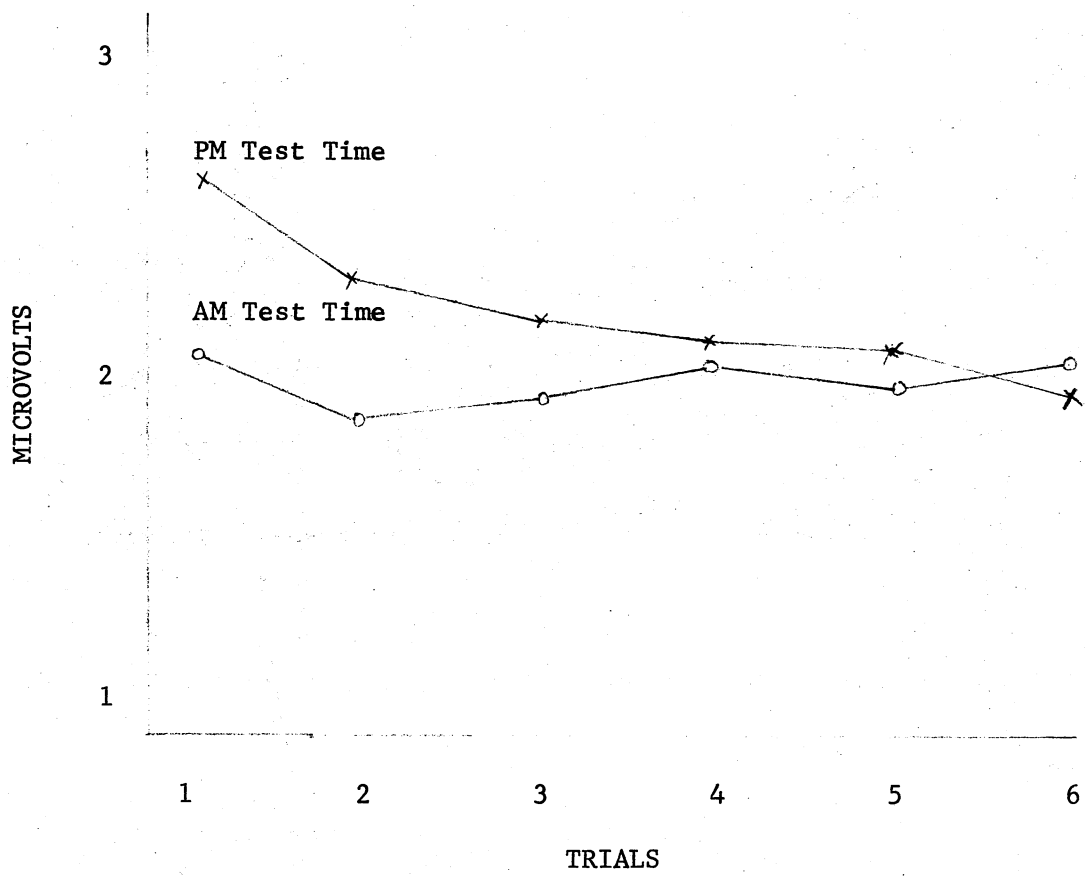
Figure 5. Pretest-Test Time x Trials
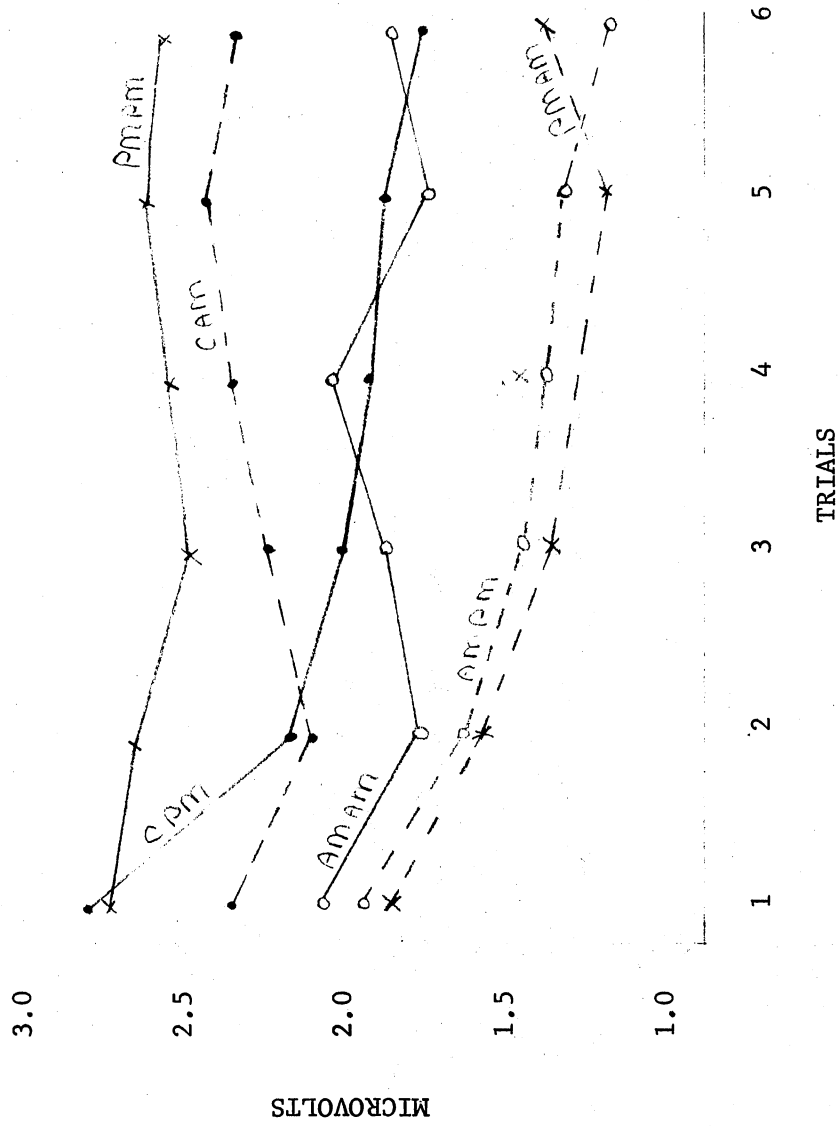
Figure 6. Pretest-Training x Test Time x Trials

TABLE IV

PLANNED COMPARISONS (LSD) TEST PERIOD

Average Comparisons

Controls	3.2611
Mean of Morning and Afternoon Biofeedback	2.3993
Difference	.8618 (P < .001)
Mean of Morning Biofeedback Group	2.27
Mean of Afternoon Biofeedback Group	2.53
Difference	.26 (P < .3)

TABLE V

AOV SUMMARY TABLE CONCERNING THE INDEPENDENT
VARIABLES TREATMENTS (MORNING BIOFEEDBACK
VERSUS AFTERNOON BIOFEEDBACK VERSUS CON-
TROLS) AND TEST TIME (MORNING VERSUS
AFTERNOON) DURING THE TEST PERIOD
WITH MICROVOLTS AS THE DEPENDENT
VARIABLE

Source	SS	df	MS	F	P
Total	495.7035	127			
Between	329.5243	37			
A (Treatments)	44.3692	2	22.1846	2.89	NS
B (Test Time)	10.7076	1	10.7076	1.40	$< .25$
A x B	27.8144	2	13.9072	1.80	$< .25$
Error (a)	246.6431	32	7.7075		
Within	166.1792	190			
C (Trials)	2.8862	5	.5772	.70	NS
A x C	23.1524	10	2.3152	2.80	$< .01$
B x C	4.4571	5	.8914	1.078	NS
A x B x C	3.4523	10	.3452	.417	NS
Error (b)	132.2453	160	.8265		
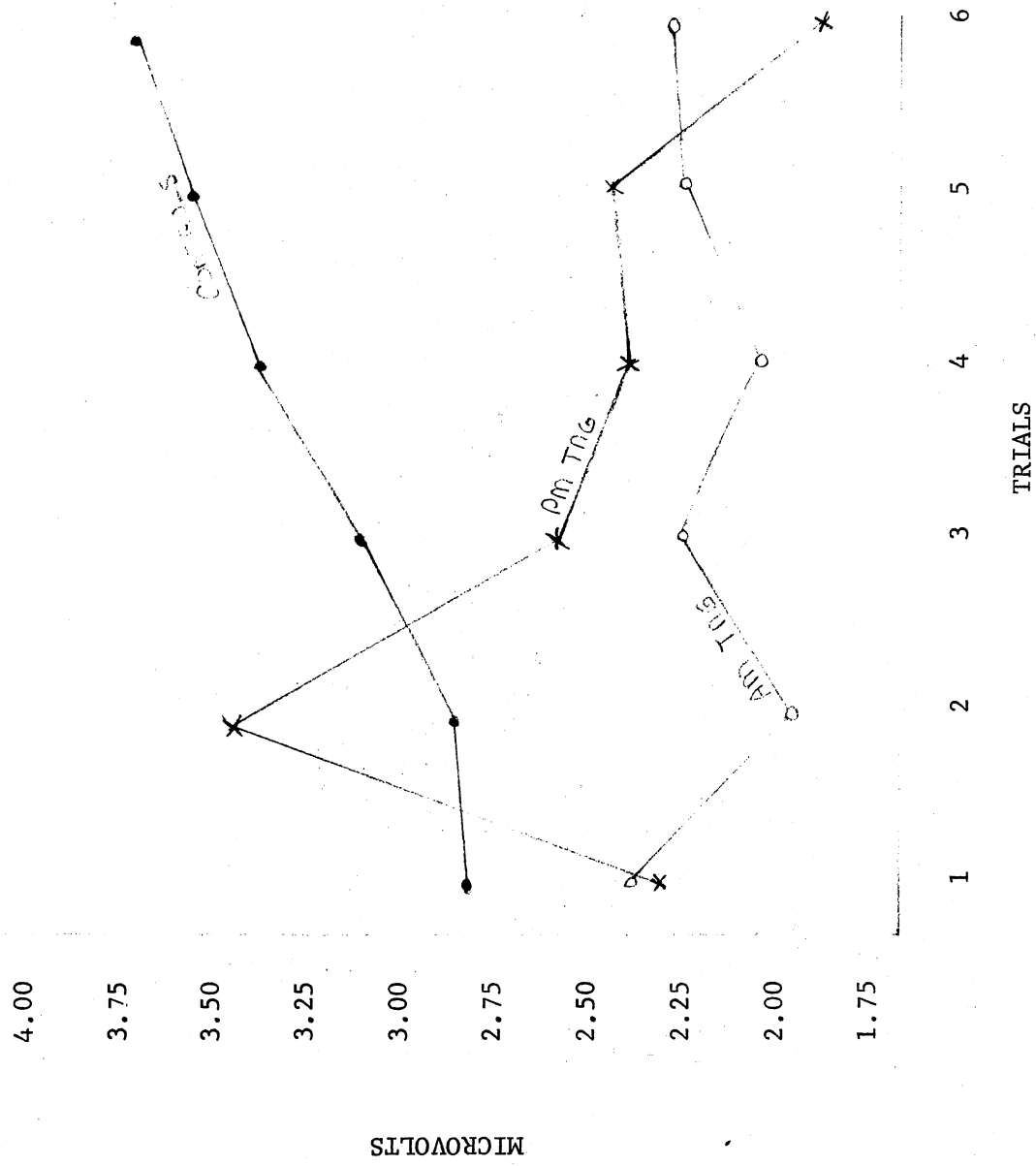
Figure 7. Test Period-Training x Trials

lower than the controls (P < .001). Though the EMG level of the afternoon trained biofeedback group was lower than the morning trained biofeedback group, this differences was not significant. The trials factor in the recovery period also reached significance (P < .01). In Figure 8 there can be seen an initial large drop in EMG levels from trials one to two. Then through trial eight, there was a gradual rise followed by another decrease in EMG levels. The test time by trial interaction also achieved significance (P < .05). The EMG level drop that took place on trial eight for those subjects tested in the morning was the primary factor in producing this significant interaction (Figure 9).

TABLE VI

AOV SUMMARY TABLE CONCERNING THE INDEPENDENT
VARIABLES TREATMENTS (MORNING BIOFEEDBACK
VERSUS AFTERNOON BIOFEEDBACK TRAINING
VERSUS CONTROLS) AND TEST TIME (MORN-
ING VERSUS AFTERNOON) DURING THE
RECOVERY PERIOD WITH MICRO-
VOLTS AS THE DEPENDENT
VARIABLE

Source	SS	df	MS	F	P
Total	514.0576	379			
Between	363.3362	37			
A (Treatments)	59.8165	2	29.9082	3.64	< .05
B (Test Time)	19.8731	1	19.8731	2.42	< .25
A x B	20.7361	2	10.3680	1.26	NS
Error (a)	262.9105	32	8.2159		
Within	150.7214	342			
C (Trials)	22.0733	9	2.4522	6.07	< .01
A x C	4.0973	18	.2276	.56	NS
B x C	6.8367	9	.7596	1.88	< .05
A x B x C	1.4123	18	.0784	.19	NS
Error (b)	116.3054	288	.4038		

TABLE VII

LSD TEST RECOVERY PERIOD

Pairwise Comparisons	AM Bft (1.7876)	PM Bft (1.49)
Controls (2.3615)		.8715 (P .001)
AM Bft (1.7876)	.5785 (P < .001)	.2976

Average Comparisons

Controls	2.3615
Mean of AM and PM Bft	1.6388
Difference	.7272 (P < .001)

When the test trials and recovery trials analysis (16 trials of variance were pooled, the treatment factor was still significant at the .05 level (Table VIII). Both the means of the morning and the afternoon biofeedback groups were significantly lower (P < .001) than the controls (Table IX). There were, however, no significant differences between the two experimental groups. In an examination of the individual performances of subjects in the experimental groups, it did not appear that any parti- cular subset of subjects was responsible for the lack of significant dif- ferences (Table X). The trials factor was also significant (P < .01). The significant trials effect was primarily due to the reduction in EMG levels as the subjects moved from the stress period to the recovery period as illustrated in Figure 8. Table XI summarized the means for each of the three groups during the training and the test phases.

Table XII gave the analysis of variance for errors produced in the nonsense syllable memorization task. No significant differences were

found among groups. An analysis of the distribution of the errors of the three treatment groups was also conducted. No significant differences among distribution patterns were found (Table XII).
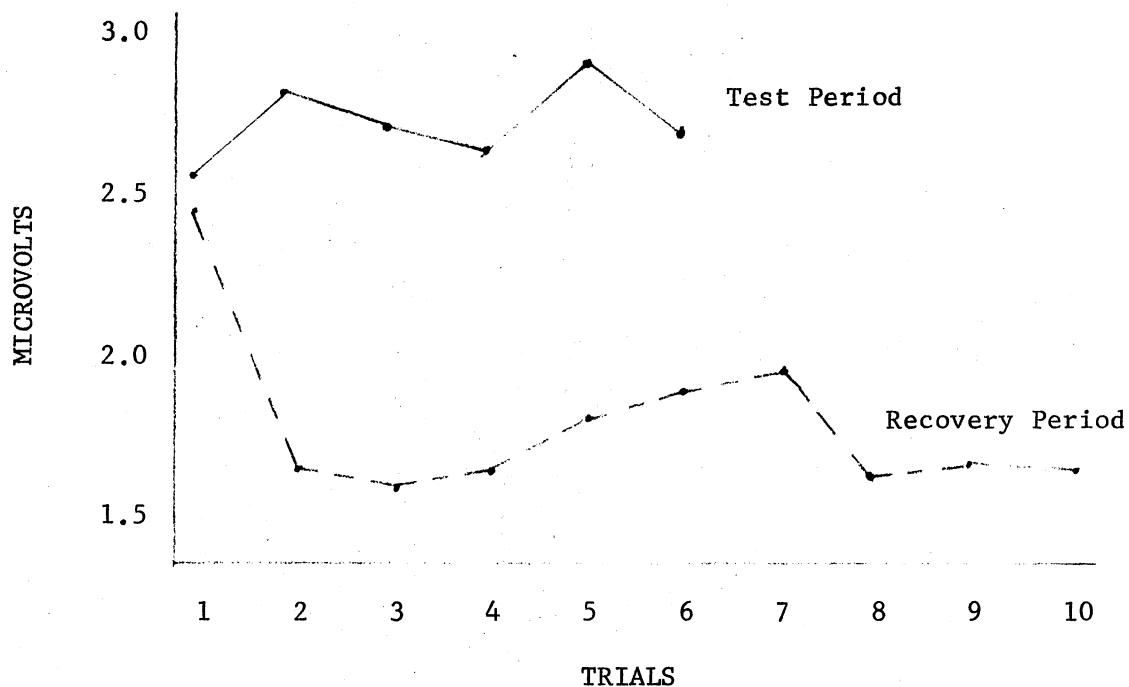
Figure 8. Test and Recovery Trials
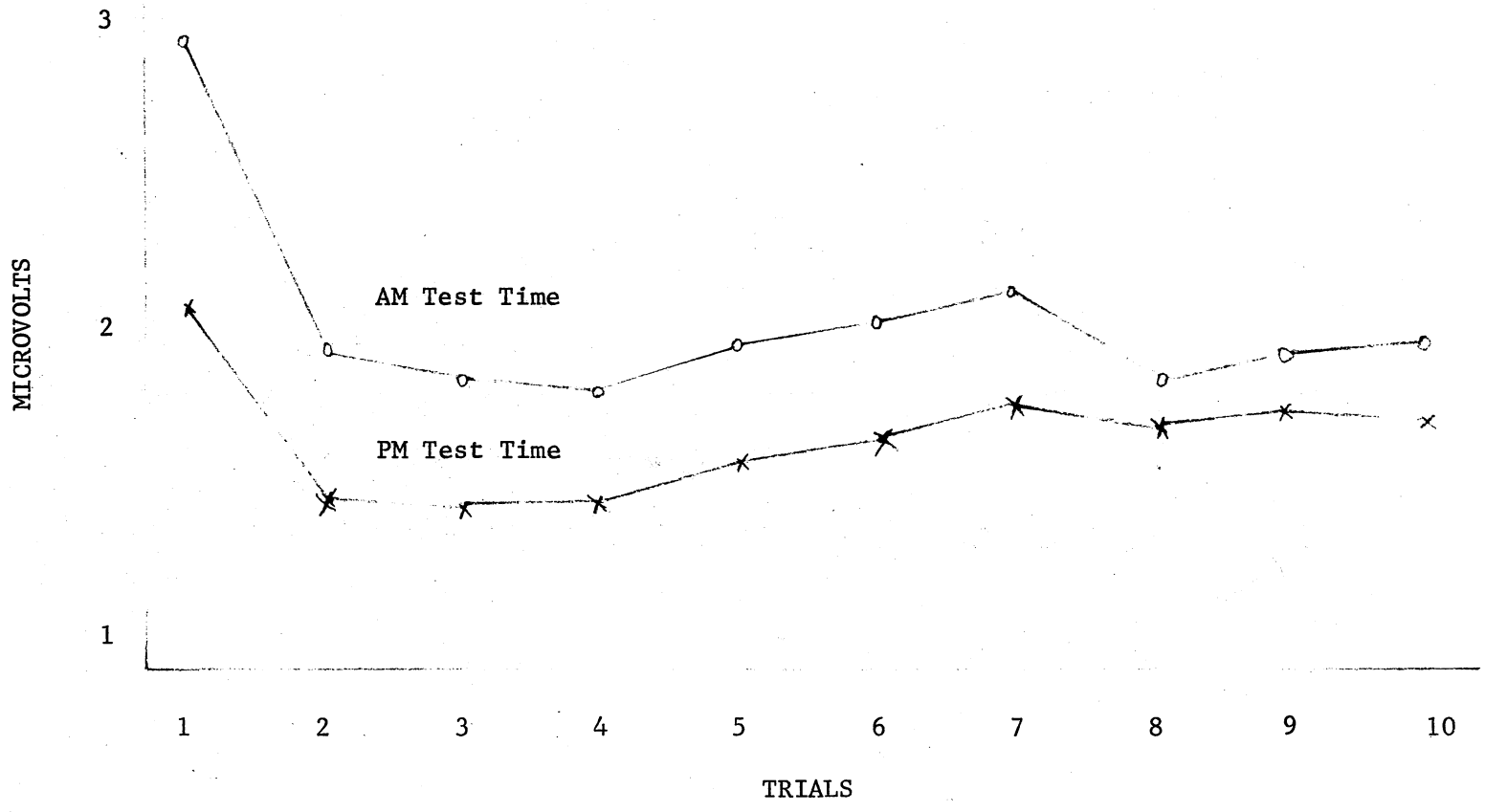
Figure 9. Recovery Period-Test Time x Trials

TABLE VIII

AOV SUMMARY TABLE CONCERNING THE INDEPENDENT
VARIABLES TREATMENTS (MORNING BIOFEEDBACK
VERSUS AFTERNOON BIOFEEDBACK TRAINING
VERSUS CONTROLS) AND TEST TIME
(MORNING VERSUS AFTERNOON)
DURING THE TEST PERIOD
AND RECOVERY PERIOD
POOLED WITH MICRO-
VOLTS AS THE
DEPENDENT
VARIABLE

Source	SS	df	MS	F	P
Total	1116.3762	607			
Between	571.1029	37			
A (Treatments)	101.0506	2	50.5253	4.1170	< .05
B (Test Time)	31.2955	1	31.2955	2.5500	< .10
A x B	46.0825	2	23.0412	1.8770	< .25
Error (a)	392.6743	32	12.2710		
Within	545.2763	570			
C (Trials)	131.5776	15	8.7718	11.4550	< .01
A x C	30.3571	30	1.0019	1.3300	NS
B x C	6.5790	15	.4386	.5720	NS
A x B x C	9.2252	30	.3075	.4016	NS
Error (b)	367.5374	480	.7657		

TABLE IX

THE MEAN EMG SCORES OF AM AND PM BIOFEEDBACK
SUBJECTS IN THE TRAINING, TEST AND
RECOVERY PERIODS

AM Biofeedback Group

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
Tng	2.93	1.17	1.76	1.26	1.38	.80	1.88	1.46	1.70	1.27
Test	3.94	2.14	1.89	3.31	1.61	1.36	1.66	3.01	2.01	1.78
Recovery	2.91	1.07	1.33	2.78	1.51	.96	1.24	1.84	1.24	1.58

PM Biofeedback Group

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
Tng	1.31	1.10	1.27	1.50	1.33	1.10	1.65	1.06	2.25	1.39
Test	3.65	1.36	2.00	1.76	2.13	1.92	2.35	1.64	5.24	3.28
Recovery	1.17	1.85	1.20	1.09	1.45	1.56	1.59	2.07	1.36	1.57

TABLE X

LSD TEST OF POST HOC COMPARISONS TEST AND
RECOVERY PERIOD (POOLED)

	AM Bft	PM Bft
Pairwise Comparisons	1.8781	1.8811
Controls (2.6987)	.8205 (P < .001)	.7318 (P < .001)
AM Bft (1.8781)		-.0029
Averaged Comparisons		
Controls	2.6987	
Mean of AM and PM Bft	1.8796	
Difference	.8190 (P < .001)	

TABLE XI

SUMMARY TABLE OF MEANS

Groups	Tng Phase	Pretest	Test	Recovery	Test and Recovery
Controls		2.14	3.26	2.36	2.70
AM Bft	1.56	1.70	2.27	1.79	1.88
PM Bft	1.40	2.02	2.53	1.49	1.88

TABLE XII

AOV SUMMARY TABLE CONCERNING THE INDEPENDENT
VARIABLES TREATMENTS (MORNING VERSUS
AFTERNOON BIOFEEDBACK VERSUS CON-
TROLS) AND TEST TIME (MORNING
VERSUS AFTERNOON) DURING THE
TEST PERIOD WITH NUMBER OF
NONSENSE SYLLABLE ERRORS
AS THE DEPENDENT
VARIABLE

Source					
Total	5476.764	3737			
A (Treatments)	48.486	2	24.2430	.150	NS
B (Test Time)	4.447	1	4.4470	.028	NS
A x B	363.075	2	181.5375	1.147	NS
Error	5060.756	32	158.1486		

TABLE XIII

CHI SQUARE SUMMARY TABLE CONCERNING THE
DISTRIBUTION PATTERN OF THE INDEPEN-
DENT VARIABLE TREATMENTS (MORNING
BIOFEEDBACK VERSUS AFTERNOON
BIOFEEDBACK VERSUS CON-
TROLS) WITH NONSENSE
SYLLABLE ERRORS AS
THE DEPENDENT
VARIABLE

Nonsense Syllable Errors	Treatment Groups			
	Control	Am Tng	PM Tng	
Under 40	4 (4.263)	3 (2.368)	2 (2.368)	9
41 - 50	4 (3.789)	2 (2.105)	2 (2.105)	8
Over 51	10 (9.947)	5 (5.526)	6 (5.526)	21
	18	10	10	

X^2 = .355, df = (3 - 1) (3 - 1) = 4 Not Significant

CHAPTER VI

DISCUSSION

The results indicated that as training sessions progressed subjects trained in the afternoon reached lower EMG levels than did subjects trained in the morning even though the afternoon subjects started at initially higher levels. The concept of circadian rhythms was used to explain these results.

The higher EMG levels of the afternoon trained biofeedback subjects in session one was consistent with previously observed data gathered on circadian rhythms. Luce (1970, p. 20) observed afternoon hours were associated with higher temperature levels and higher EMG levels. However, as sessions progressed, the EMG levels of the afternoon biofeedback group began to drop consistently below those of the morning biofeedback subjects. The superior performance of the afternoon biofeedback group after the first session was also consistent with the observed performance of subjects in Kleitman's 1963 study in which he found performance in tasks like card dealing, card sorting, mirror drawing, hand steadiness, body sway, multiplication, code transcription, and nonsense syllable copying varied directly with increases in body temperature. The second study by Kleitman, Titelbaum, and Deiveson (1938) and studies by Blake (1967) and Wilkinson (1967) also showed results which indicated superior performance correlated with increased body temperature. The reasons hypothesized by previous researchers for improved performance were based on

the subject's more efficient physiological functioning and on increased alertness.

The improved performance of the afternoon trained group can be explained by more efficient learning. Because learning was more effective in the afternoon, it might be expected that afternoon trained subjects would eventually outperform morning trained subjects even though the afternoon trained subjects began at initially higher tension levels.

Further support for the argument that circadian rhythms was the causal factor came from the correlation between EMG levels and core body temperatures as training progressed. Initially, the afternoon trained subjects had higher core temperatures than the morning trained subjects, and the afternoon trained subjects had higher EMG levels than those subjects trained in the morning. The correlation was positive. The higher core temperatures along with the higher EMG levels for the afternoon trained subjects were expected given previous research with circadian rhythms. The higher core temperatures for the afternoon subjects also predicted more efficient learning; and as sessions progressed, the afternoon subjects did, in fact, learn to relax more effectively. Also, as training progressed, the correlation changed from positive to negative. The reason for the change to a negative correlation was due to the progressively lower EMG levels achieved by the afternoon trained subjects. In summary the initially higher temperature levels for the afternoon biofeedback group could explain why the correlation between body temperature and EMG level changed to a negative. The subjects with initially higher core body temperatures were learning more efficiently; the subjects with higher core temperatures were generally the afternoon subjects.

The significant trials factor indicated people reached lower tension levels as the trail period progressed. This alone, however, did not indicate learning was taking place. The lower levels of relaxation could very easily be explained by a natural ability to relax regardless of the feedback received; however, the significant sessions effect supported the hypothesis that people were learning to relax and were using this ability to achieve even lower levels in subsequent sessions. These results supported other studies where subjects having biofeedback training reached significantly lower EMG levels than controls having no training (Alexander and Hansar, 1974; Coursey and Frankel, 1974; Haynes, 1974; Budzynski and Stoyva, 1969; and Budzynski, Stoyva, Adler, and Mullaney, 1973).

The afternoon biofeedback group did prove to be more effective in learning to relax as training sessions progressed. The question must be asked how clinically significant was this finding? That question must be answered in light of a number of factors. First, the average change in tension levels from trial 1 to 21 was 2.33 to 1.26 microvolts. This was a difference of 1.07 microvolts. The mean difference between the morning and the afternoon biofeedback groups in the fifth training session was .3 microvolts. Therefore, time of day accounted for .3/1.07 or 27% of the change. A factor accounting for 27% of the reduction in tension levels would certainly be conceptualized as potentially clinically significant. As demonstrated by the test situation, it did not necessarily mean that transfer to a test situation was automatic. Perhaps, transfer would take place in some situations, but it did not really occur in this situation. As discussed earlier, a larger number of training sessions would increase the probability of transfer, or methods of

stress training would have to be developed to insure such transfer.
Until that time, however, the demonstrated superiority of the afternoon
biofeedback group could still serve a useful purpose. In training ten-
sion headache subjects to relax, it was not unusual to find them reaching
a sticking point in their training. They might find, for instance, they
could not achieve a level less than 2 microvolts. Sometimes, this ex-
perience could become very frustrating for clients, and it might lead
them to quit training prematurely. If the clients were being trained
in the morning, it might be wise to switch them to an afternoon time to
help them overcome the barriers they had reached. Such changes might
ensure their staying in the program.

In the test and the recovery periods when the morning and the
afternoon biofeedback trained groups were combined and compared with the
controls, the results indicated transfer of training took place. (See
Table IX). The subjects in the biofeedback groups were able to use what
they learned in the training sessions to reduce their tension levels in
the stress period as compared with the controls. This effect carried
over to the recovery period where the experimental groups continued to
turn in superior performance.

These results supported previous data reported on the effectiveness
of biofeedback training. For example, Alexander and Hansar (1974) and
Coursey and Frankel (1974) both reported EMG frontalis biofeedback train-
ing was more effective when compared with control subjects who were only
told to relax. When subjects receiving a combination of autogenic and
Jacobsonian relaxation training were compared with biofeedback trained
subjects, the latter again turned in superior performances. Similarly,
EMG biofeedback training was found to be superior to pseudofeedback or

no feedback (Budzynski and Stoyva, 1969; and Budzynski, Stoyva, Adler, and Mullaney, 1973). All of the above training procedures had one factor in common; these procedures compared biofeedback groups to control groups during the acquisition period. The data from this thesis allowed for the extension of the conclusion of the superiority of biofeedback trained subjects to a stress situation. The results indicated subjects can use their biofeedback training to effectively reduce their tension levels during stress and during recovery from stress. Without such demonstrated positive results, it would not be as likely that the reported reduction in tension headaches was really a function of biofeedback training. Now that it was known that biofeedback trained subjects could effectively reduce their frontalis EMG levels during stress, it became less likely that a placebo factor was responsible for the reported reduction in tension headaches following biofeedback training.

It was possible to argue that the controls did more poorly than the biofeedback trained groups not because the controls did not receive biofeedback training but because the test surroundings were less familiar to the controls than it was for the biofeedback subjects. The biofeedback subjects received five training sessions in the test room, but the controls practiced at home and had received little exposure to the test room or to the experimenter. To discover the ultimate answer would be to do a study in which the controls did spend the same amount of time in the laboratory prior to the stress situation. But, until then, there would be one piece of evidence which did not support this argument. In the pretest period when subjects were told to sit quietly, there were no significant differences between the two groups. If the controls were

tense because of the unfamiliar surroundings, it should have shown up, especially in the initial phases of the pretest period, but it did not.

Though the afternoon biofeedback group achieved lower tension levels in the training phase, as sessions progressed this finding did not transfer to the stress session. Significant differences between the morning and the afternoon groups were not attained during the test and during the recovery periods.

These results should not vitiate the fact that significant differences were attained in the training period. The question that might be asked is how to arrange it so that transfer could take place. For instance, subjects could quite readily learn a task; but when they were subjected to stress, they might not make use of their abilities. Perhaps a critical part of biofeedback training must be a stress training procedure which would help ensure transfer to critical situations.

Another reason transfer did not take place had to do with the small number of training sessions involved. Subjects receiving biofeedback training for tension headaches usually received 16 to 20 training sessions. It was quite possible that if a larger number of training sessions were undertaken, then transfer would have taken place. The Table of Means (see Table X) did give some encouragement that with more training significant differences between the morning and the afternoon groups might be attained. The means of the morning and the afternoon groups in the recovery period of the stress period were 1.79 and 1.49 microvolts, respectively. The recovery period was the period of the stress phase which was most similar to the training phase, and the one in which transfer of training would most likely have taken place. Though the differences in the two means were not significant, they were in the same

direction as was found in the training period. Therefore, it was quite possible that a larger number of sessions (15 or 20) could produce significant differences in the morning and the afternoon groups in recovery from stress. Also, in the stress period by trial six (see Figure 9) the afternoon group reached a point where it was at a lower level than the morning group. It is possible that if the stress period were a more prolonged one, then the afternoon group might have reached a significantly lower level than the morning trained group.

The two biofeedback and the control groups changed over the three periods of the stress phase in the following fashion. The introduction of the stress task influenced the tension levels to the point of erasing any biorhythm influence based on the time of day that had been present during the pretest. However, the previous biofeefback training still showed its effects during the test period by reduced tension levels in comparison to the controls. It appeared that the impact of the stress agent did not prevent the subjects from using what they had learned. Therefore, stress overode any biorhythm effect on muscle tension, but not the effects of biofeedback training.

In the stress period the rank order of the three groups initially was the same as the pretest period, but the differences in their tension levels changed as trials progressed. The most important change was the steadily increasing tension levels of the control subjects as trials progressed. The afternoon biofeedback subjects also increased their tension levels initially. After trial two, however, what they had learned in the training period apparently took hold, and these subjects began to reduce their tension levels. The impact of the biofeedback training on the morning subjects took place more quickly in comparison

with the afternoon group. After trial number two, the subjects did not

further reduce their tension levels; in fact, there was a slight rise.

The afternoon biofeedback subjects continued, on the other hand, to

maintain steady drops until by trial six they were the lowest of the

three groups. The rank order of the three groups in trial six in order

of decreasing EMG levels were: the control group, the afternoon biofeed-

back group, and the morning biofeedback group. The rank order was main-

tained in the recovery period, and there was no treatment by trials

interaction during the recovery period. All three groups decreased their

EMG levels at the same rate in the recovery period. Any relative changes

among the three groups as a result of the stress or the treatments had

taken place by the last trial of the stress period. The main conclusion

from this finding was that the value of biofeedback training made itself

felt in the stress period. The significant difference found among the

control group and the biofeedback groups in the recovery period was a

continuation of the changes that had already taken place in the stress

period.

There were no significant differences among the groups on the basis

of their learning nonsense syllables. The nonsense syllables (Appendix)

were chosen to be difficult; and as a result, there were very wide dif-

ferences in performances. A number of subjects gave no correct responses.

It appeared that some of the subjects simply quit trying to master the

task. With a task that produced such a wide disparity in responding, it

was possible that the task was not sensitive enough to detect any dif-

ferences which were produced by the different training approaches.

There was one extraneous variable which could have produced some

error. The room was not sound proofed. As a result, some outside noise

did drift through the walls. The subjects did wear headphones which produced a continuous biofeedback signal, and the headphones did help to eliminate most of the noise. Also, the door to the room was insulated and particular care was taken to see if that when noise was present, that if any discernible changes were present in the EMG levels. No changes were noted. During the debriefing, subjects were asked if outside noise had bothered them. They uniformly replied that it had not. Some individuals said they could occasionally hear outside noise, but it sounded very far away.

Further research could take a number of directions. For instance, experimental subjects could be given a single biofeedback session. Controls would also be given a single session consisting of meditation training, autogenic training, or self-hyponosis. Then all subjects could be tested under a stress condition. Such a design would focus on the single question of whether biofeedback training was superior to alternate types of training in alleviating tension under stress conditions. This experiment would evaluate the argument that environmental differences might have an impact on EMG levels in the present experiment. A second profitable experiment would be to delete the controls and would be to extend the number of sessions to 16 for those people in the morning and afternoon biofeedback groups. (This number of sessions would more closely approximate the typical clinical situation.) The subjects could then be tested under a stress condition to see if significant differences were achieved as a function of the larger number of trials.

For research purposes in the area of biofeedback, this study was important. It pointed out that any study utilizing EMG biofeedback must

take into account circadian rhythms as a possible vitiating factor.

Subjects in control and in experimental groups must receive their treat-

ments so that time of day (i.e., circadian rhythms) is factored out.

CHAPTER VII

SUMMARY

This experiment was designed to compare the performance levels of
subjects given EMG frontalis biofeedback training in the morning hours
with subjects given the same training in the afternoon hours. Subjects
in both groups underwent five 20-minute training sessions. Body core
temperatures were measured in all training sessions to examine the con-
tributions of circadian rhythms for any differences found. People in
both experimental groups were placed in a stress situation which involved
the memorization of nonsense syllables. A control group receiving no
biofeedback training also underwent the stress phase. Electromyographic
levels of the experimental and of the control groups were compared in
the pretest, test, and recovery periods of the stress phase. Perfor-
mances in mastering the stress task (nonsense syllable memorization)
were also observed.

All of the biofeedback subjects appeared to increase their abilities
to learn to relax as sessions progressed. The subjects who received
biofeedback training in the afternoon reached lower electromyographic
levels than the morning subjects as training sessions progressed. The
differences in performance levels between the two experimental groups
appeared to be best explained by the more efficient learning on the
part of the subjects trained in the afternoon. The more efficient learn-
ing was consistent with previous research that indicated more efficient

functioning occurred in the afternoon hours when body core temperature was reaching a maximum. The practical clinical significance of these training results was discussed.

In the stress phase of the experiment the biofeedback trained subjects reached significantly lower levels of tension than the controls in both the stress and recovery periods. The afternoon trained subjects did not reach significantly lower tension levels than the morning trained subjects though there was evidence of a trend in that direction. Reasons for a failure of the transfer of the performance differences between the two experimental groups to the stress phase were discussed. No differences were found among groups with respect to the performances during the stress task of nonsense syllable memorization. Lack of differences among groups with respect to the stress task might have been due to the wide variances in performances among subjects.

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APPENDIX

INSTRUCTIONS TO MEDITATION GROUPS

You breathe in and out all day and night, but you are never mindful of it, you never for a second concentrate your mind on it. Now you are going to do just this. Breathe in and out as usual, without any effort or strain. Now, bring your mind to concentrate on your breathing-in and breathing-out; let your mind watch and observe your breathing in and out; let your mind be aware and vigilant of your breathing in and out. When you breathe, you sometimes take deep breaths, sometimes not. This does not matter at all. Breathe normally and naturally. The only thing is that when you take deep breaths, you should be aware that they are deep breaths, and so on. In other words, your mind should be so fully concentrated on your breathing that you are aware of its movements and changes. Forget all other things, your surroundings, your environment; do not raise your eyes and look at anything. Try to do this for 20 minutes.

At the beginning, you will find it extremely difficult to bring your mind to concentrate on your breathing. You will be astonished how your mind runs away. It does not stay. You begin to think of various things. You hear sounds outside. Your mind is disturbed and distracted. You may be dismayed and disappointed. But if you continue to practice this exercise, you will gradually, by and by, begin to concentrate your mind on your breathing. After a certain period, you will experience just that split second when your mind is fully concentrated on your breathing, when you will not hear even sounds nearby, when no external world exists for you. This slight moment is such a tremendous experience for you, full of joy, happiness and tranquility, that you would like to continue it. But still you cannot. Yet, if you go on practicing this regularly, you may repeat the experience again and again for longer and longer periods. That is the moment, when you lose yourself completely in your mindfulness of breathing. As long as you are conscious of yourself, you cannot concentrate on anything.

During the 20 minute session, there will be 30 second breaks every five minutes. Remember to keep your eyes closed, and do not talk or move except during the 30 second breaks.

LIST OF NONSENSE SYLLABLES

DEF	PIJ
DRF	NAC
DKT	MAQ
VGB	RYD
VRT	SOZ
VMB	WAH
QGF	TEB
QPB	XEL
QJT	YUG
QKT	CYR

VITA

Dennis Edward Mercadal

Candidate for the Degree of

Doctor of Philosophy

Thesis: THE CONTRIBUTIONS OF CIRCADIAN RHYTHMS AND BIOFEEDBACK TRAINING
IN LEARNING TO RELAX AND MINIMIZING TENSION UNDER STRESS

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