EMG Biofeedback as a Generalized Relaxation Technique

David Cunningham

University of Central Florida, dcunningham3@cfl.rr.com

This Masters Thesis (Open Access) is brought to you for free and open access by STARS. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of STARS. For more information, please contact STARS@ucf.edu.

STARS Citation
Cunningham, David, "EMG Biofeedback as a Generalized Relaxation Technique" (1979). Retrospective Theses and Dissertations. 408.
https://stars.library.ucf.edu/rtd/408
EMG BIOFEEDBACK AS A
GENERALIZED RELAXATION TECHNIQUE

BY

DAVID CUNNINGHAM
B.A., University of Central Florida, 1977

THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science: Clinical Psychology
in the Graduate Studies Program of the College of Social
Sciences at the University of Central Florida;
Orlando, Florida

Summer Quarter
1979
ABSTRACT

Ten college students serving as volunteer subjects were randomly assigned to one of two groups. One group received EMG biofeedback training using feedback from the frontalis muscle only, and the other group received EMG biofeedback training using feedback from several muscle sites. It was hypothesized that subjects who were given EMG biofeedback relaxation training sequentially from several muscle sites would be able to lower EMG levels at these sites to a significantly greater degree than subjects who received EMG biofeedback relaxation training using feedback from the frontalis muscle only. Both groups were given a pre-training baseline session, nine training sessions, and a post-training baseline session.

Comparing the mean pre-training and post-training baseline EMG levels of each group at each muscle site using t-tests showed that there was no significant reduction of EMG muscle activity at any monitored muscle site due to either frontalis feedback training only or multiple muscle feedback training.

This failure to obtain significant training effects may have resulted from using college students as subjects since they were not trying to relieve a stress-
related disorder and they exhibited low initial baseline EMG levels. It is suggested that future research on the generalization of EMG biofeedback training be done using a clinical population having elevated EMG levels.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>iv</td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>II. METHOD</td>
<td>10</td>
</tr>
<tr>
<td>Design</td>
<td></td>
</tr>
<tr>
<td>Subjects</td>
<td></td>
</tr>
<tr>
<td>Apparatus</td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td></td>
</tr>
<tr>
<td>III. RESULTS</td>
<td>14</td>
</tr>
<tr>
<td>IV. DISCUSSION</td>
<td>18</td>
</tr>
<tr>
<td>APPENDIX A INFORMED CONSENT FORM FOR</td>
<td>20</td>
</tr>
<tr>
<td>PARTICIPATION IN BIOFEEDBACK LAB EXPERIMENT</td>
<td></td>
</tr>
<tr>
<td>REFERENCES NOTES</td>
<td>20</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>23</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Individual Subject Average EMG Levels</td>
<td>15</td>
</tr>
<tr>
<td>2 Mean Baseline EMG Levels and Mean Change Scores for Each Group at Each Electrode Site</td>
<td>16</td>
</tr>
</tbody>
</table>
I. INTRODUCTION

In EMG biofeedback, sensors which detect the electrical activity of motor neurons are placed on the surface of the skin over muscles. The amplitude of this electrical activity, quantified in terms of microvolts, is directly proportional to the degree of muscular contraction. This electrical activity is then amplified by an electromyograph (EMG) and fed back to an individual on an immediate basis in the form of auditory or visual information which is also proportional to the degree of muscular contraction. By using the feedback information an individual can learn to voluntarily control the activity of the monitored muscle.

EMG biofeedback appears to be the most clinically useful of all biofeedback techniques, having been applied to a range of disorders that include tension headache (Budzynski, Stoyva, Adler, & Mullaney, 1973), asthma (Kotses, Glaus, Bricel, Crawford, & Edwards, Note 1), hyperactivity in children (Braud, 1978), diabetes (Fowler, Budzynski, & Vanden Bergh, 1976), insomnia (Freedman & Papsdorf, Note 2), and speech and motor dysfunction in cerebral palsied persons (Finley, Niman, Standley, & Ender, 1976).
When using EMG biofeedback in the variety of applications listed above, training is conducted with the individual receiving feedback of frontalis (forehead) muscle activity to aid in the goal of reducing muscle activity. This general usefulness of EMG biofeedback may be due to effective relaxation of the monitored muscle, which then generalizes to other areas of the body musculature and/or other physiological systems. It has been suggested that a reduction in muscle activity leads to lowered arousal in the central nervous system (Budzynski & Stoyva, 1969) and the autonomic nervous system (Gellhorn & Keily, 1972). Both questions, of generalization of EMG biofeedback training over a widespread area of the body musculature, and generalization of effects to other physiological systems, deserve further analysis if we are to understand the widespread clinical effectiveness of EMG biofeedback relaxation training.

The focus of this paper will be on the question of generalization of effects from the monitored muscle to other muscles of the body. To answer this question two things need to be established: 1) the effectiveness of training at the initially monitored muscle from which feedback is given, and 2) whether the effects of training at one muscle site will generalize to other muscles.

Several studies (Budzynski & Stoyva, 1969;
Coursey, 1975; Ohno, Tanaka, Takeya, Matsubara, Kuriya, & Komemushi, 1978; Reinking & Kohl, 1975) have clearly established that it is possible to reduce frontalis muscle activity using EMG biofeedback. In an early study, Budzynski and Stoyva (1969) had three groups of five subjects each undergo three sessions of either accurate frontalis feedback, irrelevant (false) feedback, or no feedback (silent condition) to determine whether a high degree of control in reducing frontalis muscle activity could be learned using EMG feedback. Superiority of the accurate feedback was shown in that after the three training sessions the feedback group had lowered frontalis EMG levels by 50%, while the irrelevant feedback group had decreased frontalis activity by 28%, and the no feedback group had decreased EMG levels about 24%. Coursey (1975) conducted an experiment comparing EMG frontalis feedback training, brief facial relaxation instructions, and a control condition in which subjects were told to relax as much as possible using whatever means they could. There were three groups of ten subjects for each condition, and all received seven training sessions. Coursey found the EMG feedback group had reduced frontalis EMG activity to a significantly lower level than the other two groups, which did not differ from one another in the final analysis. Ohno, et al. (1978) did a study on the voluntary control of
frontalis activity using two groups of ten subjects each given five 40-minute training sessions. One group was given frontalis EMG feedback and told to relax their foreheads with the help of a sound (auditory feedback) proportional to their EMG level. The second group, a control group, was told to relax their foreheads, and given no other information. Results showed that the biofeedback group relaxed the frontalis more quickly and consistently than the control group. In a study comparing various forms of relaxation training, Reinking and Kohl (1975) employed five groups of subjects in the following conditions: 1) classical Jacobson-Wolpe instructions, 2) EMG frontalis feedback, 3) EMG feedback plus Jacobson-Wolpe instructions, 4) EMG feedback plus a monetary reward, and 5) a no-treatment control group. All groups received three baseline sessions and 12 one-hour relaxation training sessions. The four treatment groups reduced frontalis EMG levels significantly in comparison to the no-treatment control group which did not reduce frontalis activity at all. Also, the EMG feedback groups, in comparison to the group receiving Jacobson-Wolpe instructions alone, reduced frontalis EMG activity to a significantly lower level.

Evidence concerning the generalization of effects of frontalis EMG feedback training to other muscles of the body is equivocal. Wilkinson (Note 3), in a review
of the literature regarding the use of EMG biofeedback as a general relaxation technique, did not find any significant evidence of generalization. There is one exception. Glaus and Kotses (Note 4) used three groups of ten subjects in their study of the generalization of frontalis EMG biofeedback training. One group was instructed to increase frontalis muscle activity using frontalis EMG biofeedback; the second group was instructed to decrease frontalis muscle activity using frontalis EMG biofeedback; and the third group was given false frontalis EMG feedback with half the group instructed to increase and half instructed to decrease their frontalis muscle activity. Frontalis activity and forearm flexor (brachioradialis) muscle activity were monitored simultaneously with two separate electromyographs. Forearm flexor activity reflected changes in frontalis muscle activity. There were increased flexor activity in the frontalis increase group, decreased flexor activity in the frontalis decrease group, and no significant change in the false feedback group; but it was not until the third of three sessions that significant group differences appeared. Other evidence supporting the generalization of effects is not very strong. Stoyva and Budzynski (1974) attempted to show generalization of EMG biofeedback training employing three groups of subjects under the following conditions:
1) auditory EMG feedback from the frontalis, 2) auditory EMG feedback from the forearm extensor, and 3) false EMG feedback tape recorded from the frontalis muscles of other subjects. Both the frontalis and forearm EMG levels were recorded on all subjects. All subjects were instructed to decrease muscle activity by decreasing the frequency rate of audible clicks that was proportional to the activity of the monitored muscle. Data showed that only the frontalis feedback group decreased both frontalis and forearm EMG levels significantly. Though the extensor feedback group significantly decreased forearm EMG levels, there was virtually no change in frontalis EMG levels. It must be noted that while the frontalis feedback group decreased forearm EMG levels by 45%, the false feedback group decreased their forearm EMG levels by 39%. This similarity in reduction of forearm EMG levels does not seem to be related to the generalization of frontalis muscle activity since only the frontalis feedback group significantly reduced their frontalis EMG levels.

Basmajian (1976) speculates that when using the frontalis as the site to train control of muscle activity, generalization of training will occur because EMG levels from the forehead do not necessarily reflect the activity of only the frontalis muscle. He states that "the integrated EMG from forehead surface
electrodes generally reflects the total or global EMG of all sorts of repeated dynamic muscular activities down to about the first rib" (p. 370). Unfortunately Basmajian does not back this hypothesis with any data.

There is concrete experimental evidence indicating that EMG biofeedback training of the frontalis will not generalize to other muscles. Alexander (1975) used two groups of subjects in a study to assess EMG biofeedback training as a relaxation technique. One group received three sessions of EMG feedback from the frontalis with instructions to decrease muscle activity, along with before and after training baseline sessions. The other group served as controls and had baseline readings taken for five sessions. EMG data were recorded sequentially from the frontalis, forearm extensor, and leg extensor. Though the frontalis EMG feedback group significantly reduced frontalis activity, forearm extensor activity significantly increased and the leg EMG did not change. The only significant change for the control group was an increase in forearm EMG levels. Alexander concludes that this evidence shows EMG biofeedback training as being highly discriminative rather than promoting generalization. Shedivy and Kleinman (1977) conducted an experiment which supports Alexander's conclusions. Eight subjects were trained to increase and decrease frontalis activity using frontalis EMG
feedback, while the activity of neck muscles was being monitored simultaneously. The subjects did significantly raise and lower frontalis EMG levels, but the only significant effect on the neck muscles was an increase in activity during frontalis relaxation. The preceding experimental findings have important clinical implications. Kohli (Note 5) has found that when a person has a complaint of chronic muscle tension that causes pain in one part of the body, several groups of muscles are affected. For example if a person has chronic muscle tension headaches, not only is the frontalis involved, but also the neck and shoulder muscles are. Treating one muscle group may only bring temporary symptom relief.

While the experimental evidence clearly shows that an individual can learn to control frontalis muscle activity, the unresolved issue is whether this control of frontalis activity will generalize to other muscles of the body.

The purpose of this study was to investigate whether or not a sequential EMG biofeedback relaxation training of several muscle sites will result in significantly greater generalization of effects than EMG biofeedback relaxation training using feedback from the frontalis muscle only. It was hypothesized that subjects who were given EMG feedback relaxation training
from several muscle sites would be able to lower EMG levels at these sites to a significantly greater degree after training in comparison to subjects who receive EMG feedback relaxation training using feedback from the frontalis muscle only.
II. METHOD

Design

Subjects were randomly assigned to one of two groups before participating in the experiment. The frontalis muscle training group (FM) received a pre-training baseline session, nine sessions of EMG biofeedback relaxation training using feedback from the frontalis muscle, and a post-training baseline session.

The multiple muscle training group (MM) also received a pre-training baseline session, nine EMG biofeedback relaxation training sessions, and a post-training baseline session. However, for the MM group, the nine EMG feedback training sessions consisted of three sessions using feedback from the frontalis, followed by three sessions using feedback from the right forearm extensor, followed by three sessions using feedback from the posterior cervical (neck) muscles.

Subjects

Ten undergraduate students from the University of Central Florida served as volunteer subjects. After screening to exclude students with medical disorders, and those taking medications, five were randomly assigned to each of the two experimental groups.
Students selected to serve as subjects were required to read and sign an informed consent form (see Appendix A) before beginning participation in the experiment.

**Apparatus**

All EMG levels were monitored with one Autogen 1700 electromyograph using a 100-200 Hz. frequency band-pass. A multiple input selector which permits sequential monitoring of three different sets of electrodes was used to assess EMG levels at the frontalis, posterior cervical muscles, and the right forearm extensor during the pre-training and post-training baseline sessions. An Autogen 5600 data acquisition center was used to collect all EMG data during the study.

**Procedure**

The pre-training and post-training baseline sessions were identical in format for both the FM group and MM group. Subjects were instructed to relax as much as possible while keeping movement to a minimum. No EMG feedback was given in either baseline session. EMG data were taken from the three electrode sites in the following fixed sequence: frontalis, followed by the forearm extensor, followed by the neck muscles. Data were collected at two-minute intervals for a total of 24 minutes. Using the multiple input selector, the electromyograph was switched to the next electrode site.
in the fixed sequence following each two-minute average reading. Repeating this fixed sequence of monitoring the three electrode sites for 24 minutes resulted in four two-minute average EMG level readings at each of the three electrode sites.

Analog auditory EMG feedback was used in the training sessions. This feedback was in the form of audible clicks. The frequency of the clicks varied in direct proportion to the amount of muscle contraction. A high level of muscle EMG activity resulted in a fast click rate, and a low level of muscle EMG activity resulted in a slow click rate. EMG feedback was given to the subjects through headphones in all training sessions.

In the training sessions the FM group received nine sessions of frontalis EMG feedback relaxation training. Frontalis EMG data were recorded every two minutes over a total period of 24 minutes in each training session.

The MM group also received nine EMG feedback relaxation training sessions. However, the MM group received three sessions using EMG feedback from the frontalis, followed by three sessions using EMG feedback from the right forearm extensor, followed by three sessions using EMG feedback from the posterior cervical (neck) muscles. In all training sessions, EMG data were
recorded at two-minute intervals for a total of 24 minutes.

Instructions to both the FM group and MM group during the training sessions were as follows: Try to relax as much as possible using the feedback as a guide to the amount of muscle activity. Fast clicks mean there is a lot of muscle activity; slow clicks mean there is less muscle activity. Try to make the clicks go as slowly as you can by relaxing deeply.
III. RESULTS

For each subject the average EMG level at each electrode site (frontalis, forearm extensor, and rear neck) during the pre-training and post-training baseline sessions was computed. Baseline change scores (ΔB) were also computed by subtracting the average EMG level of the post-training baseline session from the average EMG level of the pre-training baseline session (Baseline 1 - Baseline 2). These average pre-training and post-training baseline EMG levels along with average baseline change scores for each subject are shown in Table 1.

Mean pre-training and post-training baseline EMG levels and mean change scores for each electrode site (forehead, forearm, neck) are shown in Table 2. The comparison of pre- and post-training baseline EMG levels of the frontalis muscle showed no significant effect of training for the FM group, \( t(4) = 1.004, P > .05 \), and no significant training plus generalization effects for the MM group, \( t(4) = 1.481, P > .05 \). The pre- and post-training baseline EMG levels of the forearm extensor showed no significant generalization effects from frontalis feedback training for the FM group, \( t(4) = -0.414, P > .05 \), and no significant training plus
<table>
<thead>
<tr>
<th>Site</th>
<th>Group</th>
<th>Frontalis Only Baseline 1-Baseline 2=B Δ</th>
<th>Multiple Muscle Baseline 1-Baseline 2=B Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontalis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>Frontalis Only</td>
<td>1.429 1.541 -.112</td>
<td>S1</td>
</tr>
<tr>
<td>S2</td>
<td>Frontalis Only</td>
<td>1.990 1.200 .79</td>
<td>S2</td>
</tr>
<tr>
<td>S3</td>
<td>Frontalis Only</td>
<td>1.417 1.326 .09</td>
<td>S3</td>
</tr>
<tr>
<td>S4</td>
<td>Frontalis Only</td>
<td>1.500 1.894 -.394</td>
<td>S4</td>
</tr>
<tr>
<td>S5</td>
<td>Frontalis Only</td>
<td>2.003 1.106 .897</td>
<td>S5</td>
</tr>
<tr>
<td>Forearm Extensor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>Forearm Extensor</td>
<td>.450 .443 .007</td>
<td>S1</td>
</tr>
<tr>
<td>S2</td>
<td>Forearm Extensor</td>
<td>.408 .572 -.164</td>
<td>S2</td>
</tr>
<tr>
<td>S3</td>
<td>Forearm Extensor</td>
<td>.311 .317 -.006</td>
<td>S3</td>
</tr>
<tr>
<td>S4</td>
<td>Forearm Extensor</td>
<td>.509 .341 .168</td>
<td>S4</td>
</tr>
<tr>
<td>S5</td>
<td>Forearm Extensor</td>
<td>1.067 1.194 -.127</td>
<td>S5</td>
</tr>
<tr>
<td>Cervical Muscles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>Cervical Muscles</td>
<td>2.308 1.846 .462</td>
<td>S1</td>
</tr>
<tr>
<td>S2</td>
<td>Cervical Muscles</td>
<td>1.299 2.434 -1.135</td>
<td>S2</td>
</tr>
<tr>
<td>S3</td>
<td>Cervical Muscles</td>
<td>2.272 1.273 .999</td>
<td>S3</td>
</tr>
<tr>
<td>S4</td>
<td>Cervical Muscles</td>
<td>1.494 1.456 .038</td>
<td>S4</td>
</tr>
<tr>
<td>S5</td>
<td>Cervical Muscles</td>
<td>2.768 1.966 .802</td>
<td>S5</td>
</tr>
</tbody>
</table>
TABLE 2
MEAN BASELINE EMG LEVELS AND MEAN CHANGE SCORES FOR EACH GROUP AT EACH ELECTRODE SITE

<table>
<thead>
<tr>
<th>Site</th>
<th>Frontalis Only</th>
<th>Multiple Muscle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Frontalis</td>
<td>1.668</td>
<td>1.413</td>
</tr>
<tr>
<td>Forearm Extensor</td>
<td>.657</td>
<td>.573</td>
</tr>
<tr>
<td>Cervical Muscles</td>
<td>2.029</td>
<td>1.795</td>
</tr>
</tbody>
</table>
generalization effects for the MM group, \( t(4) = 2.287, p > .05 \). The pre- and post-training baseline comparisons of EMG levels at the neck muscles also showed no significant generalization of effects from frontalis feedback training for the FM group, \( t(4) = .615, p > .05 \), and no significant training plus generalization effects for the MM group, \( t(4) = -.002, p > .05 \).

In summary, there was no significant reduction of EMG muscle activity at any monitored muscle site due to either frontalis feedback training only or multiple muscle feedback training.
IV. DISCUSSION

It was hypothesized that this experiment would show that subjects who were given EMG biofeedback relaxation training sequentially from several muscle sites would be able to lower EMG levels at these sites to a significantly greater degree than subjects who received EMG biofeedback relaxation training using feedback from the frontalis muscle only.

This hypothesis was not supported. Data analysis showed that neither the FM group nor the MM group was able to lower EMG levels significantly at any of the training or other muscle sites (forehead, forearm, neck).

It is unclear why the lack of any training effects occurred. This failure to obtain significant training effects may have resulted from using college students as subjects since they exhibited low initial baseline EMG levels. Table 2 shows that the highest pre-training baseline mean EMG level at any of the monitored muscle sites was only 3 microvolts. Budzynski (1973) uses an EMG level of 3 microvolts as a criterion of successful EMG training for his clinical patients at the Applied Biofeedback Institute. Since the nonclinical sample of subjects used in this study had such low
EMG levels prior to training and none had stress-related disorders which they were trying to relieve, they may not have been adequately motivated to put their full effort into the biofeedback training. Also, the Law of Initial Values applied to skeletal muscle relaxation training (Kinsman & Staudenmeyer, 1978) suggests that high baseline EMG levels will be associated with greater decreases in EMG activity for any type of relaxation training. Lower pre-training baseline EMG levels should be related to smaller decreases in EMG activity.

The question of whether EMG biofeedback training generalizes to muscle groups other than the one used for feedback deserves further study. Perhaps this would best be done using a clinical population having elevated EMG levels and real motivation for successful training.
APPENDIX A

INFORMED CONSENT FORM FOR PARTICIPATION IN BIOFEEDBACK LAB EXPERIMENT
Informed Consent Form for Participation in Biofeedback Lab Experiment

Read the following information carefully before signing this form!

You will be required to participate in eleven sessions, each lasting approximately 35 minutes. Sessions will be scheduled three times a week on Monday, Wednesday, and Friday.

During the first session the muscle activity from your forehead, right forearm and neck will be monitored for 24 minutes. The next nine sessions will involve EMG (muscle activity) biofeedback relaxation training. In the last session, the muscle activity from your forehead, right forearm, and neck will again be monitored for 24 minutes.

If at any time during the experimental sessions you begin to feel uncomfortable or reluctant to continue, you are encouraged to inform the person working in the lab so that your participation can be terminated.

I have read and understand the preceding information and consent to participate in this experiment.

DATE ___________________________ SIGNATURE ___________________________
REFERENCE NOTES


REFERENCES


