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Richman, Steven

**FRONTALIS FEEDBACK AND INSTRUCTIONAL SET IN RELAXATION
TRAINING: EFFECTS ON FRONTALIS TENSION AND OTHER
PHYSIOLOGICAL VARIABLES**

City University of New York

Ph.D. 1984

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FRONTALIS FEEDBACK AND INSTRUCTIONAL SET
IN RELAXATION TRAINING:
EFFECTS ON FRONTALIS TENSION
AND OTHER PHYSIOLOGICAL VARIABLES

BY

STEVEN RICHMAN

A dissertation submitted to the Graduate
Faculty in Psychology in partial
fulfillment of the requirements for the
degree of Doctor of Philosophy, The City
University of New York.

1984

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This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

FRONTALIS FEEDBACK AND INSTRUCTIONAL SET
IN RELAXATION TRAINING:
EFFECTS ON FRONTALIS TENSION
AND OTHER PHYSIOLOGICAL VARIABLES

by

Steven Richman

Adviser: Professor Daniel V. Caputo

This study examined the potential of frontalis EMG feedback as a facilitator of frontalis muscle tension reduction and general relaxation, as measured by reduced sternomastoid muscle tension and skin conductance level and increased fingertip skin temperature. It was proposed that the outcome of frontalis feedback relaxation training is dependent upon the nature of instructions provided to subjects. It was predicted that active instructions (suggesting conation, by presenting the training as a task to be accomplished) are not as effective as passive instructions (suggesting a non-striving approach to training) in facilitating either reductions in frontalis tension or changes in other variables indicative of relaxation. General instructions (informing subjects that the feedback signal is an indicator of overall relaxation) were predicted to be more effective in facilitating general relaxation, but less effective in reducing frontalis tension than specific instructions (informing subjects that the

signal represents forehead muscle tension). Instructions plus feedback were predicted to be superior to instructions alone, in facilitating both frontalis tension reduction and general relaxation.

Relaxation instructions, designed to be specific-active, specific-passive, general-active, and general-passive, were written and validated. Four groups, of eight subjects each, received these instructions; another four groups of eight subjects received comparable instructions and were provided with feedback. All physiological variables were monitored over five training sessions, each providing two 10-minute training periods.

Results strongly supported the superiority of feedback over no-feedback for the reduction of frontalis tension. This effect could not be attributed merely to superior motivation of feedback subjects. There was no indication of motivational inequity among the eight groups. There was no indication that instructional set had any effect on frontalis tension. General instructions seemed to facilitate more general muscular relaxation. Frontalis feedback was not any more effective than instructions alone in facilitating changes in variables other than frontalis tension. Subjects achieved significant progressive reductions in frontalis and sternomastoid tension and in skin conductance level over minutes of a trial and over sessions, indicating increasing relaxation. Fingertip skin temperature did not conform to this pattern, decreasing over minutes and showing no change over sessions.

ACKNOWLEDGEMENTS

I wish to acknowledge, first, the support given to me by my family: my wife, Sandy, my son, Josh, and my mother, Ann. Without their unconditional love, understanding, and encouragement, the hard times would have been harder and the good times, meaningless.

I would like to express my deep gratitude to Dr. Daniel V. Caputo. Beyond serving as a scholarly mentor, guiding me in all aspects of my professional development, he has consistently been a caring friend.

The two other members of my Supervisory Committee also have my sincere gratitude. Dr. Nancy Hemmes and Dr. Philip Ramsey were involved in this research from its inception, assisting in its design and in the interpretation of results.

I must also thank the two "outside" readers who served on my Examining Committee, Dr. Wilma Winnick and Dr. Paul Bindler. Their comments and suggestions were thoughtful and constructive.

The assistance of John Leong, Alan Boord, and the staff of the Queens College Computer Center is greatly appreciated. The BMDP statistical programs were invaluable in the data analysis process.

Over the past 15 years, I have shared more experiences with Al Kluger than with any person other than my wife. His companionship and assistance as a colleague and as a fellow graduate student have always been appreciated; his friendship will always be cherished.

The love and support of my closest friends never had to be asked for, but were always there. For this, I thank Ira and Sandy Berenhaus, Al and Mal Kluger, and Andy Glover.

With love, I dedicate this work to the memory of my father, Jack Richman, who, by the way he lived, provided me with the highest of ideals.

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CHAPTER 1

Introduction

Overview

Providing subjects with a feedback signal which accurately reflects the level of tension in the frontalis (forehead) muscles has been suggested as an effective method for facilitating voluntary relaxation of the frontales and for evoking a more general relaxation response as indicated by changes in other muscles and other physiological response systems. Both the necessity of feedback for producing optimal tension reduction in the frontales and the generalization of frontalis tension reduction to other physiological responses indicative of relaxation have been challenged.

A review of earlier studies in this area appears to indicate that the conflicting results reported are due to the fact that training parameters in studies of frontalis feedback training have varied widely. The present study tested one aspect of the assumption that the effects of frontalis feedback training are dependent upon the precise nature of the training provided. It was specifically proposed that the outcome of frontalis feedback-assisted relaxation training is dependent upon the nature of the instructions provided to the subject. It was predicted that instructions characterized as active, which present the training as a task to be accomplished, are not as effective as passive instructions, which suggest a non-striving

approach to the training, in producing either reductions in frontalis tension or changes in other variables indicative of general relaxation. It was also predicted that instructions which are specific, i.e., which inform the subject that the feedback signal represents frontalis tension, lead to greater tension reductions in these muscles than general instructions which inform the subject that the signal represents an overall indicator of physiological relaxation. General instructions, however, were predicted to lead to more generalized physiological changes than specific instructions. It was further predicted that, given the training parameters of the present study, subjects receiving feedback from the frontales would be more successful at reducing frontalis tension and other physiological indices of arousal than subjects receiving comparable instructions to relax but no feedback. To test these predictions four groups of subjects, presented with relaxation instructions designed to be specific and active, specific and passive, general and active, and general and passive respectively, received auditory feedback of frontalis tension. Four additional groups received comparable relaxation instructions but no feedback. Frontalis tension, sternomastoid (neck) muscle tension, peripheral (fingertip) skin temperature and skin conductance were monitored over the course of five training sessions.

Frontalis Electromyographic Biofeedback

Biofeedback training refers to a variety of techniques employed to teach an individual to gain voluntary control over some aspect of his physiological functioning. The training is based on the assumption that providing an external signal which covaries with the response to be controlled (and which thus provides clear and accurate feedback as to changes) facilitates the development of response control. Biofeedback training of somatic (e.g., muscle tension), visceral (e.g., temperature and blood pressure) and central nervous system (e.g., electroencephalographic) responses has produced varying degrees of success in training individuals to control these classes of responses. Such control has putatively aided in the treatment of a wide range of medical and psychological disorders (Brown, 1977).

A review of the biofeedback literature reveals that the frontales have been overwhelmingly chosen as the target muscles for electromyographic (EMG) feedback training. Interest in using feedback procedures to teach voluntary control of frontalis tension reduction arises from: 1) the assumption that these muscles are difficult to relax (Balshan, 1962) and thus represent a good test of the efficacy of EMG feedback training in general; 2) possible clinical benefits due to the presumed role of the frontales in muscle tension headaches (Stoyva, 1977); 3) the assumption that the frontales are particularly sensitive to

states of anxiety and arousal (Stoyva & Budzynski, 1974); and 4) a suggestion in an early report that deep relaxation of the frontales is associated with general muscular relaxation (Budzynski & Stoyva, 1969). Thus feedback training of frontalis tension reduction has been of interest both because of possible effects on frontalis tension itself and because of the possibility of more generalized effects.

Frontalis Feedback for the Facilitation of Voluntary Control of Frontalis Tension

There is a good deal of evidence which indicates that subjects receiving EMG feedback, reflecting the amount of tension in the frontales, can achieve significantly lower levels of tension in these muscles than subjects instructed to relax the frontales but receiving no feedback (Alexander, 1975; Alexander, French & Goodman, 1975; Budzynski & Stoyva, 1969; Burish & Hendrix, 1980; Coursey, 1975; Haynes, Moseley & McGowan, 1975; Kinsman, O'Banion, Robinson & Staudenmeyer, 1975; Ohno, Tanaka, Takeya, Matsubara, Kurya & Komemushi, 1978; Stern & Berenberg, 1977). Feedback groups have also been shown to be superior in frontalis tension reduction to groups receiving both instructions to relax and false feedback (Budzynski & Stoyva, 1969; Gatchel, Korman, Weis, Smith & Clark, 1978; Stern & Berenberg, 1977) or instructions to relax and post-trial verbal feedback indicating whether tension reduction was more or less successful than on the preceding trial (Kinsman, et al.,

1975). Furthermore, frontalis feedback has been found to be associated with relaxation of the frontales comparable to or greater than that associated with meditation (Fee & Girdano, 1978) or relaxation instructions based on Jacobson's or Wolpe's procedures (Fee & Girdano, 1978; Haynes, et al., 1975; Reinking & Kohl, 1975).

Some investigators have, however, questioned the superiority of frontalis feedback over even simple instructions to relax the forehead muscles (Alexander, White & Wallace, 1977; Burish, Hendrix & Frost, 1981; Davis, 1980; Nielsen & Holmes, 1980; Yock, 1978).

Alexander et al. (1977) found that while subjects who received auditory feedback of frontalis tension were able to reduce tension significantly, these reductions did not differ significantly from those achieved by a group in which subjects were merely instructed to relax their forehead muscles as best they could. Alexander et al. claim that the discrepancy between their results and prior data, indicating frontalis feedback to be more effective than simple instructions, is due to the failure of previous investigators to motivate control subjects adequately. To provide motivation, control subjects in the Alexander et al. study were told that they would eventually be receiving biofeedback training and were informed that their "earnest and purposeful attempt to relax the relevant muscles just as much as they possibly could was absolutely crucial both in the scientific evaluation of the effectiveness of

biofeedback and in their own evaluation of how much more effective EMG biofeedback might prove to be in comparison with their ability to relax their muscles prior to feedback training" (p. 554). This method of motivating control subjects may have differed from that of other studies. However, considering the number of studies supporting the superiority of feedback, all instructing their subjects differently, it seems unlikely that none provided adequate motivation for their instructions-only subjects.

There are, in fact, a number of other procedural differences between Alexander et al. (1977) and previous studies which could account for the different results. In instructing their feedback subjects Alexander et al. "stressed that the use of EMG biofeedback as a relaxation training technique is still in the experimental stage...." (p. 553). Such information might have produced an ambiguous expectancy in subjects as to the outcome of the feedback training. A recent study (Goldberg, Weller & Blittner, 1982) indicates that subjects given ambiguous expectations with regard to the outcome of frontalis feedback training perform more poorly than subjects given positive expectations. In this study subjects who were told that prior personality tests had shown them to have "great potential to control their neuromuscular systems" (p.547) achieved significantly lower frontalis muscle tension levels in feedback training than did subjects who were told that their personality tests were inconclusive with regard to

their ability to control their neuromuscular systems. By suggesting that evidence regarding the effectiveness of feedback training was inconclusive, Alexander et al. (1977) may have been inhibiting optimal performance in the feedback training. It seems that a clearer test of the efficacy of feedback as compared to an instructions only control would involve the appropriate motivation of feedback as well as control subjects.

Another difference between Alexander et al. and studies demonstrating the superiority of feedback concerns the amount and distribution of training time provided to subjects. Rather than providing one or two extended periods of continuous feedback within a training session, periods of feedback were alternated with periods of relaxation with no feedback in the Alexander et al. study. Periods of feedback were 4 minutes and 14 seconds in duration. Seven such periods, a total of only 29 minutes and 38 seconds of feedback training over the course of three sessions, provided data for the evaluation of the feedback training effect. While some of the studies demonstrating the superiority of feedback have employed either brief individual exposures to feedback (e.g., Alexander, 1975; Budzynski & Stoyva, 1969; Gatchel et al., 1981; Ohno et al., 1978) or short total training times (e.g., Alexander, 1975; Haynes et al., 1975) only one of these studies employed both brief exposures and short total training (Alexander, 1975). Interestingly, Alexander et al. (1977) recognize that their

use of brief exposures to feedback, "cycling on and off" (p. 557) as they refer to it, represents a departure from most previous studies. They question the likelihood that this procedural difference could have produced their result by citing earlier research done in their laboratory (Alexander, 1975). While Alexander (1975) did find feedback versus instructions-only differences employing similar brief exposures, it should be noted that instructions to feedback subjects in that study did not contain the ambiguous expectancy conveyed in the Alexander et al. (1977) study. To attenuate further the possible significance of brief exposure times Alexander et al. (1977) state that "since it is quite possible that the contingent feedback stimulus does not make a unique contribution to training in any case, serving rather to motivate and goal direct performance, it is unlikely that cycling versus noncycling could make any substantial difference in outcome" (p. 557). Here, with what appears to be circular reasoning, the authors have assumed the validity of their conclusion in order to prove that procedural differences between their study and previous studies did not contribute to the conclusion which they reached.

One further potentially important difference between Alexander et al. (1977) and previous studies relates to the selection of subjects. Alexander et al. specifically excluded from participation any subjects who reported problems related to muscle tension. While not explicitly

stated in the study under discussion, this requirement had, in previous studies by Alexander and his colleagues (Alexander, 1975; Alexander et al., 1975), resulted in the exclusion of subjects who complained of tension headaches or muscle aches. This selection procedure might be expected to give rise to groups with initially lower frontalis tension levels and consequently to groups less capable of demonstrating reductions in frontalis EMG.

Had Alexander et al. (1977) failed to obtain a significant reduction in tension for their feedback group, the procedural differences discussed above could easily have been seen as possibly contributing to their discrepant result. However, the feedback group did attain significantly reduced frontalis EMG levels; it merely did not demonstrate performance that was superior to that of the control group. While it is possible that longer or different training could have led to further decreases in frontalis EMG levels for the feedback group, the authors state that the baseline levels and amount of reduction in EMG found in their study are comparable to those obtained in studies which demonstrated biofeedback to be superior to instructions alone. In fact, this statement is difficult to evaluate since measured EMG levels are dependent on a number of measurement variables which are not always reported (e.g., how EMG is quantified: as an integral average or based on peak-to-peak activity; and the frequency bandpass over which EMG is measured). Comparison of the results of

Alexander et al. (1977) and those of a study apparently employing similar measurement procedures, but providing substantially longer training and demonstrating the superiority of feedback over control procedures (Reinking & Kohl, 1975), shows the latter study to have demonstrated greater reductions in EMG than the former. It should be noted that this comparison is approximate since it is based on values estimated from graphically presented data.

However, the frontalis feedback group in the Alexander et al. (1977) study demonstrated a change from a resting baseline of approximately 8 microvolts to a level of approximately 6 microvolts (figure 2, p. 555); the comparable group in the Reinking and Kohl (1975) study showed a change from a resting baseline of approximately 8 microvolts to a level of approximately 1 microvolt (figure 1, p. 597). So the possibility remains that, given more or different training, the feedback group in the Alexander et al. (1977) study might have further reduced their frontalis tension levels, perhaps to levels lower than those achieved by the instructions only group.

Davis (1980) reported that subjects given instructions to relax as best they could, achieved levels of tension in the frontales that did not differ from those achieved either by subjects receiving feedback from the frontales or by subjects receiving averaged feedback from a number of muscle sites. She, too, attempts to reconcile her results with those of other studies by stating that her instructions-only

group was more adequately motivated. According to Davis, the basis of this superior motivation was that her subjects were told to relax prior to each trial, rather than just once at the beginning of each session. In this study, as in that of Alexander et al. (1977), factors relating to the inadequacy of the feedback training procedure are as likely to be responsible for the failure to obtain differences as are factors relating to the presumed adequacy of the control procedure. Here, again, both the total amount of training (35 minutes) and particularly the duration of each exposure to feedback (70 seconds) were, by comparison to other studies, relatively short. The scheduling of sessions was also unique in the frontalis feedback literature in that the first two sessions, each providing ten 70-second trials, occurred on the same day with a 10-minute intersession interval and the final session did not occur until one week later. Data indicating that intersession interval plays a role in the effectiveness of frontalis feedback training (Kondo, Canter & Knott, 1977), with shorter intersession intervals leading to greater reductions, provide one more possible explanation for the failure of Davis (1980) to find differences between feedback and no-feedback groups. One further difference between Davis' study and others concerns the nature of the feedback presented to subjects. The majority of frontalis feedback studies provide subjects with feedback signals that vary continuously over the entire range of EMG values produced by the subject. Davis employed

a procedure in which, initially, each subject's median pretraining EMG level was used as a threshold value. EMG activity at or below this value produced feedback in the form of an auditory click occurring at a constant rate of one per second. EMG activity above the threshold was accompanied by proportional increases in the click rate. The median EMG obtained on each training trial served as the new threshold level for the subsequent trial. This procedure was intended as a means of shaping progressively lower EMG levels. Unfortunately, the procedure provides, predominantly, feedback which gives the subject more information about failures than about successes. Differential feedback is provided only for increases in EMG above the threshold level. A subject who reduces EMG below the threshold within any particular trial receives the same feedback regardless of the magnitude of the decrease. This seems an inefficient method of shaping lower levels of EMG. Davis' findings of no difference between feedback and control groups and of no change in EMG across sessions, could be due not to a failure of biofeedback, but rather to a failure of the particular feedback procedures employed.

Yock (1978) also reports the failure of a feedback group to achieve lower levels of frontalis tension than an instructions-only group. As in the Alexander et al. (1977) and Davis (1980) studies individual exposures to feedback were relatively brief: each trial consisted of 4 minutes of training. Unfortunately, the total amount of training

provided, the exact nature of the feedback, the instructions provided to subjects and the levels of EMG obtained are not contained in Yock's brief report. The incomplete nature of this report makes it difficult to compare to other studies.

Burish et al. (1981) provided subjects with one of four types of relaxation instructions: single instructions (provided once, at the beginning of training); repeated instructions (provided prior to each relaxation period); relaxation training (taped passive muscle relaxation instructions); and no instructions (subjects merely told to sit quietly). Half of the subjects received instructions only while the other half received feedback of frontalis EMG as well as instructions. All subjects received 20 minutes of training in one session. For all but the relaxation training groups, training was given in four 5-minute periods, separated by 1-minute rest periods. Relaxation training subjects were given only one rest period, after 15 minutes of training, "so as not to disrupt their relaxation training procedure" (p.596).

Results indicated that none of the groups receiving feedback and/or instructions differed from one another, but that each of these seven groups achieved significantly lower frontalis tension than the group which received no instructions and no feedback. While this is interpreted as supporting the equivalence of instructions and instructions plus feedback in reducing frontalis tension, a number of points qualifying this conclusion should be noted. As in

the studies previously discussed (Alexander et al., 1977; Davis, 1980; Yock, 1978) there is a question as to the adequacy of of the feedback training provided. It seems reasonable to assume that subjects enter the laboratory with some ability to relax their forehead muscles. Five minute exposures to feedback and/or 20 minutes of total training time may be insufficient to demonstrate a feedback training effect over and above this ability. That less than optimal training effects occurred is suggested by the fact that unlike most studies of frontalis EMG reduction (even those showing no difference between feedback and no-feedback groups) analyses here apparently failed to find any significant reductions in EMG either across minutes of a training period or across periods within the session.

Nielsen and Holmes (1980) provided their subjects with both longer individual exposures to feedback (20 minutes) and longer total training times (80 minutes over the course of four sessions) than the studies already discussed and still found feedback subjects to achieve frontalis tension levels which did not differ from those attained by instructions-only subjects. However, because training followed the viewing of a stress inducing film and particularly because actual levels of EMG were not reported (only inferential statistics were presented), this study, too, is rather difficult to interpret in relation to others. Adding to the difficulty in interpreting the results of this study is the fact that although feedback subjects did not

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differ from controls during the course of training, they did demonstrate a significantly greater ability to lower frontalis EMG following the conclusion of training during a period in which they were anticipating the viewing of a stress inducing film. It is possible that such a post-training effect could occur in the absence of any significant effect during the training itself; however, something was apparently being learned during the course of feedback training.

Considering the number of studies, cited earlier, which demonstrated that frontalis feedback is associated with greater reductions in frontalis tension than either simple instructions to relax or more formal relaxation procedures and in light of the many procedural differences between those studies and the ones which failed to demonstrate the superiority of feedback, it seems unwarranted to claim, as do Alexander et al. (1977) that "it remains to be experimentally demonstrated that EMG biofeedback is truly an efficient method of learning reduced muscle tension even in highly circumscribed muscle groups" (p.558). However, the fact that a number of studies have failed to demonstrate the superiority of feedback over simple instructions does represent a challenge to the usefulness of feedback procedures. What does seem to be warranted is: 1) a recognition of the fact that the outcome of frontalis feedback training is most likely dependent upon the specific training parameters chosen; 2) an evaluation of which

training parameters are most likely to affect the outcome of training; and 3) a reevaluation of the usefulness of feedback in frontalis muscle tension reduction procedures.

Frontalis Feedback for Eliciting a
General Relaxation Response

Background

Interest in using frontalis feedback training as a general relaxation procedure arose initially from a suggestion in an early report that the attainment of deep relaxation of the frontalis muscles was accompanied by general muscular relaxation. Budzynski and Stoyva (1969) had observed that subjects, trained through feedback procedures to reduce frontalis tension, typically gave subjective reports of a generalization of relaxation to other muscle groups. Stoyva and Budzynski (1974) related this finding to Jacobson's (1938) progressive muscle relaxation technique, Luthe's (1963;1969) autogenic training and Wolpe's (1958) systematic desensitization which they interpreted as being supportive of the idea that deep muscular relaxation can serve as a means of eliciting a general "low arousal condition with certain anti-stress properties" (Stoyva & Budzynski, 1974, p.370). Indeed, a series of studies in their laboratories indicated that reduced frontalis tension, attained through the use of feedback techniques, was accompanied by reduced forearm muscle tension, decreased cortical activation (as indicated by elevated two-flash thresholds) and, at least for subjects

with initially high frontalis EMG levels, decreased heart rate (Stoyva & Budzynski, 1974).

Since these observations were made, the question of whether feedback training of reduced frontalis tension levels can be used to induce general physiological changes indicative of relaxation has never been unequivocally answered. Evidence has been offered indicating that such training can lead to decreased tension in other, untrained, muscles (Davis, 1980; Freedman & Papsdorf, 1976; Glaus & Kotses, 1978; O'Connell & Yeaton, 1981; Sagberg & Kveim, 1981) as well as to autonomic and central nervous system responses indicative of general relaxation (Blanchard, Haynes, Kallman & Harkey, 1976; DeGood & Chisholm, 1977; Delman & Johnson, 1976; Freedman & Papsdorf, 1976; Gatchel et al. 1978). Furthermore, studies which have demonstrated reduced anxiety as a result of frontalis feedback assisted relaxation training (Canter et al., 1978; LaValle, Lamontagne, Pinard, Snable & Treteault, 1977; Raskin, Johnson & Rondesvedt, 1973; Townsend, House & Addario, 1975) can be cited as evidence, though indirect, of a generalized relaxation response occurring in conjunction with such training. A number of studies have, however, purported to find no evidence of generalized muscular relaxation (Alexander, 1975; Fridlund, Fowler & Pritchard, 1980; Glaus & Kotses, 1979; Shedivy & Kleinman, 1977) or changes in other physiological systems (Alexander et al., 1977; Burish & Hendrix, 1980; Burish, Hendrix & Frost, 1981; Davis, 1980;

Fee & Girdano, 1978; Nielsen & Holmes, 1980; McGowan, Haynes & Wilson, 1979) or in subjective measures of anxiety or tension (Alexander, 1975; Alexander et al., 1977; Burish & Hendrix, 1980; Burish et al., 1981; Reinking & Kohl, 1975) occurring as a result of frontalis feedback training.

Studies Assessing Changes in Other Muscles

Evidence indicating generalized responding. Freedman and Papsdorf (1976), in a study designed to assess the effects of frontalis feedback on the sleeping patterns of sleep-onset insomniacs, provided three groups, each of which consisted of six subjects, with frontalis feedback training, progressive muscle relaxation training, or a set of exercises unrelated to relaxation (which served as a placebo control), respectively. Each group received six 30-minute training sessions over the course of a two week period. For the feedback group each session included 24 minutes of continuous auditory feedback from the frontalis. In each session heart rate as well as frontalis, masseter and forearm extensor muscle tension were monitored for three 1-minute intervals. These intervals occurred at the end of a 5-minute pretraining adaptation period, in the middle of the training period and at the end of the training period. Analyses of data indicated that both progressive relaxation and frontalis feedback groups achieved significant reductions within sessions in the tension levels of all monitored muscles and in heart rate, while the control group showed only minimal changes in these measures. Changes occurring across sessions were not reported.

Glaus and Kotses (1978) provided two groups of ten subjects each with feedback of frontalis tension in the form of auditory clicks whose frequency varied proportionally with frontalis EMG level. One group (FI) was instructed to increase and the other (FD) to decrease the frequency of the clicks. Subjects were uninformed as to the source of the clicks or any strategies which would facilitate controlling their frequency. A third group (NC) of ten subjects listened to pre-recorded clicks (non-contingent on frontalis EMG); half of these subjects were instructed to increase and half to decrease the click rate. Each subject participated in three 20-minute sessions scheduled on three consecutive days. Frontalis and brachioradialis (a forearm muscle) tension were recorded at the end of each of the 20 minutes of each training period. While it is not explicitly stated, these recordings most likely represented momentary readings taken from myograph meters. Results indicated a significant training effect for frontalis tension. When compared to the NC group, groups receiving feedback of frontalis EMG showed significant increases or decreases in frontalis tension corresponding to the instructions which they received. Generalization of this training effect to brachioradialis activity was assessed in two ways, giving rise to conflicting interpretations. Considering group data, it was found that FI and FD subjects showed brachioradialis tension that was consistently higher and lower, respectively, than NC subjects. These group differences reached significance

only in the third session. This would seem to indicate that with sufficient training feedback assisted increases or decreases in frontalis tension are accompanied by concomitant increases or decreases in brachioradialis tension. Difficulty in interpreting this result arises from a discrepancy between the original report (Glaus & Kotses, 1978) and what appears to be a later, more extensive report of the same data (Glaus & Kotses, 1979). In the latter report the authors claim that for brachioradialis there were no reliable group differences, although graphically presented data (Glaus & Kotses, 1979, Figure 2, p. 517) appear to conform to the original report of differences developing in the expected direction on the final day of training. A within-subjects measure of the covariation between frontalis and brachioradialis tension was obtained by deriving concordance rates for direction of change (increase, decrease or stable) from one minute's reading to the next. Covariation was considered to have occurred each time the two muscles either remained stable or changed in the same direction. For each subject a percent of covariation was computed for each session based on 19 possible occurrences of covariation. Using these measures Glaus and Kotses (1978) report that while covariation remained stable for the NC group subjects, feedback subjects tended to show less, rather than more, covariation over sessions.

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Glaus and Kotses (1978) argue that their within-subject data provide a more sensitive indicator of individual patterns of covariation between muscles than their group data. While this may be true, it might also be argued that in the context of assessing whether the provision of feedback from the frontales can lead to reductions in the tension of other muscles, an estimate of tension based on the entire control period might be more reasonable than an evaluation based on samples of moment to moment covariation. Muscle tension levels are relatively labile physiological measures; levels observed at any one moment may not necessarily be representative of the level manifested over some immediately preceding period of time. Momentary muscle twitches can produce elevated EMG readings even within a general pattern of relaxation. If there is a general pattern of relaxation over time in a pair of muscles, comparisons based on directional changes monitored once a minute may not reflect this overall pattern as well as measures averaged over the entire relaxation period.

O'Connell and Yeaton (1981) report a tendency for covariation between tension in the frontalis and the semispinalis capitis (a muscle in the back of the neck) which did not change over the course of five 20-minute recording intervals in three sessions. Each session provided one 20-minute period of feedback training for muscle tension reduction. Half of the subjects (n=12) received variable pitch auditory feedback from the frontales

while the other half (n=12) received feedback from the semispinalis capitis. Twenty-minute periods in which all subjects were told to relax as best as they could without feedback preceded training in the first and followed training in the last session. Tension in both muscles was sampled simultaneously at 20-second intervals within each 20-minute period, providing 60 pairs of muscle-tension readings per period.

Analyses of data for the individual muscles indicated that there was a significant decrease in frontalis tension both within and across recording periods. For semispinalis capitis the only significant effect was a decrease in tension within recording periods. These decreases were not dependent upon which muscle provided the feedback signal. The failure of the source of feedback (frontalis versus semispinalis capitis) to be a factor in significant decreases in tension is to be expected if in fact feedback is producing generalized muscle tension changes. However, as O'Connell and Yeaton point out, this is a weak argument for generalization because it is based on accepting the null hypothesis.

Cross-correlation coefficients of frontalis and semispinalis capitis tension were computed for the 120 (24 subjects X 5 recording periods) pairs of time series obtained in this study. Of these, 57 were found to be significantly greater than zero, 63 were found not to differ from zero and none was significantly less than zero. An

ANOVA based on these cross-correlations showed no significant effects for either source of feedback or recording period. While these data do not demonstrate increasingly generalized responding, they do suggest a persistent concordance of response between the two monitored muscles. The means of the five cross-correlations for each subject were obtained and ranged from 0.02 to 0.63, indicating that there are perhaps significant individual differences in degree of muscle tension covariation. The overall mean of cross-correlations was 0.34.

As a final assessment of covariation, linear trends were calculated for the 240 curves obtained (24 subjects X 5 sessions X 2 muscles). The correlation coefficient for the 120 pairs of slopes was significantly greater than zero ($r = +0.45$, $p < .05$).

O'Connell and Yeaton interpret their results as providing support for the existence of a modest association between the activity of the forehead and neck muscles and as an indication that frontalis feedback should be further investigated as a potential general relaxation procedure. Since a no-feedback control group was not employed, any observed covariation of muscle tension cannot, of course, be attributed to the provision of feedback. The persistent presence of covariation across sessions, however, does suggest the potential usefulness of frontalis feedback training as a means of reducing tension in muscles other than the frontales.

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Davis (1980), who found feedback to be no more effective in reducing frontalis EMG than simple instructions to relax (see above), also reports results relevant to the question of generalization of tension reduction to other muscles. Data for forearm extensor, masseter and semispinalis/splenius muscles were collected in each session only before and after training periods and thus do not relate directly to changes occurring during training. Both forearm and masseter muscles showed significant decreases from baseline to post-training measurements, while semispinalis/splenius showed no such change. There were no group differences, indicating that the changes which did occur could not be attributed to the provision of feedback. Since the feedback training procedure did not produce reductions in frontalis tension itself that were greater than those achieved by control subjects, the question remains as to whether different training parameters could have produced group differences not just in the frontales, but also in the untrained muscles. The fact that significant decreases were found to occur in a number of muscles implies a covariation of activity which at the very least is not incompatible with the idea that more adequate feedback procedures could have led to further decreases not only in the frontales, but in the other muscles as well.

Sagberg and Kveim (1981) monitored tension levels in the frontalis, forearm extensor, masseter, sternomastoid, semispinalis/splenius and leg (peroneus group) muscles for

two groups of subjects. One group received vibratory tactile feedback of frontalis tension and the other of forearm tension. Thirty minutes of continuous feedback training was provided for each group in a single session. Results of this study are rather difficult to interpret. While no significant changes occurred in either target muscle during training, subjects receiving frontalis feedback did produce significant reductions in leg muscle tension and reductions in masseter tension which approached significance. Although information about the significance of obtained coefficients is not provided, cross-correlational analyses seem to support the existence of covariation of activity among muscles in the head and neck (frontalis, masseter, semispinalis/splenius and sternomastoid). In general these muscles showed moderate correlations during pretraining baseline measurements (mean cross-correlation coefficient = +0.42). Furthermore, there is some evidence that frontalis feedback enhanced this covariation. For the group receiving frontalis feedback, cross-correlations increased for all six pairs of head and neck muscles from baseline to the end of the feedback period. For the group receiving forearm feedback all six cross-correlations decreased from baseline to the end of the feedback period. By the last 5 minutes of the feedback period, the mean cross-correlation between the six pairs of head and neck muscles was +0.54 for the frontalis feedback group and +0.25 for the forearm feedback group.

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Rather than attributing their results to generalized muscular responding, Sagberg and Kveim discuss the possibility that the higher cross-correlations for the frontalis group could be due to frontalis sensors monitoring signals from nearby muscles as well as from the frontales. If this were the case, these subjects would actually be receiving feedback representing generalized changes in the tension of a number of muscles in the head and neck area. Reductions in the tension of other muscles in the area could then not be attributed to a generalization of relaxation from the frontales. While such a possibility has implications for understanding the mechanism whereby frontalis feedback may be a good general relaxation procedure, in a practical sense, if frontalis feedback does (for any reason) facilitate reduction of tension in a number of muscles, this suggests the usefulness of the procedure.

Evidence indicating no generalized responding.

Alexander (1975) reports results purporting to show the failure of feedback assisted reductions in frontalis tension to generalize to extensor muscles of either the forearm or the lower leg. Feedback, in the form of a click rate proportional to frontalis EMG, was provided in six 4.5-minute blocks, two per session over the course of three sessions. Each session also provided feedback subjects with two 4.5-minute periods in which they were instructed to relax without the aid of the feedback signal. Control subjects received the same number of training blocks as

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feedback subjects and were instructed to relax as much as possible, focusing especially on the relevant muscles. As compared to the control group, feedback subjects demonstrated significant reductions in frontalis tension over sessions. For both groups there were significant increases in forearm tension across sessions while there were no significant changes in leg muscle tension.

Difficulty in interpreting these results arises from the fact that while evaluations of frontalis tension were based on levels achieved in both feedback and non-feedback blocks, evaluations of tension in the untrained muscles occurred only during non-feedback blocks. During these non-feedback blocks the tension at the three muscle sites was measured sequentially, rather than simultaneously. The authors do not report frontalis data separately for feedback and non-feedback blocks. It may be that the significant reduction in frontalis tension levels was a function of changes occurring during the feedback, but not the non-feedback blocks. The possibility then exists that generalization of frontalis tension reduction was assessed during periods when in fact there was no such reduction. At the very least it should be borne in mind that this study does not represent an assessment of the changes in the tension of untrained muscles during frontalis feedback, nor does it provide for an assessment of simultaneous changes in the muscles monitored.

Shedivy and Kleinman (1977) provided eight subjects with five sessions of bidirectional frontalis feedback training. Each session included two 10-minute frontalis tension decrease and two 10-minute frontalis tension increase training periods. For half of the subjects sternomastoid tension was monitored in addition to frontalis tension; for the other half semispinalis/splenius and frontalis tension were monitored. Results indicated that subjects were able to increase and decrease frontalis tension significantly relative to a baseline measure. There were, however, no significant changes in the other monitored muscles which could be attributed to the observed changes in the frontales.

Fridlund et al. (1980) monitored tension levels in eight muscles for four subjects over the course of five 30 minute frontalis feedback relaxation training sessions. In addition to the frontales, the muscles monitored were: left and right sternomastoids, right semispinalis/splenius, left and right forearm extensors, and left and right lower leg extensors. Although there were significant decreases in frontalis tension across sessions, there were no significant session effects for any other muscles. Analyses of changes in the tension level of individual muscles within sessions were not provided.

For each subject seven cross-correlations (comparing the frontales with each of the other muscles) were computed based on 960 measurements taken from each muscle in the

first feedback session. While the authors do not provide the obtained cross-correlations or indicate which or how many differed significantly from zero, they do provide a number of summary statements about these analyses. All significant cross-correlations were positive in sign and were described as being "moderate at best, with the strongest ... relationship in any subject accounting for only 36% of the variance...." (p. 51). The strongest covariations occurred between the frontales and the neck muscles, with the limb muscles showing weaker or no correlation with the frontales. Since cross-correlations were obtained for only the first session, no assessment of changes in tensional covariation which might have occurred as a function of training can be made.

Because a no-feedback control group was not employed, the results of this study, like those of O'Connell and Yeaton (1981) and Shedivy and Kleinman (1977), cannot be interpreted as arising from the provision of feedback. The possibility exists, for example, that the obtained reductions in frontalis tension were due to adaptation effects. These decreases in frontalis tension may or may not have occurred had no feedback been provided. Without a no-feedback control group it is difficult to assess the adequacy of the feedback training: the actual decrease in frontalis tension across sessions, though significant, appears, from the graphically presented data (Fridlund et al., 1980, Figure 1, p.50), to be rather small. That the

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feedback training provided may not have been optimal for producing tension reductions in the frontales is suggested by the fact that data for two additional subjects was not evaluated because visual inspection indicated no frontalis tension reduction. In the absence of a strong effect on frontalis tension itself, it may be unreasonable to expect significant decreases in the tension of other muscles. Naturally, the lack of appropriate control also precludes the attribution of covariation, seen in the cross-correlational analyses, to the feedback manipulation.

Fridlund et al. interpret the results of their study as providing evidence against the usefulness of frontalis feedback as a general relaxation technique. Considering the cross-correlations which indicated some relationship between the frontales and at least the nearby neck muscles, a more accurate interpretation might be that the results, in demonstrating some degree of tensional covariation, do not preclude the potential role of frontalis feedback in the development of a generalized relaxation response.

In summary, studies assessing generalization of feedback assisted frontalis tension reduction to other muscles have provided equivocal results, neither demonstrating powerful generalization nor producing any compelling evidence that given appropriate training such an effect could not be fostered.

Studies Assessing Changes in Other Physiological Variables

In considering studies which have evaluated the effects of frontalis feedback training on a number of different physiological responses, it should be considered that failure to find a totally consistent pattern of relaxation does not mean that the feedback procedure is not potentially useful as a relaxation technique. To this author's knowledge no relaxation technique has been demonstrated to produce such a totally integrated pattern of physiological activity.

Evidence indicating generalized responding. Blanchard et al. (1976) compared groups receiving blood pressure feedback, frontalis EMG feedback or instructions to relax and reduce blood pressure on their ability to decrease blood pressure and frontalis tension. All groups participated in four sessions, with each session providing 20 minutes of training. Dependent measures were mean change from session baseline of blood pressure and frontalis EMG. The groups receiving frontalis feedback showed a significant change in ability to reduce tension from the first to the fourth session and achieved a greater reduction in tension in the fourth session than either of the other groups. While the group receiving blood pressure feedback reduced blood pressure more than the EMG feedback group in the first session, in the three subsequent sessions these two groups did not differ in ability to decrease blood pressure. Both the blood pressure and the frontalis feedback groups showed significant improvement across sessions in ability to

decrease blood pressure, while the instructions only group showed no training effect.

Delman and Johnson (1976) provided three groups of subjects with two 2-hour training sessions of frontalis feedback, progressive muscle relaxation, or self-relaxation instructions. Respiration rate, heart rate, frontalis EMG, finger blood volume and skin conductance were measured for 1 minute intervals at each of 16 points over the course of the 4 hours of training. The group receiving frontalis feedback training showed the greatest decreases in both frontalis tension and heart rate. No significant changes in respiration rate occurred. Skin conductance and finger blood volume showed a paradoxical effect in that "relaxation for all subjects was accompanied by relative peripheral vasoconstriction and skin conductance increases" (p.181). This effect was most pronounced in finger blood volume where subjects achieving the lowest frontalis EMG and heart rate showed the greatest vasoconstriction. While this study fails to show a totally integrated relaxation response accompanying frontalis feedback training, the heart rate data do indicate some degree of generalization of training.

DeGood and Chisholm (1977) report the results of two studies which indicate that frontalis feedback produces a more generalized pattern of physiological responses than does parietal alpha electroencephalographic (EEG) feedback. In the first study two independent groups of subjects received either frontalis EMG feedback or parietal alpha EEG

feedback. Neither group was made aware of the source of their feedback and all subjects were instructed to use the feedback signal as an aid to relaxation. Both groups engaged in a single training session which included 40 minutes of continuous feedback training. The final 2 minutes of a 6 minute pre-training adaptation period provided resting baseline measures for frontalis EMG level and alpha density. When these values were compared to mean values for the final 5 minutes of the training period, it was found that the group receiving EEG feedback showed only significant increases in alpha density. The EMG feedback group, however, achieved a more generalized relaxation as evidenced by both a significant decrease in frontalis EMG and a significant increase in alpha density.

Subjects in the second study reported by DeGood and Chisholm were eight laboratory assistants all of whom had had 1 to 2 hours of previous feedback training, but were unaware of the outcome of the first study. Each subject participated in two sessions, each consisting of four 10 minute feedback blocks. Each block provided a different feedback contingency: frontalis EMG decrease; frontalis EMG increase; parietal alpha enhancement; and parietal alpha suppression. In addition to frontalis EMG and parietal alpha, respiration rate, heart rate and finger pulse volume were monitored during each feedback period. Comparisons of the last 4 minutes of training under each feedback condition to baseline levels were for the most part compatible with

the interpretation that EMG feedback for reduced frontalis tension produced the most consistent pattern of relaxation. During frontalis decrease periods subjects showed decreased frontalis tension levels, increased alpha density, decreased heart rate and decreased respiration rate. Analysis of finger pulse volume data provided the only inconsistent result, indicating relative vasoconstriction in both EMG increase and EMG decrease conditions. Considering that this finding confirms the earlier report of Delman and Johnson (1976), DeGood and Chisholm (1977) consider two possible explanations for the paradoxical decreased peripheral blood flow occurring within an overall pattern of decreased arousal. Such an effect could be due either to "a compensatory mechanism correcting for decreased cardiac output" or to "a thermal maintenance response stemming from the reduced bodily heat production accompanying muscular relaxation" (p.263).

Further support for the effectiveness of frontalis feedback as a means of reducing arousal, as measured by a number of physiological indices, is provided by Gatchel et al. (1978). In this study two groups of six subjects received either frontalis feedback or false feedback training while frontalis EMG, heart rate, respiration rate and skin conductance level were monitored. Feedback of frontalis tension was provided over the course of two sessions and consisted in each session of six training blocks. Each block provided 3 minutes of control with

feedback, 1 minute of attempting to control frontalis tension in the absence of the feedback and 1 minute of rest. For half of the true feedback subjects all blocks were tension decrease blocks; the other half received alternating decrease and increase blocks. Thus, while all frontalis feedback subjects received a total of 36 minutes of feedback, for half of these subjects only 18 minutes represented relaxation training. False feedback subjects were asked only to decrease tension and heard a "feedback" signal which indicated that EMG was decreasing. Because subjects receiving alternating increase and decrease feedback training blocks did not differ in their performance (one assumes that this means on all physiological measures) during decrease trials from subjects receiving only decrease blocks, data for these two groups were combined. Analyses were based on data recorded during a 3 minute baseline period and the first and last training blocks of the second training feedback session. Although not explicitly stated both of these blocks were most likely tension decrease blocks for the subjects who had received both increase and decrease training. Results indicated that frontalis-feedback subjects achieved significantly greater reductions in frontalis EMG and heart rate than the false-feedback subjects. While the true feedback subjects also demonstrated significant reductions in respiration rate, these did not differ significantly from those achieved by false feedback subjects. For both groups of subjects

there were significant increases in skin conductance level, representing for the frontalis feedback group the only deviation from a totally consistent pattern of relaxation.

One fairly consistent finding in the studies reviewed in this section is that successful feedback assisted frontalis relaxation training is accompanied by reductions in heart rate (DeGood & Chisholm, 1977; Delman & Johnson, 1976; Gatchel et al., 1978). This result is also reported by Freedman and Papsdorf (1976) whose study was considered in the section dealing with generalization to other muscles.

Evidence indicating no generalized responding. Fee and Girdano (1978) compared frontalis EMG biofeedback, meditation, progresssive muscle relaxation, placebo control and no activity control groups on frontalis EMG, respiration rate, heart rate, skin potential and fingertip skin temperature. This study provided subjects with more extensive training than most others: two 30 minute training periods per day for five consecutive days. Unfortunately, no data are presented for changes occurring during these training periods. Analyses of all physiological variables are based on comparisons of 5 minutes of pre-training activity and 5 minutes of activity monitored following the final training session. For feedback subjects these were periods in which no feedback was provided. These analyses indicated significant reductions in frontalis tension for only the feedback and meditation groups. The only other significant changes in physiological measures were

reductions in respiration rate for the meditation and progressive muscle relaxation groups.

Fee and Girdano discuss their results in the context of Gellhorn's (1964) theory that reduced muscle tension leads to general relaxation by way of a centrally mediated rebalancing of ergotropic and trophotropic systems occurring in response to reduced proprioceptive input to the central nervous system. Fee and Girdano themselves state that "little is known about the amount and duration of muscle relaxation needed to achieve this result" (p.155). These authors did provide their subjects with substantially more training than most other studies. It is unclear, however, why they chose to assess physiological measures over such a brief (5-minute) interval following the final training period, rather than during the course of the training. Furthermore, the authors do not specify at what point, following the final 30 minutes of training, physiological measures were recorded. If the 5-minute measurement interval did not immediately follow the termination of the final training period, then there is some question as to whether such an interval provides sufficient time in which to evoke a trophotropic response. Even if the measures were recorded immediately following the termination of the feedback signal (for the feedback group), the measurement procedure represented a deviation from the standard training regimen (requiring, one would assume, additional instructions) and thus might have been somewhat arousing.

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McGowan et al. (1979) assessed frontalis EMG, heart rate, fingertip temperature and blood volume pulse for frontalis feedback and instructions only subjects during baseline, training, stress (visualization of a feared stimulus) and post-stress adaptation periods. The single session study included two consecutive sequences of these different periods. Each training period was 10 minutes in duration. While frontalis tension was found to be significantly lower for frontalis feedback than for instructions-only subjects during some of the experimental periods (i.e., first stress, second training, second stress and second post-stress periods), no significant group differences were found for any of the other physiological variables. Because the total amount of training provided was so short (20 minutes) and particularly because stress was introduced into the training situation it is difficult to generalize the findings beyond the specific conditions of this study.

Burish and Hendrix (1980) also provided frontalis feedback and instructions-only groups with just two 10-minute training periods. Frontalis tension and fingertip skin temperature were monitored. Results were similar to those of McGowan et al. (1979), in that a group difference in frontalis tension did not appear until after the first 10-minute training period and no group difference was found in fingertip temperature.

A number of studies, in which frontalis feedback training was ineffective in reducing frontalis tension below levels achieved by instructions-only controls, also report the failure of such training to modify the activity of other physiological variables. Thus, feedback of frontalis tension has been reported to be no better than instructions to relax in producing changes in heart rate (Alexander et al., 1977; Davis, 1980), pulse rate (Burish et al., 1981), finger pulse volume (Burish et al., 1981), respiration rate (Alexander et al., 1977), skin conductance (Alexander et al., 1977; Nielsen & Holmes, 1980) or fingertip skin temperature (Alexander et al., 1977; Burish et al., 1981). In evaluating the findings of these studies one must consider the possibility that more effective feedback training procedures, perhaps producing significant reductions in the frontalis, could have also effected changes in other monitored physiological responses. Procedural details of these studies and results relating to frontalis tension were discussed previously in the section concerning frontalis feedback for frontalis tension reduction.

Studies Assessing Changes in Subjective Measures

As an assessment of the value of frontalis feedback training as a general relaxation technique a number of investigators have included in their studies evaluations of changes in subjective reports of anxiety or tension which accompany such training (i.e., in cognitions relating to

tension or anxiety). Studies which have assessed such variables in normal populations have generally found that while changes toward lower anxiety or decreased tension sometimes occur, these changes are not greater for feedback than for control subjects. The finding of no difference between feedback and control subjects has been reported for self-report rating scales of amount of tension (Alexander, 1975; Reinking & Kohl, 1975), the state scale of the State-Trait Anxiety Inventory (Alexander, et al., 1975; Alexander, et al., 1977) and the Affect Adjective Check List (Burish & Hendrix, 1980; Burish et al., 1981). For two of these studies (Alexander et al., 1977; Burish et al., 1981) the finding of no difference in cognitive measures is, perhaps, not surprising, since no difference was obtained between feedback and control groups in frontalis tension itself. In general, the studies cited employed relatively brief feedback training: under 30 minutes of total training time. While it might be argued that the development of generalized physiological and subjective relaxation could take longer than this, two of the studies cited (Alexander et al., 1975; Reinking & Kohl, 1975) did, in fact, provide substantial training and yet found no differential subjective effects. Reinking and Kohl (1975) provided feedback subjects with 3 hours of training (15 minutes per session for 12 sessions). They found that while ratings of how tense subjects felt (on a scale of 1 to 10) decreased significantly over sessions, the decreases for feedback

subjects did not exceed those for other treatment groups or for a no-treatment control group. Alexander et al. (1975) provided three groups, receiving auditory feedback with eyes closed, auditory feedback with eyes open and visual feedback, with five 20-minute frontalis feedback training sessions. A fourth group of subjects received the same number of training sessions, but were merely told to relax as best as they could. The group receiving auditory feedback with eyes closed was the only one to achieve significant reductions in frontalis tension. Although there was a trend for this group to show greater decreases than others in state anxiety from pre- to post-session measures, this effect did not attain significance.

In summary, the limited evidence which exists provides little support for reported cognitive effects (beyond those attainable with verbal relaxation instructions) accompanying frontalis feedback relaxation training in normal subjects. It should be noted, however, that a number of studies employing patients with elevated anxiety and providing extensive training have found frontalis feedback to be an effective means of reducing anxiety (Canter et al., 1975; LaVallee et al., 1977; Raskin et al., 1973; Townsend et al., 1975).

Theoretical Considerations

Many of the studies which have attempted to assess whether frontalis feedback training can serve as a general relaxation procedure seem to have done so as a test of the

assumption (explicit in some cases, implicit in most) that reduced frontalis tension leads automatically, perhaps through a centrally mediated mechanism such as that proposed by Gellhorn (1964), to an integrated relaxation response. According to Gellhorn hypothalamic mechanisms control the balance between two antagonistic response systems. The ergotropic system mediates increased sympathetic activity, increased muscle tone and increased cortical activation; the trophotropic system mediates increased parasympathetic activity, decreased muscle tone and reduced cortical excitation. Gellhorn proposes that one means of shifting the balance toward trophotropic activity is to reduce proprioceptive input from the striate musculature. He specifically points to the facial musculature as being important in controlling the balance of hypothalamic mechanisms.

If Gellhorn's theory is valid then reduced frontalis tension should decrease the proprioceptive input to the hypothalamus and consequently cause a general shift toward trophotropic activity. Gellhorn does not specify the magnitude or temporal characteristics of the change in proprioceptive input which might be necessary to produce a dominance of the trophotropic system. Such an effect might require the attainment of extremely low frontalis tension levels, sustained low levels or both. If this is the case, then there are at least two implications for studies which have assessed the relationship between frontalis tension

reduction and other physiological changes. First, covariation between frontalis tension and other variables may not apply over the entire range of frontalis tension. It may be that while extremely low frontalis tension is associated with general relaxation (as indicated by a number of physiological measures), at higher frontalis tension levels those measures may have little or no relationship to frontalis tension. Second, training which is of short duration, either in terms of individual exposures to feedback or total training time, while perhaps sufficient to produce reductions in frontalis tension, may not produce changes which are capable of influencing the ergotropic/trophotropic balance. Longer total training may be necessary to learn to produce sufficient decreases in frontalis tension and longer training periods may be necessary on any given occasion in order for the general relaxation effect to occur.

If Gellhorn's theory is not valid, if greatly reduced proprioceptive input from facial muscles does not automatically evoke general relaxation, then the relationship between even very low frontalis tension levels and other indices of relaxation may be variable or insignificant. One might then observe low frontalis tension either in the context of general relaxation or in its absence. Frontalis tension reduction may, in fact, occur through two different mechanisms. A comparison with mechanisms of increased muscle tension may clarify this

point. An increase in the tension of any specific muscle can be a relatively isolated phenomenon, involving only the muscle in question or a small group of related muscles. Such might be the case in the performance of a well-practiced voluntary movement or in the occurrence of a momentary facial expression. However, increased tension in the same muscle might occur as part of a more global response mechanism, involving not only general increases in muscle tension, but also changes in such variables as heart rate, respiration rate, blood pressure, patterns of blood flow, skin conductance level and central nervous system activity. Such is the case in the "fight or flight" reaction of general sympathetic activation. If one accepts the existence of a general relaxation response, such as that proposed by Benson (1975), then reductions in muscle tension can similarly be seen to take place through either of two mechanisms. Frontalis relaxation may be part of a generalized relaxation response: that is, when one becomes deeply relaxed, muscle tension levels including those in the frontales may decrease. However, it is conceivable that one could relax deeply, as measured by a number of physiological responses, and still tense a single muscle, or conversely, that one could achieve low tension levels in a single muscle in the absence of other physiological responses indicative of lowered arousal or deep relaxation. If so, then simply training reduced levels of frontalis tension may not be sufficient to elicit a general relaxation response.

However, if frontalis tension reduction does normally constitute one aspect of a general relaxation response, then perhaps feedback from these muscles can serve as a guide to the evocation of that response, serving as an indicator of its progressive development. From this point of view, the appropriate question to ask is not whether frontalis tension reduction produces general relaxation, but rather what frontalis feedback procedures, if any, can be used to facilitate frontalis tension reduction within the context of a more global relaxation response, rather than as an isolated phenomenon. Stoyva (1979) has similarly argued that the degree of generalization of frontalis tension reduction will vary with the conditons of training and that "we are left with the question of specifying the conditions that promote the occurrence of generalization" (p.345).

The Need for Systematic Evaluation
of Training Parameters

A possible explanation for the equivocal nature of the results cited, both with regard to frontalis tension reduction and more generalized effects, is that there is no single procedure defined by the label "biofeedback training for frontalis tension reduction". It seems reasonable to assume that the outcome of a learning procedure, in which external feedback of a physiological response is intended to facilitate voluntary control of physiological activity, will depend not only on the provision of the feedback itself but

rather upon the characteristics of the entire procedure. Such considerations prompted Burish and Hendrix (1980) to refer, not simply to EMG biofeedback, but rather to "the EMG biofeedback training package" (p137). It is almost certainly true that feedback from the frontales in the absence of appropriate instructions and training parameters will not be sufficient to produce changes in either frontalis tension itself or any other physiological or psychological variables. There is, after all, nothing magical or automatic about providing a feedback signal.

There has been a great deal of variation among studies in the nature of the feedback training provided. Instructions provided for subjects, the nature of the feedback signal, duration of individual exposures to feedback, and the total amount of training are all factors which have varied widely and which could possibly have contributed to varying outcomes.

Since instructions are rarely given verbatim, it is not always possible to characterize the nature of instructions given to subjects in a particular study. It is clear, however, that studies have varied as to the subjects' knowledge regarding the source of the feedback signal and the goal of the training. In many studies instructions informed subjects that the feedback signal represented frontalis tension and that they were to reduce that tension, but stressed also that general relaxation would either facilitate or accompany frontalis tension reduction (e.g.,

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Alexander, 1975; Burish et al., 1981; Davis, 1980; Fee & Girdano, 1978; Freedman & Papsdorf, 1976; O'Connell & Yeaton, 1981). In other studies instructions focused specifically on frontalis tension, apparently with little or no mention of general relaxation (e.g., Alexander et al., 1975; Sagberg & Kveim, 1981; Shedivy & Kleinman, 1977). Still others provided instructions which deliberately did not inform the subjects of the source of the feedback signal. In some such studies (DeGood & Chisholm, 1977; McGowan et al., 1979) subjects were instructed to relax and told that the signal represented an indication of how relaxed they were; in another (Glaus & Kotses, 1979), subjects were merely instructed to try to control the feedback signal and were given no information about what responses might have been relevant to that task.

Most studies of frontalis feedback have employed auditory feedback signals. There have, however, been variations within the auditory modality in the nature and method of presentation of the signal. Most studies have provided subjects with a tone whose frequency varied in proportion to the level of tension in the frontales (e.g., Burish et al., 1981; DeGood & Chisholm, 1977; Freedman & Papsdorf, 1976; Haynes et al., 1975; McGowan et al., 1975; Nielsen & Holmes, 1980; O'Connell & Yeaton, 1981; Shedivy & Kleinman, 1977). While in most of these studies the feedback tone was continuous, in one (Nielsen & Holmes, 1980) the tone was pulsating. Other studies have used as a

feedback signal a clicking stimulus whose frequency varied with changes in frontalis tension (e.g., Alexander, 1975; Alexander et al., 1975; Alexander et al., 1977; Davis, 1980; Fee & Girdano, 1978; Gatchel et al., 1978; Glaus & Kotses, 1979). While the majority of auditory feedback studies used signals which were available to subjects at all levels of frontalis tension, some, as a shaping procedure, provided feedback only when tension was above some threshold level which was systematically reduced over the course of training (DeGood & Chisholm, 1977; Davis, 1980). Visual feedback of frontalis tension has generally been avoided since an early study (Alexander, et al., 1975) found it to be less effective in reducing frontalis tension than auditory feedback. The reason for this finding is probably related to the fact that recordings of frontalis tension most likely reflect the tension in nearby muscles as well (Alexander et al., 1975; Sagberg & Kveim, 1981). Visual feedback necessitates keeping the eyes open which increases the likelihood of eye movements and thus makes the feedback signal more variable and more difficult to control. That eye movements could be responsible for the superiority of auditory over visual feedback is supported by the finding that subjects provided with auditory feedback but told to keep their eyes open did not reduce frontalis tension as well as subjects receiving auditory feedback with eyes closed (Alexander et al., 1975). Some studies have, however, employed visual feedback. Reinking & Kohl (1975)

allowed subjects to sample both auditory and visual feedback modalities and to choose which they would receive. Burish and Hendrix (1980) provided subjects with both auditory and visual feedback. One study provided frontalis tension feedback in the form of a variable frequency tactile vibration applied to the volar surface of the arm (Sagberg & Kveim, 1981).

One other feedback signal characteristic which may be of importance is whether the signal represents direct feedback of instantaneous frontalis activity or feedback averaged over some brief time interval. It may be that "raw" EMG which is very variable from instant to instant provides too much information for the learner to be able to benefit. A smoothed signal, averaged over 1 or 2 seconds may facilitate the development of control (Autogenic Systems, Inc., 1975a, p. 22). Unfortunately, systematic evaluation of this parameter has not, to this author's knowledge, appeared in the feedback literature. Furthermore, information regarding this aspect of the feedback signal is typically not provided.

Perhaps the greatest amount of variability among studies occurs in the temporal characteristics of the training procedures. Both the total amount of training provided and the distribution of training time, factors which are considered critical in many types of learning, have varied widely from study to study. Total amount of training has ranged from 20 minutes (e.g., Burish & Hendrix, 1980; Burish

et al., 1981; Haynes et al., 1975; McGowan et al., 1979) to 5 hours (Fee & Girdano, 1978). The duration of individual exposures to feedback has ranged from 70 seconds (Davis, 1980) to 40 minutes (DeGood & Chisholm, 1977).

One further factor which could have contributed to the variability of results relates to subject selection. While most studies employed subjects who were not screened as to baseline levels of anxiety or tension, several specifically rejected subjects who reported any possible problem relating to muscle tension (Alexander, 1975; Alexander et al., 1975; Alexander et al., 1977; Fridlund et al., 1980) and one study used only subjects who reported great difficulty in managing everyday anxiety and stress (Gatchel et al., 1978).

Whether or not frontalis tension reduction and/or general relaxation occur during the course of frontalis feedback training may well be dependent upon the entire procedural context in which feedback is presented. Furthermore, it may be that those training conditions which are most effective in reducing frontalis tension are not necessarily the optimal conditions for eliciting a general relaxation response. Although the need for systematic evaluation of training parameters in frontalis feedback training has been previously recognized (Davis, 1980; Kondo et al., 1977; Stoyva, 1979; Wilkinson, 1976) few such evaluations have appeared. It would be useful to be able to derive from previous studies, by comparing their outcomes, those training conditions which favored tension reduction in

the frontalis and/or general relaxation. However, procedural differences among studies in this area are so great as to obfuscate the role played by any one training variable.

Until more empirical evidence is obtained about the role played by various training parameters, it would seem to be incumbent upon researchers in this area to select carefully and/or to vary systematically their training conditions. The rationale for choice of training conditions has often been unclear. For example, Davis (1980), who specifically states that her research was "designed to explore training conditions that might facilitate generalization" (p. 605), employed 70 second training periods. Why such short exposures to feedback would be assumed to facilitate a generalized response is unclear. Care must also be exercised in drawing conclusions about "frontalis feedback training". Balancing a justified caution not to accept biofeedback training too quickly as a panacea or to be too bold in claims of what can be achieved through the use of feedback, there must be an equally considered caution not to reject the usefulness of biofeedback because of a failure to recognize that biofeedback is a "training package" in which feedback is just one critical element.

Cognitive Factors and Instructional Set
in Frontalis Feedback Training

Stoyva (1979) has suggested that a potentially significant factor in frontalis feedback training is the mental set of the subject. Similarly, Meichenbaum (1976) has claimed that cognitive factors, i.e., the self-statements, images and expectancies of the subject are critical to the outcome of training. Perhaps one of the most direct influences on the cognitions of a feedback subject is provided by the instructions which she is given. There is a body of research which strongly suggests that instructions given to subjects in psychophysiological studies do have an influence on the physiological variables under investigation (Barber, 1965; May & Johnson, 1973; Sternbach, 1964). Sternbach (1964) concluded that a subject's "physiological changes will be determined at least in part by what he thinks will happen, or ... by what the subject thinks we think will happen" (p.72). An empirical demonstration of the importance of cognitive factors in frontalis biofeedback training is provided by Goldberg et al. (1982), who found that subjects given positive expectations about their self-control ability achieved lower frontalis tension levels than subjects given either negative or ambiguous expectations.

In considering the use of frontalis feedback, both as a means of facilitating frontalis tension reduction and as a general relaxation procedure, at least two cognitive dimensions of instructions appear to be relevant: an active-passive and a specific-general dimension.

With regard to the active-passive dimension, urging conation, i.e., telling a subject that she is to try or attempt to do her best to reduce tension, to relax or to change the feedback signal, presents the training as a task to be accomplished through active striving. Such striving has been considered to be counterproductive to the attainment of general relaxation. Those techniques, such as progressive muscle relaxation, autogenic training and eastern meditative procedures, which have been notably successful in yielding a generalized relaxation response, stress the importance of "passive concentration" or "passive volition" in the attainment of a deeply relaxed state (Benson, 1975; Green, Green & Walters, 1970; Stoyva, 1976). Green et al. (1970) point out that although such phrases seem at first paradoxical, they are most descriptive of the approach employed by successful subjects. They further describe the attitude most conducive to general relaxation as "detached effortless volition" (p.5).

Most studies of frontalis feedback training, whether they have monitored only frontalis tension or looked for evidence of generalized physiological relaxation, have employed instructions which, while suggesting relaxation or tension reduction, have either suggested an active approach to the attainment of these ends or have failed to convey the importance of passivity. Thus, Alexander's (1975) subjects were "instructed to attempt to relax the muscle as much as possible...." (p. 658); Freedman and Papsdorf (1976) told

subjects, "Your task is to make the pitch of the tone as low as possible." (p. 258); Nielsen and Holmes (1980) told subjects, "You can use this feedback to determine whether or not what you are doing is effective in helping you to relax. Because your task in this session is to relax as much as possible...." (p. 240); Haynes et al. (1975) informed subjects that "their task was to become as relaxed as possible...." (p. 548); McGowan et al. (1979) asked their subjects to "attempt to become as relaxed as possible" (p.327); O'Connell and Yeaton (1981) report that instructions explained that "the subject's job was to lower the pitch of the tone" (p. 57); and Fee and Girdano's (1978) subjects were asked to "try to relax. Try to make the needle move to the left. Try to make the clicks slow down...." (p.327). Referring to relaxation or tension reduction as a task or a job and asking that the subject attempt or try to do her best does not seem to evoke a cognitive set which could be characterized as passive, detached or effortless.

Hurley (1978) reports results which suggest that a passive approach to training is important even for the attainment of localized reductions in frontalis tension. Subjects receiving feedback and instructions described as motorically inhibiting (somewhat, though not directly comparable to what is here called passive) significantly reduced frontalis tension, while subjects receiving feedback and motorically activating instructions (comparable to what

is here called active) did not. Hurley's results were not powerful; although the group receiving feedback and motorically inhibiting instructions was the only one to reduce tension significantly compared to baseline levels, its mean tension level did not differ significantly from those obtained for the group receiving feedback and motorically activating instructions or for groups receiving instructions but no feedback. A possible explanation for the failure of the motorically inhibiting instructions to produce a stronger effect is that while they appear to have been somewhat more passive than the motorically activating instructions they still implied a fairly active approach. Hurley reports that the motorically inhibiting instructions included such phrases as "inhibit the tension" and "decrease the tension" (p. 242). Such phrases, while perhaps less active than "produce relaxation" or "increasingly relax" (p. 242) which were part of the motorically activating instructions, still imply that something active is to be done by the subject, rather than indicating that the subject is merely to allow the relaxation to proceed. Nonetheless, significant tension decreases demonstrated by subjects receiving instructions which were relatively more passive than those given to others suggest the relevance of the active-passive dimension for frontalis tension reduction.

Stoyva (1977) states, "A prominent feature of many types of biofeedback training is a shift to a non-striving mental condition -- e.g., with frontal EMG, temperature, theta EEG

or EDR feedback. And conceptual activity shifts from normal reality-oriented cognitions to a drifting condition in which directed thinking is absent" (p. 468). If such a passive mental state is a usual and desirable outcome of frontalis feedback training, then it seems reasonable to assume that it will occur more quickly and efficiently if instructions to the subject encourage it.

With regard to the specific-general dimension of instructions, if the feedback training is intended to produce only changes in the frontales, then perhaps instructions which direct the subjects' attention to these muscles (specific instructions) would be most effective. However, if frontalis feedback is to be used as a guide to general relaxation, then perhaps it would be best that the subject be told that the feedback signal represents her overall level of relaxation or tension (general instructions). General instructions, while misleading the subject as to the source of the feedback, would inform the subject as to what the desired response is and perhaps facilitate the use of the feedback signal as a guide to evoking that response. It is not unreasonable to assume that subjects enter the laboratory with some general relaxation skills. Focusing the subjects' attention on the specific muscle from which the feedback is derived may facilitate tension reduction in that muscle but may also divert the subject from evoking a more general response.

As mentioned previously the majority of frontalis feedback studies have employed instructions which contain both specific and general aspects. That is, while subjects are typically informed that the feedback signal represents frontalis tension, they are also told that general relaxation will either facilitate or accompany frontalis tension decreases. Such instructions, while not strictly general as defined here, may be seen as occupying an intermediate position on a bipolar scale of specificity-generality. The possible effects of providing subjects with instructions which include reference to general relaxation are suggested by a comparison between the results obtained by Glaus and Kotses (1979) and those obtained by O'Connell and Yeaton (1981). It may be recalled from earlier discussion that Glaus and Kotses did not suggest general relaxation, or even frontalis tension reduction, as a means of controlling the feedback signal; subjects were just told to try to change the signal. In fact, in a debriefing interview most subjects were unaware of what response was controlling the feedback signal. Results indicated increasing specificity of muscle tension activity over the course of training; that is, covariation between the frontalis and the other monitored muscle decreased. O'Connell and Yeaton's subjects knew that frontalis tension was the source of the feedback signal but were told to relax as a means of controlling the signal. Results indicated the occurrence of covariation between the

frontalis and the other monitored muscle which did not decrease over the course of training. The different results cannot, with certainty, be attributed to the fact that O'Connell and Yeaton's instructions suggested general relaxation, since the two studies differed from one another in a number of other ways. Perhaps the most critical difference is in the muscle which was monitored as an indicator of generalized muscular relaxation. O'Connell and Yeaton monitored the semispinalis capitis (a neck muscle) while Glaus and Kotses monitored the brachioradialis (a forearm muscle). The possibility exists, however, that the results of these studies were influenced by the fact that subjects told to relax generally, in fact do produce a more general relaxation response using the feedback signal as a guide.

The only studies reviewed here which employed purely general instructions (i.e., which asked the subjects to relax and informed them that the feedback signal was an indicator of relaxation) provided conflicting results. DeGood and Chisholm's (1977) data indicated the development of a generalized relaxation response as indicated by changes in EEG alpha density, heart rate and respiration rate as well as frontalis tension. McGowan et al. (1979), however, found no evidence of general relaxation as measured by a number of physiological responses. Once again, it is difficult to speculate about the cause of these discrepant results since the two studies differed from each other in a

number of potentially significant ways (e.g., the amount and distribution of training time and the presence or absence of stressors over the course of training).

Aside from Hurley (1978), no single study known to this author has systematically manipulated either the active-passive or the specific-general dimension of instructions to determine effects either on frontalis tension or on other physiological variables. While it would be useful to compare results across studies which have used different types of instructions, such comparisons are, at best, very difficult. First, as already discussed, procedural differences among studies of frontalis feedback are great; any two studies will typically differ from one another in a number of potentially significant ways. A further problem in assessing the effects of instructional set by comparing results across studies arises from the fact that instructions are rarely reported in their entirety. Because of this, it is often difficult to classify instructions accurately as being active or passive or as being specific or general.

Purpose, Rationale for Training Parameters
and Hypotheses

The present study evaluated the roles of frontalis EMG feedback and instructional set in relaxation training. Four groups of subjects receiving auditory EMG feedback from the frontales were presented with instructions characterized as

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either specific and active, specific and passive, general and active or general and passive (see Appendices A - D). In order to assess separately the roles of feedback and instructions, four additional groups received instructions comparable to those given to the feedback groups, but without the provision of or reference to feedback (see Appendices E - H). The effects of these manipulations on frontalis tension level were assessed. In addition, the degree of generalized relaxation which occurred was assessed by monitoring sternomastoid (neck) muscle tension, skin conductance level and fingertip skin temperature.

Since a major purpose of this study was an assessment of the question of whether frontalis feedback training facilitates general relaxation, training conditions were chosen that were felt to favor the development of general relaxation. Training was provided in 10-minute blocks. All subjects received two such blocks per session for five sessions given over the course of a two to three week period, providing a total of 1 hour and 40 minutes of training. The choice of 10-minute training blocks was based upon the assumption that a generalized relaxation response takes more than just a few moments to develop. Widely accepted relaxation procedures typically involve extended relaxation periods. Pilot data in our laboratory had suggested that while feedback subjects continued to decrease frontalis tension levels over a 10 minute period, longer periods produced restlessness. Although some authors

(Alexander et al., 1977; Sagberg & Kveim, 1981) believe that little change in frontalis tension occurs after the first feedback training session, the present study continued training over five sessions. It was felt, once again, that in assessing frontalis feedback as a potential general relaxation technique, one should draw upon the more widely accepted relaxation procedures as models for the development of training conditions. Such procedures typically involve multiple training sessions. In light of evidence that feedback subjects produce greater reductions in frontalis tension with shorter intersession intervals (Kondo, et al., 1977) an attempt was made to schedule the five sessions for each subject in as short a period of time as was possible and to insure that group differences in intersession interval did not occur.

Because the majority of frontalis feedback studies have employed auditory feedback and because there is some evidence that this feedback signal modality produces the greatest training effect in the frontales (Alexander et al., 1975), feedback subjects received auditory feedback while sitting with their eyes closed. The EMG activity producing the feedback signal was averaged over approximately a 2-second period so as to reduce variability in the signal and perhaps facilitate control.

In light of the contention that subjects receiving only instructions can, if adequately motivated, achieve reductions in frontalis tension that do not differ from

those achieved by feedback subjects (Alexander et al., 1977; Davis, 1980), an effort was made in the present study to insure the adequate motivation of all subjects. Alexander et al. (1977) had informed subjects who would initially be receiving only instructions that eventually they would be receiving feedback and that their "earnest and purposeful attempt to relax the relevant muscles just as much as they possibly could" (p. 554) was critical both in their own comparison of their ability to relax with and without feedback and in the scientific evaluation of the effectiveness of feedback. This information was intended to motivate subjects by involving them in the "logic of the experimental enterprise" (p.554). In the present study, an overview of the experiment (see Appendices I and J) read by subjects at the start of the first session included the statement that "your careful attention to all instructions which are given to you is important to the conclusions which we reach." This was intended to impress upon the subject the importance of her own participation, while not suggesting the active striving approach implied in the information given to subjects by Alexander et al. (1977). Subjects were further informed, verbally, that, should they desire it, the data which they provided would be discussed with them at the conclusion of their participation in the study. As a further means of maintaining motivation, subjects were asked to read their instructions and were reminded of the importance of their careful attention to

those instructions prior to the first training block of each training session. As a means of assessing the subjects' motivation, at the conclusion of participation in the study each subject responded to a debriefing questionnaire (see Appendix K) which, among other questions, asked the subject to rate how often she felt discouraged or frustrated and how positive or negative the experience of being a subject had been.

With regard to the outcome of the study, the following major hypotheses were advanced.

Hypotheses concerning frontalis tension:

H 1: Subjects receiving feedback will achieve lower levels of frontalis tension than subjects receiving instructions only.

H 2: Subjects receiving passive instructions will achieve lower levels of frontalis tension than subjects receiving active instructions.

H 3: Subjects receiving specific instructions will achieve lower levels of frontalis tension than subjects receiving general instructions.

H 4: Subjects will achieve lower levels of frontalis tension over the successive minutes of the training block.

H 5: Subjects will achieve lower levels of frontalis tension over successive training sessions.

Hypotheses concerning other physiological variables:

- H 6: Subjects receiving feedback will achieve greater general relaxation than subjects receiving instructions only, as indicated by lower levels of sternomastoid muscle tension, higher skin temperature, and lower skin conductance level.
- H 7: Subjects receiving passive instructions will achieve greater general relaxation than subjects receiving active instructions, as indicated by lower levels of sternomastoid muscle tension, higher skin temperature, and lower skin conductance level.
- H 8: Subjects receiving general instructions will achieve greater general relaxation than subjects receiving specific instructions, as indicated by lower levels of sternomastoid muscle tension, higher skin temperature, and lower skin conductance level.
- H 9: Subjects will achieve increasing general relaxation over the successive minutes of the training block, as indicated by lower levels of sternomastoid muscle tension, higher skin temperature, and lower skin conductance level.
- H 10: Subjects will achieve increasing general relaxation over successive sessions, as indicated by lower levels of sternomastoid muscle tension, higher skin temperature, and

lower skin conductance level.

CHAPTER 2

Method

The method section will present the procedures used in the development of the instructions to be used in the study and will then present the conduct of the study itself.

Development of Instructions

The development of instructions for use in this study took place in a number of stages. Initially the guiding principles, described below, were used to prepare instructions which appeared to the experimenter and a committee of psychologists and students in psychology to vary along the desired continua (i.e., active-passive and specific-general). Instructions were to be as similar to each other as possible except for differences dictated by the manipulation of the independent variables. The only difference between instructions intended for the no-feedback subjects and those intended for the feedback subjects was to be reference to the feedback signal and its purpose. Similarly, active and passive, and specific and general instructions were to differ from each other only along their respective dimensions.

In developing specific versus general differences the primary consideration was, of course, that specific instructions would refer to changes in frontalis tension while general instructions would refer to overall or general relaxation. With regard to exact wording, the committee suggested that specific (as opposed to general) instructions

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should not refer to "relaxation" of forehead muscle tension, but rather to forehead muscle tension reduction (for active instructions) and tension release (for passive instructions). The word "relaxation" was considered to have a somewhat general connotation.

Active instructions, paralleling those used in many frontalis feedback studies, were intended to be conative in character, essentially asking the subject to try to relax herself (general instructions) or to reduce the tension in her forehead muscles (specific instructions) as best she could. The relaxation or tension reduction process was referred to as a task which, though it required effort, the subject could master. Passive instructions, conforming to the concept of passive volition, asked the subject to allow tension to flow out of the body (general instructions) or the forehead muscles (specific instructions). The relaxation or tension reduction process was described as being natural and effortless.

In order to determine if the instructions which were written in conjunction with the committee conveyed the appropriate set to the intended subject population, the four types of instructions (specific-active, specific-passive, general-active and general-passive) were presented to undergraduate students who were asked to rate them on separate 7-point scales indicating how active or passive and how specific or general they seemed. To insure that the instructions were comparable to each other in a number of

presumably critical ways, raters were also asked to judge on 7-point scales how clear or unclear and how good or bad the instructions seemed. The rating scales and the directions provided for the raters appear in Appendix L.

The instructions rated by the undergraduate students were those intended for the no-feedback subjects, i.e., they contained no reference to feedback. It was recognized that it would have been desirable, as well, to have the comparable instructions intended for feedback subjects rated prior to their use in the study. Because raters were drawn from the same population that would provide subjects for the study, limitations in the number of subjects available prohibited employing too many individuals as raters. This was of particular concern since it was anticipated (and did, in fact, occur) that the development of instructions could be an iterative process, requiring a number of ratings followed by modifications of instructions. A post hoc determination of the comparability of feedback and no-feedback instructions on the various rating scales was later provided by having subjects who would take part in the study rate their instructions at the conclusion of their participation as part of a debriefing questionnaire (see Appendix K). In the three separate rating procedures which were ultimately necessary 38, 68, and 37 raters, respectively, took part.

Because each subject in the study would be receiving only one type of instruction, each rater also received only

one type. Considering the various common usages of the words "specific", "general", "active" and "passive", it was decided that directions to raters should include definitions of what these terms referred to in the present context. It was recognized that ratings would then be dependent not only on the wording of the instructions themselves, but also upon the way in which the rating continua were defined. It was considered that this was preferable to not providing the uniformity of understanding encouraged by the provision of definitions.

Results of the rating procedure were analyzed with four 2 (active- passive) X 2 (specific-general) ANOVAs, one for each rating scale. It was decided that for instructions to be acceptable for use in the study: 1) mean ratings of active and passive instructions on the active-passive scale would have to fall on the appropriate side of the neutral point (i.e., active < 4; passive > 4) and differ significantly from each other at at least the .01 probability level; 2) the ANOVA of the active-passive rating scale data would reveal no other differences; 3) mean ratings of specific and general instructions on the specific-general scale would have to fall on the appropriate side of the neutral point (i.e., specific < 4; general > 4) and differ significantly from each other at at least the .01 probability level; 4) the ANOVA of the specific-general rating scale data would reveal no other differences; and 5) no differences would be revealed in the ANOVAs of the clear-unclear or good-bad rating scale data.

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Because of failure to meet all of these criteria instructions went through two revisions before the third validation procedure proved the instructions to be acceptable. Results of the final validation procedure (mean ratings given to the four types of instructions on the four rating scales and ANOVAs of these data) appear in Table 1. The instructions developed for use by no-feedback subjects (i.e, those used in the final validation procedure) appear in Appendices E through H; the comparable instructions intended for the feedback plus instructions subjects appear in Appendices A through D.

Conduct of the Study

Subjects. Sixty-four subjects were recruited from the undergraduate student population of Queens College of the City University of New York to serve as unpaid volunteers. To reduce variability in subjects' ages an upper limit of 40 years of age was applied to subjects. The mean age of the subjects was 20.12 years. It was required that subjects be in good physical health and that they have no previous experience with any formal tension reduction or relaxation technique. Eight subjects were assigned to each of the eight treatment groups. Because a large proportion of the volunteers were women, each group was composed of 5 females and 3 males. Eight random sequences of the eight treatment conditions were generated. As they arrived at the laboratory the first eight subjects were each assigned to one of the eight treatment groups according to this

TABLE 1

Instruction validation: mean ratings given to the four types of instructions on the four validation rating scales and ANOVA summary tables for these data. For the four scales higher means are closer to the unclear, general, passive, and bad poles of the continua, respectively.

Clear-Unclear Rating Scale						
Mean Ratings			ANOVA Summary Table			
	Active	Passive	Source	df	MS	F
Specific	1.78	1.90	A-P	1	.09	.08
			S-G	1	.09	.08
General	1.89	1.56	AP X SG	1	.46	.43
			S/AP X SG	33	1.08	

Specific-General Rating Scale						
Mean Ratings			ANOVA Summary Table			
	Active	Passive	Source	df	MS	F
Specific	1.89	1.80	A-P	1	.09	.04
			S-G	1	98.39	47.76 ***
General	5.00	5.22	AP X SG	1	.18	.09
			S/AP X SG	33	2.06	

Active-Passive Rating Scale						
Mean Ratings			ANOVA Summary Table			
	Active	Passive	Source	df	MS	F
Specific	2.00	5.40	A-P	1	111.78	70.30 ***
			S-G	1	2.49	1.56
General	2.44	6.00	AP X SG	1	0.00	<1.00
			S/AP X SG	33	1.59	

Good-Bad Rating Scale						
Mean Ratings			ANOVA Summary Table			
	Active	Passive	Source	df	MS	F
Specific	1.67	2.20	A-P	1	.09	.11
			S-G	1	.09	.11
General	2.22	1.89	AP X SG	1	1.75	2.22
			S/AP X SG	33	.79	

*** p < .001

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schedule. Each successive group of eight subjects was similarly assigned according to this original schedule. The only deviation from this procedure occurred with the final two groups of eight subjects where modifications had to be made to insure an equal number of males and females in all treatment groups.

Apparatus. All physiological variables were monitored using apparatus manufactured by Autogenic Systems, Inc., Berkeley, California. Autogen models 1700 and 1100 feedback myographs were used to monitor frontalis tension and right sternomastoid tension respectively. Each myograph unit employed Autogen electrode assemblies consisting of three gold electrodes (electrode diameter = 8 mm), each embedded in a plastic insulator cup. Electrode cups were filled with Spectra 360 Electrode Gel (Parker Laboratories, Orange, N.J.) and were applied to the skin with annular adhesive discs. Electrode placements were those recommended by the equipment manual (Autogenic Systems, Inc., 1975a) and closely conformed to those recommended by Lippold (1967). For EMG measurement of the frontalis muscles the two active electrodes were placed 1 inch above each eyebrow and 2 inches to either side of the midline. The reference electrode was placed midway between the two active electrodes. To facilitate placement of the sternomastoid electrodes the subject was asked to turn her head to the left in order to bring the sternomastoid into a visible vertical line. The first active electrode was placed

directly below the mastoid process and the second, 2 inches below the first. The reference electrode was placed within 1 inch of the second active electrode. Prior to electrode placement each EMG recording site was abraded with an alcohol saturated gauze pad to insure adequate contact. Both myograph units performed integral average (rather than peak-to-peak) EMG amplitude quantification. The frequency bandpass over which frontalis EMG was monitored was 100 to 1000 Hz; the bandpass over which sternomastoid EMG was monitored was 100 to 200 Hz.

The Autogen model 1700 feedback myograph also provided the feedback signal for subjects receiving feedback of frontalis EMG. The signal consisted of a continuous tone whose pitch was logarithmically proportional to the monitored EMG level: higher pitches were associated with higher muscle tension levels. The EMG activity giving rise to the feedback signal was averaged over a period of approximately 2 seconds.

An Autogen model 2000b feedback thermometer using a Yellow Springs Instrument Company (Yellow Springs, Ohio) model 729 thermistor was used to monitor fingertip skin temperature. The thermistor was taped over the central whorl of the distal phalanx of the middle finger of the right hand. To avoid constriction of the finger and interference with the blood flow, the tape securing the thermistor only partially encircled the finger.

An Autogen model 3400 feedback dermograph using an Autogen electrode assembly was used to monitor skin conductance level. The electrode assembly consisted of two silver/silver-chloride active electrodes and one gold reference electrode (electrode diameter = 8 mm). The electrodes were embedded in plastic insulator cups which were filled with K-Y Lubricating Jelly (Johnson & Johnson, New Brunswick, N.J.) and attached to the skin with annular adhesive discs. Following the placement suggestions in the equipment manual (Autogenic Systems Inc., 1975b), the two active electrodes were attached to the palmar surface of the right hand and the reference electrode was attached to the dorsal surface of the right wrist. The applied electrode potential was one of constant voltage (0.3 volts root-mean-square) delivered via a 10 Hz AC low-distortion sine wave.

Data from the monitoring apparatus were fed into four separate Autogen model I5000 analogue to digital optical isolator units and then into four channels of an Autogen 5400 multichannel data acquisition center. The data acquisition center controlled sampling durations and provided means and standard deviations of the monitored variables for each minute of all 10-minute recording periods (baseline and training). These statistics were printed out at the end of each 10-minute period on an Autogen model P5000 alphanumeric printer.

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The subject was seated in a padded recliner chair and her right hand was comfortably positioned in a specially designed hand holder mounted on the armrest of the chair. The hand holder limited the movement of the hand and, because the hand rested on soft screening material, allowed for circulation of air around the fingertip thermistor (see Kluger, 1983, for a detailed description of the hand holder). All subjects wore Koss model K6 headphones through which subjects receiving feedback heard the feedback signal.

Room temperature was thermostatically controlled, with the thermostat set at 75 degrees F. The reason for this relatively high room temperature was that Yates (1980) had noted that peripheral skin temperature tended to drift downward when room temperatures were cooler (68 degrees F). At higher room temperatures (77 degrees F) this drift effect was greatly attenuated.

Procedure. Each subject participated in five sessions, each of which was approximately 1 hour in duration. All sessions for an individual subject were scheduled within a two to three week period.

Upon arrival in the laboratory for the initial session the subject read a brief overview of the experiment (see Appendix I for overview presented to subjects who would be receiving specific instructions and Appendix J for overview presented to subjects who would be receiving general instructions). The overview indicated that the study was an investigation of the effectiveness of a technique for

facilitating the reduction of tension in specific muscles (specific overview) or for facilitating general relaxation (general overview). It further informed the subject that her participation would involve engaging in the technique while a number of physiological responses was being monitored. The overview stressed the importance to the study of the subject's attention to and compliance with instructions. Having read the overview, the subject was asked to sign an informed consent statement. The subject then completed a participant information form (see Appendix M). Subjects indicating that they suffered from any serious chronic medical or psychological disorder, that they regularly took a medication which could influence their performance in the study or that they had had previous training in biofeedback procedures were excluded from participation in the study. Subjects who were acceptable for participation then completed both the A-State and A-Trait forms of the State-Trait Anxiety Inventory (Spielberger, Gorsuch & Lushene, 1970). This inventory was readministered following the conclusion of training in the final session. Comparison of pre- and post-training scores was intended to provide information about changes in report of subjective anxiety.

The subject was then seated in the padded recliner chair. EMG (frontalis and sternomastoid), skin conductance level and temperature sensors were applied and headphones placed on the subject. Subjects were told that the purpose

of the headphones was to keep out external noises; no mention of feedback had been made to any subjects up to this point. Impedance levels of the EMG electrodes were checked using an impedance test circuit built into the monitoring apparatus; levels above 15 Kohms were considered unacceptable and, when obtained, required reapplication of electrodes. Once electrode placements were determined to be acceptable, the room lights were dimmed and 10 minutes of resting baseline levels of physiological activity were recorded. For these recordings subjects were asked to sit quietly with eyes closed and to move about as little as possible compatible with comfort. The purpose of the 10-minute resting baseline was twofold. It provided a measure of pretraining levels of physiological variables and served as an adaptation/habituation period in which physiological variables could stabilize. Sallis and Lichstein (1979) recommend 10 minutes as a minimum adaptation period in studies of frontalis EMG.

Following baseline recording, the room lights were brightened and the subject was presented with written instructions corresponding to the training group to which she had been assigned (see Appendices A through H). Subjects were reminded to read the instructions carefully since they were an important part of the training procedure. The lights were then dimmed to the same level as during baseline recordings. For subjects in the feedback groups, the feedback signal was turned on and the volume adjusted to

a level comfortable for the individual subject. Two 10 minute training periods separated by approximately 1 minute then ensued. Each training period, in accordance with the written instructions, began with the experimenter saying "Begin" and ended with the experimenter saying "OK". During the training periods subjects were asked to keep their eyes closed and to move about as little as possible compatible with comfort. During the 1 minute interval between training periods the subject was asked to open her eyes and to make any necessary adjustments in body position to maintain comfort. The feedback signal was not available to feedback subjects during the interval between training periods. At the conclusion of the second training period, sensors were removed and the session terminated.

The four remaining sessions began with the application of sensors and followed the same baseline and training procedures as the initial session. Prior to the first training period of each session the subject was asked to reread her instructions and reminded of their importance. Following the second training period of the final session, the subject completed both forms of the State-Trait Anxiety Inventory and a debriefing questionnaire (see Appendix K). The questionnaire included rating scales intended to assess perceived success (question I), the subject's attitude toward the training procedure which she received (questions II and VI), the subject's perception of the nature of the instructions which she used (question III), the subject's

evaluation of her own approach to her training in terms of the specific-general and active-passive dimensions (question IV) and the subject's evaluation of subjective changes which might be attributable to the training (question V).

Following completion of the questionnaire subjects who so desired had their own data discussed with them.

The general methodology of the study had been approved by the Queens College Committee for the Protection of Human Subjects.

CHAPTER 3

Results

Overview

Results strongly supported the superiority of feedback (FB) over no-feedback (NFB) conditions for the reduction of frontalis muscle tension. There was no indication, however, that instructional set had any effect on frontalis muscle tension level. That is, there were no significant differences in frontalis muscle tension between subjects receiving general (G) and those receiving specific (S) instructions or between those receiving passive (P) and those receiving active (A) instructions. As a whole subjects demonstrated decreasing frontalis muscle tension, both across minutes of a trial and across sessions. Subjects receiving feedback demonstrated greater decreases across minutes of a trial in the earlier sessions, with amount of change across minutes decreasing in an orderly fashion as a function of session. Change across minutes as a function of session was not as orderly for subjects receiving no feedback. In direct contrast to the feedback group, this group achieved the least amount of change across minutes in Session I.

Analyses of sternomastoid, fingertip skin temperature, and skin conductance level data indicated that levels of these variables were not dependent on whether or not subjects were provided with feedback.

There was evidence which suggested that subjects receiving general instructions did achieve a somewhat more general relaxation, at least in terms of muscle tension level, than subjects receiving specific instructions. This was suggested by the fact that the difference in sternomastoid muscle tension levels between subjects receiving general and those receiving specific instructions was significant at an alpha level of .10; the obtained mean for subjects who received general instructions was lower. Furthermore there appeared to be a consistent pattern of significant positive correlation between tension levels in the frontales and the sternomastoid muscles for subjects receiving general, but not for those receiving specific instructions.

The passive versus active dimension of instructions did not appear to effect any significant differences in sternomastoid, temperature, or skin conductance level data.

Data combined for all subjects for sternomastoid muscle tension and skin conductance level revealed responses indicative of increasing relaxation both across minutes of a trial and across sessions. Temperature data, however, indicated apparent increasing arousal (i.e., decreasing temperature) across minutes of a trial and no significant changes across sessions.

The detailed exposition of results, which follows, considers, first, analyses of possible confounding variables, i.e., initial baseline levels of physiological

variables, intersession interval, and subject age.

Following these considerations is a presentation of analyses of the physiological variables over the course of training. It is these analyses, directly relevant to the ten hypotheses which were advanced, which are summarized above. Next there is a presentation of analyses of the debriefing questionnaire rating scale data. Finally, analyses of the State-Trait Anxiety Inventory data are presented.

Analyses of baseline physiological measures, intersession interval and subject age

In order to assess whether there were any group differences in initial baseline levels of the monitored physiological variables which might have contributed to the obtained results, Session I baseline data for each variable were analyzed using 2 X 2 X 2 ANOVAs. The factors in these ANOVAs were FB/NFB, G/S, and P/A. Results indicated no significant differences among groups for any of the variables. Means and standard deviations of Session I baseline levels of each variable for the eight treatment groups appear in the upper panel of Table 2.

To assess whether there were any group differences in intersession interval or subject age, these variables, too, were analyzed with similar 2 X 2 X 2 ANOVAs. Results indicated no significant group differences in either variable. Means and standard deviations of these variables for the eight treatment groups appear in the lower panel of Table 2.

TABLE 2

Means and standard deviations (in parentheses) of baseline physiological data (upper panel), and subject age and intersession interval (lower panel). Units are: for muscle tension, microvolts; for temperature, degrees Fahrenheit; for skin conductance, micromhos; for age, years; and for intersession interval, days.

Variable	Group							
	Feedback				No Feedback			
	GP	GA	SP	SA	GP	GA	SP	SA
Frontalis	2.028 (1.032)	2.614 (1.043)	3.635 (2.081)	2.842 (1.177)	3.347 (2.003)	2.640 (0.996)	3.080 (0.946)	2.940 (1.721)
Sternomastoid	1.324 (0.798)	2.054 (1.575)	2.201 (0.982)	1.646 (0.435)	1.198 (0.437)	1.366 (0.711)	1.777 (0.830)	1.816 (1.115)
Temperature	87.66 (8.57)	90.58 (7.59)	86.94 (10.81)	91.03 (6.42)	90.51 (8.32)	83.68 (9.68)	92.04 (5.31)	90.26 (4.72)
Skin Conductance	8.55 (4.58)	12.21 (10.47)	6.89 (5.88)	8.87 (6.69)	7.77 (3.52)	6.80 (5.47)	8.33 (5.27)	4.67 (3.78)
Age	20.9 (2.1)	21.8 (5.3)	21.2 (3.4)	20.0 (2.3)	21.2 (3.2)	22.8 (4.0)	20.3 (2.2)	22.3 (5.7)
ISI	3.81 (0.80)	3.62 (1.00)	3.78 (1.07)	3.66 (1.05)	3.09 (0.73)	3.66 (0.72)	3.47 (0.95)	3.50 (0.90)

Analyses of physiological variables

Tables 3 through 6 present, for frontalis muscle tension, sternomastoid muscle tension, fingertip skin temperature, and skin conductance level, respectively, session means and standard deviations for each group, for Sessions I to V.

In order to test the ten hypotheses which had been advanced, separate 2X2X2X5X10 mixed design ANOVAs, with repeated measures on the last two factors, were performed on data for each of the physiological measures. The factors in the analyses were feedback versus no feedback, general versus specific instructions, passive versus active instructions, session, and minute of trial. Data for these analyses were the means of the respective physiological measures for each minute of training averaged over the two training periods in a session. Results of the analyses of frontalis muscle tension data (Table 7) relate to hypotheses 1 through 5. Results of the analyses of sternomastoid muscle tension data (Table 8), fingertip skin temperature data (Table 9), and skin conductance level data (Table 10) relate to hypotheses 6 through 10. In considering the results of these analyses, a significance level of $p = .05$ was employed for all main effects and 2- and 3-way interactions. Considering the great number of analyses performed and the greater relevance of the main effects and lower order interactions to the hypotheses which were advanced, a significance level of $p = .01$ was used to assess higher order interactions.

TABLE 3

Means and standard deviations (in parentheses) of frontalis muscle tension for feedback (FB) and no-feedback (NFB) groups, receiving general passive (GP), general active (GA) specific passive (SP), and specific active (SA) instructions, in Sessions I to V. Units are microvolts.

<u>Group</u>	<u>Session</u>					<u>Mean</u>
	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>	
<u>FB</u>						
GP (n=8)	1.533 (0.661)	1.468 (0.568)	1.386 (0.336)	1.193 (0.370)	1.169 (0.474)	1.350
GA (n=8)	2.100 (0.781)	1.516 (0.350)	1.484 (0.490)	1.543 (0.438)	1.339 (0.363)	1.596
SP (n=8)	1.993 (1.006)	1.899 (0.946)	1.493 (0.416)	1.408 (0.528)	1.476 (0.586)	1.654
SA (n=8)	1.989 (0.961)	1.829 (1.018)	1.578 (0.835)	1.553 (0.821)	1.504 (0.862)	1.691
<u>NFB</u>						
GP (n=8)	2.622 (1.963)	2.282 (1.549)	2.562 (1.760)	1.967 (1.398)	1.997 (1.624)	2.286
GA (n=8)	2.087 (0.686)	1.996 (0.821)	2.154 (0.945)	1.949 (0.740)	2.089 (0.691)	2.055
SP (n=8)	2.451 (0.976)	2.271 (0.902)	2.230 (0.796)	2.086 (0.817)	2.210 (0.412)	2.250
SA (n=8)	2.962 (1.916)	2.359 (1.913)	2.573 (2.172)	2.003 (1.425)	2.388 (2.277)	2.457
Mean (n=64)	2.217	1.952	1.932	1.713	1.772	1.917

TABLE 4

Means and standard deviations (in parentheses) of sternomastoid muscle tension for feedback (FB) and no-feedback (NFB) groups, receiving general passive (GP), general active (GA) specific passive (SP), and specific active (SA) instructions in Sessions I to V. Units are microvolts.

<u>Group</u>	<u>Session</u>					<u>Mean</u>
	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>	
<u>FB</u>						
GP (n=8)	1.414 (.751)	1.178 (.791)	1.278 (.757)	1.146 (.875)	1.135 (.734)	1.224
GA (n=8)	1.826 (1.087)	1.349 (.445)	1.342 (.536)	1.209 (.550)	1.392 (.740)	1.424
SP (n=8)	1.690 (.802)	1.820 (1.188)	1.576 (.854)	1.684 (.859)	1.420 (.503)	1.638
SA (n=8)	1.670 (.577)	1.707 (.815)	1.779 (.610)	1.485 (.463)	1.539 (.650)	1.636
<u>NFB</u>						
GP (n=8)	1.127 (.508)	1.178 (.694)	1.072 (.756)	0.938 (.640)	1.465 (.972)	1.156
GA (n=8)	1.199 (.646)	0.960 (.329)	0.977 (.344)	0.864 (.239)	1.141 (.456)	1.028
SP (n=8)	1.788 (.873)	1.647 (.982)	1.418 (.578)	1.237 (.556)	1.199 (.544)	1.458
SA (n=8)	1.586 (.900)	1.286 (.717)	1.143 (.537)	1.038 (.430)	1.021 (.369)	1.215
Mean (n=64)	1.538	1.390	1.323	1.196	1.289	1.347

TABLE 5

Means and standard deviations (in parentheses) of fingertip skin temperature for feedback (FB) and no-feedback (NFB) groups, receiving general passive (GP), general active (GA), specific passive (SP), and specific active (SA) instructions in Sessions I to V. Units are degrees Fahrenheit.

<u>Group</u>	<u>Session</u>					<u>Mean</u>
	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>	
<u>FB</u>						
GP (n=8)	86.77 (9.15)	90.17 (5.84)	89.13 (8.48)	86.91 (8.17)	88.79 (7.69)	88.35
GA (n=8)	89.88 (7.37)	88.27 (7.44)	87.38 (6.66)	90.49 (3.64)	85.65 (9.84)	88.34
SP (n=8)	87.17 (9.89)	88.66 (10.33)	84.73 (10.11)	84.60 (8.85)	84.09 (8.93)	85.85
SA (n=8)	88.62 (6.54)	89.35 (9.22)	90.49 (7.46)	88.00 (8.84)	90.44 (7.04)	89.38
<u>NFB</u>						
GP (n=8)	90.53 (7.36)	89.70 (5.12)	90.38 (5.46)	92.69 (2.34)	90.68 (6.08)	90.80
GA (n=8)	83.00 (10.57)	85.00 (9.12)	86.64 (8.70)	84.91 (5.73)	85.83 (7.95)	85.08
SP (n=8)	91.05 (7.26)	91.46 (5.40)	88.81 (5.74)	91.42 (2.77)	92.03 (2.44)	90.95
SA (n=8)	88.18 (6.23)	89.02 (6.51)	92.16 (2.46)	91.56 (3.05)	90.91 (3.68)	90.37
Mean (n=64)	88.15	88.95	88.72	88.82	88.55	88.64

TABLE 6

Means and standard deviations (in parentheses) of skin conductance level for feedback (FB) and no-feedback (NFB) groups, receiving general passive (GP), general active (GA), specific passive (SP), and specific active (SA) instructions in Sessions I to V. Units are micromho.

<u>Group</u>	<u>Session</u>					<u>Mean</u>
	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>	
<u>FB</u>						
GP (n=8)	10.84 (5.69)	9.64 (8.58)	10.81 (11.41)	5.51 (3.46)	8.08 (4.58)	8.98
GA (n=8)	14.26 (8.73)	10.53 (9.03)	9.59 (9.54)	10.44 (7.52)	10.91 (9.21)	11.15
SP (n=8)	10.62 (10.33)	8.42 (5.80)	11.46 (11.66)	6.43 (3.96)	9.82 (13.52)	9.35
SA (n=8)	11.97 (8.24)	10.46 (8.38)	9.50 (8.73)	9.62 (9.22)	8.44 (3.70)	9.98
<u>NFB</u>						
GP (n=8)	8.04 (3.36)	4.63 (2.18)	10.08 (8.75)	5.56 (3.30)	7.68 (6.91)	7.20
GA (n=8)	7.98 (6.79)	6.23 (3.84)	6.45 (3.10)	6.50 (3.85)	6.99 (5.11)	6.83
SP (n=8)	9.09 (6.23)	6.64 (5.53)	8.89 (8.81)	10.12 (13.43)	7.38 (10.57)	8.42
SA (n=8)	5.25 (4.02)	8.49 (8.68)	7.85 (7.03)	5.52 (4.14)	5.75 (3.98)	6.57
Mean (n=64)	9.76	8.13	9.33	7.46	8.13	

TABLE 7

ANOVA summary table of frontalis muscle tension training data. Only p-values less than .10 are reported.

Source	df	MS	F	p (2-tail)	
Feedback/NoFeedback (F)	1	380.059	7.46	.0084	**
General/Specific (G)	1	29.173	.57		
Passive/Active (P)	1	3.380	.07		
F X G	1	.052	.00		
F X P	1	4.710	.09		
G X P	1	2.622	.05		
F X G X P	1	20.990	.41		
Error	56	50.960			
Session (S)	4	24.720	9.83	.0000	***
S X F	4	3.618	1.44		
S X G	4	1.506	.60		
S X P	4	.947	.39		
S X F X G	4	.730	.29		
S X F X P	4	.815	.32		
S X G X P	4	1.625	.65		
S X F X G X P	4	3.527	1.40		
Error	224	2.516			
Minute (M)	9	4.513	17.41	.0000	***
M X F	9	.130	.50		
M X G	9	.092	.36		
M X P	9	.196	.76		
M X F G	9	.190	.73		
M X F X P	9	.232	.89		
M X G X P	9	.250	.96		
M X F X G X P	9	.050	.19		
Error	504	.259			
S X M	36	.110	.80		
S X M X F	36	.211	1.52	.0243	*
S X M X G	36	.082	.60		
S X M X P	36	.146	1.06		
S X M X F X G	36	.120	.87		
S X M X F X P	36	.206	1.49	.0306	*
S X M X G X P	36	.134	.97		
S X M X F X G X P	36	.114	.82		
Error	2016	.138			

* p < .05; ** p < .01; *** p < .001

TABLE 8

ANOVA summary table of sternomastoid muscle tension training data. Only p-values less than .10 are reported.

Source	df	MS	F	P (2-tail)
Feedback/NoFeedback (F)	1	56.658	3.28	.0757
General/Specific (G)	1	62.174	3.59	.0631
Passive/Active (P)	1	1.487	.09	
F X G	1	.948	.05	
F X P	1	16.200	.94	
G X P	1	5.016	.29	
F X G X P	1	.379	.02	
Error	56	17.296		
Session (S)	4	10.372	5.82	.0002 ***
S X F	4	1.026	.58	
S X G	4	4.170	2.34	.0561
S X P	4	.899	.50	
S X F X G	4	4.165	2.34	.0563
S X F X P	4	.668	.38	
S X G X P	4	.889	.50	
S X F X G X P	4	.545	.31	
Error	224	1.782		
Minute (M)	9	1.156	9.08	.0000 ***
M X F	9	.092	.72	
M X G	9	.056	.44	
M X P	9	.073	.57	
M X F X G	9	.037	.29	
M X F X P	9	.071	.56	
M X G X P	9	.123	.97	
M X F X G X P	9	.234	1.84	.0587
Error	504	.127		
S X M	36	.072	1.10	
S X M X F	36	.069	1.06	
S X M X G	36	.127	1.94	.0007 ***
S X M X P	36	.054	.83	
S X M X F X G	36	.058	.89	
S X M X F X P	36	.074	1.13	
S X M X G X P	36	.071	1.09	
S X M X F X G X P	36	.082	1.26	
Error	2016	.065		

* p < .05; ** p < .01; *** p < .001

TABLE 9

ANOVA summary table of finger-tip skin temperature training data. Only p-values less than .10 are reported.

Source	df	MS	F	P (2-tail)	
Feedback/NoFeedback (F)	1	1391.248	.79		
General/Specific (G)	1	795.531	.45		
Passive/Active (P)	1	389.488	.22		
F X G	1	2383.390	1.35		
F X P	1	4820.625	2.74		
G X P	1	3768.802	2.14		
F X G X P	1	125.518	.07		
Error	56	1759.293			
Session (S)	4	61.422	.28		
S X F	4	308.801	1.40		
S X G	4	55.948	.25		
S X P	4	214.507	.97		
S X F X G	4	36.121	.16		
S X F X P	4	235.572	1.07		
S X G X P	4	259.072	1.17		
S X F X G X P	4	316.039	1.43		
Error	224	220.712			
Minute (M)	9	4.621	5.53	.0000	***
M X F	9	5.839	6.99	.0000	***
M X G	9	5.915	7.08	.0000	***
M X P	9	3.332	3.99	.0001	***
M X F X G	9	2.520	3.02	.0016	**
M X F X P	9	.207	.25		
M X G X P	9	.815	.98		
M X F X G X P	9	.690	.83		
Error	504	.835			
S X M	36	1.856	5.54	.0000	***
S X M X F	36	.379	1.13		
S X M X G	36	.171	.51		
S X M X P	36	.155	.46		
S X M X F X G	36	.478	1.43	.0482	*
S X M X F X P	36	.368	1.10		
S X M X G X P	36	.487	1.45		
S X M X F X G X P	36	.198	.59		
Error	2016	.335			

* p < .05; ** p < .01; *** p < .001

TABLE 10

ANOVA summary table of skin conductance level training data. Only p-values less than .10 are reported.

Source	df	MS	F	p (2-tail)
Feedback/NoFeedback (F)	1	5454.489	2.78	
General/Specific (G)	1	1.920	0.00	
Passive/Active (P)	1	17.792	0.01	
F X G	1	152.620	0.08	
F X P	1	1270.827	0.65	
G X P	1	450.667	0.23	
F X G X P	1	0.103	0.00	
Error	56	1961.402		
Session (S)	4	575.874	2.44	.0475 *
S X F	4	246.878	1.05	
S X G	4	114.373	0.49	
S X P	4	304.748	1.29	
S X F X G	4	73.520	0.31	
S X F X P	4	259.679	1.10	
S X G X P	4	184.701	0.78	
S X F X G X P	4	100.066	0.42	
Error	224	235.636		
Minute (M)	9	373.724	71.06	.0000 ***
M X F	9	0.395	0.08	
M X G	9	7.173	1.36	
M X P	9	1.039	0.20	
M X F X G	9	8.773	1.67	.0939
M X F X P	9	4.858	0.92	
M X G X P	9	5.743	1.09	
M X F X G X P	9	4.722	0.90	
Error	504	5.260		
S X M	36	6.129	4.63	.0000 ***
S X M X F	36	1.834	1.38	.0646
S X M X G	36	0.833	0.63	
S X M X P	36	1.225	0.92	
S X M X F X G	36	1.474	1.11	
S X M X F X P	36	2.045	1.54	.0210 *
S X M X G X P	36	1.864	1.41	.0557
S X M X F X G X P	36	2.315	1.75	.0040 **
Error	2016	1.325		

* p < .05; ** P < .01; *** p < .001

Hypothesis 1. This hypothesis predicted that subjects receiving feedback would achieve lower levels of frontalis muscle tension than subjects receiving instructions only. This hypothesis was strongly supported by the data. Feedback subjects had an overall frontalis muscle tension level ($M = 1.573$ microvolts) which was lower than that demonstrated by subjects receiving no feedback ($M = 2.262$ microvolts). The summary table of the ANOVA performed on the frontalis muscle tension data (Table 7) indicates that this difference was significant, $F(1,56) = 7.46, p < .01$. The failure to find a significant interaction between the FB/NFB factor and either of the instructional factors (i.e., G/S or P/A) indicates further that none of the no-feedback condition was as effective as the feedback conditions for obtaining lowered frontalis muscle tension. Mean levels of frontalis muscle tension for feedback and no-feedback groups in each of the four instructional conditions are presented in Figure 1.

Hypothesis 2. This hypothesis predicted that subjects receiving passive instructions would achieve lower levels of frontalis muscle tension than subjects receiving active instructions. This hypothesis was unsupported by the data. Inspection of Table 7 reveals no significant effect of the P/A factor and no significant interaction with the other factors. This implies that the P/A dimension of instructions was not a significant factor in level of frontalis muscle tension achieved.

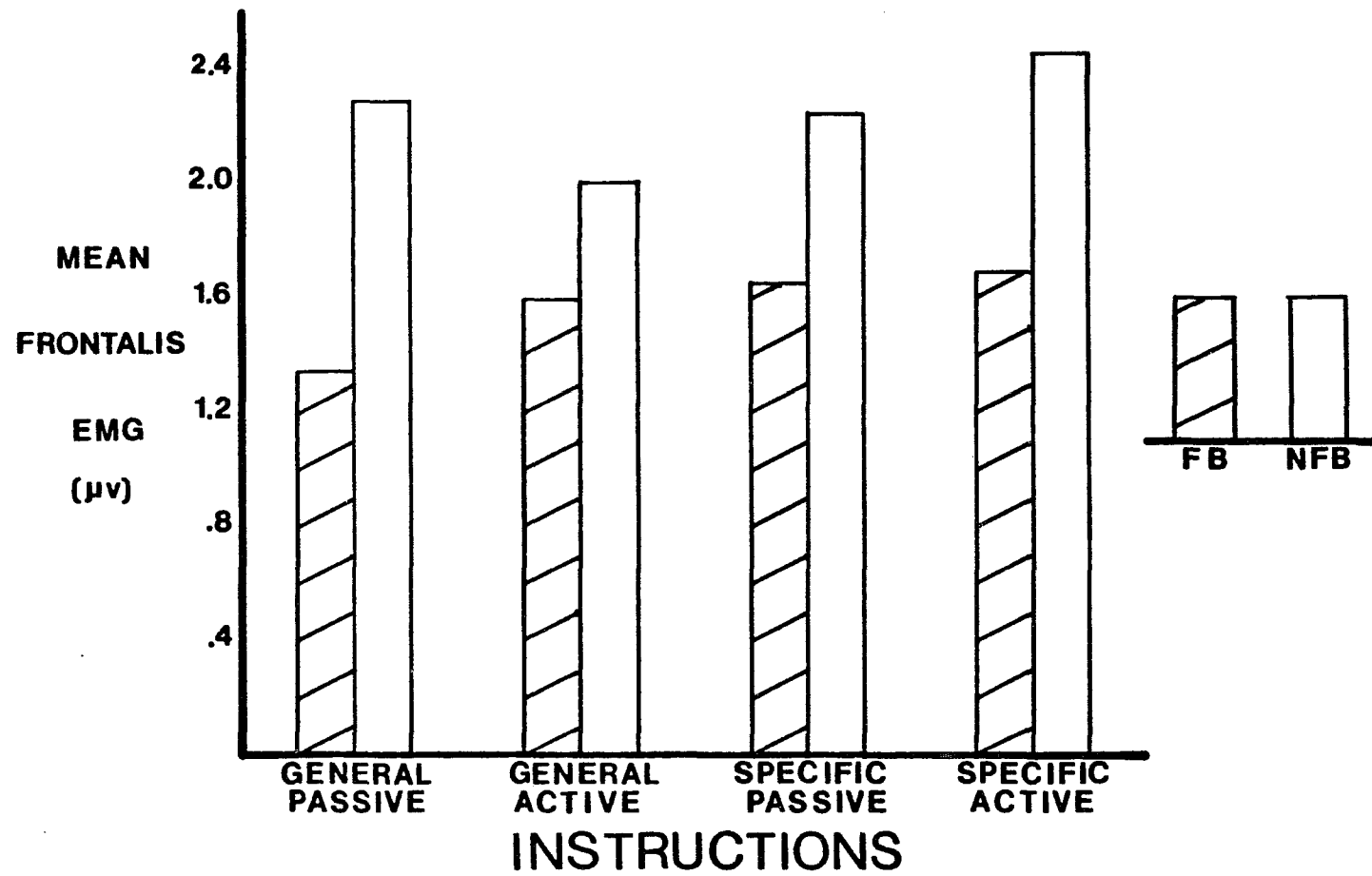


Figure 1. Mean frontalis EMG for the eight treatment groups. (n = 8/group)

Hypothesis 3. This hypothesis predicted that subjects receiving specific instructions would achieve lower levels of frontalis muscle tension than subjects receiving general instructions. This hypothesis, too, was unsupported by the data. Table 7 reveals no significant main effect of the G/S factor and no significant interaction with the other factors. This implies that the G/S dimension of instructions was not a significant factor in level of frontalis muscle tension achieved. In fact, the obtained mean frontalis muscle tension for subjects receiving general instructions was lower ($M = 1.823$ microvolts) than that obtained for subjects receiving specific instructions ($M = 2.013$ microvolts). This finding represents perhaps the most interesting negative result of the study, since it implies that even if one is using frontalis EMG feedback with the specific goal of frontalis muscle tension reduction, the provision of general instructions will not interfere with that goal.

Hypothesis 4. This hypothesis predicted that subjects would achieve lower levels of frontalis muscle tension over successive minutes of the training block. This hypothesis was supported by the data. Table 7 indicates a significant main effect for the minutes factor, $F(9, 504) = 17.41, p < .001$. Figure 2 illustrates the rather consistent decline in frontalis muscle tension over minutes demonstrated by subjects in this study. In order to assess the precise source of the obtained significance the data were analyzed

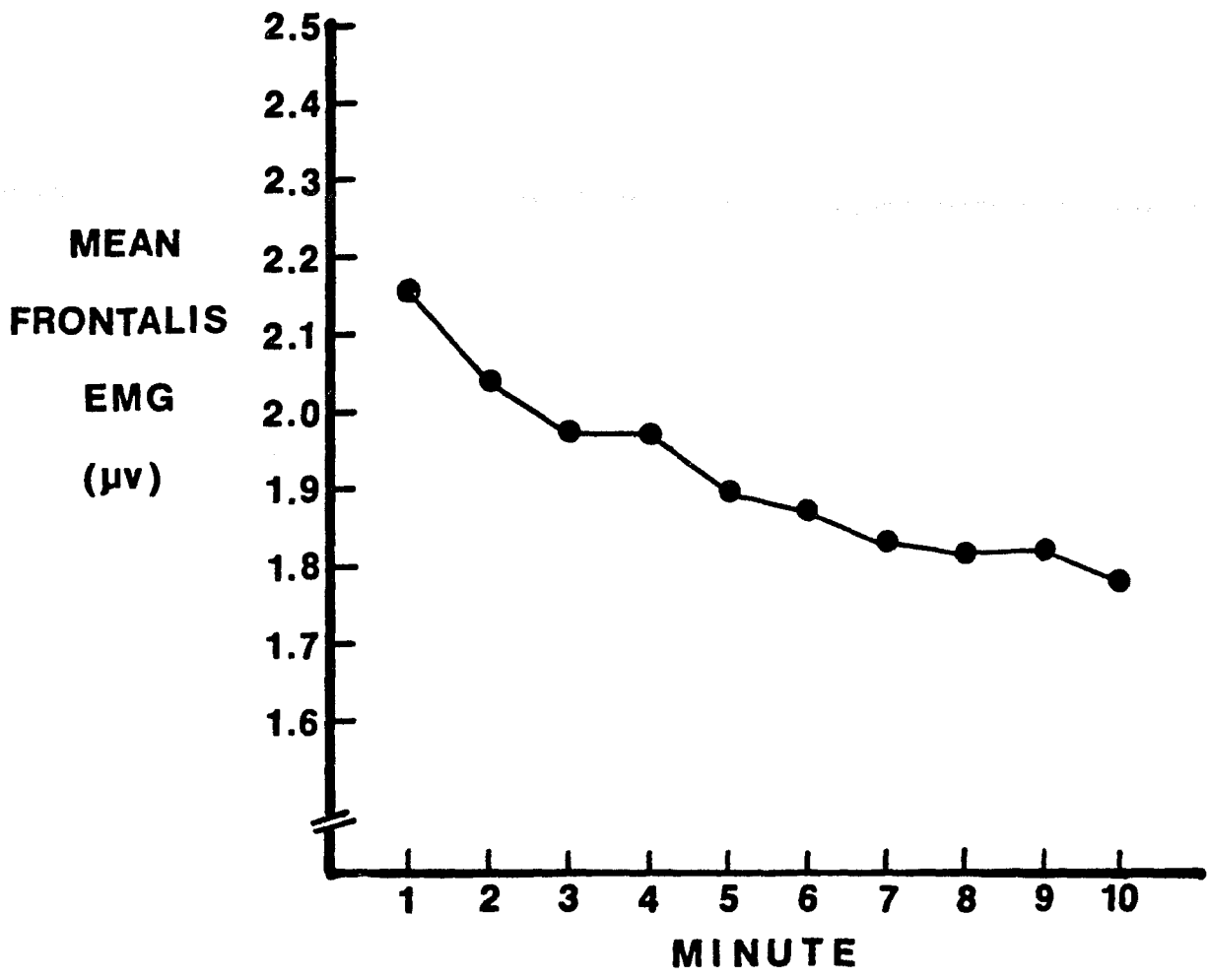


Figure 2. Mean frontalis EMG as a function of minute of training trial. (n = 64/point)

using the Shaffer-Welsch Stepwise Multiple Comparison Procedure (Ramsey, 1981; Welsch, 1977), employing an alpha level of $p = .05$. This analysis indicated that frontalis muscle tension was: significantly lower in minutes 2 through 10 than in minute 1; significantly lower in minutes 5 through 10 than in minute 2; significantly lower in minutes 7 through 10 than in minute 3; and significantly lower in minutes 7 through 10 than in minute 4. No other paired-minute comparisons were significant. The fact that minute-7 tension was significantly lower than minute-4 tension indicates that at least 7 minutes were required to reach a minimal frontalis muscle tension level. Furthermore, the possibility remains that, had training continued beyond 10 minutes, further significant reduction in frontalis tension may have occurred.

Reference to Table 7 indicates that, in addition to the main effect of minutes, there was a significant Sessions X Minutes X FB/NFB interaction, $F(36, 2016) = 1.52, p < .05$. This interaction is illustrated in Figure 3 and appears to be due to the fact that for FB subjects the amount of decrease in frontalis muscle tension over minutes declines as a function of session. For NFB subjects there is not as consistent a pattern of change in amount of decrease over minutes as a function of session: the greatest decreases appear to occur in Sessions II, IV and V. In direct contrast to the FB subjects, the greatest decreases occur in the last two sessions, with the smallest decrease occurring in the first session.

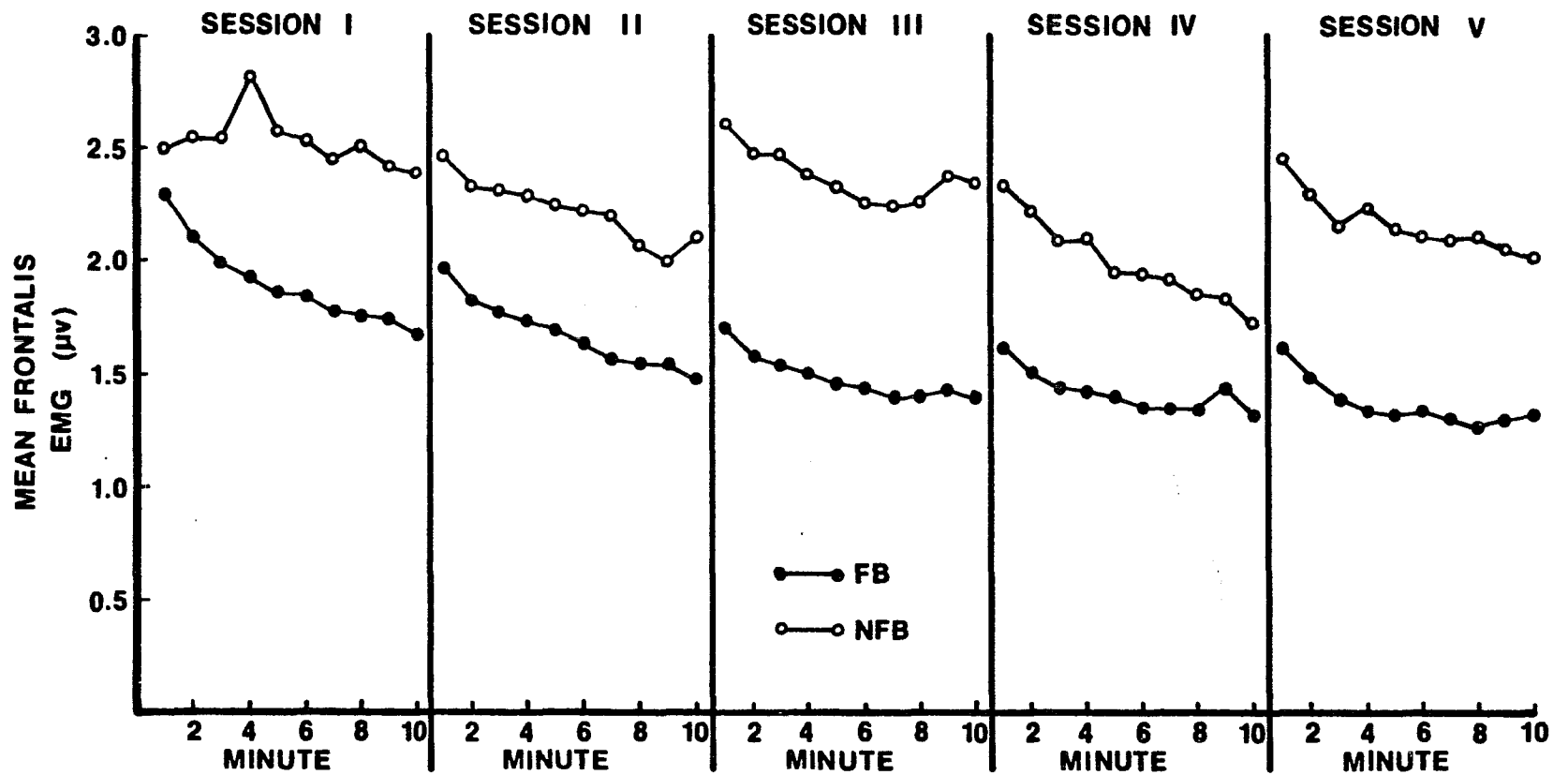


Figure 3. Mean frontalis EMG as a function of minute of training trial, over five sessions, for feedback and no-feedback groups. (n = 32/point)

Hypothesis 5. This hypothesis predicted that subjects would achieve lower levels of frontalis muscle tension over successive training sessions. This hypothesis was supported by the data. Table 7 indicates a significant main effect for the sessions factor, $F(4, 224) = 9.83, p < .001$. Figure 4 illustrates the level of frontalis muscle tension as a function of session separately for FB and NFB subjects. While there was not a significant Sessions X FB/NFB interaction, it is interesting to note that the pattern of decreasing tension across sessions appears more consistent for FB than for NFB subjects. In order to assess the source of the obtained main effect of sessions, data were analyzed using the Shaffer-Welsch procedure, employing an alpha level of $p = .05$. This analysis indicated that frontalis muscle tension was: significantly lower in Sessions II, III, IV and V than in Session I; and significantly lower in Session IV than in Session II. No other paired-session comparisons were significant. The fact that Session-IV tension was significantly lower than Session-II tension indicates that at least four sessions were required to obtain maximal reductions in frontalis muscle tension. Furthermore, the rather consistent decline in frontalis muscle tension across sessions for FB subjects (Figure 4) does not preclude the possibility that given further training these subjects may have demonstrated still further decreases.

Hypothesis 6. This hypothesis predicted that subjects receiving feedback would achieve greater general relaxation

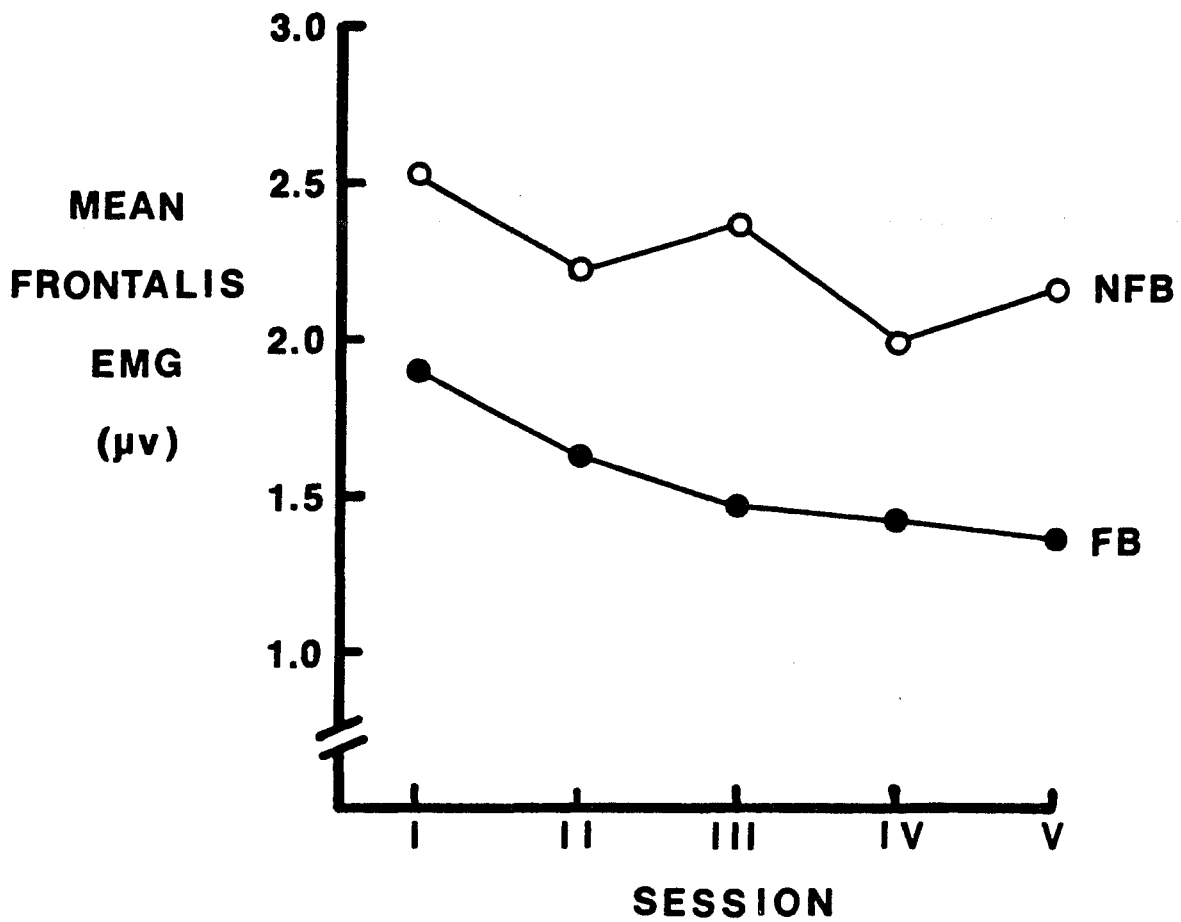


Figure 4. Mean frontalis EMG as a function of session, for feedback and no-feedback groups. (n = 32/point)

than subjects receiving instructions only, as indicated by levels of sternomastoid muscle tension, fingertip skin temperature and skin conductance. This hypothesis was, for the most part, unsupported by the results of the ANOVAs of the three relevant variables (see Tables 8, 9, and 10). In each of these analyses there is no significant main effect of the FB/NFB factor.

For fingertip skin temperature data (see Table 9), while there was no significant main effect of the FB/NFB factor, there was a significant interaction of Minutes X FB/NFB, $F(9, 504) = 6.99, p < .001$. In order to assess the meaning of this interaction planned comparisons using contrast coding were employed. Since the amount of change across the 10 minute period was considered more meaningful than the pattern of minute by minute changes, this analysis focused on comparison of the first as compared to the last 5 minutes of the training period. The analysis revealed a significant interaction in this comparison, $F(1, 504) = 4.76, p < .05$, due to the fact that while FB subjects' temperatures did not differ between these two time periods, NFB subjects had temperatures in the second 5 minutes which were significantly lower than in the first 5 minutes, $F(1, 504) = 8.29, p < .01$. Figure 5 illustrates the significant interaction. It should be noted that there was also a significant 3-way interaction among Minutes, FB/NFB, and G/S, $F(9, 504) = 3.02, p < .01$. Visual inspection of the data (Figure 6) clarifies the meaning of this interaction.

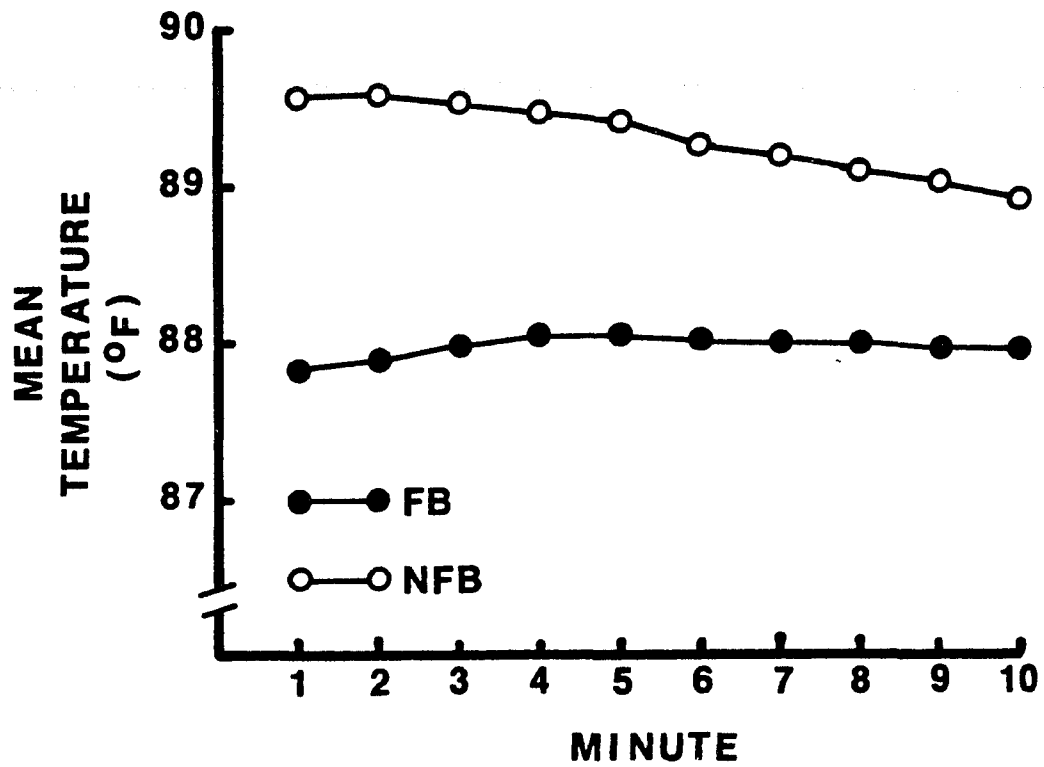


Figure 5. Mean fingertip skin temperature as a function of minute of training trial, for feedback and no-feedback groups. (n = 32/point)

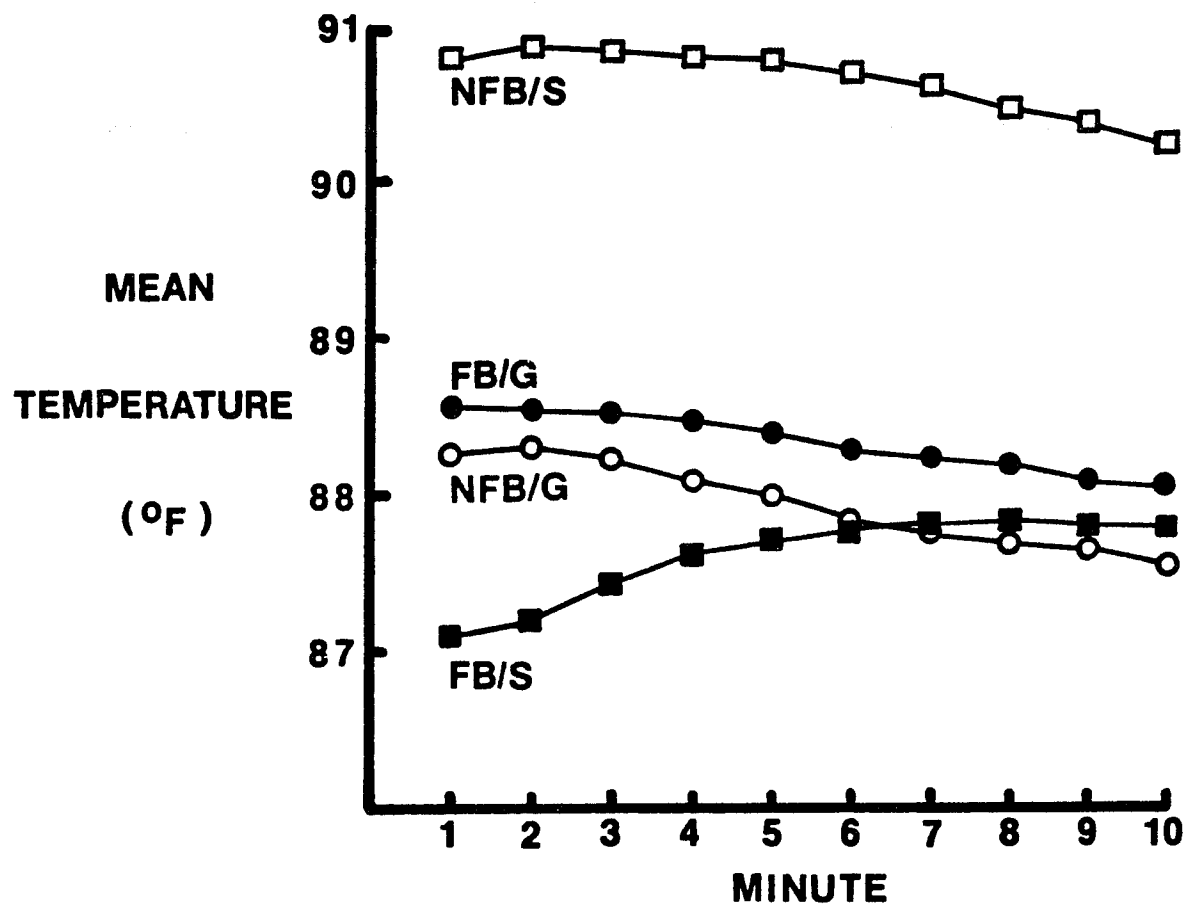


Figure 6. Mean fingertip skin temperature as a function of minute of training trial, for feedback/general (FB/G), feedback/specific (FB/S), no-feedback/general (NFB/G), and no-feedback/specific (NFB/S) groups. (n = 16/point)

The basis of the significant 2-way interaction, discussed above, seems to be that subjects receiving feedback and specific instructions demonstrate a relatively sizeable increase in temperature from the first to the last 5 minutes of the period. The function for subjects receiving feedback and general instructions appears not to differ in form from that of the two no-feedback groups, i.e., there appears to be a general decrease in temperature over minutes. This pattern has relevance for Hypothesis 8 and will be discussed in that context.

Hypothesis 7. This hypothesis predicted that subjects receiving passive instructions would achieve greater general relaxation than subjects receiving active instructions, as indicated by levels of sternomastoid muscle tension, fingertip skin temperature and skin conductance. This hypothesis was unsupported by the data. Reference to Tables 8, 9, and 10 indicates that there was no significant main effect of the P/A factor for any of the monitored physiological variables. There was, however, a significant Minutes X P/A interaction for the temperature data, $F(9, 504) = 3.99, p < .001$. An analysis employing contrast coding (analogous to that performed for the Minutes X FB/NFB interaction, discussed above) indicated that while temperatures of subjects who received active instructions showed no difference comparing the first to the last 5 minutes of the period, temperatures of subjects receiving passive instructions were significantly lower in the last as

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compared to the first 5 minutes, $F(1, 504) = 5.47, p < .05$. Thus, for changes occurring in fingertip skin temperature across the duration of a training period, results are opposite to the predicted outcome. Visual inspection of the data (Figure 7) appears to indicate that the interaction is based primarily on differences occurring in the first 5 minutes of the training period. While subjects receiving passive instructions show decreasing temperature over this period, those receiving active instructions show increasing temperature. Over the final 5 minutes, both groups show similar decreases. It should be noted (Figure 7) that while the group receiving passive instructions showed a more consistent decrease in fingertip skin temperature over the 10-minute period, the absolute level of temperature was consistently, though not significantly, higher for this group than for the group receiving active instructions.

Hypothesis 8. This hypothesis predicted that subjects receiving general instructions would achieve greater general relaxation than subjects receiving specific instructions, as indicated by levels of sternomastoid muscle tension, fingertip skin temperature, and skin conductance. On the whole, the data provided little support for this hypothesis. However, analysis of the sternomastoid muscle tension data did provide suggestive evidence that general instructions may facilitate at least a more general muscular relaxation than specific instructions. Mean sternomastoid muscle tension for subjects receiving general instructions was

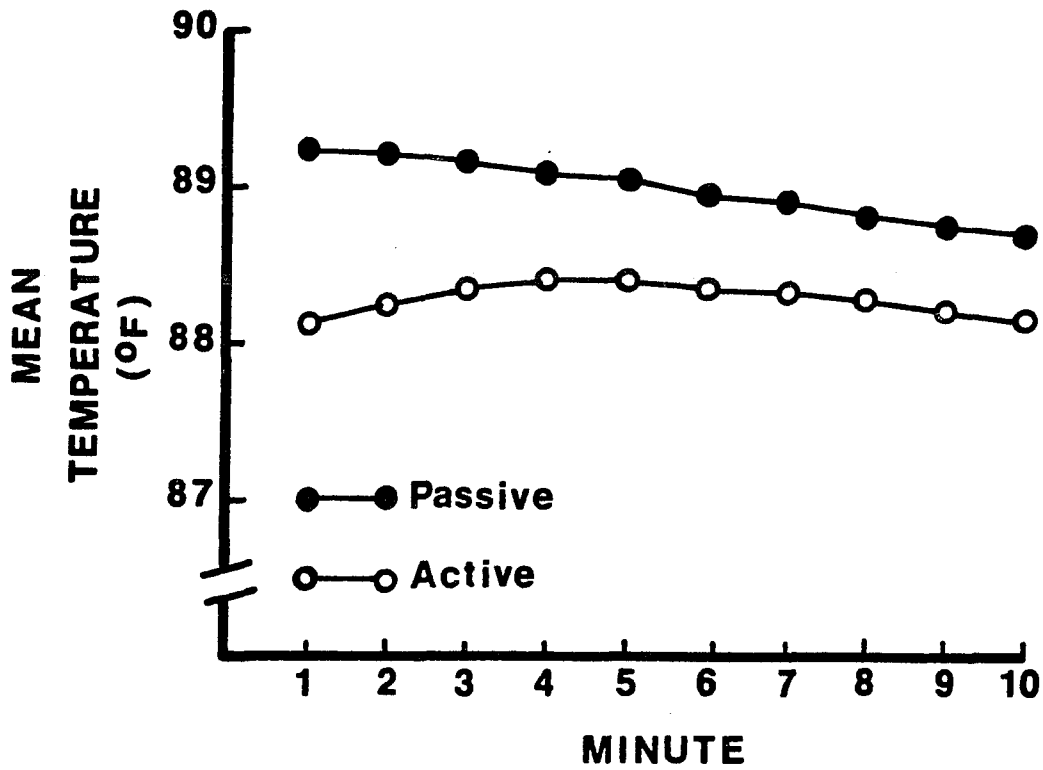


Figure 7. Mean fingertip skin temperature as a function of minute of training trial, for passive and active groups. (n = 32/point)

1.208 microvolts, while for subjects receiving specific instructions, mean sternomastoid muscle tension was 1.487 microvolts. Reference to Table 8 indicates that, while the main effect of the G/S factor was not significant at the $p = .05$ level, it was at the $p = .10$ level, $F(1,56) = 3.59$, $p = .0631$, as was the Sessions X G/S interaction, $F(4,224) = 2.34$, $p = .0561$. The less conservative alpha level was considered since correlational data (reported later) indicated a more consistent relationship between frontalis and sternomastoid muscle tension for subjects receiving general as opposed to those receiving specific instructions. Since the obtained mean muscle tension (in both muscles) was lower in subjects receiving general than for those receiving specific instructions, it was felt that the greater correlation between the two muscles, demonstrated by the general group, might have been due to a general muscular relaxation. The data relevant to the G/S and Sessions X G/S effects appear in Figure 8, which illustrates that, except for the final session, obtained mean levels of sternomastoid muscle tension were consistently lower for subjects receiving general, as opposed to those receiving specific instructions.

A significant Sessions X Minutes X G/S interaction for the sternomastoid data, $F(36,2016) = 1.94$, $p = .0007$, is illustrated in Figure 9. This effect seems to be due to the fact that the change in difference between general and specific groups over minutes of a trial is not consistent

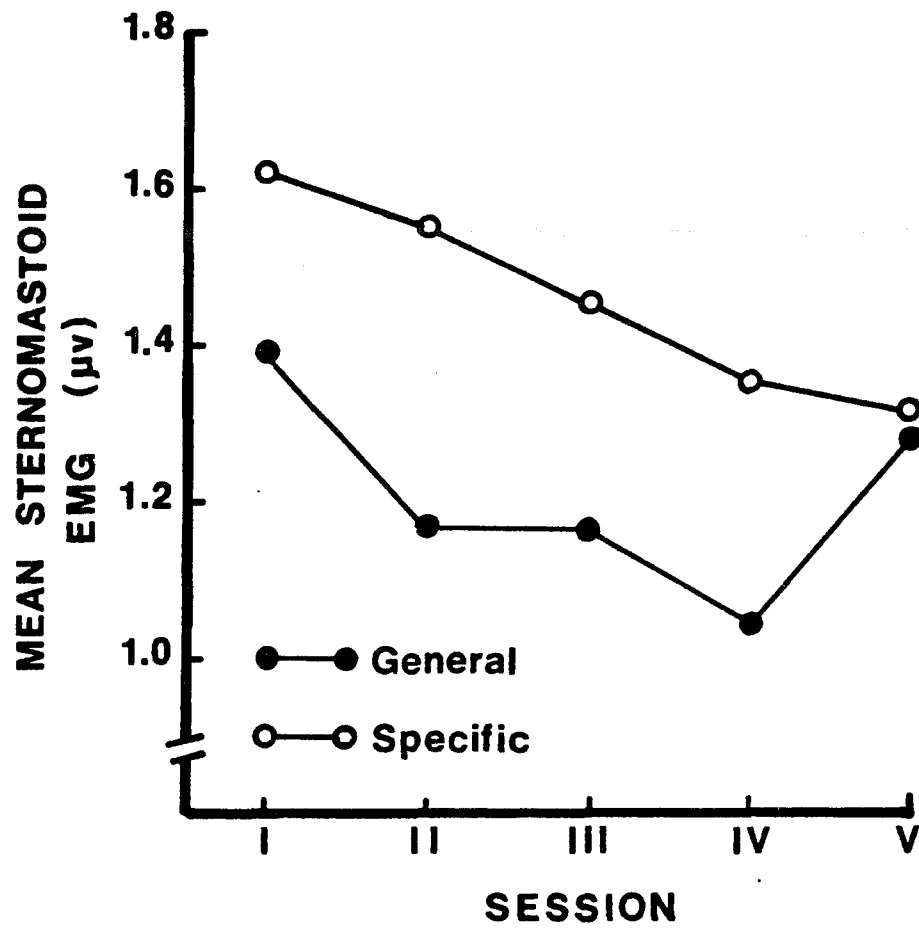


Figure 8. Mean sternomastoid EMG as a function of session for general and specific groups. (n = 32/point)

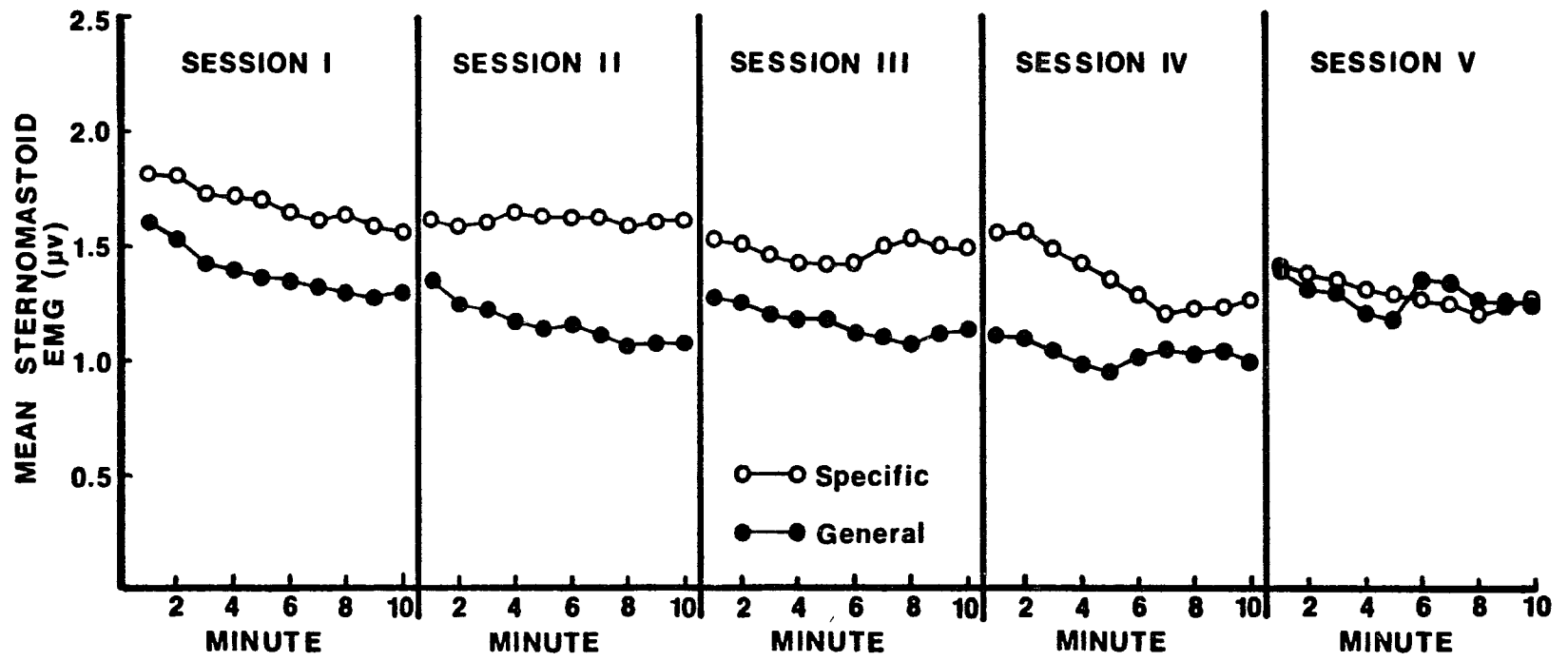


Figure 9. Mean sternomastoid EMG as a function of minute of training trial, over five sessions, for general and specific groups. (n = 32/point)

over sessions. In sessions I and V there appears to be little change over minutes in the difference between the two groups. By contrast, in Sessions II and III, the difference between the groups seems to increase over minutes, while in Session IV the difference decreases over minutes.

Analysis of the temperature data (Table 9) revealed a significant Minute X G/S interaction, $F(9,504) = 7.08, p < .001$. The contrast coding procedure (used to analyze the other minutes-by-groups interactions found for the temperature data) comparing the first to the last 5 minutes of the training period revealed no significant difference for subjects receiving specific instructions, but a significantly lower temperature in the last, as compared to the first, half of the period for subjects receiving general instructions, $F(1,504) = 7.97, p < .01$. The groups interaction based on this contrast was significant, $F(1,504) = 4.47, p < .05$. There was, in addition, a significant Minutes X FB/NFB X G/S interaction, $F(9,504) = 3.02, p < .01$. As previously mentioned, in the discussion of results relating to Hypothesis 6, this interaction appears to be due to the fact that subjects receiving feedback and specific instructions were the only ones to demonstrate a pattern of increasing temperature over the minutes of the training period (Figure 6). While this group was apparently the only one to show increasing temperature over minutes, it should be noted that this group also demonstrated the lowest initial (minute 1) temperature and that the final (minute

10) temperature achieved was not significantly higher than that of the other groups.

Hypothesis 9. This hypothesis predicted that subjects would achieve increasing general relaxation over the successive minutes of the training block as indicated by levels of sternomastoid muscle tension, fingertip skin temperature and skin conductance. This hypothesis was supported with regard to changes in sternomastoid muscle tension and skin conductance level, but generally unsupported with regard to changes in fingertip skin temperature.

Reference to Table 8 reveals a significant Minutes effect for the sternomastoid muscle tension data, $F(9,504) = 9.08, p < .001$. These data are illustrated in Figure 10. In order to determine the precise source of the obtained significance, the data were analyzed using the Shaffer-Welsh procedure, employing an alpha level of .05. This analysis revealed that sternomastoid muscle tension was: significantly lower in minutes 3 through 9 than in minute 1; significantly lower in minutes 5 through 9 than in minute 2; and significantly lower in minutes 8 through 10 than in minute 3. No other paired-minute comparisons were significant. That tension in this muscle was significantly lower in minute 8 than in minute 3 suggests that at least 8 minutes were required to obtain optimal relaxation of this muscle.

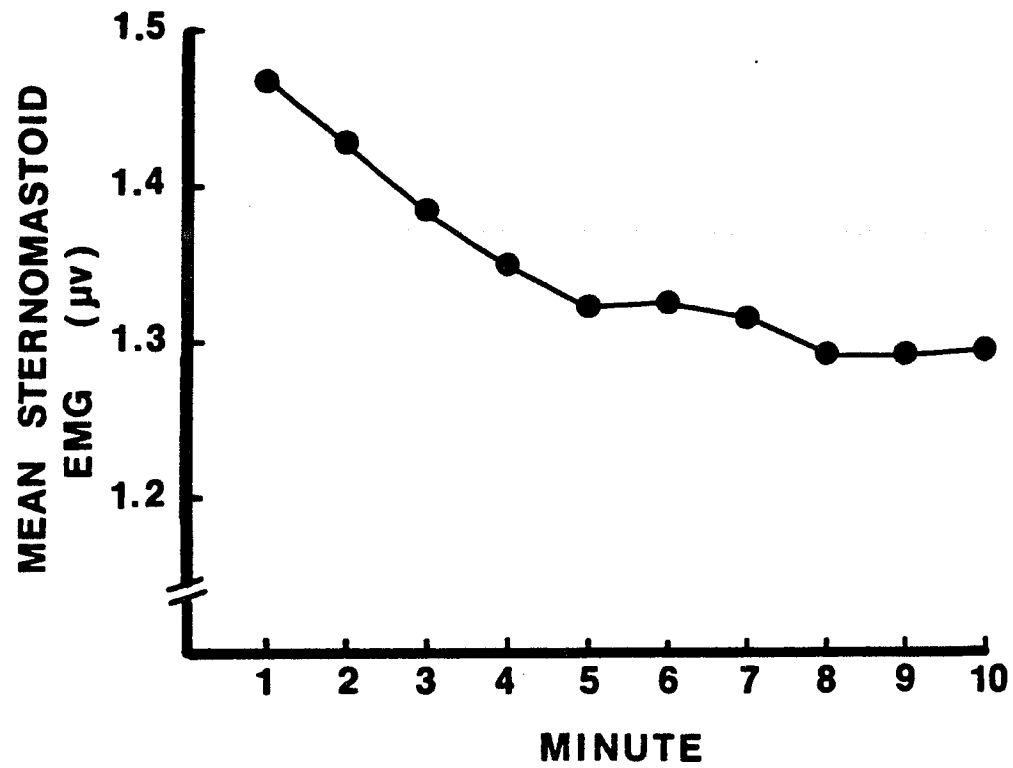


Figure 10. Mean sternomastoid EMG as a function of minute of training trial. (n = 64/point)

11)

Reference to Table 10 indicates a significant Minutes effect for the skin conductance level data, $F(9, 504) = 71.06$, $p < .001$. The data, demonstrating a rather consistent decline in skin conductance level over the 10-minute period, are presented in Figure 11. Analysis, employing the Shaffer-Welsch procedure and an alpha level of $p = .05$, revealed that skin conductance level was: significantly lower in minutes 2 through 10 than in minute 1; significantly lower in minutes 3 through 10 than in minute 2; significantly lower in minutes 5 through 10 than in minute 3; and significantly lower in minutes 7 through 10 than in minute 4. No other paired-minute comparisons were significant. A significant Sessions X Minutes interaction, $F(36, 2016) = 4.63$, $p < .0001$, illustrated in Figure 12, appears to be due to the fact that the amount of decrease in skin conductance level across minutes was substantially greater in the first than in the subsequent sessions. The higher initial level of skin conductance in Session I, implies that the greater decrease observed in this session might have represented habituation of arousal associated with anxiety about, or the novelty of, the laboratory procedures.

Data for the temperature variable provided the only evidence against Hypothesis 9. The significant main effect of minutes, $F(9, 504) = 5.53$, $p < .001$, was due to an overall decrease in temperature across the 10-minute period. Figure 13 reveals that this decrease was not consistent

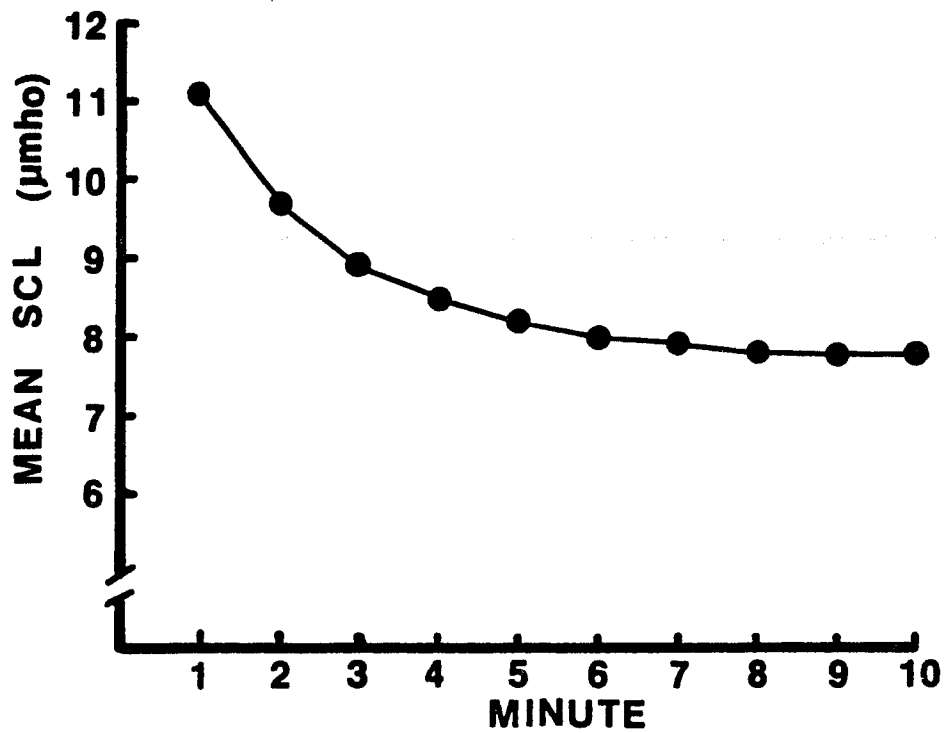


Figure 11. Mean skin conductance level as a function of minute of training trial. (n = 64/point)

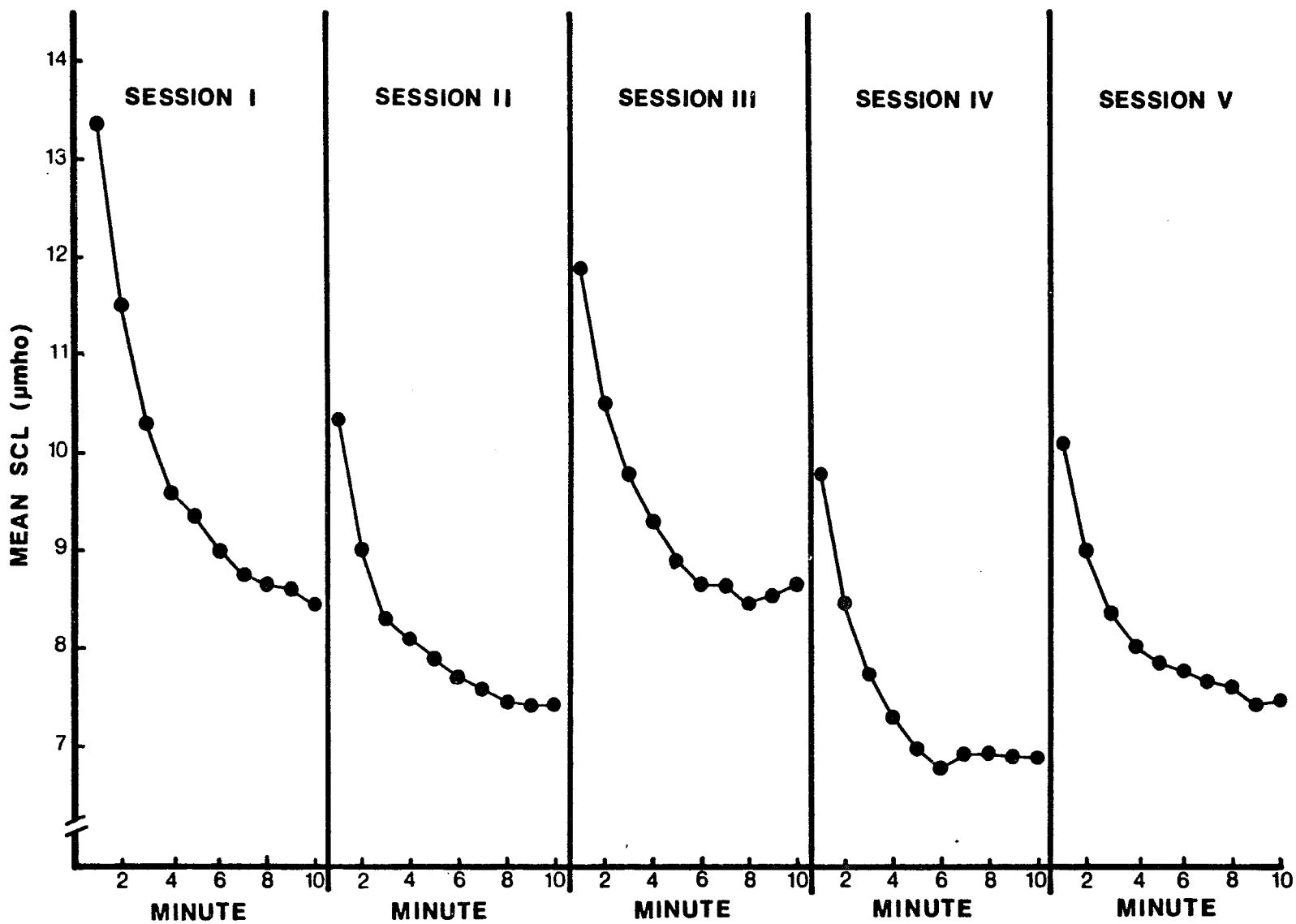


Figure 12. Mean skin conductance level as a function of minute of training trial, over five sessions. (n = 64/point)

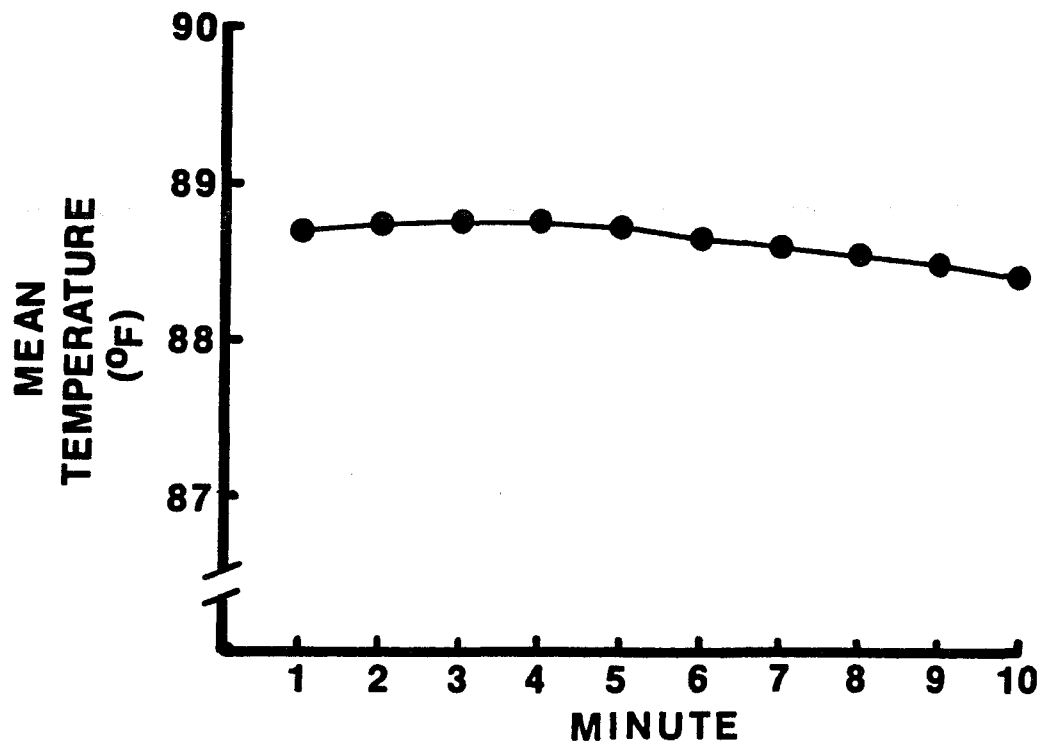


Figure 13. Mean fingertip skin temperature as a function of minute of training trial. (n = 64/point)

across the entire 10-minute period. Analysis, employing the Shaffer-Welsch procedure and an alpha level of .05, revealed that fingertip skin temperature levels were: significantly lower in minutes 9 and 10 than in minutes 2, 3, 4 and 5; and significantly lower in minute 10 than in minutes 1 and 6. No other paired-minute comparisons were significant. A significant Sessions X Minutes interaction, $F(36,2016) = 5.54$, $p < .0001$, was obtained. This effect is illustrated in Figure 14, where it can be seen that while temperature increased rapidly over the first 6 minutes of Session I, in subsequent sessions there was a rather consistent decrease in temperature over the entire 10-minute training period. It seems most likely, considering the lower initial temperature in Session I, that the increase demonstrated in that session represents an habituation effect which mirrors that seen in the skin conductance data.

It will be recalled from presentation of results relating to Hypotheses 6, 7, and 8 that, for the temperature variable, the Minutes factor was involved in significant 2-way interactions with the FB/NFB, the G/S, and the P/A factors and was also involved in a significant 3-way interaction with the FB/NFB and G/S factors. A consideration of each of these interactions appears in the presentations of data relating to Hypotheses 6, 7, and 8.

Hypothesis 10. This hypothesis predicted that subjects would achieve increasing general relaxation over successive training sessions, as indicated by levels of sternomastoid

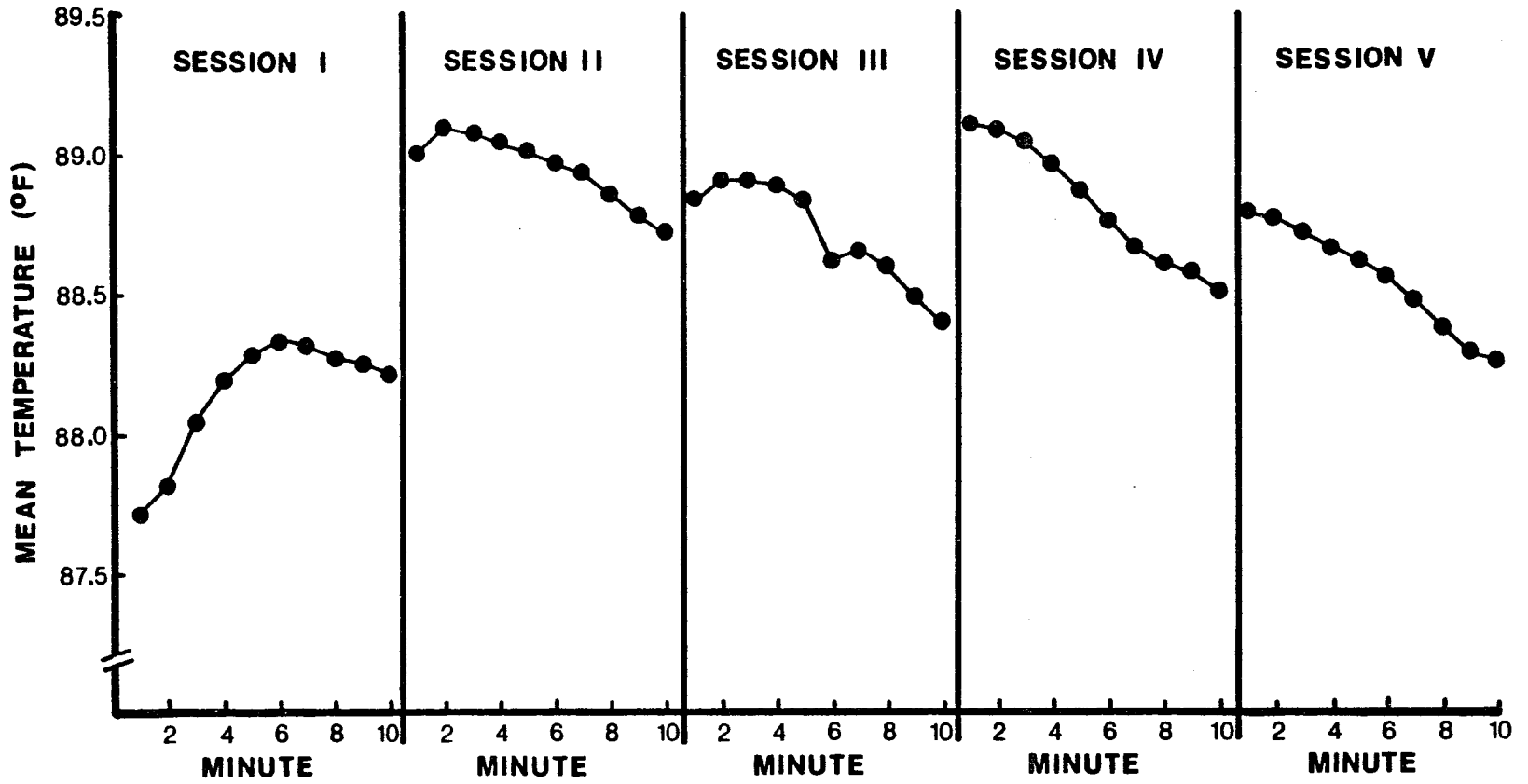


Figure 14. Mean fingertip skin temperature as a function of minute of training trial, over five sessions. (n = 64/point)

muscle tension, fingertip skin temperature and skin conductance. This hypothesis was supported with regard to changes in sternomastoid muscle tension and skin conductance level, but unsupported with regard to changes in fingertip skin temperature.

Reference to Table 8 reveals a significant Sessions effect for the sternomastoid muscle tension data, $F(4, 224) = 5.82$, $p < .001$. These data are presented graphically in Figure 15. Analysis of the data, employing the Shaffer-Welsch procedure and an alpha level of $p = .05$, revealed the basis of the Sessions effect to be that sternomastoid muscle tension was: significantly lower in Session III, IV and V than in Session I; and significantly lower in Session IV than in Session II. No other paired-session comparisons were significant.

Reference to Table 10 reveals a significant Sessions effect for the skin conductance level data, $F(4, 224) = 2.44$, $p < .05$. These data are presented in Figure 16. Analysis, employing the Shaffer-Welsch procedure and an alpha level of $p = .05$, revealed the basis of the Sessions effect to be that skin conductance level was lower in Session IV than in Session I. No other paired-session comparisons were significant.

In the case of both sternomastoid muscle tension and skin conductance level, the above analyses suggest that at least four sessions were required to obtain the lowest levels of these variables.

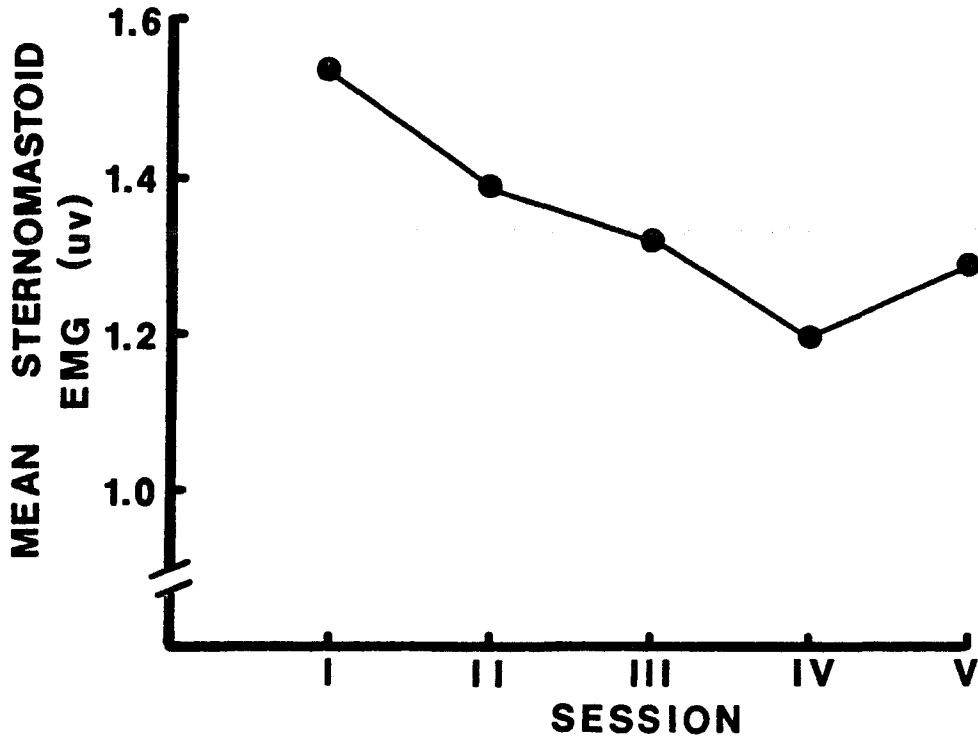


Figure 15. Mean sternomastoid EMG as a function of session. (n = 64/point)

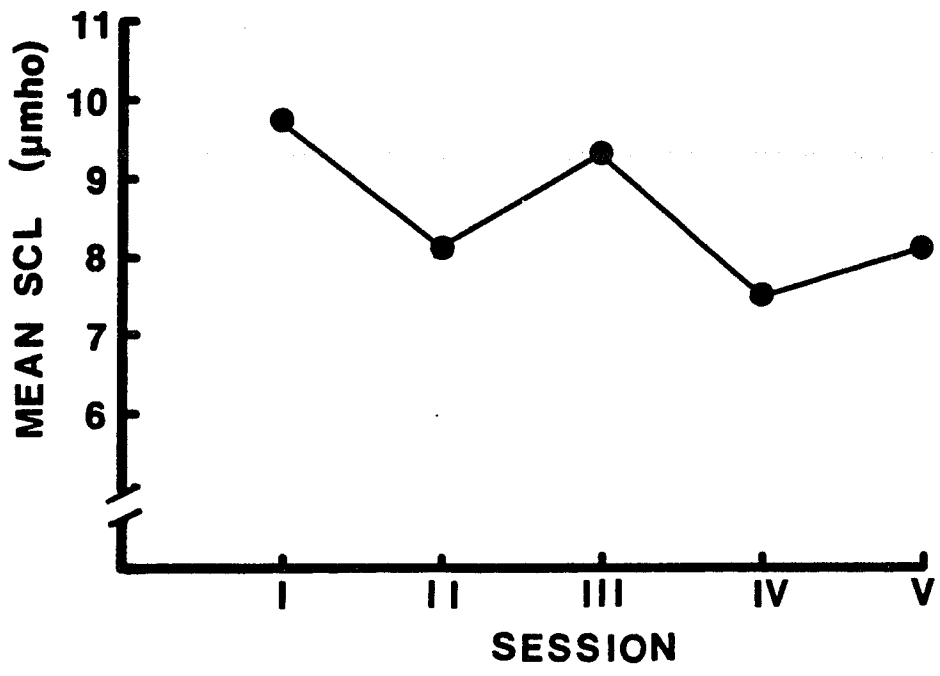


Figure 16. Mean skin conductance level as a function of session. (n = 64/point)

Analysis of fingertip skin temperature data revealed no main effect of the Sessions factor.

One further significant effect appeared in the analysis of the skin conductance data (Table 10). The interaction of all five factors was significant, $F(36,2016) = 1.75, p < .01$. Further analyses to determine the exact source of this effect were not performed. It was considered that the results of such analyses would provide idiosyncratic data (relating to effects occurring in particular minutes of particular sessions) and would not contribute to the overall interpretation of the results of this study.

Correlational Analysis. Hypotheses 6, 7, 8, and 10 represent predictions about the generality of response under the various experimental conditions and across sessions. As a means of assessing the relationship among the monitored physiological variables, intercorrelations were computed separately for various groupings of subjects: those who had and those who had not received feedback; those who had received general and those who had received specific instructions; and those who had received passive and those who had received active instructions. Data for these analyses were the mean levels of each variable as measured over the 20 minutes of training within a session. The only consistent patterns of correlation across sessions occurred between frontalis and sternomastoid muscle tension for subjects receiving general instructions and for those receiving feedback. These correlations, along with those

for the contrasting (i.e., no-feedback and specific) groups appear in Table 11. It will be noted that subjects receiving feedback and those receiving general instructions demonstrated significant correlations between tension in the two monitored muscles in three of the five sessions. By contrast, subjects receiving either no feedback or specific instructions failed to show significant correlations between these variables in any session.

Because the feedback and general groups were not independent, i.e., the feedback group contained subjects who had received general and subjects who had received specific instructions and the general group contained subjects who had and subjects who had not received feedback, further analyses were conducted to clarify the source of the significant correlations. Specifically, correlation coefficients were computed individually for each session for the four groups consisting of subjects who had received feedback and general instruction, feedback and specific instructions, no feedback and general instructions, and no feedback and specific instructions, respectively. The obtained correlation coefficients appear in Table 11. It appears that general instructions fostered a relatively consistent pattern of positive correlation between the two muscles, producing a number of significant correlations regardless of whether feedback was or was not provided. Feedback seemed to be effective in fostering such correlation only when in combination with general

TABLE 11

Correlations obtained between frontalis and sternomastoid muscle tension during Session I baseline (BL-I) and training periods in Sessions I to V. Correlations are reported for subjects receiving feedback (FB), no feedback (NFB), general instructions (G), specific instructions (S), feedback and general instructions (FB/G), feedback and specific instructions (FB/S), no feedback and general instructions (NFB/G), and no feedback and specific instructions (NFB/S).

		<u>Source of Data</u>					
		<u>Session</u>					
<u>Group</u>	<u>n</u>	<u>BL-I</u>	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>
FB	32	.347	.399*	.260	.276	.417*	.375*
NFB	32	.043	.158	.203	.160	.224	-.034
G	32	.370*	.380*	.393*	.332	.349*	.160
S	32	-.031	-.016	.008	-.187	-.035	-.101
F/G	16	.663**	.590*	.759**	.617**	.453	.490
F/S	16	.072	.217	.032	.065	.395	.297
NFB/G	16	.323	.541*	.467	.563*	.633**	.077
NFB/S	16	-.152	-.135	.050	-.196	-.158	-.144

* p < .05; ** p < .01

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instructions. Thus, it appears that the primary influence in producing the observed correlation in muscle tension was the provision of general instructions.

Because the significant correlations appeared in data from the first session, it was felt that baseline data from that session (collected prior to the introduction of training procedures) should also be analyzed. The data for these correlation coefficients were the means of frontalis and sternomastoid muscle tension as measured over the 10 baseline minutes of Session I. The obtained coefficients appear in Table 11, in the rows appropriate to the groups from which the data were derived. It will be noted that the correlations for the "General" group and for the "FB/G" group are significantly greater than zero. Furthermore, while not significant, the correlations obtained for the "Feedback" and "NFB/G" groups seem large in comparison to their respective contrasting groups. The fact that these correlations are relatively high in baseline measurement seems, initially, to compromise the interpretation that the difference between general and specific instructions was responsible for the group differences in correlation during training. Such correlations, occurring prior to training, suggest, rather, the possibility that fortuitous random selection factors gave rise to the results. However, it will be recalled that prior to baseline physiological measurements subjects read an overview of the study. Subjects who would be receiving general relaxation

instructions and subjects who would be receiving specific muscle tension reduction instructions read different overviews, appropriate to the training which they would be receiving (see Appendices I and J). While these overviews merely mention general relaxation or specific muscle tension reduction, they do represent a difference in treatment of subjects who would subsequently be receiving general and those who would be receiving specific instructions. That selection procedures which were used to assign subjects to the experimental conditions were random, is supported by the fact that there were no group differences in baseline measurements of the individual physiological measures revealed by ANOVAs of these data. In light of these facts, it seems most parsimonious to attribute the observed differences in correlation to the relative effects of suggesting general relaxation as opposed to specific muscle tension reduction.

Analyses of debriefing questionnaire rating scale responses

Subjects' responses to each rating scale of the debriefing questionnaire (see Appendix L) were analyzed with separate 2 X 2 X 2 ANOVAs. Factors in these analyses were FB/NFB, G/S, and P/A. Means of rating scale responses for the eight treatment groups appear in Table 12. All obtained significant effects are discussed in the following consideration of the individual rating scales.

Question I. Question I was intended to assess perceived success. The analysis of responses given to this question

TABLE 12

Means of debriefing questionnaire rating scale responses for the eight treatment groups.

<u>Question</u>	<u>Group</u>							
	<u>Feedback</u>				<u>No Feedback</u>			
	<u>GP</u>	<u>GA</u>	<u>SP</u>	<u>SA</u>	<u>GP</u>	<u>GA</u>	<u>SP</u>	<u>SA</u>
I	4.50	4.00	4.12	4.00	3.75	4.25	4.38	3.88
II	1.62	2.00	2.38	2.62	2.12	2.12	1.62	2.50
III 1	1.50	1.12	2.00	1.12	2.00	2.25	1.50	2.50
2	6.88	5.88	1.88	1.38	6.50	6.62	1.88	1.75
3	7.00	2.62	5.38	1.75	6.62	3.12	5.75	2.38
4	1.75	1.75	1.25	1.38	2.75	2.00	1.75	2.75
IV 1	5.25	5.88	2.50	2.00	5.75	5.12	4.00	4.75
2	4.75	1.62	4.38	2.62	5.00	3.38	4.88	3.00
V 1	2.38	2.25	2.12	1.62	2.75	2.00	3.00	1.62
2	1.75	2.00	1.75	1.38	2.00	1.62	3.00	1.50
3	1.62	1.50	1.75	1.50	2.00	1.62	2.50	1.12
VI	1.62	1.62	1.75	1.50	2.00	1.50	2.12	1.25

yielded no significant group differences. The overall mean rating (n = 64) was 4.11, indicating that, on the average, subjects felt that they had done well in complying with the instructions which they had been given.

Question II. Question II (as well as Question VI) was intended to assess the subjects' attitude toward the training procedure. Specifically, subjects were asked to rate how often they felt discouraged, frustrated, or annoyed. Analysis of responses to this question yielded a significant main effect of P/A instructions, $F(1, 56) = 4.31, p < .05$. The mean rating of subjects who had received passive instructions was 1.94; the mean rating given by subjects who had received active instructions was 2.31. The significant difference between these means, indicating more frequent frustration, annoyance, or discouragement for subjects receiving active instructions, can be interpreted as an indication that the provision of passive instructions was, at least, effective in controlling feelings of frustration which might have been associated with the training procedure.

The analysis of Question II also yielded a significant FB/NFB X G/S interaction, $F(1, 56) = 4.31, p < .05$. This interaction was due to the fact that the difference between subjects receiving general as opposed to specific instructions was greater for feedback than for no-feedback subjects. The mean ratings relevant to this interaction are: feedback and general instructions, 1.81; feedback and

specific instructions, 2.50; no feedback and general instructions, 2.12; and no feedback and specific instructions, 2.06. Thus, the receipt of general as opposed to specific instructions did not seem to affect the reported frequency of frustration for no-feedback subjects. Feedback subjects seemed less frustrated when they received general as opposed to specific instructions.

Question III. On the four scales of Question III subjects were asked to rate, in four different ways, the instructions which they had used. On the first scale subjects were asked to rate how clear or unclear their instructions seemed. The analysis of ratings on this scale yielded no significant differences. The overall mean rating ($n = 64$) was 1.75, indicating that subjects found the instructions to be moderately to very clear.

On the second scale of Question III subjects were asked to rate how specific or general (as defined in the questionnaire) their instructions seemed. The analysis of ratings on this scale yielded a significant main effect of G/S instructions, $F(1, 56) = 617.28, p < .001$. The mean rating given by subjects who had received general instructions was 6.47; the mean rating given by subjects who had received specific instructions was 1.72. Thus, not only did subjects perceive their instructions as being either general or specific, as intended, but the difference in ratings on a scale of general to specific was significant.

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On the third scale of Question III subjects were asked to rate how active or passive (as defined in the questionnaire) their instructions seemed. The analysis of ratings on this scale yielded a significant main effect of P/A instructions, $F(1, 56) = 97.28, p < .001$. The mean rating given by subjects who had received passive instructions was 6.19; the mean rating given by subjects who had received active instructions was 2.47. Thus, not only did subjects perceive their instructions as either active or passive, as intended, but the difference in ratings on a scale of active to passive was significant.

The analysis of ratings on the third scale of Question III also yielded a significant main effect of G/S instructions, $F(1, 56) = 7.48, p < .01$. While the mean ratings of subjects given general instructions ($M = 4.84$) and those given specific instructions ($M = 3.82$) fell close to the neutral point (4.0) of the active-passive scale, the significant difference indicates that general instructions were perceived as more passive than specific instructions.

On the fourth scale of Question III, subjects were asked to rate how good or bad their instructions seemed. Analysis of ratings on this scale yielded a significant main effect of FB/NFB, $F(1, 56) = 8.43, p < .01$. The mean rating given by subjects who had received feedback was 1.53; the mean rating given by subjects who had not received feedback was 2.31. Thus, while both feedback and no-feedback subjects rated their instructions on the "good" side of the neutral

point (4.0), feedback subjects perceived their instructions as being better than no-feedback subjects. It will be recalled that subjects who had received feedback demonstrated levels of frontalis muscle tension which were significantly lower than subjects who had not received feedback. To determine whether this difference could be attributed simply to the perception of instructions, correlation coefficients assessing the relationship between subjects' ratings on the good-bad scale and their frontalis muscle tension level (averaged over all training periods) were computed separately for subjects receiving feedback ($r = .117, n = 32$) and for subjects not receiving feedback ($r = .134, n = 32$). Neither of these correlations proved to be significantly greater than zero. Furthermore, the correlation between these two variables for the entire group of subjects was also not significantly different from zero ($r = .229, n = 64$). Thus, it is unlikely that the significantly lower frontalis muscle tension demonstrated by feedback subjects was due to differences in the perception of how good or bad instructions were.

Question IV. On the two scales of Question IV subjects were asked to rate, on continua of specific to general and active to passive, the approach which they took toward their training. Analysis of ratings on the first (specific to general) scale revealed, as expected, a significant main effect of G/S instructions, $F(1, 56) = 33.96, p < .001$. The mean rating given by subjects who had received general

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instructions was 5.50; the mean rating given by subjects who had received specific instructions was 3.31. Thus, on the whole, subjects reported taking approaches which conformed to the instructions which they had received. There were, however, two further significant effects revealed by this analysis: a main effect of FB/NFB, $F(1, 56) = 7.10, p < .05$, and an interaction of FB/NFB X G/S, $F(1, 56) = 8.98, p < .01$. The main effect of FB/NFB was due to the fact that subjects who had received no feedback reported having taken a more general approach ($M = 4.95$) than subjects who had received feedback ($M = 3.91$). The significant interaction was due to the fact that the difference in approach taken by subjects given specific and those given general instructions was greater for subjects receiving feedback than for those not receiving feedback. This effect is illustrated in Figure 17. It will be noted that subjects receiving no feedback reported, on the average, having taken a general approach regardless of the nature of the instructions which they received. It may be that people, merely told to reduce tension in their forehead muscles, don't know how to go about doing so, except by attempting to relax generally.

Analysis of ratings on the second (active to passive) scale of Question IV revealed a significant main effect of P/A instructions, $F(1, 56) = 24.57, p < .001$. The mean rating given by subjects who had received passive instructions was 4.75; the mean rating given by subjects who had received active instructions was 2.66. Thus, with

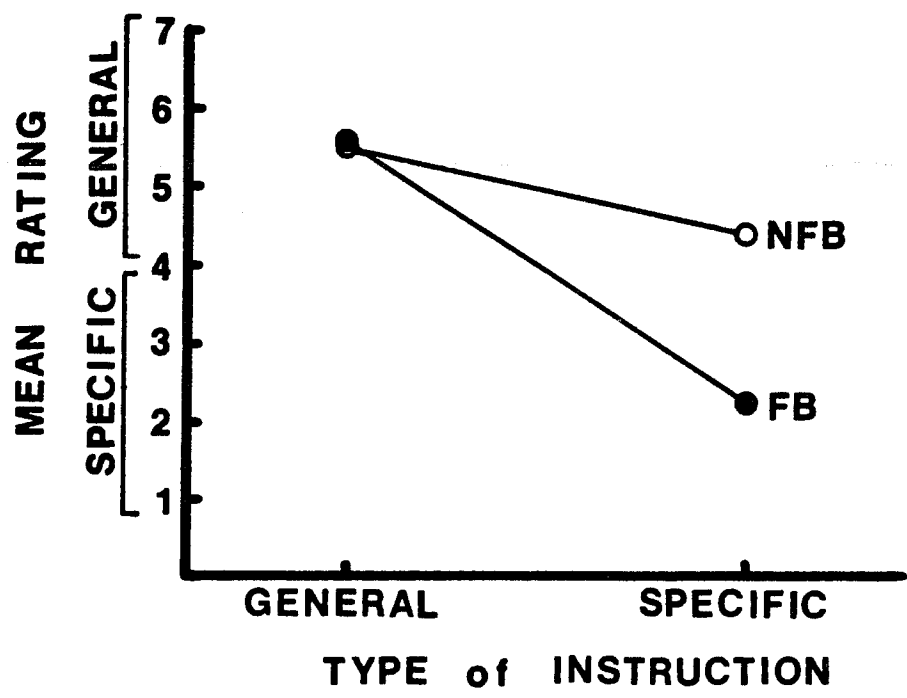


Figure 17. Subjects' ratings of how specific or general their own approach to training had been, for FB/G, NFB/G, FB/S, and NFB/S groups. (n = 16/point)

regard to the active passive dimension, subjects reported taking approaches which conformed to the instructions which they had received.

Question V. On the three rating scales of Question V subjects were asked to indicate how they typically felt at the end, as compared to the beginning, of a session. These questions were intended to assess subjective effects of the training procedures. Scale 1 was a continuum from "much better" to "much worse", scale 2 was a continuum from "much calmer" to "much more anxious", and scale 3 was a continuum from "much more relaxed" to "much more tense". Separate analyses of each of these scales all yielded significant main effects of P/A instructions (scale 1, $F(1, 56) = 6.09$, $p < .05$; scale 2, $F(1, 56) = 5.78$, $p < .05$; and scale 3, $F(1, 56) = 8.39$, $p < .01$). In each case, although subjects who had received active and those who had received passive instructions reported positive changes (i.e., indicating that they felt better, calmer, or more relaxed), those who had received active instructions gave significantly lower ratings, indicating even greater positive subjective changes. The mean ratings given by subjects were: scale 1, active = 1.87, passive = 2.56; scale 2, active = 1.62, passive = 2.12; and scale 3, active = 1.44, passive = 1.97. For scales 1 and 3 the P/A effect was the only significant one. For scale 2 there were, in addition, two significant interactions. A significant G/S X P/A interaction, $F(1, 56) = 4.43$, $p < .05$, was due to the fact that the difference

between ratings of subjects who had received passive and subjects who had received active instructions was greater for those subjects whose instructions were specific (mean active = 1.44, mean passive = 2.38) than for those whose instructions were general (mean active = 1.81, mean passive = 1.88). A significant FB/NFB X P/A interaction, $F(1, 56) = 4.43, p < .05$, was due to the fact that the difference between ratings of subjects who had received passive and subjects who had received active instructions was greater for those subjects who had not received feedback (mean active = 1.56, mean passive = 2.50) than for those subjects who had received feedback (mean active = 1.69, mean passive = 1.75). The results of scale 2 seem to indicate that the relatively smaller positive subjective changes associated with passive instructions can be counteracted by the provision of feedback and/or general instructions. With regard to feedback as a factor in altering the relative ratings associated with active and passive instructions, it should be noted that the same pattern of ratings, which caused the FB/NFB X P/A interaction on scale 2, occurred also on scales 1 and 3. That is, the obtained difference in ratings between subjects who had received active and those who had received passive instructions was greater for those who had not received feedback than for those who had. On scale 3, this interaction approached significance, $F(1, 56) = 3.51, p = .066$.

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Question VI. Question VI was intended to assess the subjects' general attitude toward their participation in the study on a scale of positive to negative. Analysis of ratings indicated no significant differences among the groups. The overall mean rating given on this scale was 1.67 (n = 64), indicating that, regardless of treatment, subjects reported a moderately to very positive attitude toward their participation.

Analysis of State-Trait Anxiety Inventory data

As a further means of assessing subjective changes which might have been associated with training under the various experimental conditions, the data provided by the two administrations of the State-Trait Anxiety Inventory were subjected to analysis. Separate 2 X 2 X 2 X 2 mixed design ANOVAs, with repeated measures on the last factor, were performed for the state and trait scales. The factors in the ANOVAs were FB/NFB, G/S, P/A, and pre-/post-training administration.

The analysis of state anxiety revealed no significant group differences. A significant decrease in state anxiety did, however, occur from the pre-training (M = 37.84) to the post-training (M = 30.19) administration, $F(1, 56) = 22.79$, $p < .001$.

The analysis of the trait anxiety also showed a significant decrease from the pre-training (M = 38.47) to the post-training (M = 36.47) administration, $F(1, 56) = 8.90$, $p < .01$. There was, in addition, a significant

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interaction of administration (i.e., pre- vs. post-) and the P/A instruction factor, $F(1, 56) = 5.22, p < .05$. This interaction is illustrated in Figure 18, and indicates that the significant decrease from pre- to post-training was contributed to primarily by subjects receiving active instructions.

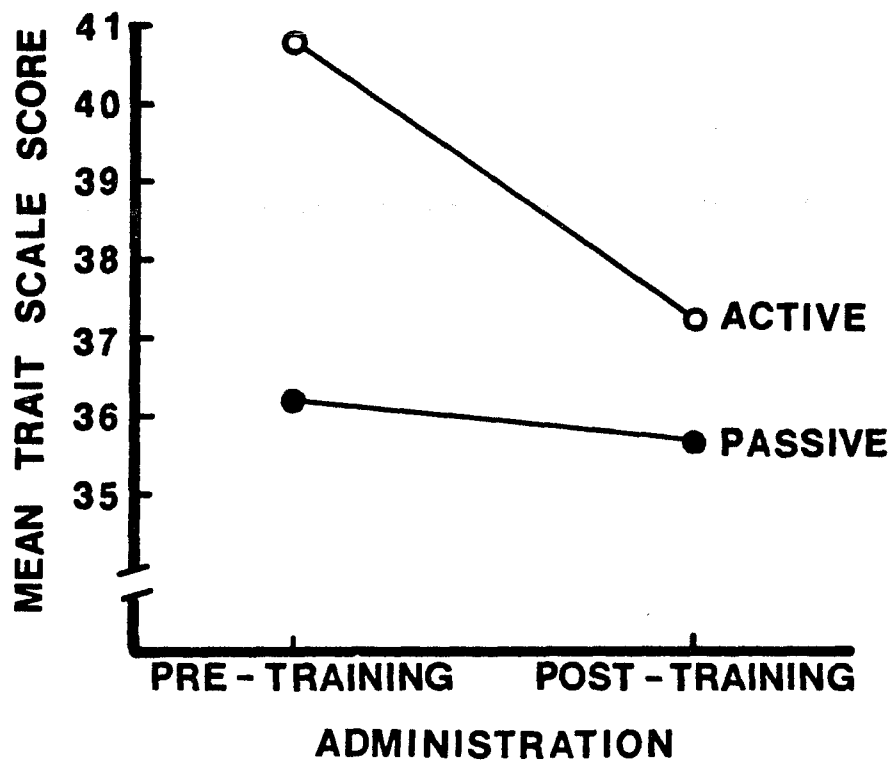


Figure 18. Mean STAI trait scale scores, pre- and post-training, for passive and active groups. (n = 32/point)

CHAPTER 4

Discussion

This study examined the potential of frontalis EMG feedback as a facilitator of both frontalis muscle tension reduction and general relaxation. In addition it examined the hypothesis that the outcome of frontalis EMG training will depend on the nature of instructions provided to subjects. The discussion which follows considers, first, the use of frontalis EMG feedback as a means of reducing frontalis muscle tension and then the use of such feedback as a facilitator of general relaxation. Following this, a number of general considerations regarding the outcome of the study are discussed. Finally, suggestions for further research and the general conclusions of this study are presented.

Frontalis EMG feedback for frontalis tension reduction

The results of this study strongly support the usefulness of feedback from the frontalis muscles as a means of facilitating the reduction of tension in those muscles. The fact that subjects who received feedback from the frontales were able to achieve significantly lower frontalis muscle tension than subjects who received similar instructions but no feedback, confirms the findings of a large number of earlier studies (Alexander, 1975; Alexander et al., 1975; Budzynski & Stoyva, 1969; Burish & Hendrix, 1980; Coursey, 1975; Haynes et al., 1975; Kinsman et al., 1975; Ohno et al., 1978; Stern & Berenberg, 1977). A number

of earlier studies had, however, failed to demonstrate the advantage of providing feedback, as compared to simply instructing subjects to relax their forehead muscles (Alexander et al., 1977; Burish et al., 1981; Davis, 1980; Nielsen & Holmes, 1980; Yock, 1978).

Factors which could have contributed to the conflicting results of these earlier studies are discussed in detail in the introduction to this study. Briefly, the argument was advanced that studies which failed to demonstrate the effectiveness of feedback were characterized by inadequate or inappropriate feedback training. It may be recalled, however, that both Alexander et al. (1977) and Davis (1980) attributed the results of studies which had demonstrated feedback to be an effective addition to instructions, predominantly to what they saw as a failure in those studies to motivate adequately subjects who received no feedback. Alexander et al. (1977) suggest that while subjects receiving feedback are motivated by "the public excitement generated by the biofeedback phenomenon" (p. 552), it is difficult to motivate control (no feedback) subjects, who consequently "become bored, frustrated or even angry" (p.552). In support of this, Alexander et al. claim that typically, in initial sessions, subjects receiving no feedback do as well as those receiving feedback, but, that as training progresses, no-feedback subjects tend to show increases in frontalis tension "often reaching final tension levels in excess of baseline levels" (p.552). Consequently,

they claim, studies which have provided only analyses of final session data may have found differences between subjects receiving and those not receiving feedback which were due as much to the increased frontalis muscle tension of the latter as to the decreased tension manifested by the former. It should be noted that of the studies cited here in support of the effectiveness of feedback only Budzynski & Stoyva (1969), Kinsman et al. (1975), and Burish & Hendrix (1980) report control groups which demonstrated increasing frontalis tension. In the first two of these studies, the groups demonstrating this behavior were not simply given instructions to relax their forehead muscles: they were provided with auditory signals (not contingent upon their behavior) to which they were asked to attend. A second control group in the Budzynski & Stoyva (1969) study, receiving instructions to relax and no irrelevant signal, showed a decrease in frontalis tension over sessions. It should be further noted that, while Budzynski & Stoyva (1969) provide analysis of only final session data, this is the exception rather than the rule in the frontalis feedback literature; none of the other studies cited here in support of the effectiveness of feedback reported analysis of only final session data.

In the present study great care was taken to provide adequate and comparable motivation for all subjects. Materials used in the recruitment of subjects did not refer to a biofeedback study, but rather, to "studies of

techniques used for muscle tension reduction and general relaxation". The overview, read by each subject prior to participation, stressed the importance of the individuals' attention to instructions. The instructions for subjects who would not receive feedback were carefully worded, so as not to appear to represent "control" conditions, but rather, legitimate training procedures. Finally, as a motivational technique suggested by Davis (1980), subjects were asked to read their instructions and were verbally reminded of the importance of the instructions prior to the first training period of each session. Furthermore, a number of rating scales included in the debriefing questionnaire were intended to provide a post hoc means of assessing motivation.

That motivational differences were not, in fact, responsible for the lower tension levels achieved by subjects receiving feedback, is supported by the analysis of the frontalis muscle tension data itself and by analyses of the debriefing questionnaire rating scale data.

The following points can be made with regard to the analysis of the frontalis muscle tension data. First, the different instructions employed in this study can, themselves, be thought of as varying motivational conditions. The fact that analysis revealed no significant interactions between instructional factors and the feedback versus no-feedback factor indicates that the superior performance of feedback subjects was not dependent upon

instructional (motivational) condition. Second, the significant decreases in frontalis muscle tension which occurred, both across minutes of a trial and across sessions, were not dependent upon the provision of feedback. Subjects not receiving feedback did show significant decreases in frontalis muscle tension across these measurement periods. It might be recalled (see Figure 3) that the decrease in tension across minutes displayed by the no-feedback subjects in the final session was substantial and among the largest which these subjects achieved in any session. This hardly seems indicative of mounting frustration or anger on the part of the subject, as would be predicted by Alexander et al. (1977). It should be noted in this context that, while frustration or anger would have been expected to have been manifested in a number of physiological responses, feedback and no-feedback groups did not differ from each other on any monitored physiological variable other than frontalis muscle tension.

Data provided by responses to the rating scales of the debriefing questionnaire also support the contention that there were no significant motivational differences between subjects who did and those who did not receive feedback.

The rating scales most relevant to the question of motivation are those of Questions II and VI which were specifically intended to assess the subjects' attitudes toward the training procedures in which they had engaged. (The reader may wish to refer to Table 12 for the rating

scale data.) Question II specifically asked the subjects to rate how often they felt annoyed, discouraged, or frustrated. Analysis of responses to this question revealed no significant difference between those subjects who had received feedback and those subjects who had not. That the failure to obtain a difference is not simply due to the subjects' desire to please the experimenter by giving a positive response, is supported by the fact that a significant difference was obtained on this scale between the responses of subjects who had received active and those who had received passive instructions; the scale apparently is a sensitive indicator of the subjects' feelings.

Question VI, which asked subjects to rate how positive or negative their experience in the study had been, also revealed no significant differences between subjects who had received feedback and those who had not.

On the three scales of Question V, which asked subjects to rate how they typically felt at the end as compared to the beginning of a session, all groups of subjects indicated positive changes. There were, once again, no significant differences suggesting that, as a group, subjects who had received no feedback perceived less of a positive change than subjects who had received feedback.

The one indication on the debriefing questionnaire rating scales of a significant difference between subjects receiving and those not receiving feedback, which could be interpreted as an indication of motivational inequity,

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occurred on the fourth scale of Question III. When asked to rate how good or bad their instructions were, both groups rated their instructions on the "good" side of the scale. However, the mean rating given by subjects who had received feedback was significantly lower (i.e., closer to the positive pole of the continuum). It was to determine whether this difference in perception of instructions could account for the differences in frontalis muscle tension, that correlation coefficients evaluating the relationship between subjects' ratings on this scale and their mean frontalis muscle tension level during training were computed. It will be recalled that coefficients, computed separately for subjects who did and for those who did not receive feedback and for both groups combined, failed to demonstrate a significant relationship between response on this rating scale and frontalis muscle tension level. Thus it is unlikely that obtained differences in frontalis muscle tension can be attributed to motivational inequities reflected in responses to this rating scale.

In light of the foregoing considerations, it seems unlikely that the differences in frontalis muscle tension obtained between subjects who did and those who did not receive feedback were due to motivational differences. It seems most reasonable to assume that the feedback signal is serving a learning (i.e., reinforcing or informational) rather than a motivational function.

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In their consideration of earlier frontalis EMG feedback studies, Alexander et al. (1977) had noted that, typically, the largest decreases in session mean EMG occur in the first session. They claim that "further decreases in mean levels over sessions are small and usually not significant by comparison. Whatever 'learning' is taking place is rapid indeed" (p.552). While it is true that most studies do find greatest decreases in frontalis EMG in early sessions, Alexander et al. cite no reference to support their contention that significant decreases do not typically occur beyond the first session. That the greatest changes occur early in training should certainly not, however, be pointed to as a means of disparaging the learning which is taking place. It appears, to this author, that what is being described is the negatively accelerated function which is typical of the relationship between performance and practice in many learning situations.

In the present study, the general pattern described by Alexander et al. (1977) did, in fact, occur. However, while subjects demonstrated their greatest decreases across the earlier sessions, further significant changes in session mean EMG did occur at least until the fourth session. Furthermore the consistent decrease in session mean EMG for subjects receiving feedback (see Figure 4) suggests that an asymptotic level may not have been reached by the end of training.

Frontalis EMG feedback for general relaxation

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Biofeedback training for frontalis muscle tension reduction does not appear to be promising as a general relaxation technique. The provision of EMG feedback from the frontales does not seem to facilitate general relaxation beyond levels which can be achieved through simply instructing an individual to relax. Subjects who received feedback in the present study did not differ in sternomastoid muscle tension, fingertip skin temperature, or skin conductance level from subjects who received no feedback.

Significant decreases in sternomastoid muscle tension and in skin conductance level did occur, both across minutes of a trial and across sessions. These changes, indicative of increasing relaxation, were, however, rather consistent across groups: except for the near significant interaction of Sessions X G/S for sternomastoid muscle tension data, the decreases were independent of treatment group. Subjects in the study seemed, by these measures, and regardless of treatment, to be demonstrating increasing levels of relaxation. It is interesting, in this context, to note that a number of previous studies, while demonstrating decreased frontalis tension for feedback groups, failed to find other physiological evidence of increasing relaxation in any of their groups. Fridlund et al. (1980) found significant decreases in frontalis tension across sessions but found no significant changes in any of seven other muscles, including the left and right sternomastoids. Fee

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and Girdano (1978) found a frontalis feedback group to demonstrate greater reductions in frontalis tension than a number of control groups, but found no significant changes in heart rate, skin potential or fingertip skin temperature. Alexander (1975) also found significant frontalis muscle tension reduction for a feedback group, but found that both this group and a no-feedback control group showed increased tension of the forearm extensor.

While one might attribute the apparent reduced arousal in the present study to adaptation or habituation, the question arises as to what may have inhibited such responses in earlier studies or encouraged them in the present one. Unfortunately, procedural differences and differences in the physiological responses which were monitored make fruitful comparison impossible. The results of the present study do seem to indicate, however, that even in a general experimental situation in which responses indicative of relaxation seem to be fostered, frontalis feedback fails to provide an advantage over simple instructions.

The fact that fingertip skin temperature did not conform to the otherwise consistent pattern of increased relaxation or decreased arousal confirms the findings of earlier studies. It may be recalled that both Delman and Johnson (1976) and DeGood and Chisholm (1977) found evidence of decreased peripheral blood flow occurring in an overall pattern of decreased arousal. Such findings, while not necessarily negating the usefulness of a concept of general

relaxation, do indicate that it may be unreasonable to expect that any relaxation procedure will yield a totally consistent pattern of decreased physiological arousal. The obvious implication for research is that evaluations of relaxation procedures should include measures of as many physiological variables as is feasible.

Another respect in which the present study supports the preponderance of previous evidence relates to the assessment of subjective changes due to the training procedures. As was the case in the majority of previous studies employing normal subjects (Alexander, 1975; Alexander et al., 1975; Alexander et al., 1977; Burish & Hendrix, 1980; Burish et al., 1981; Reinking & Kohl, 1975) feedback training proved no more effective than control conditions in reducing subjective measures of anxiety. While significant pre-to-post-training decreases occurred in both state and trait anxiety, these changes were not dependent upon the receipt of feedback training. Similarly, the debriefing questionnaire rating scales which were intended to assess subjective effects of training revealed no major effect of feedback versus no feedback.

It may be recalled that Gellhorn (1964) proposed that decreased proprioceptive input to the hypothalamus due to muscular relaxation (particularly of the facial musculature) leads automatically to a trophotropic rebalancing or relaxation response. Because subjects who received feedback in the present study did achieve significantly lower

frontalis tension than those who did not receive feedback, the failure to find effects on other physiological measures casts doubt upon frontalis tension reduction as an automatic triggering mechanism for general relaxation. However, it should be noted that all subjects, including those who did not receive feedback, did achieve significant decreases in frontalis muscle tension and concomitant decreases in sternomastoid muscle tension and in skin conductance level. It might be argued that the changes in the sternomastoid muscle tension and in skin conductance level could have been a result of frontalis tension reduction. To argue thus, one would have to assume that the "trophotropic rebalancing" demonstrated by no-feedback subjects represented the greatest effect attainable through frontalis tension reduction, and that the greater reductions in frontalis tension shown by feedback subjects therefore produced no further changes in the other physiological variables. Alternatively, one might assume that the difference in frontalis muscle tension between feedback and no-feedback groups, while statistically significant, was not great enough to produce differences in the other physiological measures. Furthermore it might be argued that the trophotropic rebalancing of which Gellhorn (1964) speaks may not have occurred at all in the present study. The observed changes in sternomastoid muscle tension and skin conductance level might have represented adaptation or habituation effects unrelated to the activity of the frontales. The

possibility exists that trophotropic rebalancing requires sustained low levels of frontalis tension beyond those achieved (even by subjects receiving feedback) in the present study. In this regard it might be noted that decreases in frontalis muscle tension continued consistently both over minutes of a trial and over sessions. For feedback subjects the final session represented the most sustained low level of frontalis tension achieved (see Figure 3). Perhaps longer relaxation periods (trials) and/or more training (sessions) might have produced still lower levels of frontalis tension and greater effects on the other monitored physiological measures.

One could argue that although the data do not support the use of frontalis tension reduction as a means of achieving general relaxation neither do they preclude such a possibility. The weight of the evidence of this and earlier studies, however, casts grave doubts on the usefulness of feedback from a single muscle as a means of achieving general relaxation.

While frontalis EMG feedback does not seem to be a uniquely effective means of evoking general relaxation, the present study provides some evidence that general instructions do promote a more general muscular response. A number of previous studies had found significant relationships to exist between frontalis muscle tension and the tension in various other muscles (Davis, 1980; Fridlund et al., 1980; O'Connell & Yeaton, 1981; Sagberg & Kveim, 1981).

Results of the present study indicate that (regardless of whether or not feedback is provided) general instructions are associated with more general muscular relaxation than are specific instructions. Subjects receiving general instructions showed a pattern (across sessions) of significant positive correlations between frontalis and sternomastoid muscle tension, while subjects receiving specific instructions failed to show such a correlation in any session. Furthermore, the obtained mean levels of frontalis and sternomastoid muscle tension are nominally, though not significantly, lower for subjects receiving general instructions than for those receiving specific instructions. For sternomastoid muscle tension this difference was significant at an alpha level of .10.

These findings may provide a basis for interpreting the different results reported by some earlier studies. While Glaus and Kotses (1979) found decreasing muscular covariation over the course of frontalis EMG feedback training, O'Connell and Yeaton (1981) found muscular covariation to remain stable. It may be recalled from the introduction to this paper that these studies differed in the nature of instructions given to subjects. Glaus and Kotses (1979) merely told subjects to change the feedback signal and gave no indication of what response might facilitate such a change. O'Connell and Yeaton (1981) provided instructions which, while indicating that the feedback represented frontalis muscle tension, suggested

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general relaxation as a means of controlling the feedback signal. Unfortunately, these studies differed from one another in a number of other ways. Perhaps the most relevant difference was that while Glaus and Kotses (1979) monitored brachioradialis (a forearm muscle) tension, O'Connell and Yeaton (1981) monitored semispinalis/splenius (a neck muscle) tension. O'Connell and Yeaton's (1981) finding of more persistent covariation could have been due either to the provision of more general instructions or to the fact that the muscle which they monitored was physically closer to the frontales. The present finding of greater muscular covariation being associated with general instructions than with specific instructions lends support to the possibility that these earlier equivocal results were, at least in part, related to the difference in type of instruction employed.

Some general considerations

It had been expected that the effects of feedback in the present study would be dependent upon one or more of the instructional or temporal variables in such a way as to suggest an explanation for the equivocal results of earlier studies. Regarding frontalis tension reduction, (where the provision of feedback was a significant factor), had the superior performance of feedback subjects occurred only with the provision of particular instructions, this would have suggested instructional differences among previous studies as potential causative factors in producing varying results.

In the present study the superior performance of feedback subjects was not dependent on the type of instructions they received. Had feedback been more effective than no feedback only in the later minutes of a trial or only in later sessions, this would have suggested that the failure of some earlier studies to demonstrate a significant feedback effect could have been due to insufficient training. In the present study, however, subjects receiving feedback demonstrated significantly lower frontalis muscle tension very early in training (see Figure 3). While these results fail to elucidate the reasons for earlier equivocal results, the fact that the effectiveness of feedback was not dependent either on type of instruction or on extended training suggests the potency of feedback as a means of facilitating tension reduction in the frontales.

Unfortunately we are left to speculate about the reasons why some earlier studies (Alexander et al., 1977; Burish et al., 1981; Davis, 1980; Nielsen & Holmes, 1980; Yock, 1978) failed to find superior frontalis muscle tension reduction associated with the provision of feedback. A number of potential explanations relating specifically to each of the relevant studies were entertained in the introduction to this paper. These explanations included the possible creation of a negative expectancy in feedback subjects in the Alexander et al. (1977) study, the use of atypical feedback contingencies and atypical intersession interval in the Davis (1980) study, and the presentation of a

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stress-inducing stimulus prior to training in the Nielsen & Holmes (1980) study. Another possibility relates to the fact that there is really no direct comparison which can be drawn between the temporal characteristics of the present study and those of studies such as Davis (1980) or Alexander et al. (1977), who employed 70-second and 4-minute 14-second trial durations, respectively. The effect of repeated short trial durations cannot be assessed by analysis of data from the present study. The possibility exists that temporal characteristics of training are important. Parametric investigations of trial duration and of total training time would serve to clarify this issue.

The failure, in the present study, to find any significant physiological effect of providing passive as opposed to active instructions is surprising. Such putatively successful relaxation procedures as progressive muscle relaxation, autogenic training and eastern meditative techniques are purported to be dependent for their success, at least in part, on the assumption of a passive attitude (Benson, 1975; Green, Green & Walters, 1970; Stoyva, 1976). Furthermore, it will be recalled that there is some empirical evidence that subjects receiving passive instructions are better able to reduce frontalis muscle tension than subjects receiving active instructions (Hurley, 1978). Because of this it was expected that the encouragement of a passive attitude would facilitate both the reduction of frontalis muscle tension and the occurrence

of changes in other physiological variables indicative of relaxation. The failure to obtain such findings should certainly not, however, be taken as a conclusive demonstration that a passive attitude is not conducive to relaxation. It may be that the manipulation of the active-passive dimension of instructions was not as effective as would have been hoped. That is, while subjects accurately recognized their instructions as being either active or passive (and even reported less frustration under the influence of passive instructions) there are indications that subjects who received passive instructions may have been distrustful of the benefits to be obtained from the adoption of a passive attitude.

Subjects who received passive instructions reported, on the three scales of Question V of the debriefing questionnaire, that they had experienced significantly less of a positive subjective change occurring due to training than did subjects who received active instructions. In light of the fact that there were no significant physiological differences associated with the provision of these different types of instructions, it seems reasonable to assume that the difference in ratings represent purely cognitive reactions to the content of the instructions themselves. That is, one could interpret these results as indicating that subjects receiving passive instructions expected, and therefore reported, less of an effect. Furthermore, subjects receiving passive instructions

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characterized their instructions on the 7-point scale of active-to-passive with a mean rating of 6.19 (between moderately and very passive), but when asked, on the same scale, to characterize the approach which they took toward their training, the mean response was 4.75 (between neutral and slightly passive). Subjects receiving active instructions characterized their instructions with a mean rating of 2.47 (between slightly and moderately active) and their approach with a mean rating of 2.66 (between slightly and moderately active). The greater discrepancy between perceived intention of the instructions and approach taken, exhibited by subjects receiving passive instructions, further supports the possibility that subjects were distrustful of and may have resisted such instructions.

Perhaps the suggestion that something can be achieved without effort runs counter to a good deal of cultural conditioning. While the concept of non-action as a means of facilitating or allowing change is basic to certain oriental philosophies (see, for example, Watts, 1957), western belief systems seem, rather, to emphasize the value of active striving to achieve goals. If subjects bring to the biofeedback training situation a cultural distrust of passivity, then instructions which request passivity and do not sufficiently dispel such distrust might produce negative expectancies in the subjects with regard to the outcome of the training. It may be recalled that Goldberg et al. (1982) demonstrated that such negative expectancies can

significantly reduce the amount of frontalis tension reduction occurring with feedback procedures.

Directions for further research

A number of suggestions for further research concerning EMG feedback can be offered.

One area of research suggested by the results of the present study is a further evaluation of the potential of general (as opposed to specific) instructions for evoking a more general muscular relaxation. In the present study, subjects who received general instructions achieved levels of sternomastoid muscle tension which were, at the $p = .10$ level, significantly lower than those achieved by subjects who received specific instructions. A replication of the present procedure, perhaps employing a larger sample and more extensive training, should be considered to determine whether this effect is reliable. Furthermore, the effects, on the tension levels of a number of different muscles (i.e., other than the sternomastoid), of general versus specific instructions, should be assessed.

Parametric investigations of the temporal characteristics of frontalis EMG biofeedback training procedures should be undertaken. Kondo et al. (1977) found intersession interval to be an important factor in the outcome of frontalis EMG feedback training, with shorter intersession intervals being associated with greater reductions in frontalis EMG. To this author's knowledge there have been no other systematic evaluations of the

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potential effects of temporal characteristics of training on frontalis muscle tension and other physiological variables. The effects of increasing trial duration and of providing extensive training, beyond several sessions, would be of interest. By the standards of the commonly employed clinical relaxation procedures, both the duration of individual trials and the total extent of training provided in most frontalis EMG feedback studies, including the present one, are brief. Certainly, the results of the present study do not preclude the possibility that further significant decreases in frontalis muscle tension could occur across the span of longer trials and/or a greater number of sessions. Furthermore, while results of the study provide no evidence to indicate that frontalis EMG feedback fosters greater general relaxation than do simple instructions, it could be argued that more effective (perhaps longer) training, producing still lower or more sustained low levels of frontalis tension, could elicit a general physiological pattern of deep relaxation.

Another area for further investigation, relating to the use of feedback procedures for evoking general relaxation, is suggested by results reported recently by Shirley, Burish, and Rowe (1982). These investigators found that subjects receiving feedback of EMG averaged from a number of muscle sites (frontalis, masseter, sternomastoid, and forearm flexor) demonstrated greater general relaxation than either a frontalis feedback or a no-treatment control group,

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as indicated by levels of pulse rate, finger pulse volume, and fingertip skin temperature. It may be, as suggested by Gellhorn (1964), that decreased proprioceptive input does trigger a centrally mediated integrated pattern of relaxation; the magnitude of the decrease in input necessary to produce this effect might be such that it is most effectively achieved through the training of simultaneous reductions in the tension of a number of muscles. The findings of Shirley et al. (1982) should be confirmed by replication and further investigation should be undertaken to determine the generality of physiological relaxation which might be evoked by their procedure. That is, a number of other physiological variables, commonly used as indices of arousal level (e.g., skin conductance and blood pressure), should be assessed. If multiple site EMG feedback is effective in producing relatively consistent patterns of decreased arousal, then the next logical questions to address are whether there are optimal combinations of muscle sites and/or training parameters which will produce this effect most efficiently.

Further investigation of the potential benefits of passivity for relaxation should be undertaken. If, indeed, our culture instills in us a distrust of passivity, then perhaps more effective methods of producing a passive attitude are necessary. In addition to providing a subject with instructions which encourage a passive approach, one might use some form of pre-training cognitive manipulation.

This could take the form of readings and/or discussions on the benefits to be obtained from "letting the body take care of itself" or perhaps the use of hypnotic suggestion as a means of fostering the appropriate attitude.

General conclusions

In summary, the following conclusions can be drawn from this study:

1. Providing EMG feedback from the frontales is an effective means of reducing the tension in those muscles below levels which are attained when motivated subjects are instructed to relax or reduce tension but not provided with feedback.

2. The provision of such feedback does not seem to facilitate general relaxation or arousal reduction beyond that which can be attained through simply instructing individuals to relax.

3. The provision of specific as opposed to general instructions was found to have no effect on the ability to reduce frontalis tension.

4. General instructions do seem to be associated with a greater covariation between the frontales and the sternomastoid muscles.

5. The provision of passive as opposed to active instructions produced no significant physiological differences.

6. Differences on subjective measures between subjects receiving passive and those receiving active instructions

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can be interpreted to suggest a resistance to or mistrust of passive instructions.

7. Continuing significant changes in physiological variables, over the course of the 10-minute training period and across the 5 sessions, suggest that future studies of muscle tension reduction and/or general relaxation employ more extensive training than was characteristic of many previous studies.

8. The failure of fingertip temperature data to conform to the pattern of other physiological variables (confirming earlier findings of relative vasoconstriction in an otherwise consistent pattern of relaxation) suggests that "general physiological relaxation" may not be as integrated a response as previously implied.

Appendix A. Instructions: Feedback/Specific/Active

Instructions

Providing a person with appropriate instructions and accurate information about the responses of specific muscles has been used as a means of gaining control over tension reduction in those muscles. The purpose of your participation in this study is to teach you how to reduce the tension in your forehead muscles as much as you can.

You will have two, 10 minute training periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the training periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between training periods.

When I say the word "Begin" and you close your eyes, I would like you to become aware of your forehead muscles and to try to reduce any tension in them to the best of your ability. A number of sensors have been placed on your skin to monitor your body's activity. To help you in trying to reduce the tension in your forehead muscles, you will hear a tone whose pitch will vary according to the actual state of those muscles. If you increase the tension in your forehead muscles, the tone becomes higher in pitch; but as you decrease the tension in your forehead muscles, the tone becomes lower in pitch. As a result of your practice with the tone, you may find that your ability to reduce the tension in your forehead muscles improves.

The reduction of tension in your muscles is a process which you can learn to control. Try to do the best you can to reduce your forehead muscle tension and to control the pitch of the tone. As you remain here trying to reduce your forehead muscle tension, you may find that you are decreasing the tension in those muscles. Your task is to reduce the tension in your forehead muscles as much as you can and to make the tone as low in pitch as possible.

If you have any questions, please feel free to ask them now.

Appendix B. Instructions: Feedback/Specific/Passive

Instructions

Providing a person with appropriate instructions and accurate information about the responses of specific muscles has been used as a means of allowing the release of tension from those muscles. The purpose of your participation in this study is to provide a setting for you that will allow the tension to flow out of your forehead muscles so that the level of tension in those muscles will be greatly reduced.

You will have two, 10 minute tension release periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the tension release periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between tension release periods.

As I say the word "Begin" and you close your eyes, I would like you to become aware of your forehead muscles and just allow any tension to drain easily out of those muscles. A number of sensors have been placed on your skin to monitor your body's activity. As a guide to the level of tension in your forehead muscles you will hear a tone whose pitch will vary according to the actual state of those muscles. If tension increases in your forehead muscles, the tone becomes higher in pitch; but as tension is released from your forehead muscles, the tone becomes lower in pitch. As a result of your experience with the tone, you may find that the release of tension from your forehead muscles proceeds more freely.

The release of tension is a natural process of your muscles which cannot be forced: "trying" to release the tension from your forehead muscles can interfere with that process. Rather than trying, just permit the tension release process to occur at its own pace. As you remain here quietly, the tension may flow easily out of your forehead muscles so that the level of tension is greatly reduced. There is no need to be concerned with "how well" you are doing or what the level of the pitch is at any moment. In fact, such concerns interfere with the natural tension release process. Allow the tension to drain easily from your forehead muscles without effort or concern and let the tone serve as a guide.

If you have any questions, please feel free to ask them now.

Appendix C. Instructions: Feedback/General/Active

Instructions

Providing a person with appropriate instructions and accurate information about the responses of the body has been used as a means of gaining control over relaxation. The purpose of your participation in this study is to teach you how to make yourself relax as deeply as you can, both physically and mentally.

You will have two, 10 minute training periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the training periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between training periods.

When I say the word "Begin" and you close your eyes, I would like you to become aware of your body and to try to reduce any tension to the best of your ability. A number of sensors have been placed on your skin to monitor your body's activity. To help you in trying to relax yourself, you will hear a tone whose pitch will vary according to the actual state of your body. If you tense, the tone becomes higher in pitch; but as you relax yourself, the tone becomes lower in pitch. As a result of your practice with the tone, you may find that your ability to relax yourself improves.

General relaxation is a process which you can learn to control. Try to do the best you can to make yourself relax deeply and to control the pitch of the tone. As you remain here trying to control your relaxation, you may find that you are producing deep relaxation. Your task is to relax yourself deeply and to make the tone as low in pitch as possible.

If you have any questions, please feel free to ask them now.

Appendix D. Instructions: Feedback/General/Passive

Instructions

Providing a person with appropriate instructions and accurate information about the responses of the body has been used as a means of allowing deep levels of relaxation. The purpose of your participation in this study is to provide a setting for you that will allow the tension to flow out of your body so that you will become deeply relaxed, both physically and mentally.

You will have two, 10 minute relaxation periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the relaxation periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between relaxation periods.

As I say the word "Begin" and you close your eyes, I would like you to become aware of your body and just allow any tension to drain easily out of your body. A number of sensors have been placed on your skin to monitor your body's activity. As a guide to how relaxed you are, you will hear a tone whose pitch will vary according to the actual state of your body. If tension increases, the tone becomes higher in pitch; but as relaxation progresses, the tone becomes lower in pitch. As a result of your experience with the tone, you may find that the relaxation process proceeds more freely.

General relaxation is a natural process which cannot be forced: "trying" to relax can interfere with that process. Rather than trying, just permit the relaxation to occur at its own pace. As you remain here quietly, the tension may flow easily out of your body and you may find yourself becoming deeply relaxed. There is no need to be concerned with "how well" you are doing or what the level of the pitch is at any moment. In fact, such concerns interfere with the natural relaxation process. Allow the tension to drain easily from your body without effort or concern and let the tone serve as a guide.

If you have any questions, please feel free to ask them now.

Appendix E. Instructions: No Feedback/Specific/Active

Instructions

Providing a person with appropriate instructions and regular practice has been used as a means of gaining control over tension reduction in specific muscles. The purpose of your participation in this study is to teach you how to reduce the tension in your forehead muscles as much as you can.

You will have two, 10 minute training periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the training periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between training periods.

When I say the word "Begin" and you close your eyes, I would like you to become aware of your forehead muscles and to try to reduce any tension in them to the best of your ability. A number of sensors have been placed on your skin to monitor your body's activity. As a result of your practice, you may find that your ability to reduce the tension in your forehead muscles improves.

The reduction of tension in your muscles is a process which you can learn to control. Try to do the best you can to reduce your forehead muscle tension and to follow these instructions. As you remain here trying to reduce your forehead muscle tension, you may find that you are decreasing the tension in those muscles. Your task is to reduce the tension in your forehead muscles as much as you can.

If you have any questions, please feel free to ask them now.

Appendix F. Instructions: No Feedback/Specific/Passive

Instructions

Providing a person with appropriate instructions and a proper setting has been used as a means of allowing the release of tension from specific muscles. The purpose of your participation in this study is to provide a setting for you that will allow the tension to flow out of your forehead muscles so that the level of tension in those muscles will be greatly reduced.

You will have two, 10 minute tension release periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the tension release periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between tension release periods.

As I say the word "Begin" and you close your eyes, I would like you to become aware of your forehead muscles and just allow any tension to drain easily out of those muscles. A number of sensors have been placed on your skin to monitor your body's activity. As a result of your experience here, you may find that the release of tension from your forehead muscles proceeds more freely.

The release of tension is a natural process of your muscles which cannot be forced: "trying" to release the tension from your forehead muscles can interfere with that process. Rather than trying, just permit the tension release to occur at its own pace. As you remain here quietly, the tension may flow easily out of your forehead muscles so that the level of tension is greatly reduced. There is no need to be concerned with "how well" you are doing. In fact, such a concern interferes with the natural tension release process. Allow the tension to drain easily from your forehead muscles without effort or concern.

If you have any questions, please feel free to ask them now.

Appendix G. Instructions: No Feedback/General/Active

Instructions

Providing a person with appropriate instructions and regular practice has been used as a means of gaining control over relaxation. The purpose of your participation in this study is to teach you how to make yourself relax as deeply as you can, both physically and mentally.

You will have two, 10 minute training periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the training periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between training periods.

When I say the word "Begin" and you close your eyes, I would like you to become aware of your body and to try to reduce any tension to the best of your ability. A number of sensors have been placed on your skin to monitor your body's activity. As a result of your practice, you may find that your ability to relax yourself improves.

General relaxation is a process which you can learn to control. Try to do the best you can to make yourself relax deeply and to follow these instructions. As you remain here trying to control your relaxation, you may find that you are producing deep relaxation. Your task is to relax yourself deeply.

If you have any questions, please feel free to ask them now.

Appendix H. Instructions: No Feedback/General/Passive

Instructions

Providing a person with appropriate instructions and a proper setting has been used as a means of allowing deep levels of relaxation. The purpose of your participation in this study is to provide a setting for you that will allow the tension to flow out of your body so that you will become deeply relaxed, both physically and mentally.

You will have two, 10 minute relaxation periods with approximately 1 minute between the two. Each period will start when I say "Begin" and end when I say "OK". During the relaxation periods, please close your eyes and move around as little as possible compatible with your own comfort. If you have to make any major adjustments in your position, it would be best if you could do so in the interval between relaxation periods.

As I say the word "Begin" and you close your eyes, I would like you to become aware of your body and just allow any tension to drain easily out of your body. A number of sensors have been placed on your skin to monitor your body's activity. As a result of your experience here, you may find that the relaxation process proceeds more freely.

General relaxation is a natural process which cannot be forced: "trying" to relax can interfere with that process. Rather than trying, just permit the relaxation to occur at its own pace. As you remain here quietly, the tension may flow easily out of your body and you may find yourself becoming deeply relaxed. There is no need to be concerned with "how well" you are doing. In fact, such a concern interferes with the natural relaxation process. Allow the tension to drain easily from your body without effort or concern.

If you have any questions, please feel free to ask them now.

Appendix I. Overview: Specific

Overview

The research in which you are considering participation is an investigation of a technique which has been used to facilitate the reduction of tension in specific muscles. As a volunteer you would engage in this technique in the laboratory while a number of your body's responses are monitored by sensors placed on the surface of your skin. You will be asked to participate in 5 sessions over a two to three week period. Each session will last approximately 1 hour, making for a total of 5 hours of your time.

This research has been reviewed and approved by the Queens College Committee for the Protection of Human Subjects: you will be exposed to no physical, psychological or social risks beyond those of everyday life.

If you do choose to participate, we ask that you abstain from alcohol and non-prescription drugs for at least 12 hours before each session. We also ask that you do not discuss the nature of your participation in the study with any other participant or potential participant until both of you have completed your last session since such discussion might prejudice the study results.

Since the purpose of the research is an investigation of the effectiveness of the technique, your careful attention to all instructions which are given to you is important to the conclusions which we reach.

If you have any questions, please feel free to ask them now.

Appendix J. Overview: General

Overview

The research in which you are considering participation is an investigation of a technique which has been used to facilitate general relaxation. As a volunteer you would engage in this technique in the laboratory while a number of your body's responses are monitored by sensors placed on the surface of your skin. You will be asked to participate in 5 sessions over a two to three week period. Each session will last approximately 1 hour, making for a total of 5 hours of your time.

This research has been reviewed and approved by the Queens College Committee for the Protection of Human Subjects: you will be exposed to no physical, psychological or social risks beyond those of everyday life.

If you do choose to participate, we ask that you abstain from alcohol and non-prescription drugs for at least 12 hours before each session. We also ask that you do not discuss the nature of your participation in the study with any other participant or potential participant until both of you have completed your last session since such discussion might prejudice the study results.

Since the purpose of the research is an investigation of the effectiveness of the technique, your careful attention to all instructions which are given to you is important to the conclusions which we reach.

If you have any questions, please feel free to ask them now.

Appendix K. (continued)

Participant impressions: Page 3

V. At the end of each session how did you typically feel, as compared to how you felt at the beginning of the session?

1 2 3 4 5 6 7
much moderately slightly no slightly moderately much
better better better different worse worse worse

1 2 3 4 5 6 7
much moderately slightly no slightly moderately such
calmer calmer calmer different more anxious more anxious
anxious

1 2 3 4 5 6 7
much moderately slightly no slightly moderately such
more more more different more more more
relaxed relaxed relaxed tense tense tense

VI. How would you rate your overall experience as a participant in this study?

1 2 3 4 5 6 7
very moderately slightly neutral slightly moderately very
positive positive positive negative negative negative

VII. Do you have any comments or suggestions?

Appendix L. Instruction Validation Form

The instructions on the following page will be used in a study of muscle tension reduction and overall relaxation. People who take part in the study will read the instructions and then will be given some training. Before we can use the instructions, we have to be sure that they tell people what we want them to. I would like you to read the instructions carefully and let me know how they appear to you by rating them in four different ways.

1. First, I would like you to rate how clear or unclear the instructions seem.
2. Second, I would like you to rate how specific or general the instructions seem.
 - Specific instructions: tell a person that he is to reduce or allow the release of tension in a specific muscle or a small group of muscles.
 - General instructions: tell a person that he is to produce or allow an overall tension reduction or relaxation of the whole body.
3. Third, I would like you to rate how active or passive the instructions seem.
 - Active instructions: suggest to a person that he is to try, or attempt, or strive to achieve muscle tension reduction or overall relaxation.
 - Passive instructions: suggest to a person that he is to allow the release of muscle tension or the overall relaxation to occur naturally, without trying.
4. Finally, I would like you to rate how good or bad the instructions seem.

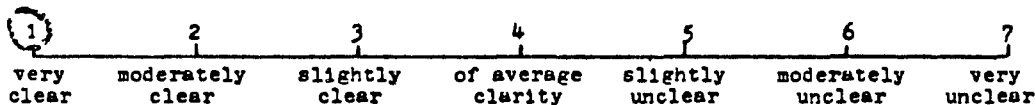
On the page following the instructions you will find four rating scales similar to the one below. By circling one number on each scale, I would like you to rate the instructions in the four ways which have been described. For example, if you feel that the instructions are very clear, you would mark the first scale as shown in the example below. You would then go on to rate the instructions on the remaining three scales.

In deciding on your ratings, feel free to refer back to the definitions given on this page.

If you have any questions about what you are expected to do, please feel free to ask them now.

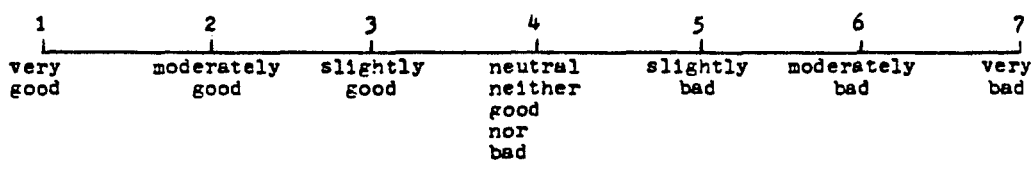
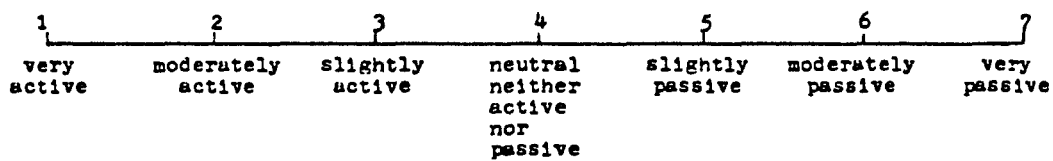
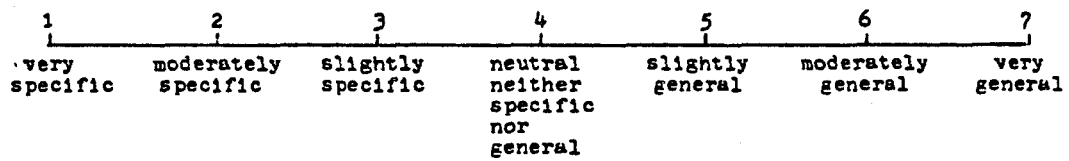
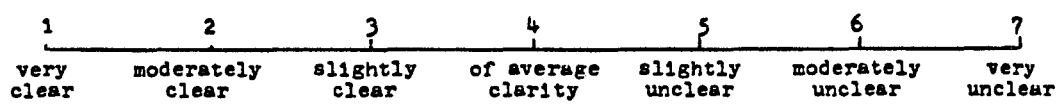
Thank you very much for your help.

EXAMPLE:



Appendix L. (continued)

The instructions which I read seem to me to be:



Appendix M. Participant Information Form

Participant Information

Date: _____

Name: _____ Birthdate: _____ Sex: _____

Address: _____ Telephone: _____

1.a. Are you being treated for, have you ever been treated for, or are you frequently troubled by:

- | | |
|-----------------------------------|--------------------------|
| _____ heart ailments | _____ anxiety |
| _____ high or low blood pressure | _____ depression |
| _____ diabetes or low blood sugar | _____ muscle aches |
| _____ epilepsy | _____ any other problems |
| _____ recurrent headaches | _____ |

b. Do you regularly use any prescription or non-prescription medication for any of the above? If so, what and how often?

2. Do you use any of the following? If so, to what extent?

- Coffee, tea or colas _____ Alcohol _____
- Tobacco _____ Marijuana _____
- Any other drugs _____

3. Have you had any previous experience with formal muscle tension reduction or general relaxation training procedures such as meditation, yoga, progressive muscle relaxation, biofeedback, hypnosis, etc.? If so, please explain: _____

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References

- Alexander, A. B. An experimental test of assumptions relating to the use of electromyographic biofeedback as a general relaxation training technique. Psychophysiology, 1975, 12, 656-662.
- Alexander, A. B., French, C. A. & Goodman, N. J. A comparison of auditory and visual feedback in biofeedback assisted muscular relaxation training. Psychophysiology, 1975, 12, 119-123.
- Alexander, A. B., White, P. D. & Wallace, H. M. Training and transfer of training effects in EMG biofeedback assisted muscular relaxation. Psychophysiology, 1977, 14, 551-559.
- Autogenic Systems, Inc. Instruction manual for the Autogen 1700. Berkeley: Autogenic Systems, Inc. 1975a.
- Autogenic Systems, Inc. Instruction manual for the Autogen 3400. Berkeley: Autogenic Systems, Inc. 1975b.
- Balshan, I. Muscle tension and personality in women. Archives of General Psychiatry, 1962, 7, 436-448.
- Barber, T. X. Physiological effects of "hypnotic suggestions": A critical review of recent research (1960-1964). Psychological Bulletin, 1965, 63(4), 201-222.
- Benson, H. The relaxation response. New York: Morrow, 1975.
- Blanchard, E. B., Haynes, M. R., Kallman, M. D. & Harkey, L. A. A comparison of direct blood pressure feedback and electromyographic feedback on the blood pressure of normotensives. Biofeedback and Self-Regulation, 1976, 1, 445-451.
- Brown, B. B. Stress and the art of biofeedback. New York: Bantam Books, Inc., 1977.
- Budzynski, T. H. & Stoyva, J. M. An instrument for producing deep muscle relaxation by means of analog information feedback. Journal of Applied Behavior Analysis, 1969, 2, 231-237.
- Burish, T. G. & Hendrix, E. M. Importance of relaxation instructions in the EMG biofeedback training package. Journal of Psychosomatic Research, 1980, 24(3/4), 137-145.
- Burish, T. G., Hendrix, E. M. & Frost, R. O. Comparison of frontal EMG biofeedback and several types of relaxation

instructions in reducing multiple indices of arousal. Psychophysiology, 1981, 18(5), 594-602.

Canter, A., Kondo, C. Y. & Knott, J. R. A comparison of EMG feedback and progressive muscle relaxation training in anxiety neurosis. British Journal of Psychiatry, 1975, 127, 470-477.

Coursey, R. D. Electromyograph feedback as a relaxation technique. Journal of Consulting and Clinical Psychology, 1975, 43(6), 825-834.

Davidson, R. J. & Schwartz, G. The psychobiology of relaxation and related states: A multiprocess theory. In D. I. Mostofsky (Ed.), Behavior control and modification of physiological activity. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1976.

Davis, P. J. Electromyographic biofeedback: generalization, and the relative effects of feedback, instructions and adaptation. Psychophysiology, 1980, 17(6), 604-612.

DeGood D. E. & Chisholm, R. C. Multiple response comparison of parietal EEG and frontalis EMG biofeedback. Psychophysiology, 1977, 14(3), 258-265.

Delman, R. P. & Johnson, H. J. Biofeedback and progressive muscle relaxation: A comparison of psychophysiological effects. Psychophysiology, 1976, 13(2), 181. (Abstract)

Fee R. A. & Girdano, D. A. The relative effectiveness of three techniques to induce the trophotropic response. Biofeedback and Self-Regulation, 1978, 3(2), 145-157.

Freedman, R. & Papsdorf, J. D. Biofeedback and progressive relaxation treatment of sleep-onset insomnia: A controlled, all-night investigation. Biofeedback and Self-Regulation, 1976, 1(3), 253-271.

Fridlund, A. J., Fowler, S. C. & Pritchard, D. A. Striate muscle tensional patterning in frontalis EMG biofeedback. Psychophysiology, 1980, 17(1), 47-55.

Gatchel, R. J., Korman, M., Weis, C. B., Smith, D. & Clarke, L. A multiple response evaluation of EMG biofeedback performance during training and stress-induction conditions. Psychophysiology, 1978, 15(3), 253-258.

Gellhorn, E. Motion and emotion: The role of proprioception in the physiology and pathology of the emotions. Psychological Review, 1964, 71, 457-472.

- Glaus, K. & Kotses, H. Generalization of conditioned frontalis tension: A closer look. Proceedings of the Biofeedback Society of America: Ninth Annual Meeting, 1978, 245-246. (Summary)
- Glaus K. & Kotses, H. Generalization of conditioned muscle tension: A closer look. Psychophysiology, 1979, 16(6), 513-519.
- Goldberg, J., Weller, L. & Blittner, M. Cognitive self-control factors in EMG biofeedback. Biofeedback and Self-Regulation, 1982, 7(4), 545-551.
- Green, E. E., Green, A. M. & Walters, E. D. Voluntary control of internal states: Psychological and physiological. Journal of Transpersonal Psychology, 1970, 2(1), 1-26.
- Haynes, S., Moseley, D. & McGowan, W. T. Relaxation training and biofeedback in the reduction of frontalis muscle tension. Psychophysiology, 1975, 12(5), 547-552.
- Hurley, G. Motorically activating versus motorically inhibiting instructions in EMG feedback training. Proceedings of the Biofeedback Society of America: Ninth Annual Meeting, 1978, 242-244. (Summary)
- Jacobson, E. Progressive relaxation (2nd ed.). Chicago: University of Chicago Press, 1938.
- Kinsman, R. A., O'Banion, K., Robinson, S. & Staudenmeyer, H. Continuous feedback and discrete post-trial verbal feedback in frontalis muscle relaxation training. Psychophysiology, 1975, 12, 30-35.
- Kluger, A. Motor skills learning as a model for visceral learning: An experimental investigation. Unpublished doctoral dissertation, City University of New York, 1983.
- Kondo, C. Y., Canter, A. & Bean, J. A. Intersession interval and reductions in frontalis EMG during biofeedback training. Psychophysiology, 1977, 14(1), 15-17.
- LaVallee, Y., Lamontagne, Y., Pinard, G., Annable, L. & Tetreault, L. Effects of EMG feedback, diazepam and their combination on chronic anxiety. Journal of Psychosomatic Research, 1977, 21, 65-71.
- Lippold, O. C. J. Electromyography. In P. H. Venables & I. Martin (Eds.), A manual of psychophysiological methods. New York: John Wiley & Sons, Inc., 1967.

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- Luthe, W. Autogenic training: Method, research and application in medicine. American Journal of Psychotherapy, 1963, 17, 174.
- Luthe, W. (Ed.) Autogenic Therapy (4 vols.). New York: Grune & Stratton, 1969.
- May, J. R. & Johnson, H. J. Physiological activity to internally elicited arousal and inhibitory thoughts. Journal of Abnormal Psychology, 1973, 82(2), 239-245.
- McGowan, W. T., Haynes, S. N. & Wilson, C. C. Frontal electromyographic feedback: stress attenuation and generalization. Biofeedback and Self-Regulation, 1979, 4(4), 323-339.
- Meichenbaum, D. Cognitive factors in biofeedback therapy. Biofeedback and Self-Regulation, 1976, 1(2), 201-216.
- Nielsen, D. H. & Holmes, D. S. Effectiveness of EMG biofeedback training for controlling arousal in subsequent stressful situations. Biofeedback and Self-Regulation, 1980, 5(2), 235-248.
- O'Connell, M. F. & Yeaton, S. P. Generalized muscle changes during EMG relaxation training. Psychophysiology, 1981, 18(1), 56-61.
- Ohno, Y., Tanaka, Y., Takeya, T., Matsubara, H., Kuriya, N. & Komemushi, S. Biofeedback modification of frontal EMG in normal subjects. Biofeedback and Self-Regulation, 1978, 3(1), 61-68.
- Ramsey, P. H. Power of univariate pairwise multiple comparison procedures. Psychological Bulletin, 1981, 90(2), 352-366.
- Raskin, M., Johnson, G. & Rondestvedt, J. W. Chronic anxiety treated by feedback-induced muscle relaxation. Archives of General Psychiatry, 1973, 28, 263-267.
- Reinking, R. H. & 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(6), 595-600.
- Sagberg, F. & Kveim, K. B. Simultaneous EMGs from six sites during muscular relaxation: A comparison between forehead and forearm feedback. Psychophysiology, 1981, 18(4), 424-431.
- Sallis, J. F. & Lichstein, K. L. The frontal electromyographic adaptation response: A potential source of confounding. Biofeedback and Self-Regulation, 1979, 4(4), 337-339.

- Schandler, S. L. & Grings, W. W. An examination of methods for producing relaxation during short-term laboratory sessions. Behavior Research and Therapy, 1976, 14, 419-426.
- Shedivy, D. J. & Kleinman, K. M. Lack of correlation between frontalis EMG and either neck EMG or verbal ratings of tension. Psychophysiology, 1977, 14(2), 182-186.
- Shirley, M. C., Burish, T. G. & Rowe, C. Effectiveness of multiple-site EMG biofeedback in the reduction of arousal. Biofeedback and Self-Regulation, 1982, 7(2), 167-184.
- Spielberger, C. C., Gorsuch, R. L. & Lushene, R. E. Manual for the State-Trait Anxiety Inventory (STAI). Palo Alto, California: Consulting Psychologists Press, 1970.
- Stern, G. S. & Berenberg, J. L. Biofeedback training in frontalis relaxation and enhancement of belief in personal control. Biofeedback and Self-Regulation, 1977, 2(2), 173-182.
- Sternbach, R. A. The effects of instructional sets on autonomic responsivity. Psychophysiology, 1964, 1(1), 67-72.
- Stoyva, J. M. Self-regulation and the stress-related disorders: A perspective on biofeedback. In D. I. Mostofsky (Ed.), Behavior control and modification of physiological activity. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1976.
- Stoyva, J. M. Why should muscle relaxation be clinically useful? Some data and 2 1/2 models. In J. Beatty & H. Legewie (Eds.) Biofeedback and behavior: NATO conference series. New York: Plenum, 1977.
- Stoyva, J. M. Some unresolved issues in the generalization of muscle relaxation. In N. Birbaumer & H. D. Kimmel (Eds.), Biofeedback and self-regulation. Hillsdale, N.J.: Lawrence Erlbaum Associates, Inc., 1979.
- Stoyva, J. M. & Budzynski, T. H. Cultivated low arousal - an anti-stress response? In L. V. Dicara (Ed.), Recent advances in limbic and autonomic nervous system research. New York: Plenum, 1974.
- Townsend, R. E., House, J. F. & Addario, D. A. A comparison of biofeedback-mediated relaxation and group therapy in the treatment of chronic anxiety. American Journal of Psychiatry, 1975, 132(6), 598-601.

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Watts, A. W. The way of Zen. New York: Vintage Books, 1957.

Welsch, R. E. Stepwise multiple comparison procedures. Journal of the American Statistical Association, 1977, 77(359), 566-575.

Wilkinson, M. A critical review of the current use of electromyographic biofeedback in general relaxation training. Canadian Counsellor, 1977, 11(4), 182-184.

Wolpe, J. Psychotherapy by reciprocal inhibition. Stanford: Stanford University Press, 1958.

Yock, T. J. Electromyographic feedback as a relaxation procedure: A psychophysiological evaluation. Proceedings of the Biofeedback Society of America: Ninth Annual Meeting, 1978, 245-246. (Summary)