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Attention Mechanisms in EMG Biofeedback

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ATTENTION MECHANISMS IN EMG BIOFEEDBACK

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This Dissertation submitted by Randy Scott Roth in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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This Dissertation meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Dean of the Graduate School

Permission

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ABSTRACT

This study assessed the impact of selected task, instructional and personological variables as they contribute to relaxation during frontalis EMG biofeedback. Subjects (n = 60) divided equally by sex and high versus low absorption were randomly assigned to one of five groups. Four groups (n = 48) comprised a Feedback x Instruction factorial and were provided either contingent or noncontingent feedback information and pre-training instructions that either emphasized a passive attention approach to acquired self-relaxation or were nonspecific. Care was taken to avoid task instructions for noncontingent feedback subjects which would be deceiving or countertherapeutic. A fifth no-treatment (resting) control group was also included to assess the affects of adaptation on frontalis EMG. Relaxation was operationally defined by changes in frontalis EMG as observed across three training sessions.

The results indicated that subjects receiving contingent EMG biofeedback were significantly lower in frontalis muscle tension across sessions. However, subjects in general did not demonstrate a significant negative linear trend in EMG during training and treatment conditions did not differ significantly from no-treatment controls in rate of within-session decline of EMG. Pre-training instructions, gender and absorption main effects were nonsignificant but a significant Instruction x Sex x Absorption interaction was obtained. Relaxation performance during Session 1 was found to significantly predict EMG levels for Session 3. The findings were interpreted to provide only partial support for the efficacy of EMG biofeedback. In addition, learned control of relaxation was viewed as a complex process involving interactions among instructional, task and individual difference factors.

CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

The appearance of biofeedback therapy on the clinical psychology horizon has provided renewed interest in the study of psychophysiologic self-regulation and behavioral models of psychosomatic disease (Elmore & Tursky, 1978; Miller, 1974, 1978; Schwartz, 1973, 1975). Biofeedback has been hailed as a "panacea" for the treatment of numerous psychophysiologic maladies (Blanchard & Young, 1974; Brown, 1974; Budzynski, 1973; Karlins & Andrews, 1972). It also serves as a unique and powerful research instrument by which to elucidate the mechanisms of autonomic and visceral conditioning and the interrelationships among physiologic processes which underlie emotion and arousal (Schwartz, 1975). Despite the growing clinical application of human biofeedback, the parameters which contribute to optimal therapeutic outcome remain poorly understood (Cuthbert & Lang, 1976; Shapiro & Surwit, 1979). Theories of biofeedback learning differ in terms of the specific function attributed to the feedback signal in facilitating treatment effects (Black, 1972; Brener, 1977; Lang, 1976) and the role of cognitive factors in mediating these effects (Katkin & Murray, 1968; Meichanbaum, 1976; Surwit, 1978). Similarly, the relationship between individual difference factors and biofeedback performance has yet to be clarified (Tarler-Benlolo, 1978). If biofeedback is to fulfill its heuristic and clinical potential, rigorous studies are needed to clarify: (a) whether the results produced by the training are reducible to the specific effects of biofeedback (Miller, 1978; Miller & Dworkin, 1974), (b) the conditions under which biofeedback-mediated voluntary control is facilitated (DiCara, 1975; Miller, 1974; Shapiro, 1974), and (c) the character of individual for whom biofeedback is the treatment of choice (Barber, 1976a).

Biofeedback has traditionally been described as a behavior therapy (Birk, 1973; Elmore & Tursky, 1978) relying on the principle of operant reinforcement for its conceptual rationale (Shapiro & Schwartz, 1972; Wickramasekera, 1976). In this view, the information conveyed by the exteroceptive feedback signal is conceptualized as a reinforcing stimulus which, when presented contingent upon appropriate changes in a criterion physiologic response, provides the necessary conditions for learned voluntary control over the target system. However, a review of the clinical biofeedback literature and relevant studies pertaining to the learned control of psychophysiologic responses provides equivocal support for this view (Blanchard & Young, 1973, 1974; Roth, 1975). Studies demonstrating learning effects attributable to biofeedback training have been criticized for lack of rigor in experimental design (Cuthbert & Lang, 1976) and, in particular, the failure of many investigators to control for placebo and adaptation effects (Miller, 1978; Miller & Dworkin, 1974; Shapiro & Surwit, 1976). These methodological flaws qualify the validity of conclusions drawn from the literature regarding the efficacy and mechanisms of biofeedback learning. Moreover, there is evidence from well-controlled biofeedback studies that control subjects receiving bogus feedback information during training are capable of producing appropriate changes in the criterion responses (e.g., Kondo & Canter, 1977) and that, at times, these changes are equivalent to those observed for experimental trainees receiving true contingent feedback (Jones & Holmes, 1976; Kondo, Canter & Knott, 1975; Levenson, 1976). These findings call into question the specificity of the biofeedback effect and the legitimacy of the reinforcement model of the biofeedback process (Surwit & Keefe, in press).

Greater understanding of biofeedback performance might be derived from careful study of the operation of comparable self-regulatory strategies (Barber, 1976a). It is well known that individuals exposed to a variety of techniques other than biofeedback are capable of autonomic, visceral and somatomotor control heretofore associated exclusively with somnambulistic hypnotic subjects and Eastern contemplative masters. Hypnosis (Barber, 1969; Hilgard, 1975), meditation (Glueck & Stroebel, 1975; Wallace, Benson & Wilson, 1971), yoga (Dalal & Barber, 1969; Das, 1963), autogenic training (Luthe, 1963) and various relaxation therapies (Benson, 1975; Jacobson, 1938; Yorkston & Sergeant, 1969) have collectively been recruited to treat numerous anxiety-based psychophysiologic disorders commonly targeted by biofeedback clinicians. These techniques share in common the capacity to induce in trainees a subjective state of low arousal which is accompanied by a decrease in central nervous system activation and sympathetic tone (Benson, Beary & Carol, 1974a; Budzynski, 1976; Stoyva & Budzynski, 1974). Comparative studies examining the therapeutic effectiveness of these procedures, including biofeedback, have consistently found that as a group these techniques are equally potent in facilitating a desirable clinical outcome (Jacob, Kraemer & Agras, 1977; Shapiro & Surwit, 1976). This evidence has led some biofeedback theoreticians to characterize biofeedback training as one of a class of strategies which primarily function to assist the individual in learning generalized relaxation (Barber, 1976a; Shapiro & Surwit, 1976; Surwit & Keefe, in press).

If biofeedback is merely another form of relaxation training, then it follows that factors related to promoting relaxation will be important in facilitating biofeedback therapy. Benson and his colleagues (Benson et al., 1974a; Wallace et al., 1971) have published several reports describing a successful but simple technique for eliciting the "relaxation response" which they speculate represents a parasympathetic corollary to the well-known "fight-flight" response described by Cannon (1936). Benson (1975) argues that four variables--a quiet place, a comfortable position, a neutral stimulus to attend to, and a passive attitude during relaxation--are sufficient conditions for fostering the learned control of self-relaxation. His emphasis on cognitive-attentional factors in mediating relaxation is interesting as it parallels the growing appreciation among behavior therapists for the prominence of attentional processes during states of excessive arousal (Kaplan, 1974; Sarason, 1975; Wine, 1971) and in producing relaxation during systematic desensitization (Wilkins, 1971; Yulis, Brahm, Charnes, Jacard, Picota & Rutman, 1975).

Instead of attributing therapeutic changes to the operation of a feedback-information loop, an alternative explanation of biofeedback-relaxation training is that certain task and instructional variables facilitate learned control of autonomic arousal. The typical clinical biofeedback setting includes all the factors described by Benson (1975) to be inherent to relaxation. The trainee sits in a comfortable position (e.g., an easy chair), in a quiet place (e.g., therapist's office). He is provided a relatively neutral, monotonous stimulus (e.g., feedback signal) to attend to and, commonly, he is encouraged to adopt a "letting go," permissive and casual posture toward the biofeedback training experience (Pelletier, 1975). This model would consider the accuracy of the feedback signal nonessential in promoting the acquisition of autorelaxation capabilities.

It follows, then, if biofeedback can mediate depths of relaxation beyond that attainable through elicitation of the relaxation response, then among biofeedback subjects who are provided instructions emphasizing Benson's cognitive-attentional factors those who receive true contingent feedback information should evidence more profound relaxation than control subjects receiving inaccurate pseudofeedback Jessup, Neufeld & Mersky, 1979). If biofeedback is nothing more than an over elaborate, mechanized variant of simple relaxation training, then the addition of contingent feedback should prove of little benefit in facilitating greater relaxation among subjects already practicing Benson's relaxation technique. Furthermore, subjects receiving either Benson's relaxation therapy or biofeedback therapy should exhibit greater degrees of relaxation following training than no-treatment control subjects if both of these relaxation techniques possess specific effects on physiologic activity beyond that attributable to habituation and motor inactivity.

The present study addressed these issues by examining the effects of cognitive-attentional factors during EMG biofeedback training. Subjects received either neutral pre-training information or instructions emphasizing attentional focusing, minimized distractibility and a passive attitude toward relaxation as presented by Benson (1975). In addition, half the subjects receiving both of these pretreatment preparations were administered contingent frontalis EMG biofeedback while the remaining subjects received noncontingent, bogus feedback information during training. A fifth no-treatment "resting" control group was added for comparison purposes.

Equal numbers of male and female subjects were included in the study to determine possible sex differences in relaxation performance. Subjects were also divided based on their degree of "absorption" as measured by the Tellegen Absorption Scale (TAS) (Tellegen & Atkinson, 1974). The trait absorption was selected for inclusion since the capacity for total attentional involvement indicated by absorption seems similar to cognitive alterations believed to occur during relaxation and, consequently, may be predictive of performance during biofeedback-relaxation training.

EMG biofeedback was selected as the biofeedback modality by which to study relaxation processes because of the unusually strong evidence supporting its clinical utility (Blanchard & Young, 1974) especially for problems of anxiety (Raskin, Johnson & Rondestvedt, 1973; Townsend, House & Addario, 1975) and pain resulting from sustained muscle contraction (Jessup et al., 1979). A measure of skeletal muscle action potential is believed to be a valid index of sympathetic arousal

(Budzynski & Stoyva, 1972; Gellhorn, 1967; Jacobson, 1938; Malmo, 1966) and, as such, supports the use of EMG level as a quantifiable index of relaxation.

The Feedback Factor in Biofeedback

In human biofeedback the subject is seated in a reclining chair or lies comfortably supine while attending to a feedback signal (e.g., light or tone) which relays information to the trainee regarding the activity of a targeted physiologic response. Electronic equipment is generally required to augment the electric response data and convert it to a form accessible to the subject's sensory awareness. Response systems are chosen for monitoring based on their hypothesized functional relationship with clinical symptomatology (e.g., frontalis muscle-tension headache). By providing the trainee with knowledge of moment-to-moment changes in the disturbed physiologic system, the individual is expected to learn to exert volitional control over that system when in the biofeedback situation and, later, in the absence of feedback.

Biofeedback was originally included under the rubric of behavior therapy (Birk, 1973; Blanchard & Young, 1973) because of its apparent focus on modifying observable behaviors (e.g., autonomic, somatomotor and neurophysiologic response systems) through the application of response-contingent reward (e.g., feedback information). From the perspective of operant learning theory, the feedback signal is believed to function as a reinforcing stimulus when it informs the trainee that he has attained the task criterion (e.g., therapeutic change in the target response). This conceptual scheme relies on the assumption that knowledge of response state is a sufficient condition for visceral learning, a viewpoint not without eloquent challenge (Black, 1972). If knowledge of results can be construed as reinforcement, then feedback and reinforcement have been inextricably confounded in biofeedback research (Blanchard & Young, 1973). Schwartz and Johnson (1969) conclude that feedback alone may not be sufficiently potent reinforcement to facilitate desirable biofeedback results. Peper and Mulholland (1970) illustrate the paradigmatic confusion surrounding the "feedback as reinforcer" polemic by concluding,

> The status of the feedback signal is ambiguous. Is it analogous to the (a) proprioceptive, visual, tactual and acoustic feedback stimuli which informs the monkey that it has pressed a key? Or is it (b) reinforcement, or (c) both? This is a fundamental point that can be examined experimentally (p. 12).

For biofeedback to establish itself as a rational treatment, it must do more than simply demonstrate desirable effects. It is the burden of biofeedback enthusiasts to empirically establish the validity of the central biofeedback hypothesis--namely, that with training and proper incentives, the presentation of accurate information regarding specific physiologic activity will facilitate the acquisition of willful control over the monitored response. Therapeutic biofeedback outcome must be found to result from the specific effects (e.g., feedback information) of the training rather than potent non-specific placebos (Miller, 1978).

Clarifying the role of the feedback signal in biofeedback is primarily a methodological issue (Jessup et al., 1979). The results of single case and group outcome studies provide little information about the nature of treatment-specific effects. These designs can only establish evidence for a therapeutic effect or the comparative efficacy of two or more interventions. Control group studies are necessary to isolate the factors related to biofeedback success (Blanchard & Young, 1974). Several studies have incorporated pseudofeedback subjects who receive a false or yoked feedback signal during training. This procedure controls for the single dimension of the feedback process which defines the uniqueness of biofeedback therapy, accurate response information. In studies of this type, care must be taken to insure that pretraining instructions regarding the biofeedback task avoid misleading the trainee unnecessarily or countertherapeutically and still remain unconfounded with the response-contingency factor (Jessup et al., 1979).

Numerous studies have attempted to discern the role of the feedback factor during biofeedback training. Reports comparing the performance of contingent feedback subjects with control subjects administered noncontingent response information have been equivocal in their conclusions. In one of the first such attempts, Cleeland, Booker, and Hosokawa (1971) utilized a within-subjects design to assess the effects of true and false feedback on alpha wave production. All ten subjects received alternating feedback conditions. Utilizing percentage of alpha as the dependent criterion, no significant increase in alpha was observed when subjects were accurately monitored for the EEG activity. In a clinical study, Jones and Holmes (1976) administered EEG alpha biofeedback to assist alcoholics in learning to relax. Half the subjects were given accurate information regarding the occurrence of alpha while the remainder received irrelevant feedback which they were led to believe reflected alpha. Subjects underwent three 20-minute training sessions. The analysis indicated that true alpha biofeedback was not particularly advantageous in promoting increases in alpha production.

In the area of cardiac biofeedback, early studies appeared to verify the response-contingent feedback concept of biofeedback learning. Brener, Kleinman, and Goesling (1969) found that control of heart rate was significantly improved during contingent biofeedback when compared to false feedback controls. Blanchard, Young, and McLeod (1972) report that true feedback facilitated learned heart rate acceleration significantly more than noncontingent feedback during heart rate biofeedback. However, Bergman and Johnson (1971) observed no differences in heart rate control for groups receiving accurate and irrelevant feedback information. In a critical review of the cardiac biofeedback literature up until 1973, Blanchard and Young (1973) concluded that the evidence was mixed regarding whether accurate, contingent feedback information is a necessary ingredient in productive cardiac biofeedback. More recently, Levenson (1976) failed to obtain a true feedback superiority when comparing true versus false feedback during heart rate biofeedback. In an especially well-designed experiment, Rupert and Holmes (1978) applied cardiac biofeedback in treating hospitalized male patients for extreme anxiety using a two-by-three factorial plus one design. Subjects received instructions to either raise or lower their heart rate during one of three feedback conditions: true biofeedback, placebo (false) biofeedback, and instructions only--no biofeedback. A seventh no-treatment control group was also added. Subjects received four separate training sessions and one follow-up session. Surprisingly, for reducing heart rate, instructions to decrease heart rate either presented alone or in combination with true or false feedback were no more effective than simply sitting quietly. For heart rate acceleration, instructions plus contingent feedback was more effective than instructions alone or instructions combined with pseudofeedback in raising heart rate. Other findings of interest were that, in general, subjects did not demonstrate a learning effect over trials in their ability to control heart rate nor did they exhibit transfer-of-training effects during follow-up assessment.

Among EMG biofeedback studies, Budzynski, Stoyva, and Adler (1970) and Budzynski, Stoyva, Adler, and Mullaney (1973) have reported that contingent EMG biofeedback significantly reduced the frequency of tension headaches when compared to pseudofeedback which produced no noticeable effect on headaches. Coursey (1975) compared frontalis EMG for three groups receiving: EMG biofeedback, instructions to relax with a constant tone present but no feedback, and a third group simply told to relax. Results indicated that true feedback subjects exhibited consistently deeper frontalis relaxation than the two control groups. All three groups reported significantly decreased subjective anxiety following training. Kondo and Canter (1977) attempted to discern the relative potency of true and false EMG biofeedback in alleviating tension headache pain. Twenty patients were equally divided into experimental and control conditions. Following training true feedback trainees demonstrated a significant reduction in the frequency of headache occurrence as compared to controls. In contrast to Budzynski et al. (1970, 1973) control subjects did show decreasing trends in EMG level and headache frequency. It would appear that, unlike the ambiguous findings for alpha wave and heart rate biofeedback, contingent EMG biofeedback is more effective than placebo, noncontingent EMG feedback in inducing muscular relaxation and decreased headaches. However, these EMG studies lack rigorous controls for the feedback factor such that definitive conclusions cannot be made. For example, it remains to be determined whether this true EMG biofeedback supremacy effect will be sustained when contingent feedback subjects are compared with attention-placebo (e.g., an inert treatment) (Paul, 1969) and no-treatment (adaptation) controls (Jessup et al., 1979). An attention-placebo group controls for the non-specific effects of a treatment and includes all features of the technique except the variable of experimental interest. No-treatment groups permit a measure of the effect of passage of time on the dependent criterion.

In summary, it is incumbent upon the field of biofeedback to establish empirical support for the uniqueness of its effect. The role of response-contingent feedback information remains central to resolving such questions of clinical validity and specificity of treatment effects. Theoretical justification for the feedback-as-reinforcement model is confused by methodological weaknesses which confound the feedback variable with numerous placebo factors and fail to rigorously control for their effects. It would appear that among biofeedback modalities only for EMG biofeedback is the evidence consistent for supporting the efficacy of response contingent feedback information in facilitating psychophysiologic self-regulation. However, these data require replication within a design which compares true and pseudofeedback subjects with attention-placebo and no-treatment control groups.

Biofeedback as Relaxation Therapy

In 1976, in the preface to an edited collection of the previous year's most representative biofeedback experiments, Barber (1976a) persuasively argued for the inclusion of biofeedback in the class of psychophysiologic self-regulatory strategies. He noted that while biofeedback has been effective in cultivating autonomic and visceral learning, subjects undergoing training in hypnosis, meditation, yoga, Jacobsonian relaxation therapy and autogenic training are known to demonstrate similar feats of self-control. Barber (1976b) argued that this evidence corresponds with a growing appreciation for the remarkable capacity of individuals to tap their "human potentialities" to acquire self-control for therapeutic purposes. Barber (1976a) reasoned that if biofeedback produces clinical effects which are comparable to but no greater than other self-control techniques, it is plausible that the effects of these techniques are mediated by common factors, at least in part. Furthermore, examination of the active components of related treatments may provide insight into specific factors contributing to biofeedback performance. Barber (1976a) and others (Shapiro & Surwit, 1979) urge that comparative studies be undertaken to determine which techniques or combination of strategies are most effective.

There is a growing consensus that biofeedback as a clinical tool offers effective but not unique therapeutic benefit. Beatty (1972) distributed subjects among three groups--alpha EEG biofeedback, instructions for producing the "alpha" experience (e.g., mental calmness), and alpha biofeedback plus instructions. All three groups displayed reliable increases in alpha wave activity over experimental trials. They did not differ in degree of alpha enhancement or in their pattern of acquisition of learning. The findings were also replicated for beta wave activity. Beatty concludes that when alpha biofeedback subjects are informed about the nature of the task, it becomes questionable to attribute feedback learning to the feedback per se since simple instructions may be all that are necessary.

Blanchard, Theobald, Williamson, Silver, and Brown (1978) compared autogenic-thermal biofeedback with progressive muscle relaxation and a waiting list control group in the treatment of migraine headaches. The two treatment groups included home practice. Both relaxation and biofeedback subjects showed significant improvement on measures of total headache activity, duration of pain and consumption of analgesic medications. Waiting list subjects remained unchanged. On follow-up the two treatment conditions were assessed to be similar in promoting headache relief.

Surwit, Shapiro, and Good (1978) compared twenty-four hypertensive patients who were trained in either cardiac (e.g., blood pressure) biofeedback, frontalis EMG biofeedback or Benson's (1975) simple meditation technique. Patients received eight treatment sessions and were also seen for follow-up. All subjects irrespective of group showed significant decreases in blood pressure of equal magnitude. Jacob et al. (1977) reviewed the literature on the use of relaxation therapy in the treatment of hypertension, and concluded that relaxation techniques as a group share four common features--task awareness, mental focusing, muscular relaxation and regular practice. Jacob et al. suggested these features offer treatment effects beyond those attributable to placebo factors.

In the area of EMG biofeedback, the trend in the experimental findings continues to favor comparability of biofeedback with other self-relaxation strategies (Elmore & Tursky, 1978; Surwit & Keefe, in press). In a promising study, Reinking and Kohl (1975) found that subjects provided frontalis EMG biofeedback were significantly more relaxed for frontalis EMG level than subjects trained in progressive muscle relaxation or not treated at all. However, in the same year, three reports appeared which contradicted this finding. Haynes, Moseley, and McGowan (1975) found no differences between frontalis EMG biofeedback and passive relaxation instructions in inducing reductions in EMG values. Similarly, Kondo et al. (1975) treated anxiety among depressed female psychiatric patients with either EMG biofeedback or verbal relaxation training. The latter was found to produce more consistent decreases in anxiety than biofeedback. In a headache study, Cox, Freundlich, and Meyer (1975) noted significant and therapeutic changes in several measures of tension headache activity for patients receiving frontalis EMG biofeedback training and verbal relaxation instruction. Both these methods were equivalent in contributing to pain relief and significantly more effective than medication-placebo controls.

It would seem that comparative group outcome studies, for the most part, support the view that biofeedback subjects are effective in attaining significant depths of relaxation and in modifying psychosomatic dysfunction but that subjects learning various relaxation methods demonstrate equivalent skill (Shapiro & Surwit, 1979). These findings are noteworthy because they consistently associate biofeedback effects with relaxation therapy. In fact, the concept of relaxation holds important implications for the biofeedback process (Barber, 1976a). Methodologically, in biofeedback research relaxation serves for different designs as either an independent variable or dependent criterion or both. Relaxation instructions and physiologic relaxation are generally confounded with feedback procedures such that the relative contributions of biofeedback and relaxation to biofeedback therapy outcome remain obscure (Tarler-Benlolo, 1978). Blanchard and Young (1974) have suggested that biofeedback may be merely an elaborate means to learn to relax. Budzynski (1976) and Stoyva (1973) utilized biofeedback techniques to cultivate states of low arousal in order to study cognitive processes associated with deep relaxation. Not surprisingly, Reeves and Shapiro (1978) argued that the addition of relaxation instructions during biofeedback training enhances therapeutic gain. Following a critical review of the role of relaxation in biofeedback, Tarler-Benlolo (1978) concluded that the nature of the interaction between biofeedback and relaxation in producing optimal clinical gains remains to be elucidated. She further suggested that by clarifying this interaction, it may be possible to improve the efficiency of biofeedback-relaxation interventions. For example, certain combinations of relaxation instruction and biofeedback may prove more effective for eradicating specific psychosomatic disorders when compared to single modality treatments. Moreover, factors which are found to be active components in inducing deep relaxation may have similar effects during biofeedback (Barber, 1976a; DiCara, 1975).

Attention and Relaxation

In pursuing a better understanding of the parameters of efficacious biofeedback performance, it has been asserted that the role of relaxation is of central concern (Jacob et al., 1977; Tarler-Benlolo, 1978). The treatment components inherent to other relaxation therapies may hold heuristic value for research examining biofeedback outcome (Barber, 1976a). Benson with his colleagues (Beary & Benson, 1974; Benson, 1975; Benson et al., 1974a; Wallace et al., 1971) have devoted the greatest attention to uncovering the antecedent conditions of relaxation. They have identified the "relaxation response," a coordinated anti-stress pattern of physiologic change similar to the hypometabolic effects observed during meditation (Wallace, 1970). These physiologic changes include diminished muscle tension, respiratory function (decreased respiratory rate, oxygen consumption and carbon dioxide elimination) and heart rate, increased galvanic skin resistance, and greater abundance of alpha and theta wave on the electroencephalogram (Wallace et al., 1971).

Beary and Benson (1974) conceive of the relaxation response as a centrally-integrated hypothalamic response which produces a generalized decrease in sympathetic nervous system activity (e.g., arousal) while, perhaps, stimulating parasympathetic activation. Originally described by Hess (1957), the relaxation response appears to represent a parasympathetic corollary to the more well-known stress induced "fight-orflight" response described initially by Cannon (1936). Learned control of the relaxation response has been conceptualized as an anti-stress state which can be applied to assist psychosomatic patients in resisting the pathogenesis of stress-related disease (Benson et al., 1974a; Stoyva & Budzynski, 1974). Research substantiating the utility of the relaxation response in combating psychophysiologic dysfunction is promising, particularly for the treatment of hypertension (Benson, Marzetta & Rosner, 1974c; Surwit, Shapiro & Good, 1978), headaches (Benson, Klemchuk & Graham, 1974b) and anxiety (Greenwood & Benson, 1977).

To determine the factors associated with control over the relaxation response, Benson (1975) reviewed a large body of literature pertaining to various religious, contemplative and clinical techniques which share in common the promotion of relaxation. These methods included hypnosis, meditation, yoga, Jacobsonian progressive muscle relaxation, Schultz's autogenic therapy and others. To elicit the relaxation response, Benson (1975) identified four components:

1. a quiet environment,
2. a mental device upon which to affix attention,
3. a passive attitude during the experience, and
4. a comfortable position.

Factors 1 and 4 seem obviously related to inducing relaxation as they function to exclude distractions and eliminate undue muscle tension, respectively. Since a major deterrent to relaxing involves the mind's incessant "chatter" (DeRopp, 1968) and "grinding" tendency to shift its center of focus (Deikman, 1963), the presence of an object upon which to constantly attend provides the individual with a vehicle by which to escape from distracting thoughts. The mental device also fosters a shift from normal, decision-oriented consciousness to more illogical and internally focused thought. Finally, but most importantly, the trainee is encouraged to adopt a noncritical, passive, "let it happen" approach to the relaxation task. Benson (1975) adds,

> The passive attitude is perhaps the most important element in eliciting the Relaxation Response. Distracting thoughts will occur. Do not worry about them. When these thoughts do present themselves and you become aware of them, simply return to the repetition of the mental device. These other thoughts do not mean you are performing the technique incorrectly. They are to be expected (p. 160).

A strikingly similar framework for cultivating deep relaxation has been proposed by Shapiro and Zifferblatt (1976) in their experimental analysis of Zen breath meditation. The authors extended Benson's ideas by identifying a five-stage process in achieving the benefits of this meditative practice. In the initial stage the individual picks a quiet spot, assumes a comfortable (e.g., lotus) position, and begins to focus his awareness on breathing through the nose. Next, he may count each breath (e.g., 1, 2, . . . up to 10), or may simply try to become immersed in each breath. The practice of self-observation of breathing is often accompanied by erratic alterations in this behavior. Invariably, the beginning meditator soon forgets about the task and a variety of unrelated thoughts and images occur. In the third stage, the individual is redirected to focusing his attention on his breathing and does so with greater efficiency accompanied by less effort. With practice, the meditator soon acquires the ability to observe intrusive mental events when they occur, and still continue to focus on breathing. Covert events such as fears, thoughts, fantasies, and images are viewed with a "relaxed awareness" and without judgment. Finally, there occurs a gradual reduction in spontaneous covert activity such that the individual becomes increasingly receptive to less distinct internal and external stimuli.

In agreement with Benson, Shapiro, and Zifferblatt, numerous writers have attributed a critical role to mental focusing and attention deployment in the control of autonomic hyperarousal. Jacob et al. (1977) extracted mental focusing as one of four key features common to relaxation therapies found effective in the treatment of hypertension. Rachman (1968) suggested that it is the emergence of a mentally calm state rather than the induction of phsiologic relaxation which is responsible for the successful treatment of anxiety disorders by behavior therapists. In the area of systematic desensitization, several researchers (Davison, 1968; Greenwood & Benson, 1977; Wilkins, 1971; Yulis et al., 1975) have argued that the treatment effects (e.g., relaxation) attributed to counterconditioning (Wolpe, 1973) actually result from shifts of attention away from emotionally charged or otherwise arousing stimuli. Similarly, an attention deployment explanation has been put forth to explain the mechanisms underlying the behavioral treatment of sexual dysfunction secondary to excessive anxiety (Geer & Fuhr, 1976; Kaplan, 1974), insomnia (Borkovec & Fowles, 1973), test anxiety (Sarason, 1975; Wine, 1971) and psychosomatic disorders modifiable through biofeedback (Lazarus, 1975).

Sustaining one's mental focus on a single object for extended periods is likely to precipitate a state of altered consciousness in which thought processes revert from the waking, rational and externallyoriented mode to cognitive activity associated with regressive primary process material (e.g., illogical thoughts, increased visual imagery, increased aggressive and sexual content) (Deikman, 1963; Kubie & Margolin, 1942; Ludwig, 1966; Stoyva & Budzynski, 1974). An example of this phenomenon is reported in a study by Lesh (1970) in which counselors were taught a simple Zen meditation technique (e.g., focused attention) to determine whether meditation training increases empathy. Lesh's subjects reported a variety of strange and disturbing experiences while undergoing training including sexual preoccupations, lack of concentration, self devaluation, acute awareness of innermost motives, and bizarre fantasies. Subjects undergoing EMG biofeedback to attain very profound depths of relaxation note changes in body image, bizarre disjointed imagery and a loosening of the reality oriented frame of reference (Budzynski, 1976). These mental aberrations are associated with low muscle tone and certain brain wave rhythms (e.g., theta) (Budzynski & Peffer, 1973) and seem quite similar to the hypnagogic imagery reported by subjects immediately prior to sleep onset (Foulkes & Vogel, 1965).

Budzynski (1977) suggested that the creation of states of low arousal or "twilight states" opens a channel to the unconscious with its predominance of sexual, hostile and irrational drives. During normal waking consciousness, psychological defenses function to maintain disturbing conflictual and offensive ideation from awareness (Rapaport, 1951). In psychosomatic patients, relaxation tends to break down the defense system resulting in a flood of unconscious material into awareness (Adler & Adler, 1976). Budzynski (1977) considered a neuropsychological model to explain this process by suggesting that relaxation compromises the rational, analytic and reality-oriented functions of the left hemisphere and, as a result, the individual's cognitions become dominated by the visual, illogical and emotional mode of the right hemisphere. Such right hemisphere thinking can become quite alarming to the individual undergoing a relaxation experience. Emotional investment and preoccupation with such thoughts can be deleterious to efforts to relax as they are likely to stimulate hypermetabolic changes associated with anxiety and stress (Benson, 1975; Fehmi, 1975). It is at this juncture that a passive, receptive cognitive style can be instrumental in furthering relaxation. By instructing subjects to maintain a "detached calmness" (Pelletier, 1975) and return to the mental device when they become distracted to primary process ideation, subjects learn to avoid distressing thoughts. This deployment of attention to nonarousing stimuli insulates the individual from cognitive processes antithetical to relaxation.

In the area of biofeedback, a passive attitude has been singled out as a primary factor responsible for successful training (Green & Green, 1974; Green, Green & Walters, 1970; Pelletier, 1975; Stoyva, 1973). Peper (1976) studied "adepts" or meditators who demonstrated extraordinary autonomic and neurophysiologic control while completing distracting tasks. He discovered that two features characterized these individuals--a constant state of "passive attention" and a preoccupation with the method or process of behavior rather than focusing on goals and objectives. The processes interfering with passive attention are those of anticipation and striving. To illustrate his point, Peper reported the case of a young woman suffering from Raynaud's disease (chronic peripheral vasoconstriction) who was undergoing thermal biofeedback designed to facilitate increased peripheral blood flow. The patient demonstrated marginal improvements over the first six minutes of training. She became frustrated and decided to stop actively trying to control her skin temperature at which time dramatic increases in skin temperature were observed. In the same vein, Surwit (1978) contended that passive attention rather than feedback procedures per se account for the therapeutic gains noted in successful thermal biofeedback subjects.

Fehmi (1975) has developed a self-practice procedure which aims to facilitate EEG biofeedback training by establishing a permissive and nonjudgmental state of attention. This "open focus" technique was an outgrowth of an earlier observation that attentional flexibility correlated with success during alpha wave EEG biofeedback. Fehmi (1973) observed that subjects receiving alpha feedback training failed to demonstrate learning effects until they gave up their effortful achievement-oriented approach to the feedback task. Large amplitude and synchronous alpha waves were associated with a state of mind which remained detached from any single internal thought or external event. By asking trainees to visualize an "objectless image" the individual learns to broaden his focus of attention and in so doing, will acquire a predilection towards the "letting go" of perceptions. Examples of open focus exercises are "Can you imagine the distance between your ears?" or "Can you imagine the space between your eyes?" (Fehmi, 1975).

Despite the frequent anecdotal reference to focused and passive attention among biofeedback outcome investigators, very little of an empirical nature is known about the contribution of these attentional factors to biofeedback learning. This state of affairs is somewhat surprising since all biofeedback procedures include directing the subject to focus his attention on some extrasensory signal. In addition, subjects are encouraged not to "try too hard" during training and to maintain a receptive posture (Pelletier, 1975). Thus, in the great majority of previous biofeedback research these cognitive factors have been confounded with the particular feedback procedures employed.

To the author's knowledge only two studies have examined the contribution of these attentional processes to relaxation training. An initial experiment relating attention and internal psychophysiologic control was attempted by DuPraw (1972), who studied the effects of a Focused Attention (FA) procedure on heart rate deceleration. She asked FA subjects to listen to a fifteen-minute tape which included suggestions to remain passive during the training and for the subject to sustain his attentional focus on his heart rate in order to facilitate relaxation. This group was compared with a progressive relaxation treatment condition and a control group which was instructed to slow their heart rate utilizing any strategy the subjects preferred. All three groups evidenced significant reductions in heart rate within sessions although no differences emerged across treatment groups. In an attempt to extend the findings of DuPraw (1972), Barrick (1973) compared Focused Attention and progressive relaxation treatments with a biofeedback training condition. Heart rate deceleration again served as the target response. The results indicated that true physiologic feedback and focused attention were equally effective in aiding subjects to relax, and that each of these treatments were significantly more effective than progressive relaxation. Taken together, these findings support the active contribution of focused and passive attention in the acquisition of self-relaxation.

When applied to biofeedback training, this evidence raises several intriguing questions. Are biofeedback effects reducible to the operation of these attentional processes during feedback training? Does the addition of passive attention instructions enhance the learning of biofeedback-mediated relaxation? What is the relative effectiveness of attentional mechanisms versus biofeedback in facilitating physiologic self-regulation?

Personality, Biofeedback and Absorption

For biofeedback outcome investigators the initial question, "Is biofeedback effective?" must evolve into a more careful inquiry into the conditions under which biofeedback is optimally effective and the person characteristics that predict for whom biofeedback is the treatment of choice (Coursey, 1975; Strupp & Bergin, 1969). Regarding the latter, very little is known regarding the contribution of individual difference factors to biofeedback performance (Shapiro & Surwit, 1979; Tarler-Benlolo, 1978).

In most studies comparing personological factors and feedback training, the variables selected for consideration are well-known "trait" dimensions drawn from the large literature pertaining to personality psychology. For example, <u>locus of control</u> (Rotter, 1966) describes a highly investigated dimension of personality related to an individual's perceived sense of control over his personal destiny. By completing a short questionnaire, subjects can be measured in terms of their degree of internal-external locus of control. Internal subjects are said to have a general feeling of control over the predictable events which define their lives while externals view themselves to be at the mercy of unforeseen, random and uncontrollable events of fate. Ray (1974) utilized a locus of control scale to dichotomize subjects into "internal" and "external" groups. During operant cardiac biofeedback, the internal subjects exhibited significantly greater ability to accelerate heart rate while external subjects were more facile in heart rate deceleration. Johnson and Meyer (1974) found that internals were better suited to utilize EEG biofeedback to produce an increase in the abundance of alpha activity in the EEG spectra when compared to external trainees. Perhaps more interestingly, the authors noted an alteration in locus of control in the direction of increased "externality" for those subjects who were unable to acquire self-control over the alpha wave frequency. Cox et al. (1975) obtained no relationship between locus of control and headache relief for patients undergoing frontalis EMG biofeedback therapy. In contrast to Johnson and Meyer (1974), Cox et al. reported that all three of their treatment conditions--EMG biofeedback, progressive muscle relaxation, and medication-placebo control--demonstrated pre-post shifts in locus of control with all groups significantly more internal at the completion of treatment. In addition to examining the predictive power of locus of control in biofeedback, these combined findings raise intriguing questions about the effect of biofeedback training in promoting personality change.

Several biofeedback reports have utilized the Autonomic Perception Question (APQ) (Mandler, Mandler & Uvilla, 1958) to discriminate the extent to which feedback subjects perceive autonomic and visceral processes during various states of intense emotion and arousal. The implicit assumption underlying this line of inquiry is that self-perception of visceral functions is correlated with autonomic learning during biofeedback (Brener, 1977). Bergman and Johnson (1971) observed that subjects who experience extreme degrees of autonomic awareness (either high or low) were less accomplished in controlling their heart rate during cardiac biofeedback than subjects in the mid-range on the APQ factor. Blanchard et al. (1972) adopted a different method to score the APQ and found that subjects high in autonomic awareness had significantly more difficulty controlling heart rate during biofeedback training than low scorers.

In the selection of personality dimensions for scrutiny in biofeedback studies, it seems reasonable to include person factors relevant to the subjective experience of biofeedback performance (Fehmi, 1973) or to performance during comparable self-control techniques (Barber, 1976a). The present study considered the role of "absorption" (Tellegen & Atkinson, 1974) in predicting relaxation effects during EMG biofeedback. The cognitive style associated with absorption is well suited to the attentional processes implicated in successful relaxation. There is evidence from several studies which support the validity of absorption in predicting task performance during comparable relaxation therapies such as hypnosis and meditation.

Absorption represents an individual's tendency toward total involvement of cognition and attention with an object in awareness. Originally termed "fluidity" (Thorkelson, 1973), the absorption dimension describes a unique kind of perceptual awareness in which the individual's sense of "self" or self-reflective capacity becomes obscured by a transient but intensified preoccupation with a real or imagined object. The motivational-affective component underlying absorption is compared with Fitzgerald's (1966) construct of "openness to experience" by defining a high degree of absorption to indicate "a desire and readiness for object relationships . . . that permit experiences of deep involvement" (Tellegen & Atkinson, 1974, p. 275). Tellegen initially speculated that "fluid" individuals have direct access to unconscious, primary process material as they are generally more conscious of a greater range of internal motives and feelings (Thorkelson, 1973). Later (Tellegen & Atkinson, 1974) Tellegen's thinking focused less on intrapsychic access and more on absorption as depicting a predilection for entering a state of total or broadened engagement of sensory and fantasy functions. Absorption is characterized by three basic attentional-perceptual transformations: (a) a heightened sense of "realness" of the attentional object, (b) diminished distractibility, and (c) an altered sense of reality in relation to environmental (external) and self-generated (covert) stimuli (Tellegen & Atkinson, 1974).

A capacity for attentional flexibility and an attraction towards altered states of consciousness are two cognitive factors which have been speculated to correlate with relaxation and psychophysiologic self-regulation (Davidson, Schwartz & Rothman, 1976; Ludwig, 1966). Roberts, Kewman, and MacDonald (1973) suggested that an individual's ability to alter his state of waking consciousness will be included among task and motivational factors which are eventually found to mediate the acquisition of autonomic control. Peper (1976) argued that a change in posture from effortful concentration to "passive attention" is the single most critical factor in determining whether an individual learns psychophysiologic self-control. Following alpha EEG biofeedback training, subjects who demonstrate success in increasing the abundance of alpha activity during training describe their experience as calming, warm and relaxed (Brown, 1970; Hart, 1967; Kamiya, 1969). In addition, these subjects report a state of "nonsensory awareness" or absorption in internal feelings and thoughts which is reliably associated with enhancement of occipital alpha (Plotkin, 1976). Fehmi (1971) observed that skillful EEG alpha biofeedback trainees experience a broadening of their focus of attention as they improve in relaxation performance (e.g., increased alpha). Taken together these experimental reports suggest that atypical states of attention and variations in normal waking consciousness accompany the relaxation experience. As these events are said to be common among individuals who score high in absorption, these persons should demonstrate facility in learning how to relax.

There is growing evidence that the self-regulation of attentional processes as measured by absorption is an important factor in an individual's response to biofeedback-related techniques such as hypnosis and meditation (Davidson & Goleman, 1977). These data are not surprising in view of the historical relationship between antecedents of the absorption variable and hypnotic susceptibility. Based on the seminal work of Shor (1960; Shor, Orne & O'Connell, 1962) and extended by others (Ås, O'Hara & Munger, 1962; Fitzgerald, 1966; Lee-Teng, 1965; Taft, 1969, 1970), these investigators constructed true-false inventories to measure the frequency of hypnotic-like or trance episodes occurring among a college population during normal waking activity. In the typical design, questionnaire items were correlated with measures of hypnotic susceptibility with a subsequent item-analysis establishing a brief psychometric instrument which consistently correlated to a low but significant degree with hypnotizability (Ås, 1962; Lee-Teng, 1965).

In developing the absorption scale, Tellegen borrowed items from Ås (Ås et al., 1962) and Lee-Teng (1965) and included them within a larger personality inventory which was administered to 481 female undergraduates for whom suggestibility scores were known. A series of factor analyses revealed three independent factors--ego resiliency (stability-neuroticism), ego control (intraversion-extraversion) (Block, 1965) and absorption (Tellegen & Atkinson, 1974). Only absorption correlated significantly with hypnotizability; this finding has since been replicated (Finke & MacDonald, 1978; Spanos & McPeake, 1975a, 1975b). The authors pointed out that the psychological functions characterized by absorption have generally been ignored by contemporary cognitive theorists. However, they noted that similar phenomena have been discussed in relation to Eastern contemplative meditation (Goleman, 1971; Van Nuys, 1973), peak experiences (Maslow, 1962), altered states of consciousness (Ludwig, 1966) and the effects of psychedelic drugs (DeRopp, 1968).

Following publication of the Tellegen Absorption Scale (TAS) in 1974, several studies attempted to discern correlates of absorption beyond its known association with hypnotizability. Thorkelson (1973) found high as compared with low absorption subjects to be reliably more productive of theta wave activity, which is suggestive of a state of deep relaxation, although they produced significantly less alpha output. In addition, she obtained moderate but consistent correlations between absorption and measures of creativity and fantasy activity. In a cross-sectional study Davidson, Goleman & Schwartz (1976) explored differences in trait anxiety and absorption among subjects who differed in duration of meditation practice. Significant linear trends across groups were obtained for both measures indicating that the longer one practices meditation the greater is his tendency toward absorption as trait anxiety declines. Spanos and McPeake (1975b) found that women on the average are significantly higher in absorption than men and that, in general, high absorption subjects tend to have a more favorable attitude towards hypnosis. In an unpublished study, Roth (1977) also observed that females tend to exhibit greater absorption. Furthermore, absorption was found to be independent of several cognitive tasks which rely heavily on concentration and vigilance. The clarification of absorption as orthogonal to vigilance is corroborated by the evidence for a strong relationship between absorption and "sustained nonattention" (Spanos, Rivers & Gottlieb, 1978).

In the only published report incorporating absorption within a biofeedback study, Roberts, Schuler, Bacon, Zimmerman, and Patterson (1975) compared high versus low absorption in a skin temperature task. Subjects were provided auditory feedback pertaining to fluctuations in monitored skin temperature. The experimental task involved evidence for voluntary and bidirectional control of digital skin temperature. While experimental subjects were able to produce large and appropriate changes in skin temperature during feedback training, these effects were independent of the subject's absorption score.

It appears, then, that absorption describes a stable measure of attentional flexibility which indicates a tendency towards mental immersion of a vivid imaginative quality with objects in awareness. It has been repeatedly speculated that attentional flexibility represents a critical component in the learned control of relaxation functions. Absorption predicts task performance during hypnosis and meditation, which are two relaxation strategies known to cultivate a state of low arousal. Accordingly, absorption may be hypothesized to predict relaxation performance during EMG biofeedback.

CHAPTER II

METHOD

General Design

The present study attempted to examine selected task, instructional and individual difference factors as they contribute to relaxation during EMG biofeedback training. Relaxation was operationally defined by changes in frontalis muscle tension as measured in microvolts and obtained continuously during baseline and successive training sessions. Four groups comprising a Feedback x Instruction factorial were provided either true or false feedback and pre-training instructions that either emphasized a passive attention approach to acquired self-relaxation or were non-specific. Care was taken to avoid task instructions which would be deceiving or countertherapeutic for subjects receiving pseudofeedback. In addition to providing a test for main effects on the independent factors (e.g., feedback, instruction) and potential cumulative learning effects across sessions, this design also permitted a comparison of treatment effects. Subjects receiving pseudofeedback and attentional instructions represent an approach described by Benson (1975) to acquire relaxation. This group and true feedback subjects were compared with a fifth no-treatment (resting) control group which was added to assess the effects of adaptation and motor inactivity on frontalis EMG. Subjects were also divided equally by sex and absorption to determine whether these individual difference factors were associated with relaxation performance.

Subject Selection

Subjects (n = 60) for the present study were drawn from the pool of male and female undergraduates enrolled in introductory psychology courses at the University of North Dakota. These students were initially asked to complete a 234-item Experience Inventory (EI) developed by Roth (1976) for use in the present study. The EI is a true-false questionnaire which assesses a number of content areas related to the individual's perception of his own cognitive style, including particular emphasis on attentional processes. It was assembled with items drawn from previously published inventories (Ås et al., 1962; Fitzgerald, 1966; Lee-Teng, 1965; Roberts & Tellegen, 1973; Shor et al., 1962; Taft, 1970) and experimental reports (Coe & Sarbin, 1966) and was administered in order to obtain subject scores on the Tellegen Absorption Scale (TAS) (Tellegen & Atkinson, 1974) which was embedded with the EI. The TAS is a 34-item self-report scale which measures an individual's disposition for experiencing episodes of total attentional involvement with an object in awareness. An affirmative response to scale items such as "If I wish, I can imagine (or daydream) some things so vividly that they hold my attention as a good movie or story does" or "I like to watch cloud shapes change in the sky" indicates a tendency towards absorption. The TAS has been found to correlate positively with hypnotizability (Spanos & McPeake, 1975a, 1975b; Tellegen & Atkinson, 1974) and duration of meditation practice (Davidson, Goleman, & Schwartz, 1976), while remaining orthogonal to measures of neuroticism and introversion-extraversion (Tellegen & Atkinson, 1974).

At the same time they completed the EI, prospective subjects were solicited to participate for course credit in a study of "methods in learning to relax." Persons reporting a history of epilepsy, diabetes, hypoglycemia, cardiac irregularities, frequent headaches or a hearing impairment were excluded from consideration. Similarly, individuals who had previously received formal instructions in relaxation (e.g., hypnosis, meditation, biofeedback) or who were currently taking medication under prescription were also excluded from participation.

Remaining subjects were categorized by degree of absorption and gender. The absorption factor was dichotomized by defining High Absorption (HA) versus Low Absorption (LA) according to whether the individual fell above or below the mean ($\overline{X} = 20$), respectively, for the distribution of all TAS scores obtained from the original EI testing ($\underline{n} > 100$). From this pool, 60 subjects were selected to configure a 2 x 2 factorial (Absorption x Sex) such that an equal distribution by sex of HA and LA cells was formed. From this arrangement, subjects were randomly assigned by quadrant to one of five experimental groups. For example, the 15 male subjects whose TAS scores exceeded 20 were included in the quadrant identified as HA males. These subjects were assigned by means of a table of random numbers to one of five treatment groups (described in Groups below) thereby including three HA males within each group. A similar procedure was employed to assign LA males, HA and LA females. A one-way ANOVA on TAS scores across the five experimental conditions indicated no differences, $\underline{F}(4, 55) = 0.020$, $\underline{p}$ = ns, among the groups on the absorption factor.

The mean age for all subjects was 19.0 years (males = 19.5, females = 18.6) with a range of 17 to 25.

Setting and Apparatus

All instructions, baseline measures, and relaxation training were accomplished in a small carpeted room located adjacent to the U.N.D. Psychological Services Center. This research space is equipped with rheostat-controlled lighting and a one-way mirror which permits continuous observation of the subject from an adjacent alleyway. The subject sat in a comfortable recliner upon which was mounted a set of stereo headphones and the EMG electrode cable. Except for a small table for preparatory materials (e.g., tissues, electrode paste, etc.), all other apparatus was located in the alleyway beyond the visual and auditory range of the subject.

A BFT 401 Feedback Myograph was employed to monitor peak-to-peak action potential emanating from the subject's frontalis (forehead) muscle. The signal produced by this shielded low-noise (less than 1 microvolt) pre-amplifier was conveyed to a BFT 215B Time Period Integrator which converts the muscle potential data to digital form. This integrated readout reflects the degree of absolute muscle potential averaged over variable time intervals. For the present study 60-second time trials were used. The BFT 215B is constructed to prevent unwanted electrical "noise" from interfering with the incoming EMG signal.

Three BFT nondisposable silver-silver chloride surface electrodes were placed across a four inch expanse on the subject's forehead, one inch apart and one inch above the eyebrows (Davis, 1959). Electrodes were held in place by a flexible rubber band fitted around the subject's head with the ground electrode aligned with the forehead midline.

Feedback Signal. For those subjects who received contingent EMG biofeedback training, the BFT 401 Myograph produced a constant volume, continuous (e.g., nonintegrated) feedback signal audible through earphones. Immediate and precise information regarding frontalis electromyographic activity was conveyed to the subject by way of alterations in the pitch of the signal with variations corresponding in both direction and proportion to changes in frontalis muscle tension. When the subject's muscle tension increased the signal pitch rose proportionately. As the EMG potential in the forehead dropped the signal's pitch declined.

The audible signal heard by noncontingent feedback subjects was actually the audiotaped record of a frontalis EMG biofeedback training signal tone obtained several weeks earlier from a young female trainee. Within a five day period this woman participated in 1 baseline and 3 frontalis EMG biofeedback sessions. The final 3 sessions were tape recorded. The setting and apparatus were identical to that described above. Her pre-training preparation involved standard instructions for EMG biofeedback therapy; relax, attempt to reduce the signal pitch to attain deeper relaxation, be aware of internal thoughts and feelings as they relate to greater relaxation (i.e., decreases in pitch), don't "try too hard," remain passive and let the relaxation experience occur naturally.

In taping these three biofeedback sessions every effort was made to approximate the circumstances under which experimental subjects would eventually experience EMG biofeedback training. This care was taken to insure that the character and quality of the feedback signal provided noncontingent feedback subjects approximated as closely as possible the signal being produced by their contingent feedback counterparts. Each of the three taped training sessions represented a "typical" performance by a successful biofeedback trainee. Initially, the feedback signal was quite variable and the pitch remained at relatively high levels. As the trainee "settled down" and became more responsive to the biofeedback training, the fluctuations in pitch and absolute levels of signal frequency progressively declined in tandem. By the end of each session the tone was resting at a level suggesting that considerable reduction in frontalis muscle tension had been achieved.

All noncontingent feedback subjects listened to the three taped feedback protocols in their proper sequence (i.e., Taped Session #1 during their first relaxation training session, Taped Session #2 during their second relaxation session, etc.).

Procedure

Collection of Baseline Data. Following selection for participation in the study, the subject was brought to the experimental training room, seated in the recliner, and attached to the electromyogram for the purpose of baseline measurement. To insure that forehead skin resistance did not exceed 10K ohms, designated electrode sites were thoroughly scrubbed with an abrasive skin cleanser, rinsed with alcohol and interfaced with the surface electrode by a dab of conductive paste. After being reassured that there was no possibility of receiving an electric shock from the equipment, the subject was asked to sit back comfortably, with eyes closed, and encouraged to relax as completely as possible for the ensuing fifteen minutes. The subject was cautioned against excessive bodily and facial movements. No feedback information was provided. Five separate measures of resting EMG were obtained with readings of frontalis muscle potential integrated over one-minute intervals every third minute.

Experimental Training. Each subject received three sessions of relaxation training, the nature of which varied depending on the treatment condition to which he or she had been assigned (see Groups). Only one relaxation session was completed within a single day. All training sessions were completed during the daylight (e.g., 9:00 a.m. to 5:00 p.m.) although no attempt was made to balance time of training across subjects. The average length of participation (including baseline) for the typical subject was 10 days with a range from 5 to 26 days. Skin preparation and electrode placement followed the guidelines described for baseline recording. Following preparation and prior to each training experience, the subject listened to a brief audiotaped instruction which was presented through stereo earphones. All pre-training instructions were recorded by the author. This message was followed by fifteen minutes of relaxation training with the feedback signal (either contingent or noncontingent) also presented via earphones.

For data collection purposes, frontalis muscle potential was monitored continuously throughout each session. Similar to the baseline measurement, frontalis muscle tension levels were obtained every third minute by integrating the incoming EMG signal over a 60-second interval. Thus, five data points were obtained for each subject per training session and served as the primary dependent measure in the statistical analysis.

Debriefing. Immediately following the third relaxation training session, the subject was provided an opportunity to discuss his or her experiences and reactions to participation in the study. This was an informal discussion and no systematic description of subject reactions were obtained. At the same time, the subject was informed that he or she would receive by mail a written explanation describing the objectives of the experiment and the rationale for the various treatment procedures. To minimize possible contaminating effects from intersubject communications, this debriefing statement was sent to all subjects following the last subject's final training session.

Groups

Following group assignments, subjects received a baseline and 3 relaxation training sessions. The nature of their relaxation exercise coincided with one of the following conditions:

1. Attentional Instruction - Contingent Feedback (AICF)

Instructions. Prior to the start of each training period, the subject was provided a brief explanation regarding the nature of the task to follow. He or she was informed that a tone would soon be heard through the earphones, and that this tone had a dual purpose in assisting them in their task of self-relaxation. On the one hand, it was explained that the tone served as a "barometer" which reflected moment-to-moment changes in levels of tension and relaxation. As the tone rose in pitch, it would signal that the subject was becoming tenser; conversely, as the tone declined it meant that, at that precise moment, he or she was reducing bodily tension and becoming more relaxed. The subject was instructed to reduce the feedback signal and maintain it at the lowest possible level as a goal in promoting the greatest degree of relaxation.

In addition, it was suggested that the tone could also function as a "vehicle" for cognitive-attentional processes which, if properly controlled by the trainee, would facilitate greater depths of relaxation. Emphasis was placed on the ability to focus attention on the tone to the exclusion of all distractions, and to become perceptually immersed in it. Subjects were cautioned that during the feedback-relaxation experience they might notice the intrusion of random, bizarre or painful thoughts, memories, and images. It was pointed out that maintaining a detached, casual posture toward these intrusive cognitions was a critical component in the acquisition of autorelaxation. Further, subjects were encouraged to maintain a passive "letting go" attitude during the relaxation exercise and to avoid an effortful approach. These instructions borrowed heavily from previously published instructional preparations for subjects undergoing meditative and self-reflective approaches to physiologic relaxation (Barrick, 1973; Deikman, 1966; DuPraw, 1972; Fehmi, 1975). A verbatim account of the instructions administered to AICF subjects may be found in Appendix A.

Feedback. Subjects received true frontalis EMG biofeedback. The training procedures, setting and apparatus, and data collection are described in detail in the Procedures section.

2. Nonattentional Instructions - Contingent Feedback (NICF)

Instructions. Pre-training suggestions focused primarily on reduction of the pitch of the tone as the pathway to deep relaxation. A brief explanation of the bioelectronics of EMG biofeedback was provided, and then subjects were instructed to utilize any strategy they wished in their attempts to reduce the pitch of the feedback signal. The subject was asked to pay close attention to internal feelings and sensations, especially as they seemed to correspond to a decline in the signal's pitch. The task was clearly stated: "Your task is to try and reduce the pitch of the tone as much as possible, thereby reducing tension while increasing relaxation." Only brief mention was made of the need for the subject to totally concentrate on the tone and to avoid "trying too hard" during the feedback exercise. A verbatim account of the NICF instructions can be found in Appendix B.

Feedback. True and accurate frontalis EMG biofeedback was conducted in the same manner as accomplished for AICF subjects.

3. Attentional Instructions - Noncontingent Feedback (AINF)

Instructions. For this condition subjects were told that the feedback signal could facilitate their attempts at promoting relaxation in two ways. First, it was explained that the tone would serve to screen out extraneous noise which might interrupt the subject's concentration as he attempts to relax. Secondly, in similar fashion to AICF subjects, it was explained that through the control of certain cognitive-attentional processes greater relaxation could be achieved. These instructions followed verbatim the account presented AICF subjects. Briefly in review, subjects were encouraged to (a) allow their total concentration to become immersed in the feedback tone as it varies in pitch, (b) maintain a casual and relaxed attitude toward intrusive thoughts despite their possible unusual or uncomfortable content, and (c) approach the relaxation experience from a passive, noneffortful posture.

Feedback. These subjects listened to the audiotaped protocol of an individual who underwent contingent EMG biofeedback training several weeks prior to their participation in this study (see Procedures).

A verbatim account of the instructions provided AINF subjects can be found in Appendix C.

4. Nonattentional Instructions - Noncontingent Feedback (NINF)

Instructions. Subjects were told that a tone would be provided them to assist their attempts to relax during the training session. This tone would (a) block out extraneous noise which might interfere with their concentration on relaxation, and (b) produce a hypnotic-like somatic response which has been shown in previous research to occur when a monotonous tone was presented to persons engaged in relaxation training. These subjects were encouraged to relax to the best of their ability and to utilize any strategy they preferred to adopt. To control for length of pre-training instructions, the individual then listened to a short discussion concerning the role of stress in the development of a wide range of psychological disorders and the recent application of relaxation training in treating these disorders. This discussion was designed to be non-specific in content but to have some incentive value in promoting the subject's "expectancy of benefit" from his participation.

Feedback. These subjects listened to the identical audiotapes presented to the AINF group. A verbatim account of the NINF instructions can be found in Appendix D.

5. Quiet Rest Control (QRC)

These subjects simply sat quietly for four "relaxation" sessions while frontalis muscle tension values were obtained. No feedback signal was presented although the subject did wear earphones throughout each session. Prior to each session, the subject was asked to remain still with eyes closed while they allowed themselves to relax. These instructions were similar to those provided all subjects for their baseline measurement. In addition, their participation was explained in terms of interest in understanding how bodily arousal subsides under sensory-deprived conditions.

CHAPTER III

RESULTS

Data Analysis

In the clinical setting, the efficacy of EMG biofeedback therapy is typically inferred from observed therapeutic change in the frequency or intensity of clinical symptoms (e.g., headaches, anxiety) for which the individual is referred for treatment. Consequently, for clinical biofeedback studies, therapeutic outcome is assessed utilizing symptom resolution as the dependent measure of primary importance. Since subjects in the present study were purposely screened for a history of psychosomatic complaints, an alternative criterion to evaluate EMG biofeedback training was chosen, i.e., change in psychophysiologic function. The use of psychophysiologic parameters to evaluate the effects of EMG biofeedback training is based on evidence that therapeutic outcome appears to be mediated by alterations in underlying physiologic response systems (Jessup et al., 1979). Accordingly, analysis of biofeedback performance was undertaken to determine whether experimental and control subjects varied in their ability to relax by reducing frontalis muscle tension during EMG biofeedback training. During fifteen-minute baseline and training sessions, successive measures of frontalis muscle potential, calibrated in microvolts, were recorded three minutes apart. Each observation represented the mean microvolt value for the preceding 60 seconds of continuously monitored EMG activity. For each subject, five muscle potential values were obtained during each baseline and training session. These "EMG scores," plotted consecutively within-session for three successive training sessions, provided the distribution of change in frontalis EMG by which the effects of experimental training were assessed.

Dual criteria were employed to evaluate the subject's biofeedback performance and, therefore, two separate statistical approaches were used to reduce and summarize the electromyographic data. In the initial and primary analysis, EMG biofeedback performance was scrutinized in terms of cumulative change in absolute level of frontalis muscle potential. Successful EMG performance was defined by evidence for longitudinal decrement in frontalis muscle tension as observed across training sessions. EMG scores reflecting absolute muscle potential values and obtained throughout the entire training protocol were submitted to a repeated-measures analysis of covariance (ANCOVA) which adjusted the scores for pre-training baseline variation. This analysis is based on the assumption that efficacious EMG biofeedback training is positively correlated with evidence for progressive decline in resting and training EMG levels as the biofeedback regimen is accomplished (e.g., Budzynski et al., 1973; Kondo & Canter, 1977).

In the second analysis between-session comparisons were not considered. Instead, linear regression equations were calculated for within-session change in frontalis muscle tension observed during each of the three training sessions. Each equation provides an index of the slope or rate of linear change in EMG scores observed for that fifteen-minute session. These "slope scores" served as the dependent measure in a series of ANOVAs which were performed to determine whether there existed systematic differences among subjects in the steepness of EMG decline during biofeedback sessions. This analysis assumes that one important intermediary goal of EMG biofeedback training involves within-session reductions in frontalis EMG values with a higher rate of decrement predictive of increasingly greater relaxation learning. While within-session change in EMG levels provides only an indirect measure of therapeutic outcome (Jessup et al., 1979), there is evidence that mean within-session EMG levels may strongly predict headache frequency (Budzynski et al., 1973).

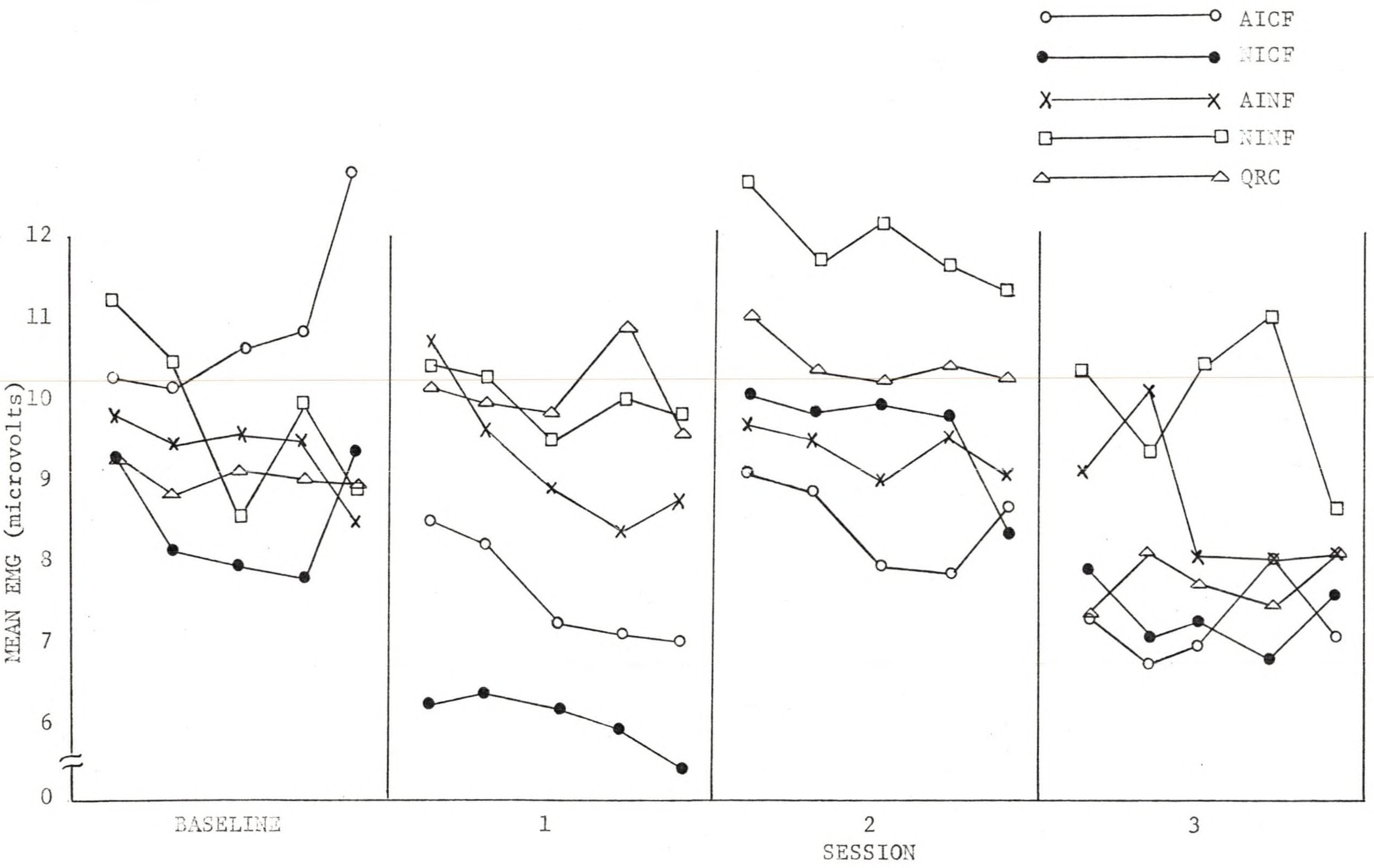
EMG Performance Data

Figure 1 depicts mean EMG scores for each group plotted separately for baseline and sessions 1, 2, and 3.

Baseline. Prior to the main analysis a one-way ANOVA was performed on mean EMG baseline to determine whether groups differed in resting levels of frontalis muscle potential. No differences in mean baseline EMG were obtained, $\underline{F}(4, 55) = .043$, $\underline{p}$ = ns. Further, $\underline{t}$-tests (Kolstoe, 1973) computed separately for all individual group by group comparisons yielded no significant differences among any of the five groups for EMG baseline levels. Table 8, located in the Appendix, lists the summary ANOVA and multiple internal comparisons.

To assess potential baseline variation for subjects categorized by the experimental factor, a four-way ANOVA (Feedback x Instruction x Sex x Absorption) was conducted on mean EMG baseline values. Only baseline data relevant to the four experimental groups (e.g., AICF, AINF, NICF, NINF) forming the Feedback x Instruction factorial matrix were

Figure 1. Mean EMG scores (microvolts) across treatment groups for baseline, Sessions 1-3.


AICF
NICF
AINF
NINF
QRC
MEAN EMG (microvolts)
12
11
10
9
8
7
6
0
BASELINE
1
2
3
SESSION

submitted for this analysis. Table 9 summarizes the ANOVA for mean baseline EMG and can be found in Appendix E. No differences in baseline were found for the feedback, instruction and sex factors. However, a significant main effect for absorption indicated, curiously, that subjects high in absorption were found to display significantly higher levels of resting frontalis muscle potential when compared to LA subjects, $\underline{F}(1, 32) = 16.04$, $\underline{p} < .001$.

Biofeedback Performance. Change in absolute level of frontalis EMG was compared across experimental groups by submitting subject within-session mean EMG scores to a five-way repeated-measures ANCOVA (Winer, 1962) which treated Feedback, Instruction, Absorption and Sex as between-subject factors and Sessions as a within-subject factor. Due to the statistically significant relationship between absorption and pretraining EMG levels, and in order to control for the possible effects of the "law of initial values" (Benjamin, 1963; Sternbach, 1966; Wilder, 1956) in which the magnitude of psychophysiologic response change observed under stimulus conditions is directly proportional to pre-experimental baseline measures, mean EMG scores were analyzed by a covariance technique which adjusted mean EMG for variations in baseline frontalis tension. Mean session EMG scores adjusted for mean baseline are listed in Table 1. These adjusted scores were submitted to a 2 x 2 x 2 x 2 x 2 (Feedback x Instruction x Absorption x Sex x Session) ANCOVA with repeated measures on the Session factor. Only the four experimental groups were considered. The results are presented in Table 2.

Table 1

Mean EMG Scores (Microvolts) for Sessions 1-3 Adjusted

for Baseline Mean EMG

	Session		
Group	1	2	3
AICF	8.00	8.90	7.70
NICF	5.54	9.10	7.07
AINF	10.01	11.84	9.56
NINF	8.79	9.71	7.98

A significant feedback effect was obtained, $\underline{F}(1, 31) = 7.068$, $\underline{p} = .01$, in which contingent feedback was associated with lower levels of frontalis EMG across the entire training protocol. Examination of Figure 1 suggests that the disparity between CF and NF subjects was generally constant across biofeedback training with greatest differences observed early in training. This inference is supported by a significant Pearson coefficient ($\underline{r} = .345$, $\underline{p} < .05$) associating the feedback factor and EMG performance during Session 1. CF subjects were significantly more relaxed than noncontingent feedback controls during the first training period. Furthermore, Session 1 biofeedback performance significantly predicted EMG levels during Session 3 ($\underline{r} = .472$, $\underline{p} < .001$). Taken together, subjects who received contingent feedback information, when compared to controls, were significantly more relaxed during biofeedback and this discrepancy in tension levels was apparent quite early in training. In addition, preliminary biofeedback performance was useful in predicting the subject's EMG levels following extended training.

Table 2

Summary ANCOVA for Mean EMG Scores with

Mean Baseline EMG as Covariate

Source	df	MS	F
Feedback (FDBK)	1	14723.633	7.068*
Instruction (INST)	1	1050.133	0.504
Sex (SEX)	1	3118.695	1.497
Absorption (ABSP)	1	6639.695	3.188
FDBK x INST	1	2895.945	1.390
FDBK x SEX	1	3739.570	1.795
INST x SEX	1	1782.508	0.856
FDBK x ABSP	1	2436.508	1.170
INST x ABSP	1	6.816	0.003
SEX x ABSP	1	943.590	0.453
FDBK x INST x SEX	1	543.305	0.261
FDBK x INST x ABSP	1	435.883	0.209
FDBK x SEX x ABSP	1	869.285	0.417
INST x SEX x ABSP	1	14857.633	7.133*
FDBK x INST x SEX x ABSP	1	26476.133	12.710**
Covariates	1	2500.945	1.201
Subjects (SUB)	31	2083.032	
Sessions (SES)	2	3884.281	1.755
FDBK x SES	2	707.438	0.320
INST x SES	2	1592.625	0.719
SEX x SES	2	249.750	0.113
ABSP x SES	2	125.125	0.057
FDBK x INST x SES	2	136.406	0.062
FDBK x SEX x SES	2	1068.219	0.483
INST x SEX x SES	2	1637.500	0.740
FDBK x ABSP x SES	2	2564.500	1.153
INST x ABSP x SES	2	1579.156	0.713
SEX x ABSP x SES	2	2589.313	1.170
FDBK x INST x SEX x SES	2	2566.563	1.159
FDBK x INST x ABSP x SES	2	377.875	0.171
FDBK x SEX x ABSP x SES	2	553.656	0.250
INST x SEX x ABSP x SES	2	25.438	0.011
FDBK x INST x SEX x ABSP x SES	2	396.531	0.179
Covariates	1	0.000	very small
SES x SUB	63	2213.819	

*p < .05
**p < .01

No differences in EMG relaxation were obtained for the instruction and sex factors. The absorption main effect approached significance, $F(4, 55) = 3.188$, $p < .10$. Opposite to prediction, HA subjects exhibited reliably higher levels of frontalis muscle tension than LA subjects during experimental training. This finding cannot be attributed to the differences observed for high and low absorption subjects for baseline EMG as this variable was controlled statistically by the covariance analysis. This finding in combination with the baseline analysis suggests that, for the present study, a tendency towards absorption was inversely related to achieving relaxation during biofeedback therapy. HA subjects were found on the average to be more tense prior to the start of training and they remained comparatively more tense despite repeated training experiences.

On the average subjects did not significantly reduce their frontalis muscle potential across sessions, $F(2, 63) = 1.755$, p = ns, nor was any experimental factor found to interact significantly to facilitate EMG biofeedback performance. The failure to obtain a session effect is contrary to previous findings (e.g., Roth, 1975), and is illustrated by Figure 2 which plots treatment group mean session EMG for baseline and training sessions. Table 3 summarizes this data in quantitative form. As is readily apparent from this view, nearly all groups displayed elevation in mean session EMG from Session 1 to Session 2. In fact, only AINF and QRC subjects defied this trend. During Session 3, however, all but NICF trainees attained greater depths of frontalis relaxation in comparison with their Session 1 performance. At least three groups (AICF, NICF, NINF) demonstrated very noticeable curvilinear

Figure 2. Mean session EMG (microvolts) across treatment groups for baseline, Sessions 1-3.

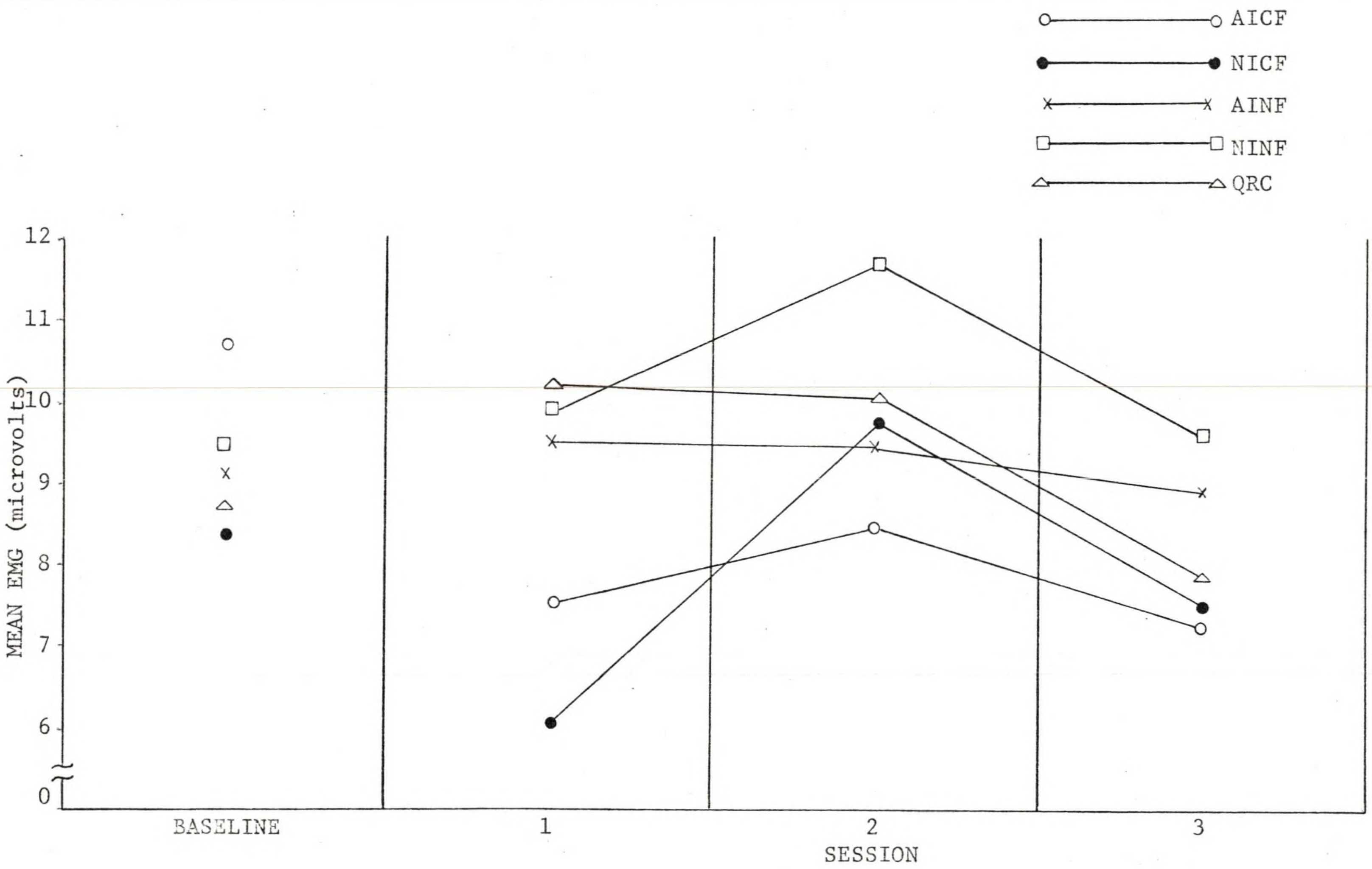

AICF
NICF
AINF
NINF
QRC
MEAN EMG (microvolts)
12
11
10
9
8
7
6
0
BASELINE
1
2
3
SESSION

Table 3

Mean Session EMG Scores (Microvolts) for Baseline,
Sessions 1-3 by Treatment Group

Group	Baseline	Session 1	 2	 3
AICF	10.70	7.53	8.43	7.23
NICF	8.46	5.95	9.51	7.43
AINF	9.20	9.22	9.23	8.47
NINF	9.61	9.97	11.79	9.52
QRC	8.87	10.07	10.26	7.72

distributions of EMG change across sessions. This mid-training "rebound effect" cannot be explained methodologically as subjects were randomly assigned to treatment conditions, received their experimental training concurrently, and completed training over variable intervals of time. For whatever reason, the failure to obtain a significant sessions effect or interaction indicates that for the "typical" subject the ability to reduce frontalis EMG was not facilitated by multiple exposures to training and that, in addition, the effects of the four experimental factors in promoting relaxation were not enhanced by additional training.

Two significant high-order interactions were found. In the first, an Instruction x Absorption x Sex interaction, $\underline{F}(1, 31) = 7.133$, $\underline{p} = .01$, indicated that HA males demonstrated greater EMG relaxation when provided cognitive-attentional instructions prior to training while LA males performed best following instructions devoid of a cognitive-attentional emphasis. The converse was true for females who differed in degree of absorption. HA females exhibited lowest levels of EMG when administered control instructions whereas LA females attained better relaxation subsequent to cognitive-attentional instruction. The Sex x Absorption interaction appeared to moderate the influence of pretraining instructions on subject's ability to reduce frontalis EMG. This effect was particularly true for noncontingent feedback subjects.

A significant Feedback x Instruction x Absorption x Sex interaction, $F(1, 31) = 12.710$, $p < .01$, indicated that during noncontingent feedback training subjects of both sexes continue to differentially benefit from cognitive-attentional manipulation depending on their tendency toward absorption. HA females preferred nonattentional instructions to achieve relaxation while their LA counterparts exhibited lower EMG scores following cognitive-attentional preparation. For NF males, high absorption was associated with more relaxation with the addition of cognitive-attentional instructions while males who possessed relatively low degrees of absorption performed most effectively in the absence of these instructions. However, when subjects were administered contingent EMG biofeedback low absorption trainees of both sexes showed differential instructional effects. Specifically, LA males appeared to benefit more from passive attention instructions if they received contingent feedback training as compared to their improved performance following control instructions under noncontingent feedback conditions. Low absorption females, on the other hand, exhibited the reverse effect. For these subjects the administration of attentional instructions in combination with true biofeedback proved deleterious to their efforts to relax, whereas these instructions were found to facilitate relaxation when LA females were observed during noncontingent feedback training. In summary, it appears that for the present study, gender and absorption interacted to modulate the effects of pre-training instructions on subsequent EMG performance. Furthermore, for LA subjects the effect of pretreatment cognitive preparation in facilitating relaxation in this study depended on the individual's sex and the nature of the feedback signal presented during biofeedback training.

The above EMG data analyses includes scores drawn from the four experimental groups AICF, NICF, AINF, and NINF. To compare whether subjects in these conditions differed from no-treatment Quiet Resting Controls on frontalis EMG, one-way ANOVAs were performed on mean EMG across all five groups for Session 1, $\underline{F}(4, 55) = 1.509$, $\underline{p}$ = ns, Session 2, $\underline{F}(4, 55) = 0.615$, $\underline{p}$ = ns, and Session 3, $\underline{F}(4, 55) = 0.621$, $\underline{p}$ = ns. All three F-ratios were nonsignificant indicating random variation in mean EMG scores for all groups across training sessions. In other words, no treatment group differed significantly from the others in its average level of frontalis muscle tension, irrespective of the phase of training. A series of $\underline{t}$-tests were then computed for individual group paired-comparisons for each training session. Table 8 provides a summary of the $\underline{t}$-tests and can be found in Appendix E. Only one significant comparison emerged, $\underline{t}(22) = 3.394$, $\underline{p} < .05$, in which for Session 1, NICF subjects were significantly more relaxed than NINF subjects. This finding is consistent with the previous evidence that true, contingent feedback was significantly associated with successful relaxation during the initial biofeedback session.

To summarize the findings regarding the effects of the various experimental conditions in facilitating reduction of absolute muscle potential during EMG biofeedback:

1. True, contingent feedback was significantly effective in producing EMG relaxation. This effect was demonstrable quite early in training.

2. The individual's initial response to EMG biofeedback training was predictive of his biofeedback (e.g., relaxation) performance during the final stage of training.

3. EMG relaxation performance during biofeedback was independent of pre-training cognitive-attentional preparation and gender.

4. HA individuals appeared to be more tense in general than LA persons and there was the suggestion that high degrees of absorption were inversely related to relaxation performance during EMG biofeedback.

5. With one exception, no differences in EMG biofeedback performance were observed among treatment groups for each phase of training.

6. Under certain feedback and instructional conditions, degree of absorption and gender appeared to interact in a complex fashion to influence subject's ability to relax during EMG biofeedback training.

Slope Analysis

The above analyses view EMG biofeedback outcome in terms of across-session, cumulative effects. For the following slope analysis, a measure of the rate of within-session change in frontalis relaxation observed during feedback training served as the dependent criterion. Epstein and Blanchard (1977) use the term "feedback control" to denote the trainee's performance in altering the target physiologic response by controlling the feedback signal while biofeedback therapy is taking place. It has been suggested that analysis of within-session change in a target physiologic response during biofeedback provides limited information about therapy outcome but can help to elucidate the nature of the biofeedback process (Jessup et al., 1979). While a measure of training performance does not guarantee symptom resolution or therapeutic success, it is reasonable to speculate a positive relationship between feedback (signal) control and successful clinical outcome.

To obtain a measure of change in frontalis muscle tension during training, linear regression equations were computed separately by session for the three separate distributions of EMG scores recorded for each subject. Each equation provides a measure of the steepness (magnitude of value) and direction (positive = increase, negative = decrease) of linear change in frontalis EMG observed for that particular session (McNemar, 1969). Three training session "slope scores" were calculated for each subject denoting feedback performance during Sessions 1-3. A fourth mean within-session slope score was derived by averaging these three scores. A list of subject slope scores categorized by treatment group may be found in Table 10 in Appendix E.

Mean within-session slope scores were submitted to a four-way ANOVA (Feedback x Instruction x Absorption x Sex) and a summary of this analysis may be found in Table 4. Only the four experimental groups were considered in this analysis. No differences in slope were obtained for the feedback instruction, absorption, and sex factors. The only finding of significance was the Instruction x Sex interaction, $F(1, 32) = 5.624$, $p < .05$. Males receiving passive attention instructions and females who were provided pretreatment control instructions demonstrated

Table 4

Summary ANOVA for Mean Within-Session Slope Scores

Source	df	MS	F
Feedback (FDBK)	1	4125.523	1.206
Instruction (INST)	1	256.688	0.075
Sex (SEX)	1	336.020	0.098
Absorption (ABSP)	1	963.020	0.281
FDBK x INST	1	1073.519	0.314
FDBK x SEX	1	1150.522	0.336
INST x SEX	1	19240.008	5.624*
FDBK x ABSP	1	4700.520	1.374
INST x ABSP	1	2929.690	0.856
SEX x ABSP	1	77.521	0.023
FDBK x INST x SEX	1	4740.188	1.386
FDBK x INST x ABSP	1	450.187	0.132
FDBK x SEX x ABSP	1	1271.020	0.372
INST x SEX x ABSP	1	2422.518	0.708
FDBK x INST x SEX x ABSP	1	581.021	0.170
Subjects	32	3421.244	

*$p < .05$

a comparative greater rate of decline in EMG scores than their experimental counterparts. The marriage of attentional instructions with males and nonattentional instructions with females in promoting relative success in relaxation is similar to the Instruction x Absorption x Sex interaction discussed above in the EMG score analysis. That finding indicated, in part, that HA males relaxed most deeply when provided cognitive-attentional pretraining preparation while HA females were most relaxed when these instructions were omitted. While absorption was not a factor in influencing the relationship between instructions and gender in the slope analysis, these converging findings do suggest consistency in the evidence for sex differences mediating the effects of pretraining instructions on EMG biofeedback-assisted relaxation.

Experimental groups were then compared with QRC subjects on subject mean session slope scores. Table 5 presents mean group slope scores listed by session. All groups displayed an overall average linear decline in EMG levels for biofeedback training sessions. AINF subjects were found to have the highest mean rate of decline in frontalis EMG followed by NINF, NICF, and AICF groups. QRC subjects, while still showing evidence for relaxation, demonstrated the least proficiency in within-session relaxation performance. Also noteworthy is the finding that the average rate of within-session reduction of EMG for all subjects declined steadily across treatment sessions.

Subject mean session slope scores were submitted to a one-way ANOVA to assess variation across groups in average rate of within-session slope of EMG change. No differences in mean slope scores across treatment conditions were obtained, $\underline{F}(4, 55) = 0.681$, $\underline{p}$ = ns. A series of $\underline{t}$-tests computed separately for paired-group comparisons and summarized in Table 6 revealed no differences among any group by group comparisons on mean session slope. These findings indicate that, overall, subjects did not differ in average rate of decline in EMG during biofeedback sessions and that the four experimental factors--feedback, instruction, absorption and sex--were independent of slope performance.

As a slope analysis provides a measure of linear trend, it is possible to test whether the distribution of scores comprising the linear function varies significantly from the null hypothesis (slope =

Table 5

Mean Group Slope Scores for Sessions 1-3

	Session			
Group	1	2	3	$\overline{X}$
AICF	-4.8	-1.3	0.5	-1.9
NICF	-2.8	-2.9	-0.9	-2.2
AINF	-8.9	-1.8	-2.9	-4.5
NINF	-4.0	-2.8	-2.4	-3.1
QRC	-2.2	-2.2	0.6	-1.3
$\overline{X}$	-4.5	-2.2	-1.5	

Table 6

Summary of *t*-tests for Group by Group Comparisons

on Mean Within-Session Slope Scores

Groups	*t*-test
AICF vs. NICF	-0.28
AICF vs. AINF	1.15
AICF vs. NINF	0.66
AICF vs. QRC	-0.31
NICF vs. AINF	0.88
NICF vs. NINF	0.39
NICF vs. QRC	-0.54
AINF vs. NINF	0.49
AINF vs. QRC	-1.35
NINF vs. QRC	-0.89

Note. df=22

0). In the present study, a test for the significance of the linear trend in within-session EMG scores attempts to discern if the slope of EMG change reliably varies from no change as represented by a "flat" distribution of EMG values. A finding of a significant linear trend suggests that the degree of change in EMG level is reliable and systematic and that a statistically significant relaxation effect has been achieved.

To test the null hypothesis that no change in within-session frontalis EMG was observed across subjects, within-session slope scores for each subject were compared with no change by a series of $\underline{t}$-tests. For each $\underline{t}$-test, subject slope scores were compared to 0 slope within treatment conditions. This analysis was performed for all groups for Sessions 1-3 and for subject mean session slope scores. A summary of the $\underline{t}$-tests can be found in Table 7. Two significant slope effects emerged from this analysis with both AICF, $\underline{t}(11) = -3.20$, $\underline{p} < .01$, and AINF, $\underline{t}(11) = -2.24$, $\underline{p} < .05$ subjects exhibiting significant reductions in EMG level during Session 1. No groups displayed significant changes in within-session EMG for Sessions 2 and 3. The overall mean within-session slope for AINF subjects approached significance, $\underline{t}(11) = -2.04$, $\underline{p} < .10$. Thus, subjects receiving attentional instructions appeared to attain significant levels of frontalis relaxation during Session 1. Subjects receiving the combination of contingent feedback and attention instructions displayed the greatest within-session reduction in frontalis EMG, this reduction occurring during the first training session. Overall, AINF subjects were most consistent in reducing EMG scores during feedback training.

Table 7

Summary of t-tests on Group Mean Within-Session Slope to Assess Degree of Change from Zero

Group	Session 1	Session 2	Session 3	Grand Mean
AICF	-3.20**	-0.57	0.26	-1.68
NICF	-2.04	-1.26	-0.45	-1.58
AINF	-2.24*	-0.48	-2.15	-2.04
NINF	-2.17	-1.08	-0.92	-1.69
QRC	-1.05	-1.38	0.33	-1.45

Note. df=11

*$p < .05$
**$p < .01$

To summarize the results of the slope analysis in determing rate of change in EMG scores within training sessions:

1. Males and females differed in their use of pre-training cognitive-attention instructions for promoting EMG relaxation during biofeedback. Cognitive-attention preparation was found to facilitate mean within-session biofeedback performance for males while inhibiting relaxation for females.

2. Subjects categorized by feedback, instructions, sex and absorption did not differ from control subjects in their rate of relaxation during biofeedback sessions.

3. While all treatment conditions displayed decline in frontalis EMG during training, the groups did not differ in the degree of linear change in within-session EMG scores.

4. Attentional instructions were associated with significant rates of relaxation but only for Session 1. Except for groups AICF and AINF during Session 1, no treatment groups exhibited significant change in frontalis EMG during any phase of training.

CHAPTER IV

DISCUSSION

This study assessed the impact of selected task, instructional and personological variables as they contribute to the ability to reduce muscle tone during frontalis EMG biofeedback. The results indicate that one important feature of EMG biofeedback-assisted relaxation is the availability of accurate, response-contingent feedback information during the feedback training. Subjects receiving contingent EMG biofeedback were significantly lower in frontalis muscle tension across training sessions. Despite a significant feedback effect, subjects in general did not exhibit a negative linear trend in EMG values during the course of training and treatment conditions did not differ significantly from the relaxation performance of no-treatment control subjects. Instructions to maintain a focused attention and passive attitude during relaxation appeared to facilitate significant within-session reductions in frontalis EMG, at least for Session 1, but no cumulative learning effect was demonstrated. Regarding individual differences and biofeedback, no sex difference main effects were obtained, although absorption was associated with elevated baseline and training levels of frontalis muscle potential. Stable individual differences in relaxation appeared early in training: relaxation performance during Session 1 was found to significantly predict EMG levels for Session 3.

This study viewed biofeedback training from the perspective of cumulative learning (e.g., change in EMG scores across sessions) and training performance (e.g., within-session slope). In terms of across-session effects, the most significant finding was the evidence confirming the specific effects of contingency of feedback in facilitating relaxation during EMG biofeedback. The superiority of true feedback subjects in reducing frontalis muscle tension across training sessions is consistent with previous evidence (Budzynski et al., 1970, 1973; Coursey, 1975; Kondo & Canter, 1977) and provides further corroboration for the potency of feedback procedures in EMG biofeedback. The significant feedback finding reflects cumulative effects of contingent feedback information and indicates that, for the three training sessions, true feedback subjects were more relaxed than pseudofeedback controls. On the other hand, when training performance is analyzed for within-session EMG changes (e.g., slope) rather than cumulative effects, a more sober view of biofeedback effectiveness emerges. Comparisons across treatment groups (including a no-treatment control group) on within-session rate of change in EMG level provided little support for the efficacy and relative superiority of biofeedback. For the present study across-session change in frontalis muscle tension was chosen as the dependent criterion of primary interest because of the assumption that biofeedback outcome (e.g., symptom resolution) is mediated by stable alterations in underlying physiologic functioning. Whereas across-session changes in EMG addresses the issue of therapeutic outcome, the analysis of within-session feedback performance provides information on the nature of the treatment process (e.g., change in physiologic state while treatment is applied) (Jessup et al., 1979).

While contingent feedback subjects were, in general, more relaxed than false feedback subjects during biofeedback training, the feedback effect seemed to operate most strongly early in training. Contingent feedback was significantly correlated with deep relaxation but only for Session 1. No relative superiority for true feedback subjects was observed for Sessions 2 and 3. The therapeutic effects of contingent feedback seemed to operate most obviously for subjects during their initial feedback session and beyond this contingent feedback appeared to lose its advantage in promoting relaxation. This finding is similar to a report by Haynes et al. (1975) which found that EMG biofeedback subjects relaxed more profoundly than pseudofeedback controls but to a similar degree with other relaxation conditions. Importantly, biofeedback subjects were observed to produce lower tension levels more rapidly than the other relaxation methods. Brown (1970) has also noted the especially rapid onset of voluntary control among her alpha EEG feedback subjects during the preliminary stage of training. This observation has led her to conceive of biofeedback as reflecting an "insight" rather than operant conditioning paradigm, pointing to the lack of linearity in the acquisition curves of skillful subjects as supportive evidence.

These findings suggest a possible contribution of response-contingent feedback in the learned acquisition of self-relaxation. If we assume that various relaxation procedures produce comparable cumulative outcome (Shapiro & Surwit, 1979), then perhaps a unique feature of accurate feedback is that it accelerates the relaxation process in a way superior to other methods. This acceleration effect (e.g., rapid relaxation) would be obscured by comparative studies showing no differences among treatments (including biofeedback) if relaxation performance were assessed toward the latter stages of training (e.g., follow-up evaluation) by which time the relative efficiency of biofeedback would have disappeared. The addition of response-contingent information during feedback training may accelerate learned relaxation by inducing more rapid reductions in autonomic arousal, or it may permit more ready associations to be drawn between cognitive and hypometabolic physiologic states, or both (Pelletier, 1975). If biofeedback is found to have particularly rapid effects in facilitating relaxation, this finding would have important implications for increasing the efficiency of relaxation training in general. For example, biofeedback may serve as a useful "priming" technique by inducing rapid relaxation in subjects prior to their being trained in other self-relaxation strategies. The combination of biofeedback with other relaxation methods may facilitate earlier acquisition in relaxation control than training in a single relaxation modality.

In spite of the significant feedback effect obtained, the results here do not strongly support the efficacy of biofeedback or Benson's relaxation model in promoting cumulative learning effects or in producing deeper relaxation during training than that demonstrated by subjects who quietly sit still for an equivalent period of time. Both factors were associated with a nonsignificant negative linear trend in EMG scores across training sessions. Further, with the exception of the Benson technique for Session 1, neither biofeedback nor passive attention instructions was associated with significant relaxation performance during training sessions. No differences in rate of relaxation emerged when experimental subjects were compared with no-treatment controls for each session of training.

The inclusion of a no-treatment resting control group represents one of the strengths of the present design and permits a comparison of treatment effects with the adaptation effects of motor inactivity on physiologic arousal. Several studies incorporating extended baseline and no-treatment controls have failed to obtain differences between experimental and control subjects for the control of a variety of response systems including alpha (Paskewitz & Orne, 1973), skin temperature (Surwit, Shapiro, & Feld, 1976), muscle tension (Packer & Selekman, 1977) and heart rate (Bergman & Johnson, 1972; Rupert & Holmes, 1978). Taken together, these findings illustrate the need for proper control procedures in evaluating the efficacy of biofeedback. In the present study the failure to compare treatment effects with a no-treatment condition would have altered considerably the nature of the findings regarding biofeedback training. Without such comparisons the finding of a significant feedback effect would have misleadingly argued for the superiority of contingent biofeedback in the learned control of relaxation. However, when we compare true feedback subjects with resting control subjects, it becomes evident that true feedback information holds little advantage for subjects in fostering hypoarousal during training.

The failure to obtain a significant learning effect among treatment groups may be a result of the relative short duration of training. Typically, biofeedback therapy is conducted for several weeks and includes from ten to twenty sessions of training. Perhaps if training had been extended beyond three sessions, a more apparent relaxation trend would have emerged. Relevant to this point is the observation among early biofeedback investigators (Brown, 1970; Stephens, Harris, & Brady, 1972) that the pattern of acquisition of self-regulation is not necessarily linear for many successful biofeedback subjects. Gallon and Padnes (1976) found that EMG biofeedback training protocols extending to forty sessions do not reveal smooth learning curves. The authors point to the absence of linearity in learning as evidence for an appreciation of the complexity of learning to control a single response such as frontalis muscle tension. They observed a pattern of EMG biofeedback performance among their psychosomatic patients suggestive of high tension peaks following sessions of relatively deep relaxation. "Effective relaxation usually occurs early in the training, sometimes even in the very first session. . . . The patient then rebounds and often finds it difficult to relax as well again for many sessions" (Gallon & Padnes, 1976, p. 13).

Subjects in the present study tended to exhibit a "rebound" in muscle tension following the initial training session. Three treatment groups (AICF, NICF, NINF) displayed quite clear curvilinear functions across sessions. Gallon and Padnes (1976) and others (Adler & Adler, 1976; Coursey, 1975; Fehmi, 1975; Luthe, 1963; Pelletier, 1975) interpret paradoxical arousal responses during relaxation therapy to indicate the disinhibiting effects of relaxation on information processing. These authors assert that as a result of induced relaxation, primary process cognition (e.g., irrational and bizarre thoughts, visual imagery, hostile or sexual ideation) and hynagogic fantasies emerge within the subject's stream of consciousness. The rebound to alertness and relative arousal (e.g., avoidance of relaxation) is said to be motivated by the anxiety and fear associated with these primitive experiences. In the present study, groups which did evidence a rebound effect did so primarily because of elevated tension levels at the beginning of the second training session. Each of these groups demonstrated clear trends in the direction of reduced muscle tone for this session. It was the relatively elevated mean EMG levels for Session 2 compared with mean EMG for Session 1 and 3 which produced the curvilinear finding. It is possible that for those subjects the anticipation of relaxation was sufficient to mobilize anxieties which were originally acquired during the first relaxation experience. The fact that AINF subjects resisted this trend suggests that passive attention instructions may have been effective in insulating the subject from this rebound effect, although if this were true one would suspect a similar finding for AICF subjects. However, the additional task of lowering the pitch of the tone for these latter subjects (NF subjects were not instructed to lower the tone) may have stimulated excessive effort in task performance resulting in increased arousal and overpowering the influence of the passive attention remarks (Fehmi, 1975).

The failure to obtain an instructional effect is surprising considering the near unanimous agreement among clinicians regarding the importance of a passive approach to the learned control of relaxation and other physiologic states. While passive attention instructions were associated with significant rates of frontalis relaxation during Session

1, this relationship was not replicated for the remaining sessions or the entirety of training. The absence of an effect is possibly due to a methodological weakness in the experimental design. It may be naive to assume that the mere instruction to maintain a passive attitude during task performance enables the subject to acquire and maintain the prescribed cognitive set for the training experience. The present design provides no independent measure of the passive attention factor. In a similar vein, Wilkins (1973) has criticized the presumed causality between positive expectancies and therapeutic success in which pretreatment instruction intended to induce an elevated expectancy of treatment benefit is said to account for such gains if they are found on post-test. Wilkins (1973) cautions that empirical relationships between instructional sets and outcome cannot be legitimately established until the presence of the instructional set is verified by measures independent of outcome.

In this regard Fehmi (1975) has commented that, for subjects who find it difficult to adopt the passive approach for biofeedback training, "even generous amounts of verbal instruction seem to have little effect on their ingrained habit of trying too hard. As a result, once trainees establish the set of active, effortful volition in the feedback session, many training sessions are necessary to dampen their effortful ardour" (Fehmi, 1975, p. 1). Thus, simply instructing subjects in passive attention five minutes prior to training may be insufficient to induce in the subject the cognitive approach characterized by the passive mode. Secondly, even if these instructions were successful, it is an open question whether their potency could withstand the vigor and habit strength of effortful pursuit. For these reasons, Fehmi (1975) developed a series of imaginative and attentional exercises which trains the subject to broaden his perception and disengage attention from thoughts.

The individual difference variables for sex and absorption were found to be statistically independent of EMG performance although the absorption effect suggested increased muscle tension throughout training for high absorption subjects. Roberts et al. (1975) found no correlation between absorption score and skin temperature control. Thorkelson (1973) on the other hand, found high absorption subjects to be quite adept at producing deep relaxation characterized by enhanced theta wave rhythms but were less skillful than low absorption subjects in increasing alpha. The discrepancy between the present results and Thorkelson's (1973) may be a function of the difference in the dependent measure of relaxation. It is not clear why absorption appeared to be associated with elevated muscle tension during baseline and training sessions. Published studies (Balshan, 1962; Matus, 1974; Smith, 1973) examining the relationship between frontalis muscle potential and personality provide little help in understanding the present findings as these reports typically are concerned with individual difference variables orthogonal to absorption (e.g., introversion-extroversion). In view of the small number of studies assessing the relationship between absorption and physiologic control, and in consideration of the tentativeness of the statistical association between training EMG and absorption, it would seem premature to draw specific conclusions from the present findings.

However, these data are suggestive that stable personality traits may contribute an important role in mediating biofeedback effects (e.g., Roessler, 1973).

The finding of a significant interaction between sex, absorption and instructions on frontalis EMG scores suggests even further the complex nature of biofeedback-relaxation performance. The data indicate that relaxation was maximized when HA males and LA females received passive attention instructions and when LA males and HA females did not. The finding for males is somewhat straightforward as it seems reasonable that subjects who possess a natural tendency towards attentional flexibility in their daily perceptual experience would benefit most when instructed to utilize these processes to assist their efforts to relax. On the other hand, for those male subjects who measure low on absorption, it would appear that instructions emphasizing absorption-like processes during relaxation training are not well suited to their abilities, resulting in poor performance. Females demonstrated an opposite tendency which may be related to the confounding of voice of the experimenter and the subject's gender. In the present design, the author's (male) voice provided pretraining instructions to all subjects. Thus, the sex of the experimenter was not crossed with sex for subjects. LA females seemed to respond appropriately as they relaxed more deeply following passive attention preparation. For HA females, however, it appears that the combination of high absorption and passive attention (e.g., absorption) instructions precipitated a paradoxical effect on relaxation performance.

Finally, one of the goals of the present study was to discover factors which are empirically established predictors of biofeedback performance. The personological variables of sex and absorption did not compare with EMG performance in a simple, straightforward relationship. Unexpectedly, it was found that EMG performance during Session 1 strongly predicted the subject's degree of relaxation for the final Session 3. If this relationship remains stable for longer training protocols it would have important implications for selecting individuals who are optimally suited for biofeedback. In contrast to personality factors, the correlation of EMG levels for Sessions 1 and 3 represents a performance measure predictive of biofeedback success. Other investigators have also observed the positive correlation of self-control performance measures with biofeedback outcome. Levenson (1977) reports that subjects who demonstrate the ability to control heart rate in the absence of feedback also exhibit the greatest control during cardiac biofeedback training. Similarly, Glueck and Stroebel (1975) found that subjects who can increase alpha density on the EEG soon after beginning feedback training exhibit strong, reliable alpha control following training. Cox (1978) reports similar evidence for EMG biofeedback trainees. While these findings require further replication, they provide a promising approach to the investigation of individual difference factors in predicting biofeedback outcome.

In conclusion, the present study provided qualified support for the efficacy of EMG biofeedback in promoting relaxation. Despite a finding that response-contingent feedback was associated with relaxation across training sessions, comparison of cumulative and within-session training effects across treatment conditions failed to support the unique contribution of either biofeedback or Benson's relaxation model in facilitating reduction of frontalis muscle tone. The relaxation learning curves exhibited by subjects across training sessions were irregular and not typical of operant conditioning phenomenon. This finding suggests that, while contingent feedback may serve as a helpful adjunct for subjects who are learning to relax, the presence of true feedback information does not appear to have the potency to increase relaxation responding in a way that is generally associated with reinforcement mechanisms. The acquisition of self-relaxation appears to be a rather complex process, especially when considering the evidence for complicated interactions between sex, instructions and personality on physiologic relaxation as obtained here. Finally, while personologic variables were not helpful in predicting relaxation levels during training, there is evidence to suggest that performance measures may hold greater predictive value in selecting individuals for biofeedback therapy.

APPENDICES

APPENDIX A

ATTENTIONAL INSTRUCTIONS - CONTINGENT FEEDBACK

Close your eyes. Take a moment and make yourself as comfortable as you can. I would like to give you some suggestions and reminders which may help you in becoming more relaxed. Following these relaxation hints, a tone will be presented through the earphones. This tone is provided for two reasons. First, it is an index of how relaxed you are at the moment you are listening to it. Specifically, it is the pitch of the tone that will let you know if, with each moment, you are becoming more relaxed or more tense. If the pitch of the tone rises that means that you are becoming tense; if the tone drops in pitch it is telling you that your body is becoming more relaxed. As most people tend to fluctuate between tenseness and relaxation, you will notice that the tone will be quite variable. For this 15 minute session and those to follow your job will be to relax to the best of your ability. You can best accomplish this by reducing the pitch of the tone as much as you can. As the pitch drops, it will mean that you are becoming more relaxed.

The second purpose of the tone is that it can be used as a vehicle by which to enhance your ability to relax. How you choose to focus your attention will greatly facilitate or inhibit your ability to relax. In the beginning fix your attention on the tone when it is presented.

Immerse your whole mind in the sound of the tone as it rises and falls. Try to exclude all other thoughts or feelings or bodily sensations. Let the perception of the tone fill your entire consciousness. Become absorbed in it.

At some point you may notice the intrusion of some random thoughts and that you are thinking about something rather than completely focusing on the tone. How you handle distraction is extremely important in learning to relax. As a person relaxes it is natural for him or her to become alert to many memories, feelings, and experiences of which he was previously unaware. You may uncover unpleasant or painful kinds of experiences. Let these experiences happen and simply witness them without judging or reacting to them in any way. Maintain a detached posture by allowing these thoughts to pass through your mind. Spread your attention across all of these random thoughts. Maintain a casual attitude toward intrusive thoughts. Your goal is to achieve a state of unobstructive flowing of consious experience where your mind's attention is not attached to any single event which arises internally or impinges from the environment. Should you find that you have gotten too involved in a single thought or experience, simply become aware of this and gently redirect your attention back to the tone. From there you can again allow your attention to broaden and spread across the field of your mind.

Relaxation is an automatic, physiologic mechanism which operates much like any other bodily reflex. Just as light striking your eye causes the pupil to automatically contract, when certain mental attitudes are present the experience of relaxation can be automatically produced. Most important of these attitudes is a passive approach toward the relaxation experience. Allow yourself to relax and permit your body to "let go" of its tension. Do not try too hard. By exerting too much effort you will defeat your goal of complete relaxation. In the past, subjects who were successful in achieving relaxation reported that they were only able to relax after they had stopped actively trying. Develop a casual and gentle approach. Self-reprimand and self-criticism are to be avoided. Learning to relax cannot be rushed.

Remember, there are four steps in learning to relax. First, reduce the pitch of the tone. Second, become absorbed in the tone. Third, maintain a casual attitude toward intrusive thoughts and feelings. And fourth, maintain a passive, effortless posture towards these thoughts and the relaxation experience in general.

APPENDIX B

NONATTENTIONAL INSTRUCTIONS - CONTINGENT FEEDBACK

Close your eyes. Take a moment and make yourself as comfortable as you can. I would like to give you some suggestions and reminders which may help you in becoming relaxed over the next 15 minutes. Following these relaxation hints, a tone will be presented through the earphones. This tone will be an index of how relaxed you are at the moment that you are listening to it. Specifically, it is the pitch of the tone that will let you know if, with each moment, you are becoming more relaxed or more tense. As most people tend to fluctuate between extremes of tenseness and relaxation, you will notice that the tone will be quite variable. For this session and those to follow your job will be to relax to the best of your ability by reducing the pitch of the tone as much as you can. Use any strategy you wish to decrease the pitch of the tone. By making correct use of the tone, you can learn to develop better skills in promoting self-relaxation.

Generally, people differ in the degree to which they are relaxed during normal daily activities. For many years psychologists have been investigating the contribution of relaxation in aiding persons who are suffering from a variety of physiological and psychological disturbances. In addition, they have tried to discover the most effective pathway to deep relaxation. In line with this area of interest, the experiment in which you now participate will attempt to examine the efficacy of different approaches of learning to relax. First, though, let me tell you a few things about how the body produces tension.

When the brain sends messages to a muscle group instructing it to contract and become tense, an electrical field is set up about that muscle area. With the use of electrodes and appropriate instrumentation, we can monitor or record the amount of electrical activity within the muscle section and, thus, gain some idea of the degree of tension exhibited by these muscles. By transforming this electrical activity into a sensory signal, such as a tone, it is possible to provide individuals with accurate information regarding how tense or relaxed they are. This information, in turn, can be used to facilitate relaxation.

Following these instructions you will hear through your earphones a tone which represents the degree to which you are tensed or relaxed. If the pitch of the tone rises that means that you are becoming tense; if the tone drops in pitch it is telling you that your body is becoming more relaxed. I would like you to use this information about your bodily state to become more relaxed. Use any strategy you wish to make the tone drop in pitch. Pay close attention to your feelings and bodily sensations, especially when they seem to be related to a decrease in the pitch of the tone. Your task is to try and reduce the pitch of the tone as much as possible, thereby reducing tension while increasing relaxation. In the beginning you may experience some difficulty in getting the pitch to decrease. Do not try too hard or this will defeat your goal of deep relaxation. Remember, keep your attention focused on the tone. Don't let your mind wander. If you find your concentration wandering, simply become aware of this and return your attention to reducing the pitch of the tone. In this way you will begin to get a feel for how you are able to let go and become more relaxed.

APPENDIX C

ATTENTIONAL INSTRUCTIONS - NONCONTINGENT FEEDBACK

Close your eyes. Take a moment and make yourself as comfortable as you can. I would like to give you some suggestions and reminders which may help you in becoming more relaxed. Following these relaxation hints, a tone will be presented through the earphones. You will notice that the tone will be quite variable and the pitch will rise and fall continuously. This tone is provided for two reasons. First, it is a way of blocking out extraneous noise which might interfere with or interrupt your attention as you try to relax. Second and more importantly, it is a vehicle by which you can learn to effectively relax. I will explain how you can do this in a moment. Your task for this 15 minute session and those to follow is to become as relaxed as you possibly can. One of the best methods to do this involves the way you choose to focus your attention and the manner in which your mind concentrates on those things which pass through it. By making correct use of the tone and maintaining a passive attitude toward your feelings, thoughts, and fantasies, you can learn to develop better skills in promoting self-relaxation.

First, how you choose to focus your attention will greatly facilitate or inhibit your ability to relax. In the beginning, fix your attention on the tone when it is presented. Immerse your whole mind in the sound of the tone as it rises and falls. Try to exclude all other thoughts or feelings or bodily sensations. Let the perception of the tone fill your entire consciousness. Become absorbed in it.

At some point you may notice the intrusion of some random thoughts and that you are thinking about something rather than completely focusing on the tone. How you handle distractions is extremely important in learning to relax. As a person relaxes, it is natural for him to become alert to many memories, feelings, and experiences of which he was previously unaware. You may uncover unpleasant or painful kinds of experiences. Let these experiences happen and simply witness them without judging or reacting to them in any way. Maintain a detached posture by allowing these thoughts to pass through your mind. Spread your attention across all of these random thoughts. Maintain a casual attitude toward intrusive thoughts. Your goal is to achieve a state of unobstructive flowing of conscious experience where your mind's attention is not attached to any single event which arises internally or impinges from the environment. Should you find that you have gotten too involved in a single thought or experience, simply become aware of this and gently redirect your attention back to the tone. From there you can again allow your attention to broaden and spread across the field of your mind.

Relaxation is automatic, physiologic mechanism which operates much like any other bodily reflex. Just as light striking your eye causes the pupil to automatically contract, when certain mental attitudes are present the experience of relaxation can be automatically produced. Most important of these attitudes is a passive approach toward the relaxation experience. Allow yourself to relax and permit your body to "let go" of its tension. Do not try too hard. By exerting too much effort you will defeat your goal of complete relaxation. In the past, subjects who were successful in achieving relaxation reported that they were able to relax only after they had stopped actively trying. Develop a casual and gentle approach. Self-reprimand and self-criticism are to be avoided. Learning to relax cannot be rushed.

Remember, there are three steps in learning to relax. First, focus your attention and become absorbed in the tone. Second, maintain a casual attitude toward intrusive thoughts and feelings. And third, maintain a passive, effortless posture towards these thoughts and the relaxation experience in general.

APPENDIX D

NONATTENTIONAL INSTRUCTIONS - NONCONTINGENT FEEDBACK

Close your eyes. Take a moment and make yourself as comfortable as you can. I would like to give you some suggestions and information which may help you in becoming more relaxed over the next fifteen minutes. Following this information a tone will be presented through the earphones. This tone is provided in order to block out extraneous noise and other sounds which may interfere with or interrupt your attention as you try to relax. You will notice that the tone will be quite variable and the pitch will rise and fall continuously. I have chosen this particular signal because of its repeatedly demonstrated hypnotic-like effect on persons who are sitting quietly and comfortably. You should expect that this smoothly varying tone will help you in achieving deep relaxation.

For this session and those to follow your job will be to relax to the best of your ability. Use any strategy you wish. To aid you in learning to relax, I would like to tell you a few things about relaxation and its use in the field of clinical psychology.

As most persons come to discover, the human body functions with varying efficiency depending on the amount of arousal which occurs at any given moment. For some tasks, such as athletic events or other strenuous activities, it is generally best to be highly aroused. On the other hand, high arousal can cause inefficiency for other kinds of tasks. Test taking is an example of an activity which suffers when the individual is excessively aroused. From these facts it would appear that an individual who is best able to adapt his or her level of arousal to the particular task at hand will be most efficient in his performance during that task. Many psychologists agree that one of the best methods to aid persons seeking this type of self-control is to teach them some form of relaxation training. All relaxation procedures share the common objectives of sensitizing the individual to his level of arousal and, furthermore, providing him with a mechanism by which to reduce overarousal. For several years researchers have been investigating the most effective pathway to deep relaxation. In line with this, the experiment in which you now participate will attempt to examine the efficacy of different approaches to learning to relax.

In addition to increasing efficiency of task performance, theories of psychopathology predict that self-relaxation skills can be important in preventing a variety of physiological and psychological disorders. Excessive stress and tension can be instrumental in the development of psychosomatic disorders including headaches, stomach ulcers, and high blood pressure. Clinical psychologists often employ relaxation training to aid persons suffering from these types of disorders.

Following these instructions you will hear a tone which will block out extraneous sounds and make it easier for you to relax. Your job for the next 15 minutes is to relax as completely as you can. Use any strategy you wish. Pay close attention to your feelings and bodily sensations, especially when they seem to be related to feelings of relaxation. In the beginning you may experience some difficulty in becoming relaxed. Do not try too hard or this will defeat your goal of deep relaxation.

APPENDIX E

Table 8

Multiple Comparison *t*-tests for EMG Scores Across Treatment Groups for Baseline and Sessions 1-3

Group	Baseline	Session 1	Session 2	Session 3
AICF vs. NICF	-1.286	-1.741	0.471	0.139
AICF vs. AINF	0.829	-0.888	-0.395	-0.811
AICF vs. NINF	0.460	-1.868	-1.492	-1.200
AICF vs. QRC	1.000	-1.082	-0.844	-0.371
NICF vs. AINF	-0.543	-1.718	0.122	-0.656
NICF vs. NINF	-0.563	-3.394*	-0.906	-1.068
NICF vs. QRC	-0.302	-1.807	-0.308	-0.211
AINF vs. NINF	0.197	0.280	1.127	0.508
AINF vs. QRC	0.220	-0.241	-0.472	0.496
NINF vs. QRC	0.348	-0.038	0.634	0.948

Note. df=22

*$p < .05$

Table 9

Summary ANOVA for Mean EMG Baseline Scores

Source	df	Ms	F
Feedback (FDBK)	1	113.422	0.020
Instruction (INST)	1	3008.520	0.533
Sex (SEX)	1	5753.164	1.020
Absorption (ABSP)	1	90450.188	16.038***
FDBK x INST	1	6360.059	1.128
FDBK x SEX	1	0.202	very small
INST x SEX	1	1328.584	0.236
FDBK x ABSP	1	737.125	0.131
INST x ABSP	1	1314.061	0.233
SEX x ABSP	1	5813.988	1.031
FDBK x INST x SEX	1	280.557	0.050
FDBK x INST x ABSP	1	5587.555	0.991
FDBK x SEX x ABSP	1	36.600	0.006
INST x SEX x ABSP	1	3702.687	0.657
FDBK x INST x SEX x ABSP	1	849.711	0.151
Subjects	32	5639.816	

***$p < .001$

Table 10

Summary of Mean Subject Within-Session Slope Scores

Group	Subject	Session			$\overline{X}$
		1	2	3	
AICF	1	-16.0	-1.5	2.7	-4.9
	2	1.4	-0.5	2.8	1.2
	3	-0.7	-6.2	-8.2	-5.0
	4	-4.5	0.9	0.5	-1.0
	5	-0.5	5.9	7.7	4.4
	6	-6.2	7.3	-0.9	0.1
	7	-6.8	2.3	-9.1	-4.5
	8	-4.0	-2.5	-4.5	-3.7
	9	-5.5	11.6	5.4	3.8
	10	-1.4	-2.7	-2.3	-2.1
	11	-2.4	-15.8	-1.5	-6.6
	12	-10.4	-14.1	13.4	-3.7
$\overline{X}$		-4.8	-1.3	0.5	-1.9
NICF	1	-3.0	1.0	-0.5	-0.8
	2	0.9	-0.7	8.1	2.8
	3	-3.1	10.3	1.9	3.0
	4	1.8	-8.4	-5.1	-3.9
	5	-4.5	6.3	-8.0	-2.1
	6	-0.2	-3.9	7.5	1.1
	7	-4.1	-0.4	0.3	-1.4
	8	-8.4	-1.2	0.9	-2.9
	9	-11.8	-9.1	-0.2	-7.0
	10	-6.3	-19.9	-17.9	-14.7
	11	-0.4	-1.2	3.0	0.5
	12	5.1	-7.2	-1.0	-1.0
$\overline{X}$		-2.8	-2.9	-0.9	-2.2
AINF	1	-0.8	4.8	-0.9	1.0
	2	-1.1	-3.1	-14.3	-6.2
	3	-3.4	-1.6	-2.4	-2.5
	4	-2.6	-0.4	-0.4	-0.9
	5	-0.8	0.5	-1.6	-0.6
	6	-28.3	-27.0	-3.9	-19.8
	7	-43.4	-0.4	-1.2	-15.2
	8	-4.3	-23.7	-0.2	-9.4
	9	-4.4	4.0	2.8	0.8
	10	-10.00	2.6	-0.1	-2.5

Table 10--Continued

Group	Subject	Session 1	Session 2	Session 3	$\overline{X}$
AINF	11	4.4	22.8	- 3.2	8.0
	12	-12.5	- 1.1	- 9.7	- 7.8
$\overline{X}$		- 8.9	- 1.8	- 2.9	- 4.6
NINF	1	-21.6	- 4.3	-12.5	12.8
	2	1.2	- 2.5	- 4.0	- 1.8
	3	- 7.6	4.1	- 0.9	- 1.5
	4	- 0.1	- 4.2	- 5.4	- 3.2
	5	- 1.2	- 1.5	- 0.1	- 0.9
	6	- 2.5	-18.2	1.7	- 6.3
	7	- 0.8	- 6.4	- 8.0	- 5.1
	8	- 7.7	- 5.1	- 8.9	- 7.2
	9	- 3.0	- 1.5	0.7	- 1.3
	10	- 0.6	7.9	- 4.3	1.0
	11	1.4	14.1	22.6	12.7
	12	- 4.9	-15.5	- 9.7	-10.0
$\overline{X}$		- 4.0	- 2.8	- 2.4	- 3.1
QRC	1	- 1.8	-16.3	8.0	- 3.4
	2	3.4	6.5	- 4.0	2.0
	3	2.1	- 5.6	9.7	2.1
	4	- 7.0	- 4.2	10.3	- 0.3
	5	- 4.2	- 2.8	- 5.3	- 4.1
	6	7.0	- 1.8	- 5.9	- 0.2
	7	- 6.6	2.1	- 8.8	- 4.4
	8	-20.9	- 3.1	0	- 8.2
	9	- 2.0	2.4	- 0.4	0
	10	3.4	- 0.9	- 0.6	0.4
	11	0.8	1.0	2.2	1.3
	12	- 0.3	- 3.8	1.8	- 0.8
$\overline{X}$		- 2.2	- 2.2	0.6	- 1.3

REFERENCES

Adler, C. S., & Adler, S. M. Biofeedback-psychotherapy for the treatment of headache: A five-year follow up. Headache, 1976, 16, 189-191.

Ås, A. A. Note on distractibility and hypnosis. American Journal of Clinical Hypnosis, 1962, 5, 135-137.

Ås, A. A., O'Hara, J. W., & Munger, M. P. The measurement of subjective experiences presumably related to hypnotic susceptibility. Scandinavian Journal of Psychology, 1962, 3, 47-64.

Balshan, I. D. Muscle tension and personality in women. Archives of General Psychiatry, 1962, 7, 436-448.

Barber, T. X. Hypnosis: A scientific approach. New York: Van Nostrand Reinhold, 1969.

Barber, T. X. Introduction. Self-control: Temperature, biofeedback, hypnosis, yoga, and relaxation. In T. X. Barber, L. V. DiCara, J. Kamiya, N. E. Miller, D. Shapiro, & J. Stoyva (Eds.), Biofeedback and self-control: 1975/1976. Chicago: Aldine, 1976. (a)

Barber, T. X. (Ed.). Advances in altered states of consciousness and human potentialities (Vol. 1). New York: Psychological Dimensions, Inc., 1976. (b)

Barrick, J. Internal response control using self-management and biofeedback techniques. Unpublished doctoral dissertation, Stanford University, 1973.

Beary, J., & Benson, H. A simple psychophysiologic technique which elicits the hypometabolic changes of the relaxation response. Psychosomatic Medicine, 1974, 36, 115-120.

Beatty, J. Similar effects of feedback signals and instructional information on EEG activity. Physiology and Behavior, 1972, 9, 253-261.

Benjamin, L. S. Statistical treatment of the law of initial values (LIV) in autonomic research: A review and recommendation. Psychosomatic Medicine, 1963, 25, 556-566.

Benson, H. The relaxation response. New York: William Morrow & Co., 1975.

Benson, H., Beary, J., & Carol, M. The relaxation response. *Psychiatry*, 1974, *37*, 37-46. (a)

Benson, H., Klemchuk, H. P., & Graham, J. R. The usefulness of the relaxation response in therapy of headache. *Headache*, 1974, *14*, 49-52. (b)

Benson, H., Marzetta, B. R., & Rosner, B. A. Decreased blood pressure associated with the regular elicitation of the relaxation response: A study of hypertensive subjects. In R. S. Eliot (Ed.), *Stress and the heart* (Vol. 1). New York: Futura, 1974. (c)

Bergman, J. S., & Johnson, H. J. The effects of instructional set and autonomic perception on cardiac control. *Psychophysiology*, 1971, *8*, 180-190.

Bergman, J. S., & Johnson, H. J. Sources of information which affect training and raising of heart rate. *Psychophysiology*, 1972, *9*, 30-39.

Birk, L. Biofeedback-furor therapeuticus. *Seminars in Psychiatry*, 1973, *5*, 361-364.

Black, A. H. The operant conditioning of central nervous system activity. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory*. New York: Academic Press, 1972.

Blanchard, E. B., Theobald, D. E., Williamson, D. A., Silver, B., & Brown, D. A. Temperature biofeedback in the treatment of migraine headaches. *Archives of General Psychiatry*, 1978, *35*, 581-588.

Blanchard, E. B., Young, L. D., & McLeod, P. G. Awareness of heart activity and self-control of heart rate. *Psychophysiology*, 1972, *9*, 63-68.

Blanchard, E. B., & Young, L. D. Self-control of cardiac functioning: A promise as yet unfulfilled. *Psychological Bulletin*, 1973, *79*, 145-163.

Blanchard, E. B., & Young, L. D. Clinical applications of biofeedback training. *Archives of General Psychiatry*, 1974, *30*, 573-589.

Block, J. *The challenge of response sets*. New York: Appleton-Century-Crofts, 1965.

Borkovec, T. D., & Fowles, D. C. Controlled investigation of the effects of progressive and hypnotic relaxation on insomnia. *Journal of Abnormal Psychology*, 1973, *82*, 153-158.

Brener, J. Visceral perception. In J. Beatty & H. Legewie (Eds.), Biofeedback and behavior. New York: Plenum, 1977.

Brener, J., Kleinman, R. A., & Goesling, W. J. The effects of different exposures to augmented sensory feedback on the control of heart rate. Psychophysiology, 1969, 5, 510-516.

Brown, B. B. Recognition of aspects of consciousness through association with EEG alpha activity represented by a light signal. Psychophysiology, 1970, 6, 442-452.

Brown, B. B. New mind: New body. New York: Harper & Row, 1974.

Budzynski, T. H. Biofeedback procedures in the clinic. Seminars in Psychiatry, 1973, 5, 537-547.

Budzynski, T. H. Biofeedback and the twilight states of consciousness. In G. E. Schwartz & D. Shapiro (Eds.), Consciousness and self-regulation (Vol. 1). New York: Plenum, 1976.

Budzynski, T. H. Tuning in on the twilight zone. Psychology Today, 1977, 8, 38.

Budzynski, T. H., & Peffer, K. Twilight-state learning: A biofeedback approach to creativity and attitude change. Paper presented at the Conference on Transformations of Consciousness, Montreal, Canada, October, 1973.

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

Budzynski, T. H., & Stoyva, J. M. Biofeedback techniques in behavior therapy. In D. Shapiro (Ed.), Biofeedback and self-control. Chicago: Aldine Press, 1972.

Budzynski, T. H., Stoyva, J. M., Adler, C. S., & Mullaney, D. J. EMG biofeedback and tension headache: A controlled outcome study. Psychosomatic Medicine, 1973, 35, 484-496.

Cannon, W. B. Bodily changes in pain, hunger, fear, and rage. New York: Appleton-Century-Crofts, 1936.

Cleeland, C. S., Booker, H. E., & Hosokawa, K. Alpha enhancement: Due to feedback or the nature of the task. Psychophysiology, 1971, 8, 262-263. (Abstract)

Coe, W. C., & Sarbin, T. R. An experimental demonstration of hypnosis as role enactment. Journal of Abnormal Psychology, 1966, 71, 400-406.

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

Cox, D. J. Evolution of biofeedback facilities. Paper presented at the 12th annual convention of the Association for the Advancement of Behavior Therapy Convention, Chicago, Ill., November, 1978.

Cox, D. J., Freundlich, A., & Meyer, R. G. Differential effectiveness of electromyograph feedback, verbal relaxation instructions and medication placebo with tension headaches. Journal of Consulting and Clinical Psychology, 1975, 43, 892-899.

Cuthbert, B. N., & Lang, P. J. Biofeedback and cardiovascular self-control. Scandinavian Journal of Behavior Therapy, 1976, 5, 111-132.

Dalal, A. S., & Barber, T. X. Yoga, "yogic feats", and hypnosis in the light of empirical research. American Journal of Clinical Hypnosis, 1969, 11, 155-166.

Das, J. P. Yoga and hypnosis. International Journal of Clinical and Experimental Hypnosis, 1963, 11, 31-37.

Davidson, R. J., Goleman, D. J., & Schwartz, G. E. Attentional and affective concomitants of meditation: A cross-sectional study. Journal of Abnormal Psychology, 1976, 85, 235-238.

Davidson, R. J., & Goleman, D. J. The role of attention in meditation and hypnosis: A psychobiological perspective on transformations of consciousness. International Journal of Clinical and Experimental Hypnosis, 1977, 25, 291-308.

Davidson, R. J., Schwartz, G. E., & Rothman, L. P. Attentional style and the self-regulation of mode-specific attention: An electroencephalographic study. Journal of Abnormal Psychology, 1976, 85, 611-621.

Davis, J. F. Manual of surface electro-myography. (WADC Technical Report, 1959, No. 59-184).

Davison, G. C. Systematic desensitization as a counter-conditioning process. Journal of Abnormal Psychology, 1968, 73, 84-89.

Deikman, A. J. Experimental meditation. Journal of Nervous and Mental Disease, 1963, 136, 329-343.

Deikman, A. J. De-automatization and the mystic experience. Psychiatry, 1966, 29, 324-338.

DeRopp, R. S. The master game: Pathways to higher consciousness beyond the drug experience. New York: Delacorte, 1968.

DiCara, L. V. Introduction. In L. V. DiCara, T. X. Barber, J. Kamiya, N. E. Miller, D. Shapiro, & J. Stoyva (Eds.), Biofeedback and self-control: 1974. Chicago: Aldine, 1975.

DuPraw, V. Self-management of internal responses: Heart rate control. Unpublished doctoral dissertation, Stanford University, 1972.

Elmore, A. M., & Tursky, B. The biofeedback hypothesis: An idea in search of a theory and method. In A. A. Sugarman & R. E. Tarter (Eds.), Expanding dimensions of consciousness. New York: Springer Publishing Co., 1978.

Epstein, L. H., & Blanchard, E. B. Biofeedback, self-control, and self-management. Biofeedback and Self-Regulation, 1977, 2, 201-211.

Fehmi, L. G. Biofeedback of electroencephalographic parameters and related states of consciousness. Paper presented at the annual convention of the American Psychological Association, Washington, D. C., 1971.

Fehmi, L. G. Electroencephalographic biofeedback: Subject reports. Paper presented at the annual meeting of the American Psychological Association, Montreal, Canada, 1973.

Fehmi, L. G. Open focus training. Paper presented at the annual meeting of the Biofeedback Research Society, Monterey, California, February, 1975.

Finke, R. A., & MacDonald, H. Two personality measures relating hypnotic susceptibility to absorption. International Journal of Clinical and Experimental Hypnosis, 1978, 26, 178-183.

Fitzgerald, E. T. The measurement of openness to experience: A study of regression in the service of the ego. Journal of Personality and Social Psychology, 1966, 4, 655-663.

Foulkes, D., & Vogel, G. Mental activity at sleep onset. Journal of Abnormal Psychology, 1965, 70, 231-243.

Gallon, R. L., & Padnes, S. C. EMG biofeedback and the relaxation response. Paper presented at the Seventh Annual Meeting of the Biofeedback Research Society, Colorado Springs, Colorado, February, 1976.

Geer, J. H., & Fuhr, R. Cognitive factors in sexual arousal: The role of distraction. Journal of Consulting and Clinical Psychology, 1976, 44, 238-243.

Gellhorn, E. Principles of autonomic-somatic interactions. Minneapolis, Minnesota: University of Minnesota Press, 1967.

Glueck, B. C., & Stroebel, C. F. Biofeedback and meditation in the treatment of psychiatric illness. Comprehensive Psychiatry, 1975, 16, 303-321.

Goleman, D. Meditation as meta-therapy: Hypotheses toward a proposed fifth state of consciousness. Journal of Transpersonal Psychology, 1971, 3, 1-27.

Green, E. E., Green, A. M., & Walters, E. D. Voluntary control of internal states: Psychological and physiological. Journal of Transpersonal Psychology, 1970, 2, 1-26.

Green, E. E., & Green, A. M. Regulating our mind-body processes. Fields Within Fields Within Fields, 1974, 10, 16-24.

Greenwood, M. M., & Benson, H. The efficacy of progressive relaxation in systematic desensitization and a proposal for an alternative competitive response: The relaxation response. Behavior Research and Therapy, 1977, 15, 337-343.

Hart, J. T. Autocontrol of EEG alpha. Paper presented at the annual meeting of the Society for Psychophysiological Research, San Diego, October, 1967.

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

Hess, W. R. Functional organization of the diencephalon. New York: Grune & Stratton, 1957.

Hilgard, E. R. Hypnosis. Annual Review of Psychology, 1975, 26, 19-44.

Jacob, R. G., Kraemer, H. C., & Agras, W. S. Relaxation therapy in the treatment of hypertension. Archives of General Psychiatry, 1977, 34, 1417-1427.

Jacobson, E. Progressive relaxation (2nd ed.). Chicago: University of Chicago Press, 1938.

Jessup, B. A., Neufeld, R. W. J., & Merskey, H. Biofeedback therapy for headache and other pain: An evaluative review. Pain, 1979, 7, 225-270.

Johnson, R. K., & Meyer, R. G. The locus of control construct in EEG alpha rhythm feedback. Journal of Consulting and Clinical Psychology, 1974, 42, 913.

Jones, F. W., & Holmes, D. S. Alcoholism, alpha production, and biofeedback. Journal of Consulting and Clinical Psychology, 1976, 44, 224-228.

Kamiya, J. Operant control of EEG alpha rhythm and some of its reported effects on consciousness. In C. T. Tart (Ed.), Altered states of consciousness. New York: Wiley, 1969.

Kaplan, H. S. The new sex therapy. New York: Brunner/Mazel, 1974.

Karlins, M., & Andrews, L. M. Biofeedback: Turning on the power of your mind. New York: Warner, 1972.

Katkin, E. S., & Murray, E. N. Instrumental conditioning of autonomically mediated behavior: Theoretical and methodological issues. Psychological Bulletin, 1968, 70, 52-68.

Kolstoe, R. Introduction to statistics for the behavioral sciences. Homewood, Ill.: The Dorsey Press, 1973.

Kondo, C., Canter, A., & Knott, J. R. Relaxation training as a method of reducing anxiety associated with depression. Paper presented at the Biofeedback Research Society, February 1975, Monterey, California.

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

Kubie, L., & Margolin, S. A physiological method for the induction of states of partial sleep and securing free association and early memories in such states. Transactions of the American Neurological Association, 1942.

Lang, P. J. Research on the specificity of feedback training: Implications for the use of biofeedback in the treatment of anxiety and fear. In J. Beatty & H. Legewie (Eds.), Biofeedback and behavior. New York: Plenum Press, 1976.

Lazarus, R. S. A cognitively oriented psychologist looks at biofeedback. American Psychologist, 1975, 553-561.

Lee-Teng, E. Trance-susceptibility, induction-susceptibility, and acquiescence as factors in hypnotic performance. Journal of Abnormal Psychology, 1965, 70, 383-389.

Lesh, T. V. Zen meditation and the development of empathy in counselors. Journal of Humanistic Psychology, 1970, 10, 39-74.

Levenson, R. W. Feedback effects and respiratory involvement in voluntary control of heart rate. Psychophysiology, 1976, 13, 108-114.

Levenson, R. W. Predicting ability to control heart rate with biofeedback. Unpublished study, Indiana University, 1977.

Ludwig, A. M. Altered states of consciousness. Archives of General Psychiatry, 1966, 15, 225-234.

Luthe, W. Autogenic training: Method research and application in medicine. American Journal of Psychotherapy, 1963, 17, 174-195.

Malmo, R. Studies of anxiety. In C. D. Spielberger (Ed.), Anxiety and behavior. New York: Academic Press, 1966.

Mandler, G., Mandler, J. M., & Uviller, E. T. Autonomic feedback: The perception of autonomic activity. Journal of Abnormal and Social Psychology, 1958, 56, 367-373.

Maslow, A. H. Lessons from the peak experiences. Journal of Humanistic Psychology, 1962, 2, 9-18.

Matus, I. Selected personality variables and tension in two muscle groups. Psychophysiology, 1974, 11, 91.

McNemar, Q. Psychological statistics. New York: Wiley & Sons, 1969.

Meichanbaum, D. Cognitive factors in biofeedback therapy. Biofeedback and Self-Regulation, 1976, 1, 201-216.

Miller, N. E. Applications of learning and biofeedback to psychiatry and medicine. In A. M. Freedman, H. I. Kaplan & B. J. Sadock (Eds.), Comprehensive textbook of psychiatry (2nd ed.). Baltimore: Williams and Wilkins, 1974.

Miller, N. E. Biofeedback and visceral learning. Annual Review of Psychology, 1978, 29, 373-404.

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

Packer, L. E., & Selekman, W. L. Within-subjects controls in EMG and thermal biofeedback training: The baseline effect. Paper presented at the Eighth Annual Meeting of the Biofeedback Research Society, Orlando, Florida, March, 1977.

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

Paul, G. L. Behavior modification research: Design and tactics. In C. M. Franks (Ed.), Behavior therapy: Appraisal and status. New York: McGraw-Hill, 1969.

Pelletier, K. R. Theory and applications of clinical biofeedback. Journal of Contemporary Psychotherapy, 1975, 7, 29-34.

Peper, E. Passive attention: The gateway to consciousness and autonomic control. In P. G. Zimbardo & F. L. Ruch (Eds.), Psychology and Life. Glenview, Ill.: Scott, Foresman & Co., 1976.

Peper, E., & Mulholland, T. Methodological and theoretical problems in the voluntary control of electroencephalographic occipital alpha by the subject. Kybernetik, 1970, 7, 10-13.

Plotkin, W. B. On the self-regulation of the occipital alpha rhythm: Control strategies, states of consciousness and the role of physiological feedback. Journal of Experimental Psychology: General, 1976, 105, 66-99.

Rachman, S. The role of muscular relaxation in desensitization therapy. Behavior Research and Therapy, 1968, 6, 159-166.

Rapaport, D. The autonomy of the ego. Bulletin of the Menninger Clinic, 1951, 15, 113-123.

Raskin, M., Johnson, G., & Rondestvedt, J. W. Chronic anxiety treated by feedback-induced muscle relaxation: A pilot study. Archives of General Psychiatry, 1973, 28, 263-266.

Ray, W. J. The relationship of locus of control, self-report measures, and feedback to the voluntary control of heart rate. Psychophysiology, 1974, 11, 527-534.

Reeves, J. L., & Shapiro, D. Biofeedback and relaxation in essential hypertension. International Review of Applied Psychology, 1978.

Reinking, R. H., & Kohl, M. Effects of various forms of relaxation training on physiological and self-report measures of relaxation. Journal of Consulting and Clinical Psychology, 1975, 43, 595-600.

Roberts, A. H., Kewman, D. G., & MacDonald, H. Voluntary control of skin temperature: Unilateral changes using hypnosis and feedback. Journal of Abnormal Psychology, 1973, 82, 163-168.

Roberts, A. H., Schuler, J., Bacon, J. G., Zimmerman, R. L., & Patterson, R. Individual differences and autonomic control: Absorption, hypnotic susceptibility, and the unilateral control of skin temperature. Journal of Abnormal Psychology, 1975, 84, 272-279.

Roberts, A. H., & Tellegen, A. Ratings of "trust" and hypnotic susceptibility. International Journal of Clinical and Experimental Hypnosis, 1973, 21, 289-297.

Roessler, R. Personality, psychophysiology, and performance. Psychophysiology, 1973, 10, 315-327.

Roth, R. S. The effects of expectancy and incentive in EMG feedback training. Unpublished masters thesis, University of North Dakota, 1975.

Roth, R. S. Experience Inventory. Unpublished questionnaire, University of North Dakota, 1976.

Roth, R. S. The relationship between absorption and measures of attention. Unpublished study, University of North Dakota, 1977.

Rotter, J. B. Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs: General and Applied, 1966, 80 (Whole No. 609).

Rupert, P. A., & Holmes, D. S. Effects of multiple sessions of true and placebo heart rate biofeedback training on the heart rates and anxiety levels of anxious patients during and following treatment. Psychophysiology, 1978, 15, 582-590.

Sarason, I. G. Anxiety and self-preoccupation. In I. G. Sarason & C. D. Spielberger (Eds.), Stress and anxiety (Vol. 2). New York: Wiley & Sons, 1975.

Schwartz, G. E. Biofeedback as therapy: Some theoretical and practical issues. American Psychologist, 1973, 28, 666-673.

Schwartz, G. E. Biofeedback, self-regulation, and the patterning of physiological processes. American Psychologist, 1975, 63, 314-324.

Schwartz, G. E., & Johnson, H. J. Affective visual stimuli as operant reinforcers of the GSR. Journal of Experimental Psychology, 1969, 80, 28-32.

Shapiro, D. Operant-feedback control of human blood pressure: Some clinical issues. In P. A. Obrist (Ed.), Cardiovascular Psychophysiology. Chicago: Aldine, 1974.

Shapiro, D., & Schwartz, G. E. Biofeedback and visceral learning: Clinical applications. Seminars in Psychiatry, 1972, 4, 171-184.

Shapiro, D., & Surwit, R. S. Learned control of physiological function and disease. In H. Leitenberg (Ed.), Handbook of behavior modification and behavior therapy. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976.

Shapiro, D., & Surwit, R. S. Biofeedback. In O. F. Pomerleau & J. P. Brady (Eds.), Behavioral medicine: Theory and practice. Baltimore: Williams & Wilkins, 1979.

Shapiro, D. H., Jr., & Zifferblatt, S. M. Zen meditation and behavioral self-control: Similarities, differences, and clinical applications. American Psychologist, 1976, 31, 519-532.

Shor, R. E. The frequency of naturally occurring hypnotic-like experiences in the normal college population. International Journal of Clinical and Experimental Hypnosis, 1960, 8, 151-163.

Shor, R. E., Orne, M. T., & O'Connell, D. N. Validation and cross-validation of a scale of self-reported personal experiences which predicts hypnotizability. Journal of Psychology, 1962, 53, 55-75.

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

Spanos, N. P., & McPeake, J. D. The interaction of attitudes toward hypnosis and involvement in everyday imaginative activities on hypnotic susceptibility. American Journal of Clinical Hypnosis, 1975, 17, 247-252. (a)

Spanos, N. P., & McPeake, J. D. Involvement in everyday imaginative activities, attitudes toward hypnosis, and hypnotic suggestibility. Journal of Personality and Social Psychology, 1975, 31, 594-598. (b)

Spanos, N. P., Rivers, S. M., & Gottlieb, J. Hypnotic responsivity, meditation, and laterality of eye movements. Journal of Abnormal Psychology, 1978, 87, 566-569.

Stephens, J. H., Harris, A. H., & Brady, J. V. Large magnitude heart rate changes in subjects instructed to change their heart rates and given exteroceptive feedback. Psychophysiology, 1972, 9, 283-285.

Sternbach, R. Principles of psychophysiology. New York: Academic Press, 1966.

Stoyva, J. M. Biofeedback techniques and the conditions for hallucinatory activity. In F. J. McGurgan & R. A. Schoonover (Eds.), The psychophysiology of thinking. New York: Academic Press, 1973.

Stoyva, J. M., & Budzynski, T. H. Cultivated low arousal--An anti-stress response? In L. V. DiCara (Ed.), Limbic and the autonomic nervous systems. New York: Plenum, 1974.

Strupp, H. H., & Bergin, A. E. Some empirical and conceptual bases for coordinated research in psychotherapy: A critical review of issues, trends, and evidence. International Journal of Psychiatry, 1969, 7, 18-90.

Surwit, R. S. Warming thoughts for a cold winter. Psychology Today, 1978, 12, 112.

Surwit, R. S., & Keefe, F. J. Frontalis EMG feedback training: An electronic panacea? Behavior Therapy, in press.

Surwit, R. S., Shapiro, D., & Feld, J. C. Digital temperature autoregulation and associated cardiovascular changes. Psychophysiology, 1976, 13, 242-248.

Surwit, R. S., Shapiro, D., & Good, M. I. A comparison of cardiovascular biofeedback, neuromuscular biofeedback, and meditation in the treatment of borderline hypertension. Journal of Consulting and Clinical Psychology, 1978, 46, 252-263.

Taft, R. Peak experiences and ego permissiveness: An exploratory factor study of their dimensions in normal persons. Acta Psychologia (Amst.), 1969, 29, 35-64.

Taft, R. The measurement of the dimensions of ego permissiveness. Personality: An International Journal, 1970, 1, 163-184.

Tarler-Benlolo, L. The role of relaxation in biofeedback training: A critical review of the literature. Psychological Bulletin, 1978, 85, 727-755.

Tellegen, A., & Atkinson, G. Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility. Journal of Abnormal Psychology, 1974, 83, 268-277.

Thorkelson, K. The relationship between hypnotic susceptibility and certain personality, physiological, and electroencephalographic variables in monozygotic and dizygotic twin pairs. Unpublished doctoral dissertation, University of Minnesota, 1973.

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, 32, 598-601.

Van Nuys, D. Meditation, attention, and hypnotic susceptibility. International Journal of Clinical and Experimental Hypnosis, 1973, 21, 59-69.

Wallace, R. K. Physiological effects of transcendental meditation. Science, 1970, 167, 1751-1754.

Wallace, R. K., Benson, H., & Wilson, A. I. A wakeful hypometabolic physiologic state. American Journal of Physiology, 1971, 221, 795-799.

Wickramasekera, I. On the apparent intrusion of a recurring nightmare into an EMG feedback training procedure. In I. Wickramasekera (Ed.), Biofeedback, behavior therapy and hypnosis. Chicago: Nelson-Hall, 1976.

Wilder, J. The law of initial value in neurology and psychiatry: Facts and problems. Journal of Nervous and Mental Disease, 1956, 125, 73-86.

Wilkins, W. Desensitization: Social and cognitive factors underlying the effectiveness of Wolpe's procedure. Psychological Bulletin, 1971, 76, 311-317.

Wilkins, W. Expectancy of therapeutic gain: An empirical and conceptual critique. Journal of Consulting and Clinical Psychology, 1973, 40, 69-77.

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

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.

Wolpe, J. The practice of behavior therapy. New York: Pergamon Press, 1973.

Yorkston, N. J., & Sergeant, H. G. A simple method of relaxation. Lancet, 1969, 2, (634), 1319-1321.

Yulis, S., Brahm, G., Charnes, G., Jacard, L. M., Picota, E., & Rutman, F. The extinction of phobic behavior as a function of attention shifts. Behavior Research and Therapy, 1975, 13, 173-176.