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A COMPARISON OF ELECTROMYOGRAPHIC FEEDBACK AND PROGRESSIVE RELAXATION IN TRAINING FRONTALIS AND FOREARM MUSCLE RELAXATION

by

Denise Ann Dommers

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Master of Arts

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Denise Ann Dommers

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INTRODUCTION

It is known that therapeutic relaxation in various forms has been practiced since antiquity. Earlier relaxation therapy took the form of meditation and was a major component of religious activity. More recently techniques have been designed in which relaxation is utilized as a medical therapy tool. More specifically, autogenic training and progressive relaxation are two relaxation methods that were developed in the early 1900's by H. H. Schultz and Edmund Jacobson respectively for the purpose of treating their patients suffering from extreme tension and tension-related illnesses. The success of these therapies has been documented (Jacobson, 1957; Luthe, 1969).

Research on cats enabled Hess (1957) to find a brain mechanism for relaxation and to study the covariance of bodily responses related to this mechanism. Hess found that an area of the brain located in the anterior hypothalamus and extending to the supra and pre-optic areas, septum and inferior lateral thalamus, upon electrical stimulation produced decreased tonus of skeletal musculature, decreased blood pressure, decreased respiratory rate and pupil constriction. Termed the trophotrophic response, Hess established relaxation as an integrated hypothalamic response which results in generalized decreased sympathetic nervous system activity and perhaps also increased parasympathetic activity. The author believed that the relaxation response was the antithesis of Cannon's "emergency reaction", popularly known as the "fight or flight" response, yet just as much a defense mechanism as

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the latter. In his own words "we are actually dealing with a protective mechanism against overstress belonging to the trophotropic-endophylactic system and promoting restorative processes" (p. 40).

The bodily responses composing the relaxation response observed in man concur with those reported by Hess in the cat. Investigators have found that during the practice of transcendental meditation the following responses occur: decreases in oxygen consumption, carbon-dioxide elimination, heart rate, respiratory rate, and arterial blood lactate and increases in skin resistence and intensity of slow alpha waves (Wallace & Benson, 1972; Wallace, Benson & Wilson, 1971). Muscle tonus, not yet measured in transcendental meditation, has been shown to decrease in progressive relaxation and autogenic training (Jacobson, 1938; Luthe, 1969). Such physiologic changes are characteristic of generalized decreased sympathetic nervous system activity and are distinctively different from the conditions of quiet sitting or sleeping (Benson, Beary, & Carol, 1974).

It has thus been established that relaxation is a response which manifests itself in several physilogic changes, one of which is decreased muscle tonus. It has also been shown that progressive relaxation is an effective therapy in the treatment of stress and its related syndromes. Electromyographic (EMG) feedback is a relatively new technique for producing muscle relaxation, and is designed to treat minute changes in muscle tension as responses and bring muscle activity to desired target levels by means of operant conditioning techniques (Budzynski & Stoyva, 1969; Davidson & Krippner, 1972). It is the

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purpose of the present study to compare the relative effectiveness of a progressive relaxation technique and EMG feedback on producing the relaxation response as measured by muscle activity of frontalis and forearm muscles.

Progressive relaxation was developed by Edmund Jacobson in the early 1900's. On the premise that anxiety and muscle relaxation produce opposite physiological states and are therefore incompatible, he proposed that a therapy producing deep relaxation would be effective in treating various anxiety-related syndromes. Jacobson (1938) sharply distinguished between ordinary rest associated with such leisure activities as golfing, listening to music or reclining quietly and "clinical" or "scientific" relaxation. In the former, skeletal and smooth muscles relax partially but not fully. The remaining activity of the muscles results in varying degrees of tonus which, in turn, indicates energy expenditure, the opposite of real rest. Relaxation in the clinical sense is the end product of a long learning process in which the patient is able to voluntarily decrease muscular tension considerably below his/her prior normal resting levels. This process, which Jacobson termed progressive relaxation, consists of a series of muscular movements, originally called "tensions", which the patient performs on a regular schedule. These tensions may be more simply described as tensing and relaxing exercises which involve a limited number of muscle groups at a time. For example, a patient is seated in an easy chair with his/her arms supported on the arms of the chair and is instructed to bend his/her right hand back and then rest it in the forward position

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again. Jacobson refrained from calling these movements "exercises", however, since he believed that exercise was exclusively muscular contraction, the very opposite of relaxation, and therefore considered the terminology "relaxation exercises" highly contradictory.

It was presumed that the function of these tensions was to familiarize the patient with the "control sensation" of each movement in such a way as to teach the patient to "run" his/herself properly relaxed under all conditions. The control sensation refers to muscular kinesthetic feedback. The patient is taught that the control sensation provides a gross indication of energy expenditure. Thus, familiar with the "feeling" of the varying degrees of contraction, the patient, with extensive practice, learns to run his/herself most economically, i.e., with the minimum of energy to accomplish his/her task. No objective measure of muscle tension is involved in this procedure. The therapist observes and directs the series of tensions the patient performs, often instructing the patient to notice the difference between the control sensations and "strain signals" or joint kinesthetic feedback. As it appears, this therapy seems as if its effectiveness may lie with the power of suggestion, yet Jacobson (1967) emphasizes that this is clearly not the case: "he the [the S] should learn this for himself through his own powers of observation, rather than be told. We wish to stay away from any procedure related to suggestion, always remembering that our aim is to cultivate independence, even independence from the doctor himself. This is the essence of good teaching" (p. 136).

Progressive relaxation may proceed very gradually, concentrating

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on one muscle group each day of therapy, or it may be accomplished by covering several muscle groups in one session if the therapist is limited to a small number of sessions. Results tend to be more lasting, however, when enough time is available and the gradual approach is taken. In fact, the duration of most clinical application of progressive relaxation by Jacobson has been in the 10 to 20 month range (Jacobson, 1970). The extended time involvement for success is a noted disadvantage of this type of therapy (Edelman, 1970).

Two problems are inherent in this method (Budzynski & Stoyva, 1969). First, "how does the therapist actually know whether muscular relaxation is present or not" (p. 231)? Jacobson (1967) stated:

> there is only one way to be sure that a patient is really relaxed, and this requires electrical measurement. No one can know whether a patient is really relaxed or to what extent he is tense unless electrical measurements are made. The facts are simple, just as the doctor needs to use a thermometer to determine the temperature of a patient.
>
> Although accurate thermometers are currently supplied by manufacturers, the same cannot be said for electromyographs. Those sold commercially fail to measure action potentials of low voltage such as must be recorded to detect tonus in a person lying at rest. (p. 19)

Therefore, the "usual way is for the patient to signal that he is relaxed. However, the demand characteristics of a therapy situation are such that the patient is likely to report relaxation even in its absence" (p. 231). Secondly, what is the plight of the patient who "experiences difficulty in learning deep muscle relation" (pp. 231-232)? It is often the case that a subject is unable to determine if a particular muscle is tense or relaxed. It is also difficult for the therapist to accurately judge the state of relaxation of the patient's

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muscle. Consequently, learning control of muscle relaxation may be slow, as Jacobson's work has documented, or not present at all.

EMG feedback is a relatively new technique through which these problems in relaxation training may be eliminated. In this method, the electrical activity of muscles is detected by electrodes, amplified and transduced and is fed back in analog form to the subject in an auditory and/or visual mode. In essences, the subject is placed in a closed feedback loop where information concerning his/her muscular status is continually made known to him/her. As an example, assume that a given level of muscle activity is present and that changes relative to this level are responses. Further assume that relaxation is being trained; that is, a change to a lower level is a correct response, while a change to a higher level is an incorrect response. The frequency of a tone is made to correlate with the level of muscle tension: at high levels of tension the frequency is high and at low levels of tension the frequency is low. When a low criterion tension is reached, the tone is turned off. The subject is informed that the object is to lower the pitch and turn off the tone. It is assumed that a change to a lower frequency or the offset of the tone and silence thus acts as positive reinforcer. The onset of the tone or an increase in frequency acts as a punisher. Lower levels of tension may be shaped by changing the criterion so that the tone will cease at a lower level than required previously. This method, then, quite clearly embraces two operant conditioning principles: reinforcement and shaping target behavior via reinforcement of successive approximations.

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EMG feedback is but one branch of a larger more diverse area known as biofeedback. In biofeedback, information concerning the status of any one of a number of physiological events is fed back to the subject. The development of biofeedback is primarily a result of three recent events. The first is a change in conceptual thinking. A distinction has been perpetuated between two types of behavior: operant and respondent, the former mediated by the cerebrospinal nervous system and the latter, by the autonomic nervous system. This dichotomy, first emphasized by Skinner (1938), has its roots in early philosophy. Plato stated that "reason" controlled voluntary skeletal responses and that "emotions" governed glandular and visceral activity. He believed a "superior rational soul" was located in the head, while a group of "inferior souls" comprised the body. Consistent with his theory was the distinction made by Bichat (cited in Miller, 1969a), the eminent French neuronatomist, between the cerebrospinal nervous system, made up of the brain and spinal cord, and the dual chain of ganglia he called "little brains" running down either side of the spinal cord. The former controlled voluntary skeletal responses while the latter were responsible for visceral activity. He labeled the ganglionic system "vegetative". Current learning texts reflect these early ideas by stating that autonomically mediated responses are modifiable only through the limited respondent paradigm, while voluntary responses are subject to change via the more powerful operant conditioning method. Recently a vast amount of data has been reported which apparently refutes the theory. Using animal subjects, researchers report success in operantly conditioning changes in heart rate (DiCara &

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Miller, 1968a; Engle & Gottlieb, 1970; Miller & Banuazizi, 1968; Miller & DiCara, 1967; Trowill, 1967), blood pressure (Benson, Herd, Morse & Kelleher, 1969; Plumlee, 1969), vasomotor responses, (DiCara & Miller, 1968b), cortical activity (Wyrwicka & Sternman, 1968), intestinal contraction (Miller & Banuazizi, 1968), salivation (Miller & Carmona, 1967), and urine formation (Miller & DiCara, 1968). Similarly, researchers utilizing human subjects have reported successful attempts of operantly conditioning changes in galvonic skin response (GSR) (Fowler & Kimmel, 1962; Grings, 1965; Johnson & Schwartz, 1967; Kimmel & Baxter, 1964; Kimmel & Kimmel, 1963; Kimmel, Sternthal & Strub, 1966; Senter & Hummel, 1965; Shapiro, Crider & Tursky, 1964; Van Twyler & Kimmel, 1966), heart rate (Engle & Chism, 1967; Engle & Hansen, 1966; Shearn, 1962), and peripheral vasomotor control (Snyder & Noble, 1965, 1966).

While the above authors all have reported positive findings, many of them have been severely criticized for various shortcomings in their research which tend to make their findings invalid and/or unreliable. Such criticisms include absent or poor control groups, experimental bias effects, ignoring alternative explanations and the fact that studies were not replicable. Despite these attacks the entirety of research investigating operant control of autonomically mediated responses, in H. D. Kimmel's (1967) opinion, has perhaps shown us that "Skinner's assumption that autonomically mediated responses cannot be modified instrumentally was both premature and probably incorrect" (p. 344). In any event, the change in conceptual thinking which has resulted from

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this research has most definitely served as an essential precursor in the further development of biofeedback.

A second source responsible for the recent surge of research in biofeedback is interest in portions of the Eastern culture, more specifically Yoga and Zen meditation. For centuries eastern Yogis have been practicing meditation as a form of self control. The analogous practice in the United States is transcendental meditation, interest in which has developed only in recent years. The goal of all these practices is to facilitate relaxation and self regulation. To understand the mechanism of these practices researchers have conducted experiments using meditators and "unusual persons" as subjects. It has been stated that physiological and metabolic activity is more quiescent during meditation than during ordinary rest (Bagchi & Wegner, 1957; Wallace, 1970). Anard, Chhicia and Singh (1961) studied the electroencephalogram (EEG) alpha response of yogis and found that it was of greater duration and amplitude during meditation than during ordinary rest. They also reported that the alpha response, normally easily interrupted by extraneous stimuli, could not be blocked by various sensory stimuli during meditation. Kamiya (1968) found Zen meditators learn alpha control more rapidly than the average person. Green and Green (1975) described an individual who stuck a darning needle through his biceps with no accompanying physiological sign of pain. The subject's GSR indicated no unusual stress, thermoreceptors showed his arms were warm, (a sign of relaxation), and his EEG changed from beta to alpha as he pierced his flesh with the needle. He appeared to have acute peripheral vasomotor control as he was able to "turn off" the bleeding voluntarily when the needle was withdrawn.

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The Greens also reported that Swami Rama, an Indian Yoga, caused an electrocardiogram (EKG) signal to instantaneously change from a normal 70 beats per minute to a 300 beats per minute arterial flutter.

Finally, technological advancement has been a facilitator for biofeedback research. Modern instruments are much more accurate, inexpensive and diverse than ever before, thus providing an opportunity to more people to do research in this area.

Purely experimental applications of biofeedback have shown feedback to be effective in training vasomotor responses (Lisina, 1965), heart rate increases and decreases (Brener & Hothersall, 1966, 1967; Hnatiow & Lang, 1964), electroencephalogram alpha control (Brown, 1970; Green, Green & Walters, 1970; Honorton, Davidson & Bindler, 1971; Kamiya, 1968; Nowlis & Kamiya, 1970), and peripheral temperature control (Green, et al., 1970). When clinically applied, feedback has been used with some success in a number of areas. Electroencephalogram feedback has made progress in decreasing frequency of epileptic seizures (Johnson & Meyer, 1975), and in reducing latency of sleep onset in insomnia sufferers (Sittenfield, 1972). Electrocardiogram feedback has shown promise in correcting various cardiac arrhythmias (Engel & Bleeker, to be published; Prigatano & Johnson, 1972; Scott, Peters, Gillespie, Blanchard, Edmunson & Yoing, 1973; Wiess & Engel, 1971), and in controlling hypertension (Benson, Shapiro, Tursky & Schwartz, 1971; Elder, Ruiz, Deabler & Dillenkoffer, 1973; Miller, 1972). Temperature training has been effectively utilized in patients' preventing and eliminating migraine headaches (Adler & Adler, 1975; Peper, 1973; Sargent, Green

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& Walters, 1972, 1973; Wickramasker, 1974), and in curing symptoms of Raynaud's disease (Schwartz, 1972).

Conspicuously absent in the preceding summary has been electromyographic (EMG) research. Unlike the other areas, EMG feedback does not modify autonomically mediated behavior. Rather, the striate muscle responses are modified and these are innervated by the cerebrospinal system. The responses in question are of such minute magnitude, however, that people normally have no control over them. No "conscious discrimination" can be made by the subject within this covert realm of muscle activity. Behaviorally, this means the subject cannot "tact", or identify such a response (Skinner, 1957). For example, one can easily tact a gross motor response such as arm waving. In contrast, minute changes in muscle activity which do not result in movement or muscle tone are not usually discriminable and one is unable to tact them.

Hefferline and Perera's (1963) work on covert muscle contraction in the thumb exemplified this type of response. The authors presented a tone immediately following a minute twitch of a muscle in the subject's thumb. The subject was asked to report the tone by pressing a key with his/her right index finger. The subject was not told the objective, but simply to press the key each time he/she heard the tone. After several sessions, the intensity of the tone was gradually diminished until it was no longer presented. The subject continued to respond in the absence of the tone to 72% of the thumb twitches and 80% of the total key presses correctly reported the occurrence of a prior

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twitch. The authors summarized these findings as follows: "we had in effect, succeeded in teaching the subject a discrimination at what might be called the 'animal level'. It was clearly not a 'conscious' discrimination. Although we would say that a subject had learned to discriminate thumb-twitches, when questioned after the experiment, the subject who had never been told anything other than to respond to tones explained that he continued to press the key because he still heard the tone" (p. 61). In an earlier study, Hefferline, Keenan and Hartford (1959) utilizing negative reinforcement for the same response, came to the conclusion that, while the conditioning procedures used were operant, the responses were not correctly tacted by the responding subject. In fact, the one "group which had been informed that the effective response was a tiny twitch of the left thumb...kept so busy producing voluntary thumb-twitches that the small reinforceable type of response had little opportunity to occur" (pp. 1338-1339).

In a different type of electromyographic study, Basmajian (1963) taught human subjects to gain voluntary control of single motor units (SMU). An SMU is defined as a spinal anterior horn cell, its axon, and the muscle on which the terminal branches of the axon end. To achieve the desired result the author implanted bipolar fine-wire electrodes in or near the muscle fibers and fed back to the subject both an auditory signal and a visual display which traced the unit's activity. With practice, subjects were able to produce "various gallop rhythms, drum beat rhythms, doublets, and roll effects" (p. 441). The author feels that with the aid of feedback "pathways from the

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cerebral cortex can be made to stimulate single anterior horn cells while neighboring anterior horn cells remain dormant or depressed" (p. 441).

Clinical studies utilizing EMG feedback are much more plentiful and diverse. The retraining of muscles in paralyzed patients is the most sound research done in all the biofeedback literature. Patients with hemiplegia (Andrews, 1964; Booker, Rubow & Coleman, 1969; Brudny, Korien, Grynbaum, Friedman, Weinstein, Sachs-Frankel & Belandres, 1976; Brudny, Korien, Levidow, Grynbaum, Liederman & Friedman, 1974; Galvin & Stephen, 1976; Johnson & Garton, 1973), quadraplegia (Brudny, et al., 1974; 1976), paraplegia (Galvin & Stephen, 1976), and spasmodic torticollis (Brudny, Grynbaum & Korien, 1974; Brudny, et al., 1976; Cleeland, 1974) have all recovered significantly using feedback after long periods of no improvement with traditional physical therapy. Successful speech and motor rehabilitation in spastic cerebral palsy children using EMG feedback has been reported by Findley, Ninman, Stanley and Wansley (1976). In a related vein, Webb (1974) found EMG feedback helpful in teaching facial expressions to the blind. Another area in which feedback has proven to be therapeutically significant is the elimination of subvocalization during reading (Aarons, 1971; Hardych & Pentrinovitch, 1969; Hardych, Pentrinovitch & Ellsworth, 1966). Relief from tension headaches in patients has been popularly reported (Budzynski, Stoyva & Adler, 1970, 1973; Epstein, Hersen & Hemphill, 1974; Wickramasekera, 1972). Hanna, Wilfling and McNeill (1975), discovered that feedback from laryngeal muscle tension dramatically reduced stuttering in an

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exploratory case study. Researchers conclude that EMG feedback is an important adjunct therapy in the treatment of chronic anxiety (Gallon & Padnes, 1976; Townsend, House & Addario, 1975), and in the control of hyperactivity (Braud, 1976; Braud, Lupin & Braud, 1975). Finally, a lone case of electroocularg ram (EOG) feedback reported by Bullard, Doerr and Varni (1972) described "essentially full recovery" from essential blepharospasm, an involuntary spasm of the eye and associated musculature.

More pertinent to this thesis however is the previous research directly comparing the progressive relaxation technique with EMG feedback in training relaxation. In a single session design, Haynes, Moseley and McGowan (1975) compared the progress of normal subjects in terms of frontalis EMG change from baseline (microvolts). Subjects were divided into five groups: 1. frontalis EMG feedback (variable frequency auditory feedback), 2. relaxation A, consisting of passive relaxation instructions to attend to and relax muscles, 3. relaxation B, consisting of active tensing and relaxing exercises, 4. false feedback, and 5. no treatment control. A baseline of 5.6 minutes was immediately followed by instructions specific to the five groups. Following this, a 20 minute experimental phase ensued, structured according to the particular group. It was during this experimental phase that data were recorded and subjects practiced their prescribed relaxation technique. The feedback signal was a continuous one, a high pitched tone representing high ENG activity and a low pitched tone, lower EMG activity. The experimenter controlled the

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range of EMG activity over which the tone sounded full scale. As a subject mastered one level of relaxation, as demonstrated by the continuous low pitched tone, the experimenter increased the pitch to the middle of the frequency range and altered the contingencies such that the subject was required to relax still further in order to reduce the pitch to the previous low level. Thus, successive approximations were reinforced, shaping the subject to the lowest level of muscle activity possible for that particular individual. The Jacobson relaxation instructions consisted of alternate muscle tensing and relaxing exercises. Attention was initially focused on specific musle groups and ended with suggestions of total body relaxation. The comparative effectiveness of the various procedures was assessed by an analysis-of-covariance on change score with baseline level as the covariate. Results showed that "biofeedback was the most effective procedure in reducing EMG level...Relaxation B and control were not differentially effective in reducing EMG level" (p. 549). Also an A-test showed that "biofeedback and relaxation A resulted in significant EMG changes and that the other procedures did not result in a statistically significant change in EMG level" (p. 550). The statistics, however, do not tell the whole story. A graph plotting the averaged data of each group across time shows the active relaxation group was significantly above baseline throughout the experimental session until the last three minutes. At this point, the data points dropped below baseline. Curiously enough, this drop in muscle activity corresponded with the summary portion of the relaxation tape during which all exercises

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ceased and total body relaxation was suggested. In essence, this study compared muscular tension produced by low level contingent feedback with that present during actual exercise! The validity of this experiment may thus be seriously questioned. Finally, the one-session design tested exclusively for the immediate effects of the techniques. The strength of the various methods in terms of duration of obtained effects is unknown.

In another study Reinking and Kohl (1975) explored the differences in frontalis relaxation among five groups of normal subjects differing by training procedure: 1. classic Jacobson-Wolpe instructions, 2. EMG feedback, 3. EMG feedback plus Jacobson-Wolpe instruction, 4. EMG feedback plus monetary reward, and 5. no treatment control. These authors ran a total of 15 one-hour sessions, the first three serving as baseline recording periods. For the classical relaxation training group, each treatment session opened with a 12 minute tape "containing a combination of Jacobsön and Wolpe's instructions focusing on facial relaxation. Once the tape was finished the subjects were told to practice relaxing while their EMG level was monitored" (p. 596). This author is uncertain as to whether subjects continued to proceed with the exercises or remained still during the "practice relaxing" period. All subjects in the feedback groups chose between auditory or visual feedback, on the basis of which modality they felt most comfortable with. Instructions to the feedback group were simply to relax and "keep the feedback within a certain range" (pp. 596-597). The same instructions held for the feedback plus monetary reinforcement group

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with the addition that they were told that they would earn a dollar for each 20% decrease in action potential level from the previous session. The feedback plus relaxation training group first listened to the Jacobson-Wolpe tape and then practiced the exercises using feedback to tell them how successful their relaxation attempts were. Data were apparently recorded for 15 minutes during the actual feedback periods. A time table of session administration was not given. A group-by-sessions analysis-of-variance-repeated-measures design showed statistically significant effects for group, trials, and group-by-trials. The authors state "All groups reported increased relaxation, but EMG measures showed that in speed of learning and depth of relaxation the EMG groups were superior to the Jacobson-Wolpe group" (p. 595). However, the relaxation instruction group followed exercises that focused on facial relaxation. It is not known if the exercises were restricted exclusively to the facial area or were concentrated there although other muscles were involved. The absence of total body involvement could decrease the effectiveness of the relaxation instruction method.

A group of psychiatric patients diagnosed as anxiety neurotics served as subjects in a final study. Canter, Kondo and Knott (1975) compared EMG feedback with a modified form of Jacobson's progressive relaxation in decreasing frontalis muscle tension. The number of training sessions was dependent upon the patients stay in the hospital and ranged from 10 to 25 for the total subject population. Six sessions were given in the first ten days, with subsequent sessions at one week

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intervals for out-patients. In-patients received from three to four training sessions per week during their stay in the hospital. Sessions for both groups lasted 40 minutes with the first half-period devoted exclusively to adaptation to the lab. The last 20 minutes were used as training time. Feedback instructions were to get comfortable, close the eyes and listen to the pitch of the tone. The subject was told "to find a way (mentally or physically) to make the tone lower and keep it low" (p. 472). The progressive relaxation group followed a modified form of Jacobson's technique which consisted of concentrating on certain areas of the body rather than active tensing and relaxing exercises. The therapist made such suggestions as "relax", "let the tension out", and "try to let it go" (p. 472) during the therapy period. The first and last five minutes of each training session were recorded to compare within session progress. In addition, comparisons were made between the first five minutes of the first session and the first five minutes of the last session. When comparing tension level during the very first training session the authors stated "it can be seen that only the feedback groups showed significant drops in tension level during the initial training session" (p. 474). The overall view of the data "reveals that by the final training session the feedback group as a whole showed significantly lower tension than did the progressive relaxation group" (p. 475). However, multiple _t_-tests for paired observations were used exclusively in data analysis. This has been cited as presenting a problem (Kirk, 1968, pp. 77-78) in that the probability of making a type 1 error is increased. An analysis-of-variance or a

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multiple comparisons test designed to adjust alpha (probability) for the collection of tests would handle the data with less chance of spurious results.

The preceding three studies have unanimously indicated the superiority of feedback over progressive relaxation in producing deep relaxation of the frontalis muscle during therapy. However, to be of practical value, a good therapy must nurture independence from the therapeutic procedure, and be able to produce long term effects, two aspects which the present study investigated. Finally, the frontalis muscle has long been the recording site of relaxation literature because it has been theorized that it is highly correlated with tension levels in other areas of the body (Jacobson, 1970; Stoyva & Budzynski, 1974), and has proven to be the most difficult muscle group to relax (Budzynski & Stoyva, 1969). In this thesis, the forearm musculature made a debut in feedback relaxation therapy and was simultaneously recorded from along with frontalis activity.

The auditory signal used in this study was unlike those used in other studies in two ways: 1. it was discontinuous, and 2. it was a mixed product of 75% input from the frontalis and 25% input from the forearm. Regarding the first point, one frequency of a tone continuously traced muscle activity while it remained at criterion level or above; however, it ceased immediately upon a drop in activity below the criterion and in this sense it was discontinuous. It was proposed that the specificity of the discontinuous tone would act as a more powerful reinforcer than the hovering of a low frequency tone, since in

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the latter case, no definite goal response is required. Shaping was employed by lowering the criterion activity level following the subject's mastery of the previous higher level. Based on the operant tactics used in feedback therapy, and the absence of any objective measure of muscle responses and reinforcement thereof in the progressive relaxation group, it was hypothesized that the feedback group would attain lower levels of muscle activity for both electrode sites and would demonstrate greater longevity of effects when compared to the progressive relaxation group. Finally, because of the unequal inputs of the frontalis and forearm muscles into the signal, the contingencies arising from this led to the last hypothesis that decreases in frontalis muscle tension from baseline would be greater than decreases of the forearm tension from baseline for the feedback group.

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METHOD

Subjects

Ten Western Michigan University students, five men and five women ranging in age from 18 to 29 years old (mean age: 23.9) served as subjects. Six subjects were enrolled in the Introductory Psychology class and received bonus points for volunteering to participate. The remaining four subjects were randomly selected from a general population of students that expressed an interest in the project. One female subject was dropped from the study as she failed to follow instructions, was usually late reporting to the lab, and missed the final session entirely. The study is based on the results of the remaining nine subjects.

EMG Recording and Programming Apparatus

Training and recording were performed in a dimly lighted room equipped with the EMG recording and feedback apparatus, a comfortable easy chair, a pillow, and a foot stool. The chair was turned to an approximate angle of 45° away from the equipment. This orientation prevented the subjects from watching the data displays and allowed the experimenter to observe the subject. Temperature in the room was kept constant at $70 \pm 1^{\circ}$ F. The room, located in a basement, was isolated but was not sound attenuated. The experimenter was in the room at all times.

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All apparatus was made by Med Associates unless otherwise stated. Three Cyborg stainless steel collar type electrodes, electrode surface 1.5 cm in diameter, were affixed by double-sided adhesive discs to the forehead. Placement of the active electrodes was two inches on either side of an imaginary line drawn vertically from the nasion to the hairline and one inch above the crest of each eyebrow. The reference electrode was placed directly between the two active electrodes. Three Med Associates stainless steel electrodes, electrode surface 1.0 cm in diameter, were similarly affixed to the preferred forearm (i.e., right arm for right handers and left arm for left handers). The first active electrode was placed at a point one third of the distance from the lateral humeral epicondyle to the styloid process of the ulna. The second active electrode was placed at a point two inches in the distal direction along the same line. Both of these sites were ones of maximum visible and/or palpable contraction with extensor movement of the middle finger. The reference electrode was placed on the bony area of the elbow. The skin surface was prepared by briskly rubbing it with an abrasive fiber pad followed by wiping it with isopropyl alcohol soaked 2 by 2 inch Johnson & Johnson cotton squares until no trace of dirt was left on the square. The electrodes were filled with Redux electrode paste. Maximum acceptable skin resistence was 10 kileohms. Resistence was measured at least five minutes after the electrodes were in place to assure that the paste had sufficiently absorbed into the skin.

Forearm and frontalis muscle activities were amplified to 10,000

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total gain by Physiological Amplifiers (ANL 100). The amplified signals were then fed into EMG Couplers and Integraters (ANL 140) which were set at a low frequency cut-off of 90 Hz. The time constant was set at a sampling speed of 3,000 milliseconds. The integrated signals were fed to the Analog Mixer (ANL 137) where 75% of the frontalis muscle activity and 25% of the forearm muscle activity were combined. A Voltage Controlled Oscillator and Audio Amplifier (ANL 910) unit driven by an IRIG signal (± 1.4 volts full scale) produced the auditory feedback signal. The Voltage Controlled Oscillator (VCO) portion produced an increase in signal frequency as a function of increased input voltage. The total frequency range was 100-500 Hz. A 10-turn precision calibrator, contained in the VCO, allowed the experimenter to control the range of muscle activity over which the IRIG signal would drive full scale. The Audio Amplifier portion provided .5 watts of power at the speaker jack which was sufficient power for a large room. Signal volume was set and remained constant at a comfortable level which was individually determined for each subject. The mixed signal passed from the Analog Mixer into a Dual Threshold Comparator (ANL 300) which allowed the experimenter to set a criterion threshold and logic signal such that activity below the threshold would eliminate audio feedback. Analog to digital conversion was accomplished by feeding the signals into an Integrator (EEG 600) which summed the activity in a given frequency band and produced a proportional voltage level. The voltage values were displayed on an LED digital readout. The Integrator reset every 10 seconds; therefore, the average voltage for each 10-second time epoc

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was displayed. The digital values were simultaneously recorded on paper by a Digitec BCD Printer.

A Sony cassette tape recorder and blank tape were used to record progressive relaxation instructions by the experimenter. The recording was delivered to the subject as described in the progressive relaxation technique section.

Procedure

General description of sessions

Sessions 1 and 2 consisted exclusively of recording baseline data. Subjects were run individually. At the beginning of the first session the subject was told:

> This experiment is investigating two methods of training relaxation. Your muscle tension will be measured in order to compare the two techniques. To participate in this experiment, I only require that you report to the lab on time for all your sessions if possible and also that you please do not consume any depressants such as alcohol, or stimulants such as coffee, tea, or coke within three hours prior to reporting to the lab. If something comes up and you cannot make it to your session at the scheduled time, please call me.

The subject signed a release form and filled out a health form. The electrodes were then attached to the subject as described earlier and he/she was seated comfortably in the easy chair with his/her feet up on the foot stool and a small pillow available to support his/her neck if desired. The subject was then instructed: "Do not slouch or lay your head straight back, but rather assume a reasonably straight posture. Your arms should rest on the arms of the chair such that

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your entire arm, hand and fingers are supported. Please do not turn and watch the display windows." Once he/she was in position and comfortable, the subject was told: "Now remain as still as possible for 12 minutes during which I will record your muscle tension." Session 2, identical to Session 1 minus the introductory explanations and paper work, served as the second baseline session.

On the basis of baseline performance, sex, and whether the subject was an Introductory Psychology student or a general university student, subjects were divided into two matched groups. Assignment of technique of relaxation to the two groups was done by the tossing of a coin. The group receiving progressive relaxation was thereafter labeled JPR, while FDBK distinguished the feedback group.

Following the two baseline sessions, each group received six treatment sessions (3-8). The JPR group underwent six sessions of progressive relaxation exercises. The FDBK group received two sessions of progressive relaxation followed by four sessions of feedback. The feedback and progressive relaxation techniques are described below. Two post-treatment sessions (9, 10) were then recorded following the exact procedure as indicated earlier for baseline sessions. The first nine sessions were separated by one to three days. The final session, 10, was six to eight days following Session 9 and was thus designated as the one-week post-treatment session.

Possible changes in muscle tension as a function of time of day were controlled for by scheduling subjects at approximately the same time of day for each session.

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Feedback technique

Seven minutes of data were recorded prior to feedback training. The first two minutes of this pre-therapy period served as an adaptation period and data recorded during this time were discarded. An average value of muscle tension was quickly calculated from the remaining five minutes of data and was labeled the baseline average. The following instructions were then delivered to the subject:

> You will hear a tone that will trace your muscle tension. That is, the higher your muscle tension, the higher the pitch of the tone. Similarly, as you relax, the tone will decrease in pitch until the tone turns off. Do whatever you can to turn off the tone and keep it off. Periodically, I will set the threshold somewhat lower which will make it a little more difficult to turn the tone off. I will tell you when I am doing this. Just continue to relax and try to turn the tone off as I adjust it. We will be taking a brief break after about ten minutes.

The initial threshold was set at two microvolts below the subject's baseline average. The speaker system was connected. Further decreases were made in units of one to two microvolts at first and then in units as little as .25 and .50 microvolts as it became increasingly more difficult to master each new threshold. The decision as to what was difficult for the subject was a subjective one made by the experimenter based on the subject's particular style in responding to the feedback. Actual training lasted 20 minutes. A brief break, during which the subject could stretch or stand, was taken halfway through each session. This was done since pilot work suggested that the subjects become restless after ten to fifteen minutes of continuous feedback. Immediately following the training period, the speaker

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system was disconnected and data were recorded for five minutes which constituted the post-therapy period. Table I summarizes the data recording and treatment presentations of the FDBK group.

TABLE I

FDBK GROUP SCHEDULE

1	2	3	4	5	6	7	8	9	10
base-line	base-line	pre-therapy period JPR post-therapy period	pre-therapy period JPR post-therapy period	pre-therapy period FDBK post-therapy period	pre-therapy period FDBK post-therapy period	pre-therapy period FDBK post-therapy period	pre-therapy period FDBK post-therapy period	first post	one-week post

Progressive relaxation technique

The speaker system was disconnected at all times during progressive relaxation sessions. Seven minutes of data were recorded prior to progressive relaxation training. The first two minutes of this pre-therapy period served as an adaptation period and data recorded during this time were discarded. The subject was then told: "I will be reading you a series of instructions to tense and relax various muscles throughout your body. Just follow along. We will begin with your feet flat on the floor." The instructions comprising the treatment are listed below.

1. clench your right fist and hold, now relax

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clench your right fist again and hold, and relax

2. clench your left fist and hold, now relax

   clench your left fist again and hold, and relax

3. clench both fists and hold, and relax

   clench both fists again and hold, and relax

4. bend both arms at the elbows and make a muscle, hold, and relax

   bend both arms again and hold, and relax

5. stretch your arms straight out and hold, and relax

   stretch your arms straight out again and hold, and relax

6. push your eyebrows up and wrinkle your forehead, hold, and relax

7. now frown and bring the corners of your mouth and your eyebrows down and hold, now relax

8. now close your eyes tight and hold, and relax

9. clench your jaws together, bite down tightly, and relax

10. now press your tongue against the roof of your mouth and hold, now relax

11. press your lips together and hold, now relax

12. press your head back into the back of the chair, hold, and relax

13. now twist it to the right, hold and relax

14. now to the left, hold and relax

15. now bring your chin to your chest, press it in, hold and relax

16. shrug your shoulders up and hold, now drop them and relax

17. now bring your shoulders up, move them forward and hold, push them back and hold, foward and hold, back and hold and now relax

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18. inhale deeply and hold, now exhale and relax

    inhale again and hold, and exhale and relax

19. tighten your stomach muscles and hold it, and relax

    tighten your stomach muscles again and hold, and relax

20. now pull your stomach in and make a small waist, hold, and relax

    pull your stonach in one more time, hold, and relax

21. now sit away from the chair and arch your back, hold, and relax

    and arch again, hold, and relax

22. now press your heels into the ground and hold, and relax

23. now straighten your knees, hold your feet up and tighten your thighs, hold and relax

24. press your feet and toes down hard and hold, and relax

25. now hold your feet out once more and bend your toes to your face, hold and relax

Immediately following the exercises the subject's feet were placed back on the stool and the following summary was read to him/her.

Let your feet get completely relaxed...

then your ankles...

then your calves and shins...

then your knees...

then your thighs, buttocks and hips...

now your stomach, waist, and lower back...

and your upper back and shoulders...

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and then your arms, and hands, and fingers...

then your neck...

your jaws and all of your facial muscles...

take a deep breath in and let it out very slowly...

and take another deep breath in and let it out very slowly, and relax

Each command to tense a muscle group was followed by five to seven seconds of silence during which the subject held the muscle tensed. After this period, the subject was instructed to let go and relax the muscle group for 10 to 15 seconds. For example, on one occasion the experimenter said: "Clench your right fist and hold it"; then after five to seven seconds elapsed, the experimenter said: "Now relax." Ten to 15 seconds later the experimenter instructed the subject to tense the next muscle, and so on. The summary passage was read slowly, with pauses of three to five seconds following each line as indicated by the dots. Timing was accomplished with the aid of a watch with a second hand.

During the first two progressive relaxation sessions, the experimenter read the instructions and performed the exercises along with the subject. Corrective comments were added by the experimenter when necessary. For example, if the subject just closed his/her fingers in a loose grip when requested to clench his/her fist, the experimenter said: "Clench hard, really make a fist like this" and then demonstrated the required response. For the remaining four sessions, the same instructions, in the form of a recording of the experimenter's

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voice, were delivered via the tape recorder. A break was not included in this period because the procedure itself provided movement, deep breaths, and general repositioning of the subject in the chair. Data were recorded for five minutes immediately following the conclusion of the training procedure and constituted the post-therapy period. Table II summarizes the data recording and treatment presentation of the JPR group.

TABLE II

JPR GROUP SCHEDULE

Sessions

1	2	3	4	5	6	7	8	9	10
base-line	base-line	pre-therapy period ------- JPR ------- post-therapy period	pre-therapy period ------- JPR ------- post-therapy period	pre-therapy period ------- JPR ------- post-therapy period	pre-therapy period ------- JPR ------- post-therapy period	pre-therapy period ------- JPR ------- post-therapy period	pre-therapy period ------- JPR ------- post-therapy period	first post	one-week post

Measures

The 10-second epocs of integrated EMG activity were averaged for the 10-minute blocks constituting baseline and post-treatment sessions. The 10-second epocs of integrated EMG activity were also averaged for the five minute blocks of time constituting the pre-therapy and post-therapy periods of each training session. The resulting data points,

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for frontalis and forearm sites, were the measure of muscle tension in all subjects.

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RESULTS

Session 1 served as an adaptation period. When the baseline from Session 1 of the two groups are compared it is seen that FDBK and JPR do not differ significantly in initial frontalis, $\underline{t}$ (7) = 2.099, or forearm, $\underline{t}$ (7) = 0.100, levels.

Frontalis and forearm data were analyzed in a 2 by 9 repeated-measures analysis-of-variance comparing the two groups over sessions. Considering the frontalis data, no main effect for groups is revealed, F (1, 7) = 1.082, however, there is a significant main effect of sessions, F (8, 56) - 3.594, $\underline{p} < .01$. A significant group-by-sessions interaction demonstrates that the groups were differentially affected by the sessions, F (8, 56) = 2.084, $\underline{p} < .05$. In Figure 1, the averaged frontalis data of each group is plotted across sessions.

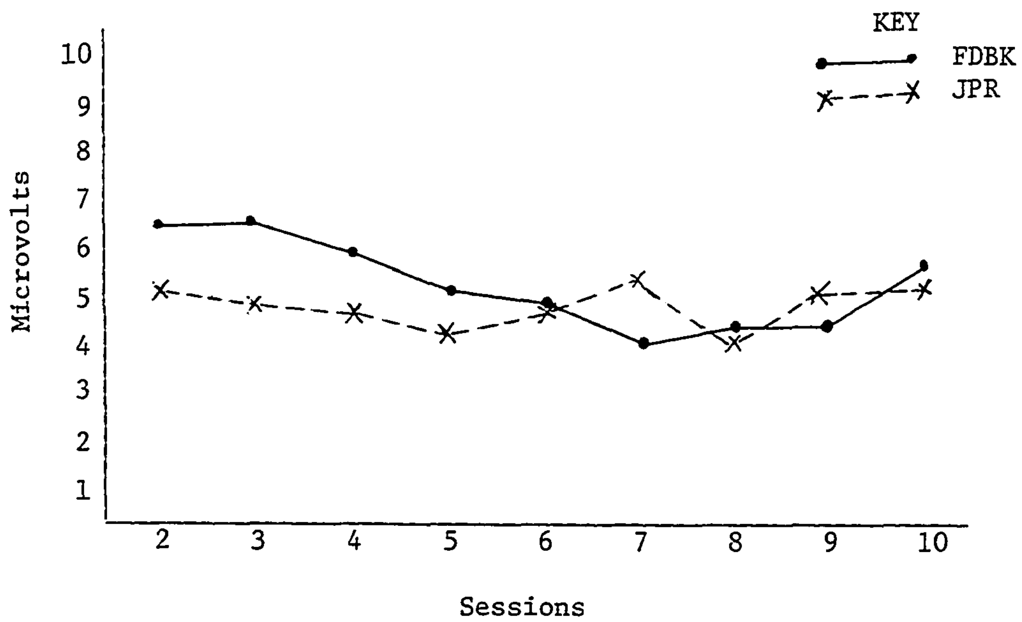

Figure 1. Averaged frontalis data across sessions.

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While no main effect is seen for groups, the significant sessions effect is seen by the general decrease in microvolts across sessions for both groups. It can be seen by the interaction that while both FDBK and JPR generally decreased muscle tension across sessions, the FDBK group displayed a comparatively greater decrease than did the JPR group.

No main effects are indicated in forearm data for groups, $\underline{F}$ (1, 7) = 0.012, or sessions, $\underline{F}$ (8, 56) = 1.794. The group-by-session interaction also proved statistically nonsignificant, $\underline{F}$ (8, 56) = 0.731. The averaged forearm data of each group is plotted across sessions in Figure 2.

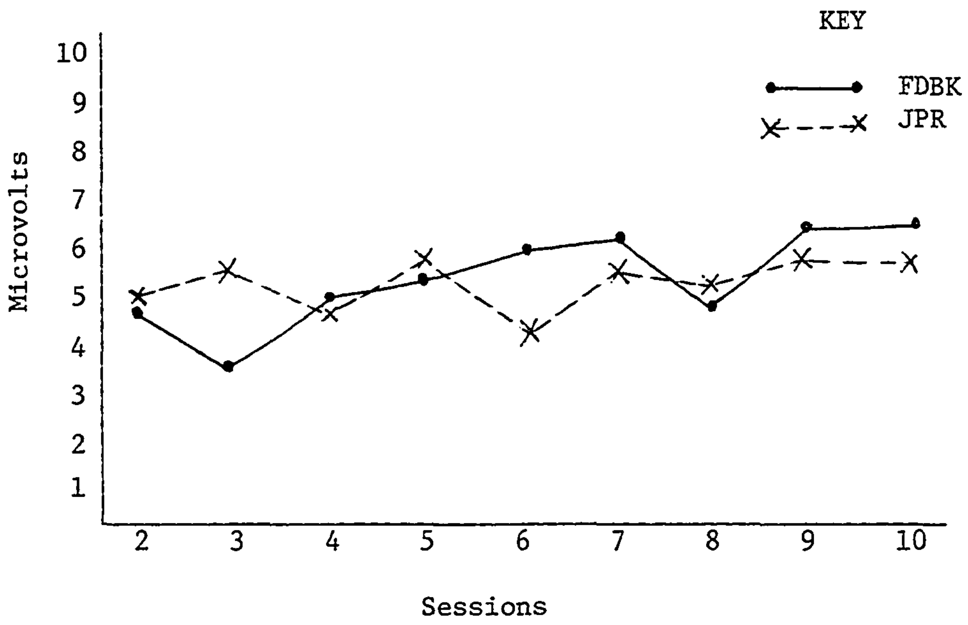

Figure 2. Averaged forearm data across sessions.

It is obvious from the close, overlapping relationship of the two lines that no significant main effect for group, or significant group-by-session interaction occurred. It appears that there was a significant effect

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of sessions, however, since the averaged data of both groups indicates an increasing trend in tension level. Statistically, significance at the .05 level was not reached, mainly due to the large error term created by great deviations in tension level from session to session by certain subjects. When the error term is large, a more dramatic effect is necessary in order for the effect to be statistically significant. That is, a greater increase in tension level over time would be necessary to obtain a significant main effect for sessions with the present within subject response fluctuation.

A y on x regression analysis of frontalis and forearm data for all subjects was performed (Schoeninger & Insko). This analysis generated a series of lines which best fit the sessions (x) versus tension level in microvolts (y) scatter plots of all subjects. The slopes of the resulting lines give an indication of the trend of tension level across sessions and are summarized in Table III.

TABLE III

SLOPES RESULTING FROM y ON x REGRESSION ANALYSIS OF FRONTALIS AND FOREARM DATA

Group	Frontalis	Forearm	Subject
FDBK	-.220	+.283	CW
	-.200	+.315	WS
	-.488	-.022	MM
	-.090	+.620	JB
	-.167	+.393	RL
JPR	+.073	+.285	PS
	-.050	+.165	JR
	-.195	+.287	FM
	+.110	-.180	HH

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It is seen that all five FDBK subjects demonstrated a general decrease in frontalis tension level over time as indicated by negative slopes. Only two of four JPR subjects produced negative slopes and the remaining two showed positive slopes indicating a general increase in muscle tension over time. The slopes comparing forearm tension progress showed the two groups to be roughly equal with only one subject out of each group having a negative slope and the rest being positive.

Longevity of the obtained effects was investigated via a dependent *t*-test analysis. Looking at the frontalis data, the FDBK group demonstrated a significantly lower tension level in the first post-session (9) than during baseline, t (4) = 4.778, $p < .01$. In the same comparison, the JPR group failed to show a significant difference from baseline, t (3) = 0.004. In a comparison of baseline to the one-week post-session (10) data, neither group reached significance, though the FDBK group exhibited a larger difference in tension level, t (4) = 2.049, than did the JPR group, t (3) = 0.000.

The forearm data of both post-sessions from the FDBK group proved to be higher, though not significantly different from baseline: t (4) = -2.775; t (4) = -2.500. The initial post-session of the JPR group also did not differ significantly from baseline, t (3) = -1.507; however, this group's one-week post-data was significantly higher than baseline, t (3) = -7.973, $p < .01$.

In this type of research, it is usually valuable to examine individual subjects' learning curves. By plotting forearm and frontalis data on the same graph it is seen that the FDBK group as a whole

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experienced a permanent inversion in tension levels of forearm over frontalis at the introduction of feedback in Session 5. A pattern developed in the FDBK group in which forearm tension levels remained below corresponding frontalis tension levels in Sessions 2-4, followed by an abrupt reversal resulting in forearm tension levels surpassing corresponding frontalis levels. This occurred by virtue of the fact that forearm levels after feedback remained higher than during pre-feedback sessions, and frontalis tension levels after Session 5 remained lower than previously, before feedback was introduced. Figures 3-7 illustrate this phenomenon, with Subject CW (Fig. 7) being the only gross exception to the pattern.

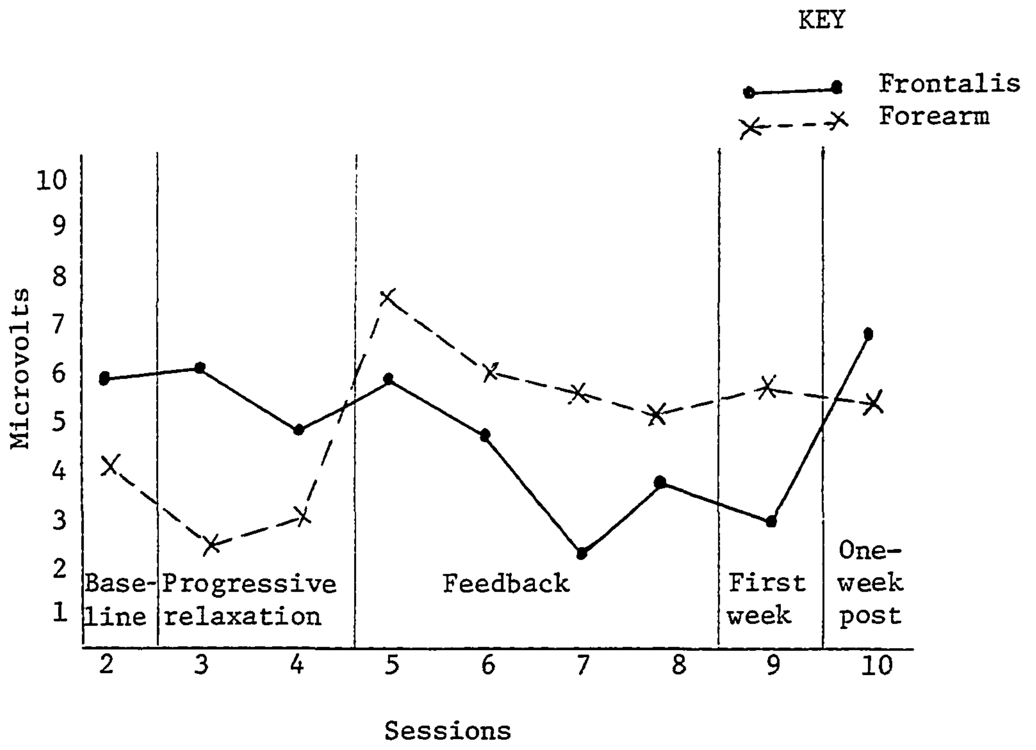

Figure 3. Group: FDBK. Subject: WS. Averaged frontalis and forearm data across sessions.

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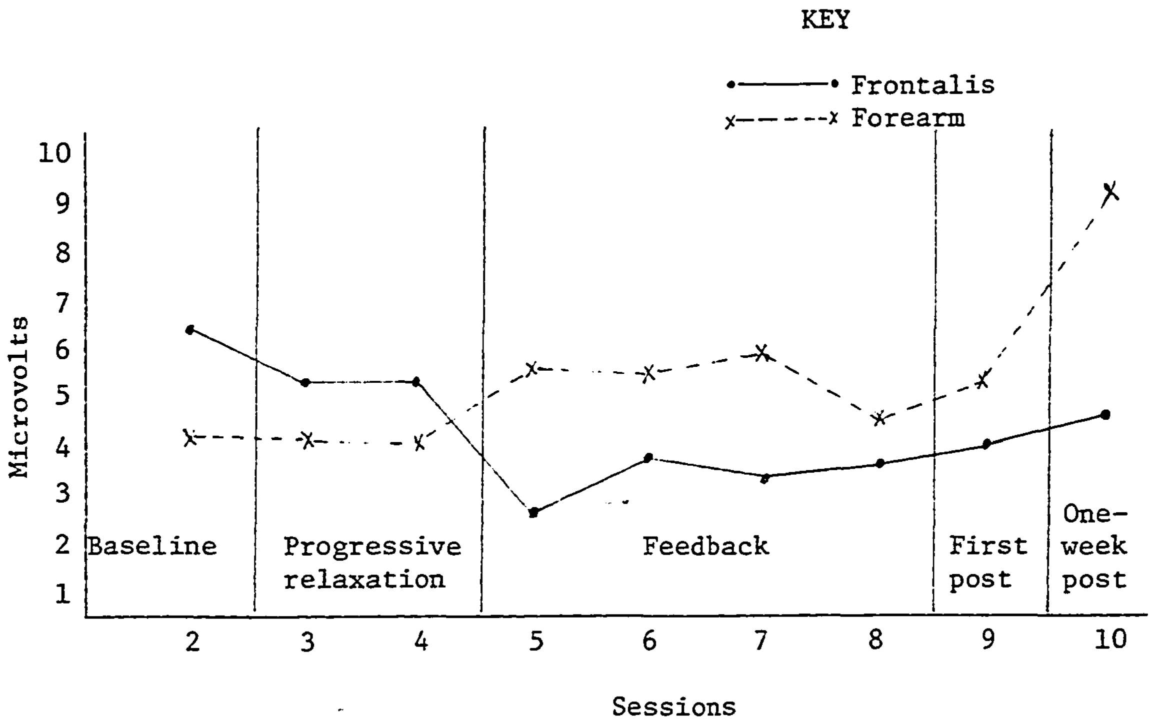

Figure 4. Group: FDBK. Subject: RL. Averaged frontalis and forearm data across sessions.

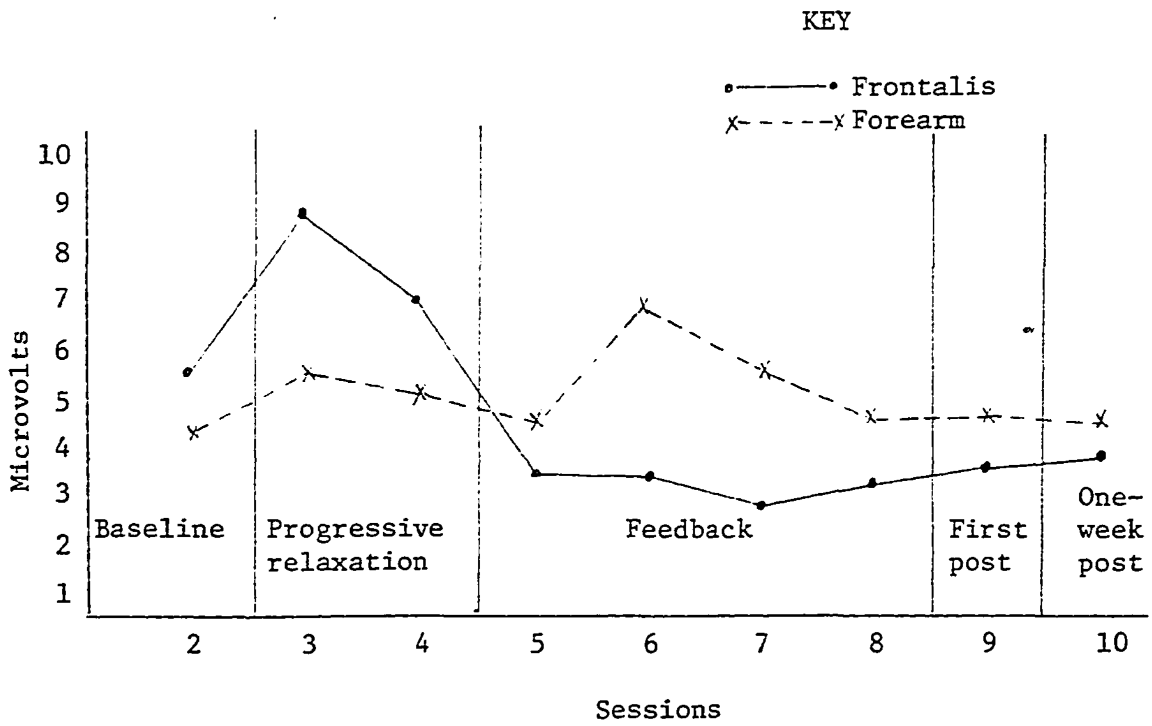

Figure 5. Group: FDBK. Subject: MM. Averaged frontalis and forearm data across sessions.

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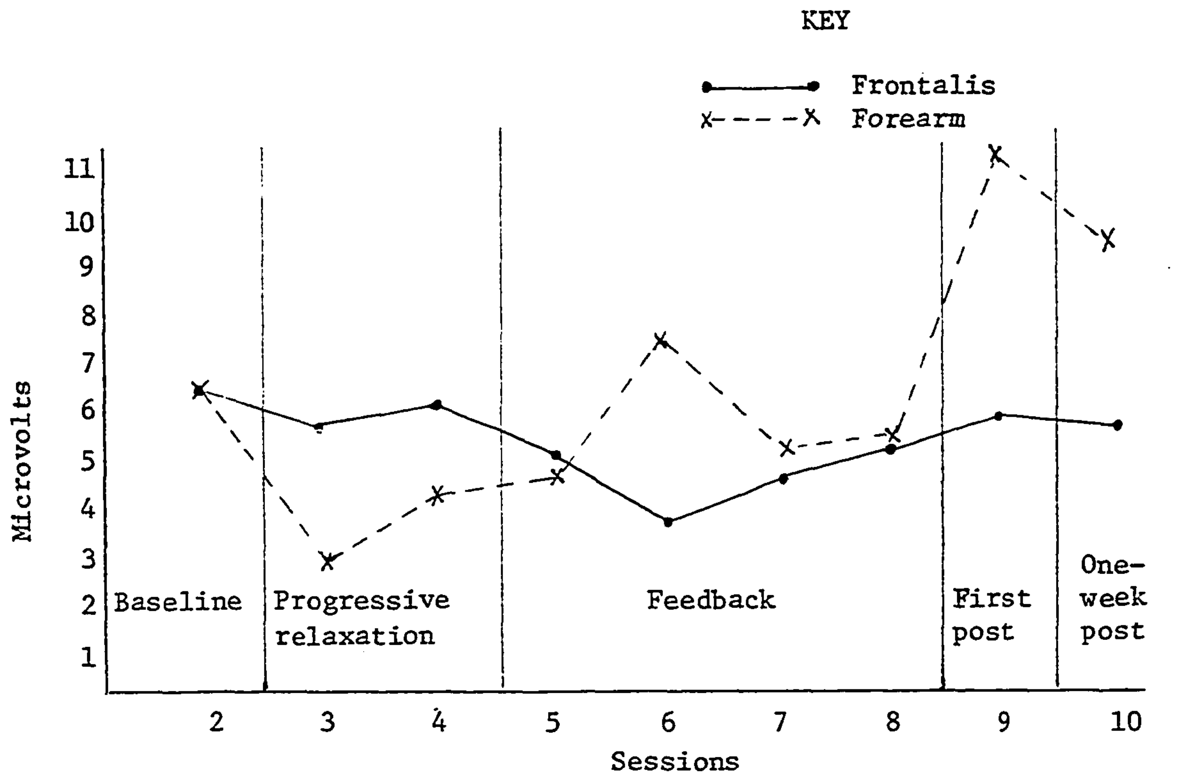

Figure 6. Group: FDBK. Subject: JB. Averaged frontalis and forearm data across sessions.

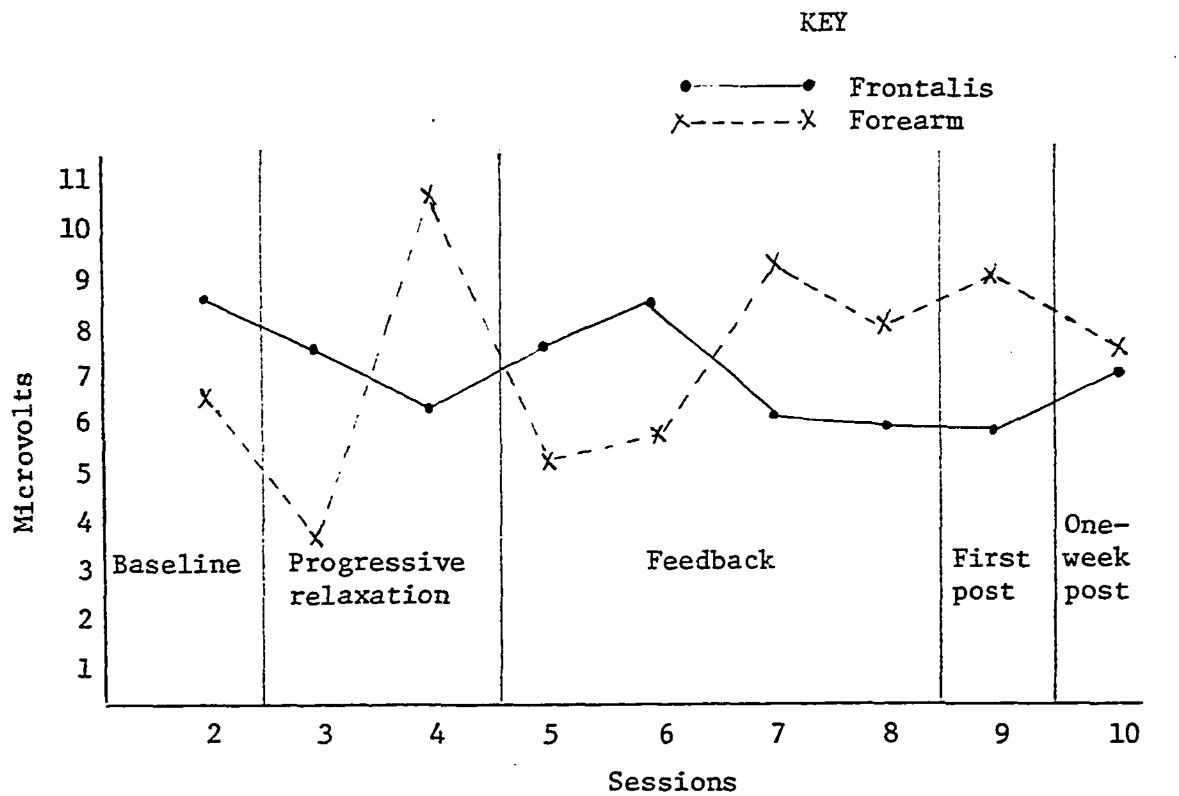

Figure 7. Group: FDBK. Subject: CW. Averaged frontalis and forearm data across sessions.

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In contrast, the JPR group (Figures 8-11) showed no similar pattern upon the introduction of progressive relaxation or at any other point.

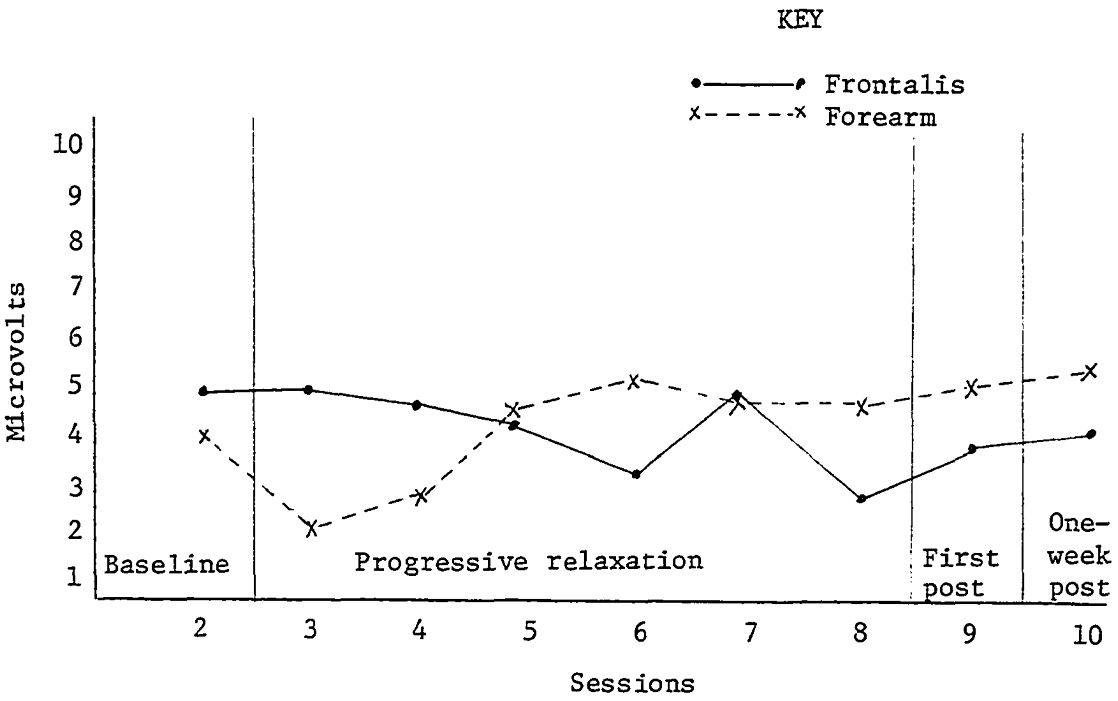

Figure 8. Group: JPR. Subject: FM. Averaged frontalis and forearm data across sessions.

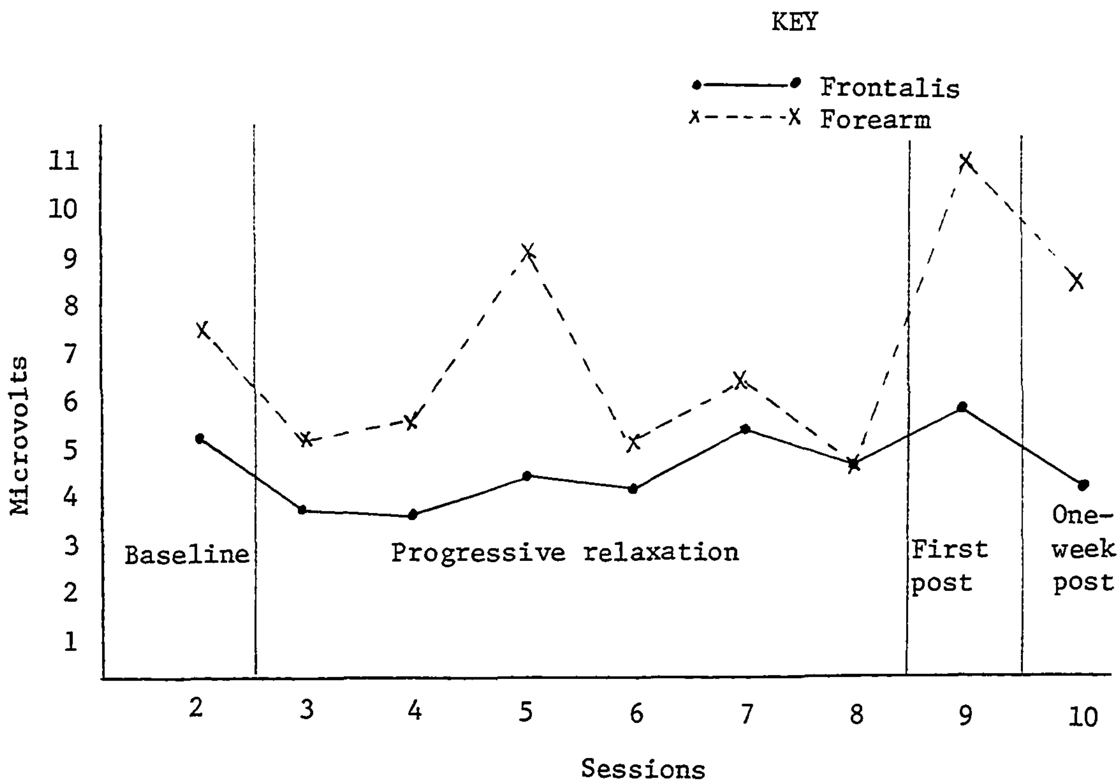

Figure 9. Group: JPR. Subject: PS. Averaged frontalis and forearm data across sessions.

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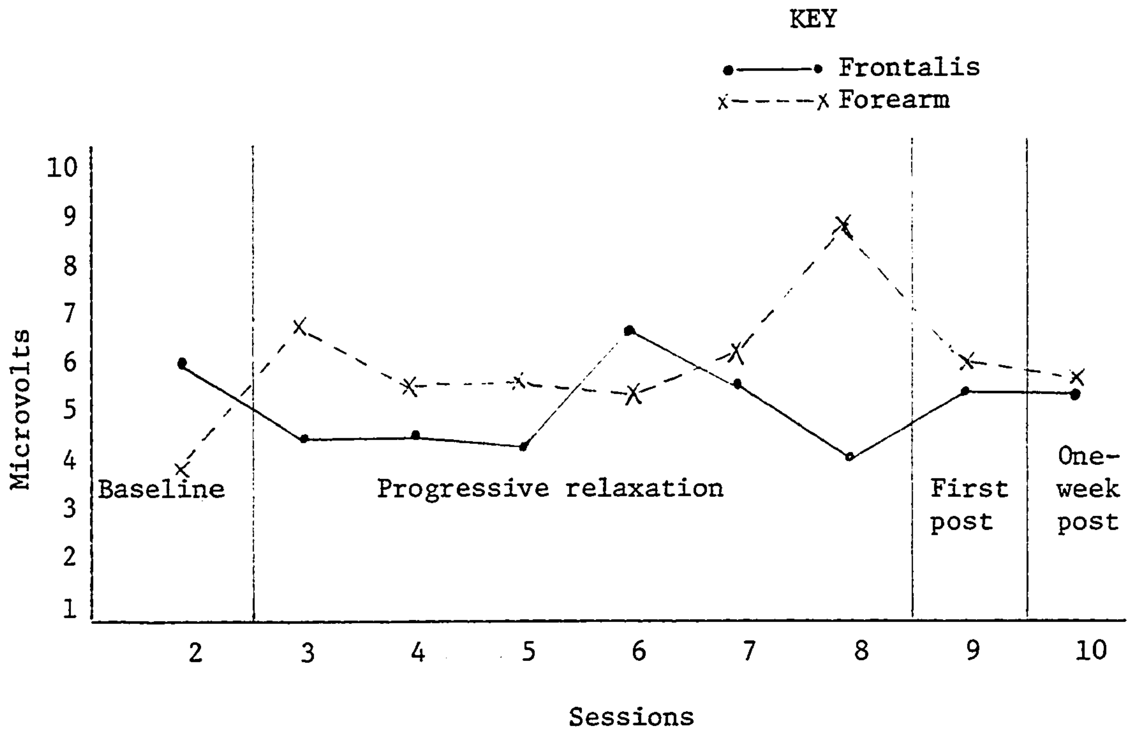

Figure 10. Group: JPR. Subject: JR. Averaged frontalis and forearm data across sessions.

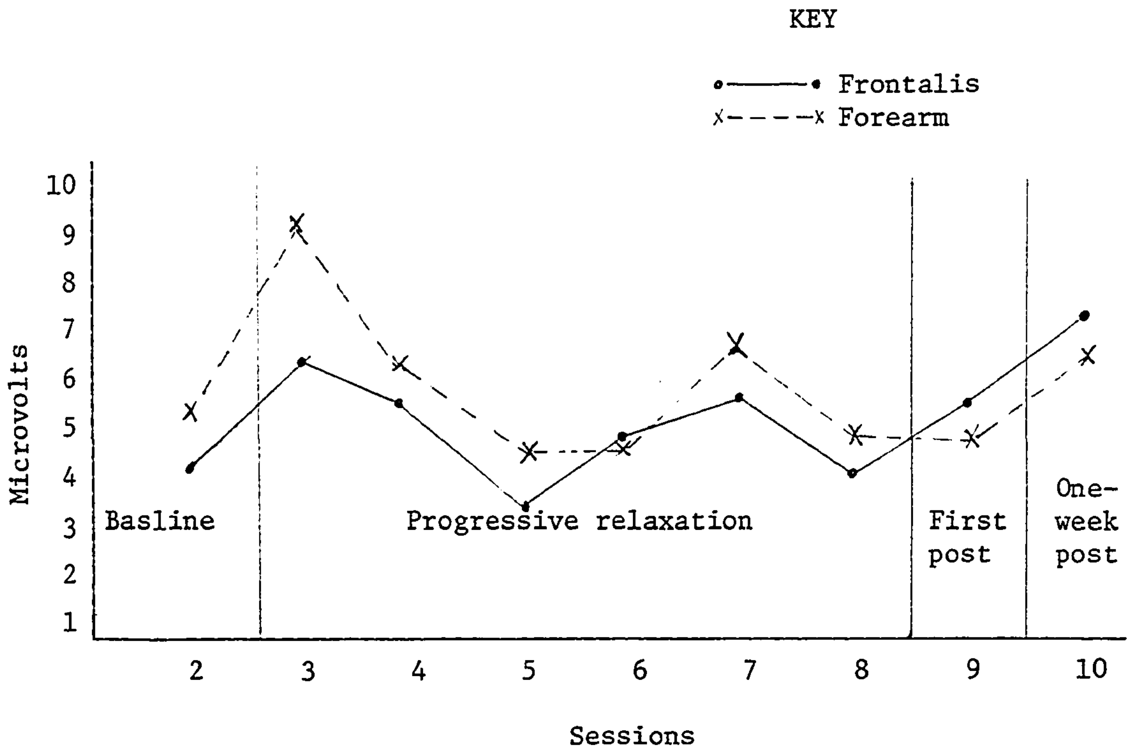

Figure 11. Group: JPR. Subject: HH. Averaged frontalis and forearm data across sessions.

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DISCUSSION

The hypothesis that the FDBK group would achieve lower levels of muscle activity than the JPR group was not supported by the frontalis data. Because of the nonsignificant main effect for groups in the analysis-of-variance this author cannot conclude that feedback was significantly more effective than the other treatment. However, the significant interaction in addition to the regression analysis pointed to the general superiority of the FDBK method. These tests indicated this by demonstrating that the FDBK group was differentially more affected over sessions than was the JPR group, and by showing that the entire FDBK group showed a decreasing trend in frontalis tension levels compared to only half of the JPR group, respectively. The results of this portion of the study basically concur with those of past studies comparing these two techniques. However, [illegible]ting depth of relaxation achieved by the two grou[illegible]s, et al., 1975; Reinking & Kohl, 1975) al[illegible] speed of attaining relaxation between the [illegible] FDBK group achieved lower levels fas[illegible]ation group. No similar difference in rate [illegible] study.

Frontalis data supported the second [illegible]gevity of the obtained effect would be greater for the FDBK group than for the JPR group. This in itself is an important finding since none of the past studies compared the present two relaxation methods on this basis. These results are of particular significance in clinical applications

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DISCUSSION

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Frontalis data supported the second hypothesis that longevity of the obtained effect would be greater for the FDBK group than for the JPR group. This in itself is an important finding since none of the past studies compared the present two relaxation methods on this basis. These results are of particular significance in clinical applications

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of relaxation methods where the duration of relief from stress is a paramount factor.

Forearm data produced unexpected findings in both groups: muscle tension remained basically unchanged throughout the experiment, or in some cases actually increased, as seen in both the regression analysis and individual learning curves. There are two possible explanations for these results, one specific to the feedback procedure and one which applies to both groups. First, the inversion of the level of forearm tension over frontalis tension level demonstrated by the FDBK group upon introduction of feedback at Session 5 could be a direct result of the 75% frontalis - 25% forearm weighted feedback. It was originally hypothesized that the amount of "decrease responding" at the frontalis and forearm sites would be proportional to the amount of input provided by each site. It appears, however, that the forearm site failed to be shaped to any extent as its input to the total signal was essentially negligible compared to the frontalis input. Thus, the frontalis muscle was the only site receiving sufficient feedback to be shaped.

Secondly, it is likely that the sitting posture assumed by all the subjects is responsible for the forearm data. Coursey (1975) selected the frontalis muscle in an EMG feedback relaxation study partially because "it is less affected by posture and gravity than most other muscles" (p. 827). Since a sitting position was required in the present study, it is possible that the forearms partially supported the upper body in keeping it erect thus resulting in the unexpectedly high forearm tension levels. Unfortunately, no other relaxation studies have recorded

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from frontalis and forearm sites, so no comparison may be made.

Finally, the hypothesis that decreases of frontalis muscle activity from baseline would be greater than decreases of the forearm from baseline for the FDBK group was supported. This fact, however, is a result of the general failure of forearm training rather than the proportional effect of the weighted feedback.

This study has been the first to compare feedback and progressive relaxation when data have been collected at times other than during actual feedback or relaxation therapy. The positive results of the longevity tests from this design are evidence for the general superiority of feedback over progressive relaxation as a therapy technique since the results were obtained in the absence of any feedback. In other words, feedback is more effective than progressive relaxation in teaching the subject to gain control over minute muscle responses in this realm of activity.

The novel use of forearm musculature in this study led to some unexpected results and has exposed a new facet in EMG feedback as well as progressive relaxation. What would be the effect of altering the percentages of input from the two muscles? How does posture effect the muscle activity? Does the location and function of the second muscle group with respect to the frontalis dictate a particular pattern of responding at the involved sites? These and other questions can be answered by pursuing further research. Subsequent studies should: incorporate more training sessions, try various relaxing postures, systematically manipulate the percentages of input each muscle group

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contributes to the feedback signal, utilize different muscles, and employ both normal and abnormal subjects to test for the relative effectiveness of the two therapies in both experimental and clinical applications.

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