EXPERIMENTER-SUBJECT EFFECTS ON BIOFEEDBACK TRAINING

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CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

Over the course of the last decade, a relatively new area of scientific inquiry has been developed which deals with the regulation of autonomic functioning through the use of immediate feedback. Biofeedback, as the area has been designated, has gained attention in the research laboratory and widespread popularity in books and magazines read by laypersons. At this time, research has indicated that heartrate, brain wave activity, muscle tension, skin temperature, blood pressure, and functioning of the endocrine system may all be subject to varying degrees of voluntary control through the use of biofeedback (Brown, 1974; Birk, 1974; Aldine-Atherton, Biofeedback and Self-Control, 1971, 1972, 1973, 1974, 1975).

The present investigation focuses on one aspect of biofeedback, the voluntary control of skin temperature. Since skin temperature changes are regulated by peripheral vasomotor control, that is the dilation and constriction of the blood vessels of the limbs which results in skin temperature fluctuations, then voluntary autoregulation of this autonomic response can be determined by means of devices measuring skin temperature. The importance of being able to measure skin temperature is reflected in the documented relationship between self-regulated skin temperature increases and relaxation. Several authors have noted that increases in the temperature of the hand or fingertip are associated with subjective feelings of relaxation for the subject (Taub, in press; Green et al., 1974). Conversely, Mittlemann and Wolff (1939), in investigating the relationship between emotional states and physiological responses, found that during periods of emotional stress (unrelaxed state), subjects' skin temperatures tended to decrease. Russell (1972) has noted a drop of up to 23°F from baserate fingertip temperatures in patients discussing particular areas of conflict.

The control of peripheral vasomotor responses has important implications which may not be readily apparent to those unfamiliar with this line of investigation. For example, Raynaud's disease (chronic vasoconstriction of the peripheral blood vessels results in restricted blood flow to the extremities causing in some cases gangrene) may be controlled by the regulation of skin temperature in those affected limbs. Then too, regulation of peripheral blood flow may play a role in the treatment of migraine headaches (Weinstock, 1972; Peper, 1973) as it is thought that migraines stem from dilated blood vessels in the cranial cavity producing intracranial pressure. Peripheral vasomotor control might also act to control bleeding from various types of wounds, and the self-regulation of temperature increases may ultimately prove beneficial in reducing tissue damage when the skin is exposed to cold temperatures (Taub, in press).

The implications for the psychotherapeutic use of these findings readily follows, i.e., if a patient is able to raise his skin temperature by means of some feedback mechanism, either internal or external, then concurrently he should be able to achieve a state of relaxation and tension reduction without specifically forcing himself to relax per se. In one published article and several presentations, Gladman and Estrada

(1974a, 1974b, 1975) outlined their use of three biofeedback devices (temperature trainer, electromyograph, and electroencephlograph) with patients whose presenting complaints would usually come under the heading of chronic psychosomatic illness. They have found that relaxation may be the key issue in patients' receiving relief from their symptoms since they contend that most of the so-called psychosomatic illnesses of the clients they have dealt with actually represent manifestations of anxiety and tension.

A general statement as to the psychophysiological means of achieving control of these functions was provided by Green, Green, and Walters (1974, p. 160). In discussing the effects of increased skin temperature of the hands as a result of increased blood flow, they noted that:

> Increased blood flow, in turn, results from vasodilation in the hands and is apparently dependent only on the decrease in neural outflow in the sympathetic section of the autonomic nervous system. In other words, in order to warm the hands by voluntary control, it is necessary to 'turn off' autonomic (sympathetic) activation, that is to relax autonomically.

They go on to state that:

> Thus, through EMG and temperature feedback training, the peripheral nervous system is relaxed, anxiety tension is reduced. . . . Whatever the neurological and hormonal details, the total effect tends toward emotional tranquility coupled with increased self-awareness and a sense of self-mastery (p. 160).

By way of explaining the above findings Green et al. (1970, p. 3) have hypothesized a psychophysiological principle which states that:

> Every change in the physiological state is accompanied by an appropriate change in the mental-emotional state, conscious or unconscious, and conversely, every change in the mental-emotional state, conscious or unconscious, is accompanied by an appropriate change in the physiological state.

Several issues are raised in any scientific inquiry utilizing the technique of biobeedback and thus the present literature review will be divided into four sections: 1) means of achieving self-regulation, 2) efficacy of biofeedback, 3) methodological considerations, and finally, 4) a statement of the problem for this research investigation.

Means of Achieving Self-Regulation

Although a few investigators have studied the influence of conscious processes on autonomic functioning (Mittelmann and Wolff, 1939), most researchers did not really question the generally held contention that bodily functions such as heartrate and skin temperature, which are regulated by the autonomic nervous system, were not subject to conscious control. However, Miller (1969) reported findings which tended to support the position that given biofeedback, rats are able to regulate many of those functions innervated by the autonomic nervous system. Once this finding was thought to be established, some investigators attempted to ascertain just how human beings went about controlling autonomic functioning. In this reivew, the author will only be concerned with the phenomena of skin temperature regulation.

In an exploratory study of skin temperature self-regulation Taub (Taub and Emurian, in press) interviewed subjects in order to determine the techniques they had employed in attempting to achieve control of their skin temperature. In general, subjects reported that when they tried too hard to either raise or lower their skin temperature, they were unsuccessful. However, when the subjects simply relaxed and allowed their temperature to increase or decrease (according to instructions) without great determination and focusing of attention, success was more likely to be achieved. Green et al. (1970), had arrived at the same conclusion in reviewing research on biofeedback, and they described the phenomenon for controlling the involuntary nervous system as "passive volition" as contrasted with the use of "active volition" used in controlling the voluntary nervous system.

Taub (in press) also noted from his research that instructions which included suggestions regarding thermal sensations may be enough to produce skin temperature changes in many subjects without the aid of biofeedback. However, he went on to note that instructions alone without the thermal suggestions did not produce significant changes.

Several researchers have contended that hypnotic susceptibility or ability to attain altered states of consciousness was a large factor in a subject's ability to manifest skin temperature self-regulation. Maslach, Marshall, and Zimbardo (1972) found that subjects trained in hypnosis were able to simultaneously regulate the differential skin temperature (difference in temperature between two cites) of their hands while waking control subjects were not able to do so. However, in a follow-up investigation by Roberts, Kewman, and MacDonald (1973) using the same differential control task, the investigators found that only one subject out of six (one of the two subjects who did not demonstrate significant temperature self-regulation) felt that hypnosis was necessary beyond the biofeedback. Then too, in a second investigation, Roberts, Schuler, Bacon, Zimmermann, and Patterson (1975) found that ability to self-regulate differential skin temperature was not related to hypnotic susceptibility nor was it related to the capacity for absorbed, imaginative attention or to various personality variables as measured with a number of MMPI indices. These conflicting results indicate that the evidence is inconclusive for hypnotic susceptibility having a significant effect on a subject's control of his skin temperature.

Another factor which has been mentioned consistently in previous research as possibly influencing the success or failure a subject experiences in attempting to control his skin temperature by means of biofeedback is the confidence a subject has in his ability (Roberts et al., 1973; Lynch, Hama, Kohn, and Miller, 1974; Roberts et al., 1975; Taub, in press). From their study, Roberts et al. (1975, p. 17) pointed out that the confidence of the subject seemed to predict their performance on the differential temperature control task. The authors went on to state that:

> . . . it seems more likely that psychophysiological variables such as autonomic responsivity or lability, interpersonal variables such as attitude toward and relationship to experimenter, and attitudinal and motivational variables such as confidence are more likely to account for many of the observed differences in learning (p. 278).

Lynch, Hama, Kohn, and Miller (1974), who did not find significant temperature self-regulation with adult subjects, concluded that a lack of confidence in the feasibility of vasomotor control may have influenced their subjects' performances.

One final factor which has also been consistently noted as influencing the control a subject demonstrates over the fluctuation of his skin temperature is the relationship between the experimenter and the subject (Roberts et al., 1973; Lynch, Hama, et al., 1974; Taub, Emurian, and Howell, 1974; Roberts, et al., 1975; Taub, in press). Taub, Emurian, and Howell (1974) have reported rather dramatic findings regarding a "person factor" variable between experimenters. They found that an experimenter who adopted an informal and friendly approach was able to train 20 of 21 subjects to self-regulate their skin temperature, while an experimenter who adopted an impersonal attitude was able to train only 2 of 22 subjects. In discussing these findings, Taub (personal communication) indicated that both experimenters were female in this study and that in further research involving both male and female experimenters a significant sex interaction effect was not found. He went on to state that in all probability, both the experimenter's relative friendliness and her confidence in the procedure were important factors influencing the results.

Not all investigators of the experimenter-subject relationship have reported positive findings. Fico (1976) instructed experimenters to be either aloof and businesslike, or more informal and warm in their attempts to train various subjects. In a third experimental condition, the experimenter was absent. Fico did not find a significant experimenter effect, although his results need to be interpreted with some caution due to methodological deviations from Taub's work, i.e., each subject was exposed to all three experimental conditions. In rating the experimenters as either warm or cold, Fico noted that subjects did demonstrate a significant difference in their perception of the experimenters, and their ratings were in the expected direction.

Throughout their work using biofeedback with patients suffering various psychosomatic illnesses, Gladman and Estrada (1974a, 1974b, 1975) have premised that one of the most important factors in their work is the personal interaction at both the verbal and non-verbal level between the therapists and clients. They contend that a relaxed, informal, and warm relationship is imperative for the clients to benefit from the various biofeedback procedures. Lynch, Hama et al. (1974), concluded that further research needed to incorporate a more thorough evaluation of the experimenter-subject interaction as this seemed to them to be a potent variable.

Efficacy of Biofeedback

Since the initial data supporting the effectiveness of biofeedback was presented (Miller, 1969), Miller (1974) has pointed out that failure to reproduce his earlier results plus the lack of control of placebo effects in biofeedback investigations warrant some caution in making unequivocal statements regarding the effectiveness of biofeedback procedures, particularly in the area of clinical applications. Several authors, not working with skin temperature control, have pointed out that feedback may not be a necessary factor for achieving autonomic control (Redmond, Gaylor, McDonald, and Shapiro, 1975; and Blanchard and Young, 1973) and may in fact interfere with the process being studied (Lynch, Paskewitz, and Orne, 1974). As noted previously, Maslach et al. (1972), found that hypnotized subjects without biofeedback have been able to demonstrate significant voluntary control.

Still with regard to self-regulation of skin temperature, numerous researchers have been able to demonstrate positive findings using either an absolute or a differential control task (Green, Green, and Walters, 1970 and 1973; Roberts, Kewman, and MacDonald, 1973; Taub and Emurian, 1973; Taub, Emurian, and Howell, 1974; Thompson, 1974; Keefe, 1975; Roberts, Schuler, Bacon, Zimmerman, and Patterson, 1975; Slattery and Taub, 1976). Briefly explained, the absolute task involves a subject's raising or lowering his absolute skin temperature, whereas the differential task involves a subject's raising or lowering his skin temperature in comparison to the temperature of another part of his body.

Taub and Emurian (1973) reported that 19 of 20 subjects were able to demonstrate unequivocal regulation of their skin temperature. Mean change for all subjects was approximately 2.5° F and ranged up to 6.5° F. Training to this level required only four sessions or around one hour of actual work with the feedback parameter. For four of the subjects tested four to five months after the initial training sessions, retention of this self-regulation ability was found to be virtually perfect. Then too, with further training (20-25 sessions), two subjects demonstrated an ability to regulate their skin temperature in opposite directions during successive periods of the same 15 minute session. The range of temperature change they displayed was from 8° to 15° F.

Further work in the same laboratory (Taub, Emurian, and Howell, 1974) indicated that with continued training, subjects were able to develop considerable anatomical precision in controlling their skin temperature, i.e., they were able to localize temperature fluctuations at specific locations. Transfer of control to other portions of the body was also achieved with the same degree of specificity. Then too, in the opposite direction when feedback was averaged over five locations on the hand, control of whole-hand temperature was demonstrated as readily as was control of a single point. Using essentially the same experimental procedure as Taub, Thompson (1974) found for all experimental groups that baseline and attained temperatures both rose significantly over the four training sessions, while two control groups receiving no feedback did not demonstrate a rise in skin temperature.

With the differential control task, Roberts et al. (1973), found that four of six subjects were able to achieve significant temperature self-regulation using hypnosis and auditory feedback. Of particular importance was the finding that all six of the subjects demonstrated the ability to significantly change the temperature of their hands (the absolute measure); however, two of the subjects were not able to do so differentially. In a follow-up investigation, Roberts et al. (1975) again found that subjects could self-regulate the differential skin temperature between their two hands to a significant degree.

Keefe (1975) investigated the same phenomenon by measuring the differential temperature fluctuations between a subject's hand and forehead. Two groups of four subjects each were instructed to either increase or decrease the temperature of their hands in relation to their foreheads. He found that all subjects were able to change their hand-forehead temperature differential in the appropriate direction. Also, results indicated that differential temperature changes were highly correlated with absolute skin temperature changes which were also measured throughout the course of the experiment.

Not all investigators have met with success in attempting to train subjects to self-regulate their skin temperatures. Surwit, Shapiro, and Feld (in press), using the absolute measure, were unable to replicate all of the positive findings reported from Taub's laboratory. In an experiment using two groups of eight subjects each, one group was instructed to lower the temperature of their hands while the other group was instructed to increase their temperature following two days during which baseline temperatures were established for each subject. While subjects in the decrease group were able to lower the temperature of their hands to a statistically significant degree, subjects instructed to increase their temperature were unable to demonstrate significant increases over baserate. Although they did consistently show a trend in the appropriate direction, and several individual subjects did demonstrate significant increases, the authors' discussed these trends in terms of an habituation process.

In another attempt to replicate the successful procedure of Taub and Emurian (1973), Lynch, Hama, Kohn, and Miller (1974) studied five unpaid adult volunteers using the absolute measurement technique. None of the subjects were able to demonstrate significant self-regulation of their fingertip skin temperature. Because these authors suspected that an undetected subject selection bias may have been at work such that their five subjects may simply have been untalented in temperature control, they next conducted a survey of 100 college students to see if any of these subjects demonstrated even a tendency towards autonomic control. Only three of these 100 subjects were able to repeatedly demonstrate even modest voluntary temperature self-regulation.

Regarding the differential control task, Lynch et al. (1974), attempted to replicate the findings of Roberts et al. (1973), using four subjects and 12 days of training; however, they were unsuccessful. Fico (1976) in two experiments was unable to find significant differential temperature changes for any of his total of 14 subjects. However, his studies involved incentive and experimenter-subject interaction variables plus a within-subject design which, by his own admission, may have resulted in multiple treatment interference. Still, it is evident from this review that unequivocal findings have not resulted from research into skin temperature self-regulation.

Finally, the issue of whether continuous feedback is needed in order for subjects to gain skin temperature self-regulation has been discussed in two works. Thompson (1974) found that while feedback was necessary during initial training to establish the skin temperature control, by the fourth session feedback was not required to demonstrate temperature increases. Taub (Taub and Emurian, 1973) had reported the same finding; that after sufficient training, skin temperature regulation was as good with feedback as it was without it.

Methodological Considerations

For the typical study investigating the effects of biofeedback on a subject's ability to regulate his peripheral skin temperature, the methodology employed is usually some variation of the procedure outlined by Taub (in press). It is as follows: subjects sit comfortably in a reclining chair, and a thermistor probe is placed on the web dorsum of the dominant hand. For the first session lasting approximately 45 minutes, subjects are told to sit quietly while skin temperature is monitored in order to establish a baseline. Then, on the next training day prior to beginning the session, the feedback information is given auditorily or visually, and it fluctuates according to whether the subjects' skin temperature is increasing or decreasing. Subjects are asked either to increase or to decrease their skin temperature.

The number of training sessions employed varies from one laboratory to another and results seem to, in part, be contingent upon the amount of training. Thompson (1974) and Taub and Emurian (1973) have successfully trained subjects in four 15-minute sessions, whereas Roberts et al. (1975), used 16 one-hour sessions. From examining the progress of subjects in his study, Keefe (1975) found that after only four training sessions, control of differential temperatures was relatively poor;

however, control was ultimately developed for the subjects after eight sessions.

Regarding room temperature during the training sessions, most investigators make mention of attempts to keep the ambient temperature and humidity within set limits of fluctuation. Obviously, major changes in room temperature would have a significant effect on skin temperature readings. Surwit, Shapiro, and Feld (in press) investigated the effects of room temperature after finding that subjects instructed to raise their absolute skin temperature (vasodilation) were unable to do so to a level of statistical significance using the same room as subjects who were able to lower their temperatures. They contended that vasodilation may be more difficult to achieve than vasoconstriction (skin temperature decrease) because of the ceiling effect. The ceiling effect represents a physiological limit to which a subject can raise his skin temperature and that this limit depends upon his core body temperature which in turn is based partly upon the ambient room temperature. Therefore, Surwit et al. (in press), conducted a second experiment in a cooler room in order to give subjects more "room to maneuver." Subjects again were unable to produce significant increases over baseline; thus working in a cooler room did not appear to aid subjects in their attempts to increase skin temperature.

Almost without exception, researchers in the area of skin temperature self-regulation have indicated that there is a great deal of variability among subjects in their ability to manifest skin temperature control. In discussing the failure of other investigators to reproduce the findings from his laboratory using the same procedures, Taub (in press) has indicated that an explanation for the discrepancies is simply not known at present.

As a result of the significant findings coming out of his laboratory, Taub (Taub and Emurian, in press) has discussed the control procedures and other indications which seemed to rule out the use of "tricks" on the part of his subjects in producing significant skin temperature control. It was found that gross maneuvers of the arms and hands did not result in significant temperature changes of the hands in comparison to the changes achieved via training. Also, for some subjects, a plexiglass box was placed over the self-regulating hand to prevent the subject from blowing on the thermistor and thus increasing the temperature reading. With other subjects, EMG recordings were made of the forearm of the self-regulating hand to determine if slight muscle contractions were being used to increase the skin temperature. No significant correlation was found between EMG and temperature change. Experimenters placed in the testing room were unable to detect any obvious "tricks' used by subjects changing their skin temperature. Subjects being able to regulate their skin temperature in first one direction and then the other over successive trials would tend to rule out the use of mediating procedures unless the procedures worked equally well in both raising and lowering temperatures, e.g., muscle contraction might account for increased temperatures, yet it would be hard put to account for decreases also. Finally, the anatomical specificity of control would seem to rule out any general mediating variables. By ruling out various "cheating" possibilities, Taub speculates that the results obtained in his laboratory appear to represent actual autonomic self-regulation by his subjects, although somatic mediation cannot be conclusively ruled out.

Some question has arisen in this particular research area regarding the issue of whether reported significant skin temperature increases with the use of biofeedback represent actual feedback effects or whether they represent an habituation process. For example, Fico cites previous research by he and his colleagues (Fico, Roth, and Rohrbaugh, 1975, as cited by Fico, 1976) where they found that subjects who simply relaxed in a lounge chair and were not given any feedback had increases in absolute fingertip temperature equivalent to the increases observed for subjects receiving extensive feedback training (no mention was made as to whether subjects were instructed to warm their fingertips or were just told to relax). Surwit, Shapiro, and Feld (in press), reported that absolute skin temperatures merely reflected changes in baseline temperature that may have resulted from an habituation process. However, Thompson (1974) in studying subjects' ability to raise absolute fingertip temperature, used two control groups. One control group was instructed to raise their temperature while receiving no feedback, the other group listened to relaxation training recordings and was given no further instructions. Neither of these two groups demonstrated significant learned control of fingertip temperature nor was there a significant rise in their baseline temperatures.

Taub (Taub and Emurian, in press) addresses the issue of an habituation process stating that:

> The data from baseline days indicate that the hand temperature of some subjects has a tendency to drift consistently in a given direction during the interval equivalent to the self-regulation period on training days. This tendency introduces a consistent bias upon which the temperature self-regulation effect must be imposed. It is important to take this factor into account in estimating the magnitude of the self-regulatory effect (p. 22).

Taub controls for this finding by ipsatizing his data for each subject, that is by algebraically subtracting temperature fluctuations from baseline readings for each subject in addition to requiring subjects to self-regulate their temperature in the direction opposite to the general drift they demonstrate during the baseline session. Although Thompson (1974) did not incorporate these procedures, he did use the relaxation control group which did not demonstrate the habituation effect.

Finally, in the area of methodological considerations, two quite different dependent variables have been used to measure the degree of skin temperature control. The absolute task which Taub has used successfully in his work (Taub and Emurian, 1973; Taub, Emurian, and Howell, 1974) involves requiring subjects to raise or lower their absolute skin temperature, usually of the hand or finger, in response to the feedback they receive regarding their performance. The differential task employed by other researchers (Roberts et al., 1975; and Fico, 1976) involves requiring subjects to raise or to lower the skin temperature of one hand relative to the temperature of another part of their body, usually the other hand. Since results are equivocal with regard to these two control tasks, i.e., significant and nonsignificant results have been reported by different researchers using one technique or the other, then a decision as to which task should be used probably needs to be based on the rationale behind each individual study.

For example, in a study where only a relatively few training sessions are to be used, the absolute control task would seem preferable since researchers have reported that adequate training can be accomplished in as few as four sessions (Taub and Emurian, 1973; Thompson, 1974). Then too, Fico (1976) has noted that the differential task is more difficult than is the absolute task. Keefe (1975), as previously mentioned, has found that control of differential temperatures was not developed until after the eighth session; thus in a study using fewer than eight sessions, the differential task would not seem appropriate. With regard to clinical applications, being able to train temperature increases with concommitant relaxation would appear to be more relevant than training temperature decreases.

A Statement of the Problem

This study then addressed several of the issues raised by previous findings in the area of self-regulation of peripheral skin temperature through the use of biofeedback techniques. The first and most important question dealt with was the impact of the experimenter-subject relationship on the subject's ability to raise his skin temperature. As cited previously, several authors have indicated that the relationship variable may have a profound effect on the subject's demonstrated ability, and it may well explain some of the discrepant findings reported in the literature.

Singer (1974), in her Presidential Address to the American Psychosomatic Society, noted that the experimenter-subject relationship may have implications for research which have not always been considered. For example, in reviewing a series of studies which attempted to systematically evaluate the psychological aspects of the experimental situation and their effects on concommitant cardiovascular responses (which would have relevance for skin temperature regulation), she noted that the authors concluded:

> . . . differences in the experimenter-subject relationships may alter the total meaning of the experimental situation so that different psychological and physiological mechanisms or responses are evoked by an otherwise identical test procedure. Small variations in technique, personnel, mannerisms, etc., which may seem unimportant and irrelevant may lead to surprisingly large changes in what actually transpires during an experiment. The findings strongly support the concept that the circulatory measurements reflect responses to these interpersonal transactions as well as responses to more obvious or standard stimuli (p. 4).

As indicated from this quote, the rationale behind the relationship question is this: to the extent that the effects of biofeedback in part represent relaxation, then being able to relax via those techniques is likely to be in part contingent upon the nature of the relationship with the experimenter.

The second issue dealt with in this investigation was the relationship between the confidence a subject has in his own ability to raise his skin temperature through the use of biofeedback and his actual performance. As previously cited, several researchers have contended that different levels of confidence may, in part, account for the wide variability among subjects in their ability to manifest skin temperature control.

Third, it has been noted that several authors investigating skin temperature regulation have hypothesized that significant temperature increases found in some experiments can be accounted for by the process of habituation, i.e., that simply sitting and relaxing in a lounge chair results in absolute fingertip temperature increases equivalent to the increases observed for the subjects receiving biofeedback training. The particular methodological characteristics of this study (see Chapter II) provided for an evaluation of the habituation vs. results of training controversy.

Fourth, the issue of the efficacy of biofeedback was addressed through an analysis of the performance of the subjects. This study used the absolute control task, and subjects were instructed to raise their fingertip temperature. The rationale for using temperature increases has both methodological and clinical bases. Because of the factors which are reported to work against significant temperature increases, e.g., the ceiling effect, then evidence of positive findings would definitely lend credence to the viability and effectiveness of biofeedback training. Then too, previous findings have consistently indicated that subjects are capable of lowering their skin temperature; however, the inconsistent research results have occurred more frequently in the area of training skin temperature increases.

CHAPTER II

METHODOLOGY

Subjects

Subjects for this study were 12 male and 12 female undergraduates enrolled in an introductory psychology course at a Southcentral U.S. University during the fall semester of 1976. Each S received extra course credit for his or her participation. In addition, 4 male graduate students at the same institution served as experimenters. Each was paid $50.00 for his participation. Subjects were selected on the basis of their meeting three criteria: 1) that they were 17 years of age or older, 2) that in filling out a Screening Questionnaire (see Appendix A) they acknowledged never having experienced migraine headaches, diabetes, epilepsy, high blood pressure, or other circulatory difficulties such as heart disease, Raynaud's Syndrome, etc., and 3) that they expressed a willingness to devote at least 45 minutes on four separate days as participation requirements for this study.

Apparatus and Setting

The experimental procedures were all conducted in a dimly lit room located at the end of a cul de sac hallway which could be sealed off to insure that subjects would not be interrupted during the training. One wall of the experimental room was equipped with a one-way mirror so that the subject, experimenter, and equipment could be monitored without disrupting the ongoing procedures. The room was equipped with a comfortable chair having padded armrests for the subject, a table for the equipment, and a chair for the experimenter. Ambient temperature was recorded at the beginning and end of each session.

The instrument used to measure skin temperature was an Autogen 2000 manufactured by Autogenic Systems Incorporated. The machine uses thermistor probes manufactured by Yellow Springs Instruments Company and is capable of measuring skin temperature in increments of $.01^{\circ}F$. Absolute temperature accuracy is rated at $-0.3^{\circ}F$ and absolute temperature resolution is rated at $0.025^{\circ}F$ according to the Autogen Manual. A temperature meter is included on the face of the instrument which reflects increases or decreases in skin temperature. The meter can be set to display different magnitudes of temperature variations, e.g., at the x2 setting, a change of $.10^{\circ}F$ of the needle represents an actual change in skin temperature of $.20^{\circ}F$. There is also an audio connector which allows earphones to be attached directly to the instrument. The machine can be set so that increases in absolute skin temperature will produce increases in the pitch of the pulsating audio feedback tone while a decrease in temperature will result in a concommitant decrease in the pitch of the tone received through the earphones. Another thermistor and the other channel were used to measure ambient room temperature. Although the Autogen 2000 has various other capabilities, the above functions were the ones which had relevance for the present investigation.

Procedure

Each subject was brought to the previously described room by his respective experimenter and asked to be seated in the chair. The respective experimenter read to the subject a brief explanation of the equipment and the attachment of the thermistor, plus instructions explaining the subject's tasks for that and for the three subsequent training sessions (see Appendix B). Before proceeding further, the subjects were asked to rate the confidence they had in their ability to regulate their peripheral skin temperature; the rating was done on a seven point confidence scale ranging from "very confident" to "no confidence" (see Appendix C). The thermistor probe was then attached with cloth tape to the center of the fingerprint of the fore-finger on the subject's dominant hand.

Subjects received four identical 45 minute training sessions scheduled on successive days. The sessions themselves consisted of a baseline period lasting 15 minutes, a training period lasting 15 minutes, and a rest period also lasting 15 minutes. Prior to every baseline period, subjects rated their confidence in performing the task as outlined previously. During the baseline or stabilization period, subjects received no feedback but were asked to sit quietly, relax, and make as few physical movements as possible. Following the stabilization period, the biofeedback machine was turned so that the subject could see the meter needle and headphones were put in place. The subjects were then instructed by the experimenter to begin raising skin temperature using the feedback provided by the needle reading plus the pitch of the pulsating tone received through the earphones. No instructions were given as to how they were to perform the task except they were asked to use internal mechanisms rather than any type of muscle contractions, movements, or blowing on the thermistor. The experimenter watched the subject to be certain that he did not attempt to use any "tricks" to increase temperature readings.

At the end of 15 minutes, the machine was again turned so that the subject could not see the temperature dial, the earphones were removed, and the subject was again asked to sit quietly, relax, and make as few physical movements as possible. This rest period lasted 15 minutes.

The experimenters recorded ambient room temperature at the beginning and end of each session. Skin temperature readings were recorded by the experimenter at the beginning of the sessions and at one minute intervals throughout the entire 45 minutes. The subjects were not allowed to see these temperature recordings until after the fourth session had been completed. The subjects were not interrupted except, as explained in the instructions, when the experimenter had to reset the temperature scale because the subject's skin temperature had either increased or decreased more than $2^{\circ}F$ (the maximum range for the feedback needle at the x1 meter setting). At these times, the experimenter simply reset the baseline temperature quantifier so that the feedback needle was again at 0.

For this study, subjects were exposed to one of two experimental conditions, i.e., a WARM or a COLD experimenter. The experimenters serving in the WARM condition (2) were instructed to maintain an informal, warm attitude in interacting and working with respective six subjects while those serving in the COLD condition (2) were instructed to take an aloof, distant and business-like stance in interacting with their respective six subjects. With regard to specific behaviors, the COLD experimenters were to initiate no conversation, to pay little or no attention to comments made by the subject, and to be brief and concise in responding to specific questions. In contrast, WARM experimenters attempted to keep their relationship relaxed by means of free-flowing, spontaneous conversation, interest in the comments and observations of the subject, and support and encouragement regarding the subject's performance. At the end of the fourth session, the subjects were asked by this author to rate their experimenter on a six-item semantic differential scale (see Appendix D) in order to determine if they perceived him in actuality as being either WARM or COLD. At this time subjects were also given a brief explanation of the intent of the investigation as well as a summary of their performance over the four sessions of biofeedback training. Any remaining questions were answered during this debriefing.

Performance Measures

Since previous experiments in the area of skin temperature regulation by means of biofeedback have used a variety of performance measures, the present study incorporated those dependent variables which appeared to have the most credence and which followed the general guidelines established for this research area. It has already been indicated that temperatures were recorded each minute by the experimenter training each respective subject. The Baserate Temperature (BRT) for every subject on each training session was computed by taking the mean of the temperatures recorded during the last five minutes of the 15 minute stabilization period. The measurement represented the subject's baseline temperature for a given session.

The mean of the temperatures recorded during the last five minutes of the 15 minute training period represented the Trained Temperature (TT). This measurement provided data as to the effects of biofeedback.

Finally, the Rest Temperature (RT) was computed by averaging the temperatures recorded during the last five minutes of the 15 minute rest period. This measurement, not found in previous research, was introduced to determine if increases in temperature as a result of biofeedback tended to reflect training or merely habituation. In other words, if during the rest periods a subject's temperature returned to approximate baserate temperature readings, then fluctuations during training periods would probably be attributable to the intervening variable of biofeedback. If, on the other hand, there was significant divergence between RT's and BRT's, specifically with RT's increasing, then this would tend to reflect an habituation process.

Two other dependent variables were used. The first was Deviation From Baserate (DFB) representing the temperature differences between BRT and TT. This difference was computed by simply subtracting the BRT from the TT for each session with negative values reflecting a decrease in attained temperatures during actual biofeedback training, and positive values an increase in trained temperatures. One of Fico's (1976) performance measures was used as the last dependent variable for this study. Positive Incremental Progression (PIP) reflected the number of times a subject was able to increase his temperature over the reading for the previous minute during the actual biofeedback training. Since temperatures were recorded on 15 occasions during training, the PIP value ranged from 0 to 15.

During the course of this experiment, a constant absolute ambient room temperature control was not feasible. Thus the actual room temperature fluctuated within a range of 10° F during the two week experimental run. Since this extraneous source of variation seemed to affect the dependent variables yet was considered to be irrelevant to the independent variables (i.e., WARM experimenters were thought to behave the same in a cooler versus a warmer room, etc.) and since ambient room temperature could be measured independently from skin temperature readings, this variable was controlled statistically.

CHAPTER III

HYPOTHESES

The first set of hypotheses had to do with the experimenter-subject relationship. Since previous research has indicated that experimenters adopting a warm, informal attitude have had more success in training subjects on biofeedback tasks than experimenters adopting a more cold and aloof attitude, it was hypothesized that subjects trained with a WARM E would demonstrate significantly better performances on the two dependent measures, i.e., Deviation From Baserate (DFB) and Positive Incremental Progression (PIP), than those subjects trained with a COLD E. Although both male and female subjects were used in this study, no significant sex differences in performance were predicted.

The second set of hypotheses had to do with the subjects' PIP performance and the confidence they had in their ability to increase peripheral skin temperature. It was hypothesized that subjects demonstrating relatively high PIP scores would have significantly more confidence in their ability than those subjects demonstrating lower PIP scores. It was further predicted that high performance subjects trained with WARM E's would have higher confidence ratings than high performance subjects trained with COLD E's. The same directional prediction was made for subjects in the low performance group.

The third set of hypotheses dealt with the question of whether biofeedback training has an effect in subjects' being able to raise their skin temperature or whether temperature increases are merely the product of an habituation process. It was hypothesized that biofeedback would account for temperature increases, and therefore no significant differences between Baserate Temperatures (BRT's) and Rest Temperatures (RT's) were predicted for subjects regardless of the experimental condition under which they trained or the day. Further, no significant differences between these two measures were predicted based upon the sex of the subject.

The fourth set of hypotheses dealt with the subjects' perception of their respective experimenters. It was predicted that WARM E's were perceived as significantly warmer based on the semantic differential scores than the COLD E's. Again, although sex of the subjects was taken into consideration in the analysis, no significant differences in their ratings were predicted.

CHAPTER IV

ANALYSES AND RESULTS

Figure 1 has been included in this chapter in order to help the reader have a better understanding of what actually took place during the course of the experiment. This figure depicts the fluctuations in unadjusted mean BRT, TT and RT's for all subjects over the four days of training.

In regard to the first set of hypotheses investigating the effects of WARM vs. COLD experimenters on the subjects' biofeedback training, DFB and PIP performance measures were used. Means for the DFB and PIP measures were examined according to the experimenter-subject relationship, sex of subject, and day. Table I includes the unadjusted means and standard deviations of these and the one other performance measure. Negative values in Table I indicate where Baserate Temperatures exceeded either Trained Temperatures (the DFB measure) or Rest Temperatures (RT-BRT). Consideration of the previously noted ambient room temperature fluctuations was provided for through the use of analysis of covariance. Such an analysis permitted the evaluation of the effects of WARM vs. COLD experimenters on subjects' skin temperature increases and decreases after a linear adjustment had been made for the effects of room temperature variation on skin temperature changes. The covariate (room temperature) was obtained by averaging the two room temperatures recorded by the experimenter at the beginning and end

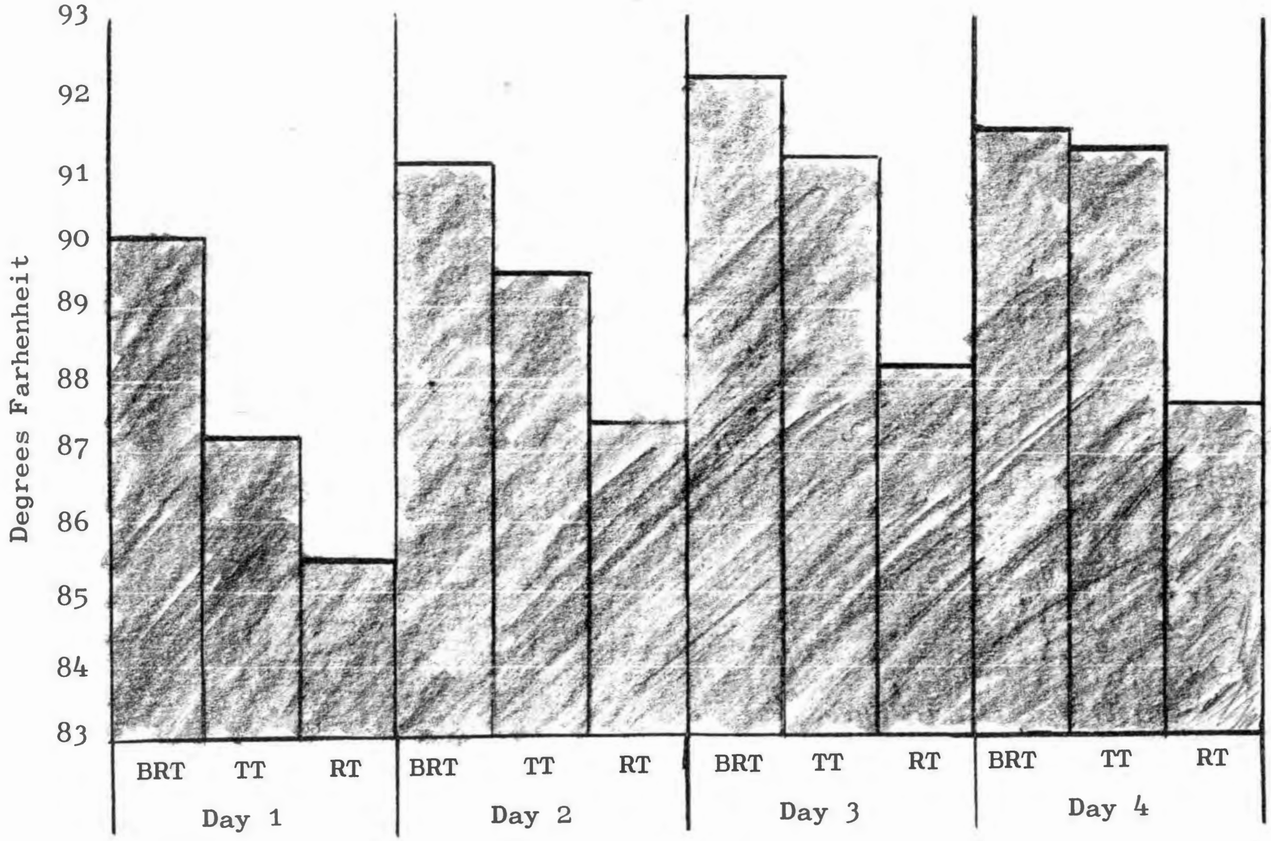

Figure 1. Average BRT's, TT's, and RT's of All Subjects Over Four Days of Training

of each session. Each measure was therefore examined in two separate 2 x 2 x 4 (WARM-COLD x SEX x DAY) split-plot factorial ANCOVA's (Kirk, 1968; Winer, 1971).

TABLE I

UNADJUSTED MEANS AND STANDARD DEVIATIONS FOR THE THREE PERFORMANCE MEASURES

	DAY 1		DAY 2		DAY 3		DAY 4	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
DFB*	-2.59	2.17	-1.55	3.72	-1.05	2.59	-.23	2.51
PIP	5.0	2.69	6.42	2.98	6.54	2.04	7.29	2.18
RT-BRT*	-4.38	4.56	-3.59	4.96	-4.03	4.36	-3.78	3.98

*Reported in degrees Fahrenheit

Support for the use of a covariance analysis was found in the correlation coefficients comparing DFB and room temperature computed over all subjects for each of the four training days (Table II). Two of the four coefficients were found to be significant ($p < .01$) indicating that on the first two training days, room temperature variability did correlate with fluctuations in the subjects' DFB performance.

TABLE II

CORRELATION BETWEEN DFB SCORES AND AVERAGE ROOM TEMPERATURE FOR EACH TRAINING DAY

Day 1	r = .56**
Day 2	r = .83**
Day 3	r = .22
Day 4	r = .01

**$p < .01$, df = 22

A significant within subjects main effect was observed for days ($F_{(1,19)} = 4.68$, $p < .05$). This indicated that the subject's DFB scores changed significantly over the four days of training. No other main nor interaction affects were significant at the $p < .05$ level. Thus, the hypothesis that subjects trained with a WARM-E would demonstrate significantly better DFB performances than subjects trained with a COLD-E was not supported. The analysis of covariance and variance summary tables for the subjects' DFB performance measure are included in Table V (A) (B) (Appendix E).

A Posteriori comparisons were performed comparing adjusted DFB means over all four training days using the Newman Keuls multiple comparison statistic. The mean Deviation From Baserate (DFB) was significantly different on day four when compared to day one ($q_{(19)} = -5.258$, $p < .01$). Since the mean had a negative value (i.e., baserate temperatures tended to be greater than trained temperatures), this showed that subjects tended to increase TT in contrast with BRT as training progressed from day one to day four. No other significant mean differences on DFB were obtained between any of the other days [see Appendix E, Table V (C)].

Also in regard to hypothesis one, the same 2 x 2 x 4 split-plot ANCOVA was used to examine the effects of WARM vs. COLD experimenters on the PIP Biofeedback performance measure. Again, support for the use of analysis of covariance where means were adjusted for the effect of room temperature fluctuations was provided by the correlation coefficients comparing PIP scores and room temperature. These coefficients were computed over all subjects for each of the four training days (Table III). Two of the four coefficients were once again found to be significant ($p < .05$) indicating that at least on the first two days of training, room temperature fluctuations correlated with variability in the subjects' PIP performance.

As with the DFB analysis, a significant main effect for days was observed ($F_{(1,19)} = 5.44$, $p < .05$). Thus, subjects' PIP scores changed significantly over the four training days. No other main nor interaction affects were significant at the $p < .05$ level [(see Table VI, (A), (B), Appendix E)]. Therefore, the hypothesis that subjects' training with WARM E's would do better than those trained with COLD E's was not supported.

Newman Keuls A Posteriori multiple comparisons were performed comparing adjusted PIP means over all four days of training. The difference between the PIP means for days one and two, one and three and one and four were all significant ($q_{(19)} = 3.519$, $p < .05$; $q_{(22)} = 3.876$, $p < .05$; $q_{(19)} = 5.787$, $p < .01$). These results demonstrated that subjects tended to increase their PIP scores from day one to day two, three and four. No other significant mean differences on PIP were obtained for any of the other days [see Appendix E, Table VI, (c)].

TABLE III

CORRELATION BETWEEN PIP SCORES AND AVERAGE ROOM TEMPERATURE FOR EACH TRAINING DAY

Day 1	r = .40*
Day 2	r = .44*
Day 3	r = .14
Day 4	r = .01

*$p < .05$, df = 22

Regarding the second set of hypotheses, 16 subjects were selected on the basis of their overall PIP scores and the experimental condition in which they participated, i.e., WARM-E vs. COLD-E, and they were divided into four groups. One group (Hi-PIP, Warm) consisted of the four subjects in the WARM-E condition with the highest PIP scores averaged over the four days. Group two (Hi-PIP, Cold) was made up of the four subjects in the COLD-E condition with the highest PIP scores over the four days. The third group (Lo-PIP, Warm) consisted of the four subjects in the WARM-E condition with the lowest averaged PIP scores, and group four (Lo-PIP, Cold) was made up of the four subjects in the COLD-E condition with the lowest PIP scores. Confidence ratings of these 16 subjects were analyzed for each of the four days using a 2 x 2 x 4 (Hi-Lo x W-C x Days) split-plot factorial ANOVA (Kirk, 1968).

A significant between subjects main effect was observed for the eight Hi-versus the eight Lo-PIP subjects ($F_{(1,12)} = 17.40$, $p < .01$). The mean confidence rating for the Hi-PIP group was 6.0; the mean confidence rating for the Lo-PIP group was 3.75. Because only two levels were being compared, this F-statistic indicated that subjects with the higher PIP performance rated themselves as being more confident in their ability to raise their skin temperature than those subjects with the lower PIP performances. No other main nor interaction affects were found to be significant (Appendix E, Table VII). Therefore, the hypotheses predicting that high performance subjects and low performance subjects trained with WARM-E's would do better than their respective group of subjects trained with COLD-E's were not supported.

Hypothesis three was concerned with the differences between BRT's and RT's for the subjects. BRT's were subtracted from RT's for each subject and Table I (page 31) includes the unadjusted means and standard deviations of this performance measure. Again, because of ambient room temperature fluctuations, the means of the differences between BRT's and RT's were analyzed using a 2 x 2 x 4 (WARM-COLD x Sex x Day) split-plot factorial ANCOVA with average room temperature representing the covariate. Justification of the covariance analysis was based on the correlations computed between the BRT-RT difference and room temperature fluctuations for all four training days (Table IV). Three of the four correlation coefficients were significant indicating that fluctuations in the BRT-RT difference tended to coincide with room temperature fluctuations.

A significant between subjects main effect was computed for sex of the subject ($F_{(1,19)} = 24.77$, $p < .01$). The adjusted means were -1.5812 for the males and -6.3201 for the females. The F-statistic indicated that the males had less of a difference between their Baserate Temperatures (BRT's) and their Rest Temperature (RT's) than did the females although for both sexes, RT's were below BRT's. Thus, the proposed hypothesis in this area was not supported. Other main and interaction affects were not found to be significant. In other words, there was no significant difference between BRT's and RT's based on day of training or experimental condition, i.e., whether the subject trained with a WARM- or a COLD-Expermenter (Appendix E, Table VIII). Therefore, the proposed hypothesis predicting no difference was not refuted.

TABLE IV

CORRELATION BETWEEN BRT - RT DIFFERENCES AND AVERAGE ROOM TEMPERATURE FOR EACH TRAINING DAY

Day 1	r = .45*
Day 2	r = .49**
Day 3	r = .41*
Day 4	r = .02

*p < .05 df = 22
**p < .01

Finally, hypothesis four focused on examining the WARM-COLD experimenter manipulation. Subjects' ratings of their respective experimenters on the six-item semantic differential scale were averaged and those means were analyzed using a 2 x 2 (WARM-COLD x Sex) ANOVA. A significant main effect was computed for the WARM vs. COLD experimental manipulation ($F_{(1,20)} = 7.00$, $p < .01$, $x\,\Omega^2 = .21$). The mean rating of subjects for the WARM experimenters was 5.867 while the mean rating of subjects for a COLD experimenters was 4.558. This F-statistic indicated that the WARM experimenters were rated as significantly warmer on the six-item semantic differential scale than were the COLD experimenters supporting the hypothesis in this area. The Ω^2 statistic would indicate that 21 per cent of the variance in experimenter ratings was accounted for by the experimental condition in which the subject trained, i.e., whether his or her experimenter was WARM or COLD. The other main effect (sex) and interaction affects were not found to be significant (Appendix E, Table IX).

CHAPTER V

DISCUSSION

This study represented an attempt to investigate several aspects of biofeedback training, specifically, those involving the use of peripheral skin temperature self-regulation. The primary focus was to examine the experimenter-subject relationship and the confidence the subjects had in their ability to raise their skin temperature. The study also provided some evaluation as to the efficacy of biofeedback training and the possibility that skin temperature training actually involves an habituation process. In the following discussion, the results of this investigation are considered along with their implications and suggestions for future research.

The first area investigated focused on factors which might affect successful biofeedback training of skin temperature self-regulation. The first factor studied was the experimenter-subject relationship and was based on the theorizing of several authors (Roberts et al., 1973; Lynch, Hama et al., 1974; Taub, Emurian and Howell, 1974; Roberts et al., 1975; Taub, in press) who contended that this interaction might be an important variable in the training of skin temperature self-regulation. Taub, Emurian and Howell (1974) have reported that a friendly informal experimenter was better able to train subjects to raise their skin temperatures than was a more impersonal experimenter. The present findings do not support these results although mention needs to be made that Taub et al. (1974), reported findings involving only female experimenters while the present investigation employed male experimenters. Taub (1976) indicated that the "person factor" does not appear to be a generalized sex-related phenomenon.

Results of the present study appear to be in line with the findings of Fico (1976) who reported a lack of a significant experimenter effect in the biofeedback training of skin temperature regulation. The subjects did rate their respective experimenters in the expected direction with regard to the WARM-COLD dimension as was the findings in Fico's (1976) study. However, the experimenter manipulation was not found to be a significant factor in any of the analyses using the various dependent variables. The fact that subjects were able to demonstrate some improvement in DFB and PIP scores over days was not influenced by the WARM-COLD manipulation. While the experimenter-subject relationship may indeed play some role in biofeedback training, it apparently does not represent the crucial variable in determining whether biofeedback will be an effective training device at least with regard to the learning of skin temperature control.

The second factor studied was the confidence a subject has in his own ability to self-regulate skin temperature. Initial theorizing for this study was based on the work of Roberts et al. (1975) who noted that the confidence of the subjects seemed to predict their performance on the biofeedback task. Lynch et al. (1974) had concluded that lack of confidence may have resulted in failure of their subjects to perform the biofeedback task. Subjects in the present study who had the highest PIP scores also rated themselves as being more confident in their self-regulation ability. Since the day of training was not a significant factor, initial confidence of the subject would appear to be the most critical variable. Therefore, a subject's confidence is an important factor in successful biofeedback training as related to self-regulation of skin temperature.

With regard to the issue of whether reported significance skin temperature increases with the use of biofeedback represent actual feedback effects or whether they represent an habituation process, the present study incorporated a control procedure not found in previous research. That is, the subjects were given a rest period after each training period during which time they were told to continue relaxing and their skin temperatures were recorded. Fico (1976) and Surwit, Shapiro, and Feld (in press) had indicated that absolute skin temperature increases reported in the literature could probably be accounted for by an habituation phenomenon, i.e., that subjects who simply relaxed and were not given any feedback would tend to show increases in absolute skin temperature. If this were the case, then subjects in the present study would tend to demonstrate skin temperature increases during the rest period and thus Rest Temperatures should have exceeded Baserate Temperatures. As was demonstrated with the present findings and as can be seen in Figure 1, the subjects' BRT's consistently exceeded their RT's. These results are more in line with the work of Thompson (1974) who reported that subjects receiving no feedback or those listening to relaxation training recordings did not demonstrate significant temperature increases over baseline levels. Therefore, the present investigation does not support the position that an habituation phenomenon would account for positive findings with the use of biofeedback skin temperature training.

The one positive finding in this area was that males demonstrated less of a RT-BRT difference than did the female subjects. A clearcut explanation for this result is not readily apparent. Sex differences have not been reported previously in the literature. Of course this difference between the males and females could have represented a chance occurrence. An alternative position is that room temperature fluctuations have a differential effect as to the subject's sex. Although a subjective explanation, this author would speculate from having observed the entire study and from having access to all of the subjects' performance data, that females were more affected by the colder room temperatures. On the days when the weather temperature dropped and the room was fairly cool (68° to 70° F), the female subjects tended to report more discomfort during training (several kept their coats on during the sessions) and although as the particular training session progressed they did show gradual temperature increases, their skin temperatures did seem to drop during the rest period. During the debriefing session, more females reported being too cold on particular days such that they could not "warm-up." Males did not appear to experience quite as much subjective discomfort as did the females.

Finally, with regard to the efficacy of skin temperature biofeedback training, it has already been indicated that the results of previous research were equivocal on this issue. For the present study, it was found that subjects did tend to increase their PIP performance from the first day of training to day two, three and four regardless of the experimental condition in which they trained. This would indicate that subjects were demonstrating some voluntary control of their skin temperature as they were raising their temperatures on a minute-to-minute basis as directed. With regard to the DFB performance measure, the finding that subjects tended to increase TT's in contrast with BRT's as training progressed from day one to day four would also indicate that subjects were exerting some voluntary control in the appropriate direction. Thus, even though subjects were not able to significantly raise their TT's above their respective BRT's, the present findings would indicate that the subjects were able to exert control of their skin temperature over the days of training; i.e., they were moving in the right direction.

The above findings are particularly relevant in view of the following factors in the experiment which would seem to have worked against successful performance of the task. First, fluctuations in ambient room temperature which correlated with the dependent variables during the first two days of training undoubtedly made the task difficult. The finding that the correlations dropped out by days three and/or four would seem to add further support for the subjects' affecting self-regulation of skin temperature. Second, the subjects received no verbal feedback during the course of the experiment as to their actual skin temperatures or their overall progress on a day to day basis; they simply had the four fifteen-minute sessions on the machine and absolute skin temperatures were not discussed. Third, a ceiling effect mitigates against temperature increases beyond a certain point and since many of the subjects demonstrated baserate temperatures which were quite high initially (90^{o} to 95^{o} F), there was not much "room to maneuver" for these subjects. In these cases, successful biofeedback training may simply constitute being able to maintain a particular temperature rather than demonstrating any actual temperature increases. Thus, the increase of TT in comparison to BRT's demonstrated by the subjects in this experiment indicates the successful influence of the biofeedback procedures. Fourth, all of the subjects selected to participate indicated that they were naive with regard to biofeedback. Several indicated they had never heard of biofeedback; none admitted having either done extensive reading in the area or having been trained previously on any biofeedback devices. It may be that some familiarity with the procedures as well as some theoretical explanations would have made the task easier (Gladman and Estrada, 1974a, 1974b, 1975). Finally, the experimenters training the subjects were not experienced with biofeedback techniques and this could obviously have affected the outcome.

Even with these factors working against successful performance of the task, subjects were able to demonstrate skin temperature control. Thus, the present findings would tend to support results that have been reported in previous research (Green, Green and Walters, 1970 and 1973; Roberts, Kewman and MacDonald, 1973; Taub and Emurian, 1973; Taub, Emurian and Howell, 1974; Thompson, 1974; Keefe, 1985; Roberts, Schuler, Bacon, Zimmerman and Patterson, 1975; Slattery and Taub, 1976) that biofeedback can enhance physiologic self-regulation.

Some criticisms relevant to this study, as well as implications for future research, will now receive consideration. As was noted previously, the study suffered a procedural flaw in that ambient room temperature was not controlled nor was this fluctuation initially included in the methodological design. In addition, both the experimenters and the subjects used in the study were relatively naive with regard to the theoretical underpinnings of biofeedback procedures. Finally, four fifteen-minute training sessions with the biofeedback machine may not have been enough exposure for the subjects to adequately learn the control required to result in significant temperature increases over baserate. While Taub and Emurian (1973 and Thompson (1974) have successfully trained subjects in four 15-minute sessions, other experimenters (e.g., Roberts et al., 1975) have used more sessions. Keefe (1975) has even reported that on the differential temperature control task, performance which is relatively poor after only four sessions improves after eitht sessions.

With regard to future research, it seems apparent that more work is needed to determine which characteristics of the subjects enhance and/or hinder the acquisition of physiological self-regulation via biofeedback. Although Roberts et al. (1975) did not find significant relationships between various characteristics of subjects (e.g., hypnotic susceptibility, absorbed imaginative attention, personality variables measured from the MMPI) and ability to self-regulate differential skin temperature, quite obviously more aspects of subjects' variability need to be explored. This theorizing is based on the understanding that particular modes of thinking, feeling and general overall functioning do affect the physiological state of the body. It follows, that particular personality characteristics would result in significant variability with regard to biofeedback performance. Along the same line, investigating the confidence a subject has in his ability to self-regulate skin temperature (or other physiological functions) is a promising area needing further investigation. This is particularly true in light of the present findings which indicated a relationship between confidence and performance. In order for biofeedback procedures to be more effective, it may be that a thorough explanation of the procedures should be included prior to initiating training so that subjects might gain more confidence.

With regard to further investigation of experimenter-subject relationship variables as they influence a subject's biofeedback performance, it might be more profitable to study the characteristics of those experimenters who have shown an ability to train large numbers of subjects. Thus, instructing experimenters to behave in a particular way, even though they may be perceived appropriately by the subjects, may not get at the actual variables which are at work in this area.

The present study was an attempt to follow-up on the work which had been previously done in the relatively new area of skin temperature control through the use of biofeedback. It also incorporated a new approach with regard to investigating confidence of the subject and the possible habituation phenomenon. The findings in general would suggest that while biofeedback seems to be an effective training device, more work is still needed in the area of investigating the parameters involved in successful biofeedback training being mindful of the suggestions which stemmed from this study.

BIBLIOGRAPHY

Aldine-Atherton. Biofeedback and Self-Control. Chicago: Aldine-Atherton, 1971-1975.

Birk, L. (ed.). Biofeedback: Behavioral Medicine. New York: Grune and Stratton, Inc., 1973.

Brown, B. New Mind, New Body Biofeedback: New Directions for the Mind. New York: Harper and Row, Publishers, 1974.

Fico, B. Effects of feedback, incentive and relationship variables on voluntary control of unilateral skin temperature. (Doctoral dissertation, University of North Dakota, 1976.)

Gladman, A. E., and N. Estrada. Biofeedback: Some clinical applications. Paper presented at Biofeedback Research Society meeting, Colorado Springs, 1974a.

Gladman, A. E., and N. Estrada. Biofeedback techniques used successfully in psychotherapy. Paper presented at 21st Annual Meeting of the Academy of Pyschosomatic Medicine, 1974b.

Gladman, A. E., and N. Estrada. A biofeedback approach in the treatment of psychosomatic illness. Paper presented at 128th Annual Meeting of the American Psychiatric Association, 1975.

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

Green, E. E., A. M. Green, and E. D. Walters. Biofeedback training for anxiety tension reduction. Annals of the New York Academy of Sciences, 1974, 233, 157-161.

Herzfeld, A. M., and E. Taub. Effect of suggestion on feedback-aided self-regulation of hand temperature. Paper presented at Biofeedback Research Society Meeting, Colorado Springs, 1976.

Keefe, F. J. Conditioning changes in differential skin temperature. Perceptual and Motor Skills, 1975, 40, 282-288.

Kirk, R. E. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Brooks/Cole Publishing Company, 1968.

Lynch, W. C., H. Hama,, S. Kohn, and N. E. Miller. Instrumental learning of vasomotor responses: A progress report. Paper presented at Biofeedback Research Society meeting, Colorado Springs, 1974.

Lynch, W. C., D. A. Paskewitz, and M. T. Orne. Some factors in the feedback control of human alpha rhythm. Psychosomatic Medicine, 1974, 36, 399-410.

Miller, N. E. Learning of visceral and glandular responses. Science, 1969, 163, 434-445.

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

Maslach, C., G. Marshall, and P. G. Zimbardo. Hypnotic control of peripheral skin temperature: A case report. Psychophysiology, 1972, 9, 600-605.

Mittlemann, B., and H. G. Wolff. Affective states and skin temperature: Experimental study of subjects with "cold hands" and Raynauds' Syndrome. Psychosomatic Medicine, 1939, 1, 271-292.

Peper, E. Frontiers of clinical biofeedback. In L. Birk (ed.) Seminars in Psychiatry, Vol. 5. New York: Grune and Stratton, Inc., 1973.

Redmond, D. P., M. S. Gaylor, R. H. McDonald, and A. Shapiro. Blood pressure and heart-rate response to verbal instruction and relaxation in hypertension. Psychosomatic Medicine, 1974, 36, 285-296.

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

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

Russell, H. L. Fingertip temperature changes during relaxation and psychotherapy. Psychophysiology, 1972, 9, 279. (Abstract)

Singer, M. T. Engagement-involvement: A central phenomenon in psychophysiological research. Psychosomatic Medicine, 1974, 36, 1-17.

Slattery, P., and E. Taub. Specificity of temperature self-regulation to feedback loci. Paper presented at Biofeedback Research Society meeting, Colorado Springs, 1976.

Surwit, R. S., D. Shapiro, and J. L. Feld. Digital temperature autoregulation and associated cardiovascular changes. Psychophysiology (in press).

Taub, E. Self-regulation of human tissue. In G. E. Schwartz, and J. Beatty (eds.). Biofeedback: Theory and Research. New York: Academic Press, in press.

Taub, E. Personal Communication, October, 1975.

Taub, E. Personal Communication, February, 1976.

Taub, E., and C. S. Emurian. Self-regulation of skin temperature using a variable intensity light. Paper presented at Biofeedback Research Society meeting, Boston, 1972. In J. Stoyva, T. Barber, L. U. DiCara, J. Kamiya, N. E. Miller, and B. Shapiro (eds.) Biofeedback and Self-Control, 1972. Chicago: Aldine-Atherton, 1973, 504. (Abstract)

Taub, E., and C. S. Emurian. Feedback aided self-regulation of skin temperature with a single feedback locus: I. Acquisition and and reversal training. Biofeedback and Self-Regulation, 1975, 2 (in press).

Taub, E., and C. S. Emurian, and P. Howell. Further progress in training self-regulation of skin temperature. Paper presented at Biofeedback Research Society meeting, Colorado Springs, 1974.

Thompson, D. J. An investigation of some parameters of acquisition of voluntary peripheral vasomotor control. (Doctoral dissertation, University of Houston, 1974.)

Weinstock, S. A. A tentative procedure for the control of pain: Migraine and tension headaches. In J. Stoyva, T. Barber, L. U. DiCara, J. Kamiya, N. E. Miller, and B. Shapiro (eds.) Biofeedback and Self-Control, 1972. Chicago: Aldine-Atherton, 1973, 515-516. (Abstract)

APPENDIXES

APPENDIX A

BIOFEEDBACK QUESTIONNAIRE

The following questionnaire is being distributed to obtain subjects for a study in Biofeedback. Completion of this questionnaire is strictly voluntary. Simply stated, if you volunteer for this study and follow through with it, you will have the opportunity of learning to relax by receiving feedback from your fingertip skin temperature by means of a Biofeedback Machine. You will also receive extra course credit for your participation.

1. Name: ______________________________

2. Age: ______________________. Sex: M F

3. Phone number where you can most readily be reached: ____________

4. At some time in my life I have experienced (check those applicable):

_______ Migraine or chronic headaches.

_______ Diabetes.

_______ Epilepsy.

_______ High blood pressure.

_______ Other circulatory difficulties such as heart disease, Raynaud's Syndrome, etc.

_______ Mental illness.

_______ Other major medical difficulties.

Specify: ______________________________

_______ None of the above.

5. I am familiar with biofeedback technique because (check all that apply)

______ I have previously participated in biofeedback training (please specify in which modalities you have trained, e.g., skin temp., EMG, EEG ______________________________
____

______ I have done extensive reading (books, Journals, articles) in the area of biofeedback.

______ I have read some articles about biofeedback in newspapers and magazines or have heard about the general idea.

______ I am not at all familiar with biofeedback training.

6. Please check the time you would be able to come in for training. If possible indicate specific times you would be availavle for a one week period.

______ Morning ______ Afternoon ______ Evening

7. Would you be willing to train on one weekend: ______ Yes ______ No

I understand that if I am selected to participate in this biofeedback study, I will be required to attend 4 sessions lasting 45 minutes over a two-week period. Further, I understand that if I do not keep all of the appointments, I will not receive extra course credit for partial participation.

____
(Signed)

____
(Date)

APPENDIX B

INSTRUCTIONS TO THE SUBJECT

Welcome! My name is ________________________ and I will be working with you as a trainer for the duration of the 4 sessions involved in this experiment. This is a biofeedback study having to do with skin temperature self-regulation. The mechanism we will be using to monitor your skin temperature is called a biofeedback machine, the Autogen 2000. This machine is operated by flashlight batteries, note there is no external electrical source, so there is no risk to you whatsoever. For the study, a thermistor will be attached to the middle of the fingerprint of your dominant hand. Temperature increases or decreases will be reflected in fluctuations to the right (increase) or left (decrease) of this needle; the scale indicating the amount (in degrees fahrenheit) of your temperature fluctuations.

Feedback during the training session will come from two sources. First, you can watch the needle to monitor increases or decreases. Second, these earphones will be placed on your head during that period and the pitch of the sound will increase with temperature increases and decrease with temperature decreases. Use either or both of these feedback sources to watch your progress.

Your participation will consist of four, 45-minute sessions including the session today. The first 15 minutes will be a stabilization period in order to determine your normal skil temperature. During that time you need to just sit and relax while I record your temperature. You will not receive feedback during this first period. Then, you will have a 15-minute training period in which you are to try and raise your temperature using the feedback devices to aid you. Previous research has indicated that increases in fingertip skin temperature coincides with feelings of relaxation; therefore as you raise your skin temperature, you should experience a state of relaxation. Finally, there will be a final 15-minute period during which you are to simply sit quietly, relax and make as few movements as possible. Again, you will not receive feedback during this period.

Before proceeding, I would like you to rate on this form the confidence you have in your ability to raise your fingertip skin temperature.

Now, we are ready to begin. I will attach this thermistor and will ask that you place your arm on this padded armrest. Although you do not have to remain rigid, please try and sit as still as possible, remaining awake throughout the whole session. Also, when it comes time to begin raising your temperature, you can use whatever internal means you like, but please don't blow on the thermistor, or use muscle contractions. Note, as you can see, the temperature meter only goes up or down 2^{o} F. Therefore, if your temperature increases or decreases more than 2^{o}F, as I expect it will, I will have to re-adjust the scale which will also re-adjust the pitch of the earphones. Once you get used to the procedure, I doubt that you will hardly notice it.

Let's begin by having you sit quietly, relax and make as few movements as possible. (15-minute stabilization)

Now, placing the earphones and moving the machine so you can see, begin to raise your skin temperature. (15-minute training)

Now, just sit quietly, relax and make as few movements as possible. (15-minutes rest)

Thank you. Your next appoint is ______________________________

APPENDIX C

CONFIDENCE RATING

Please rate the confidence you now have in your ability to raise your peripheral skin temperature through the use of Biofeedback. Simply check one of the spaces between the adjectives.

Very Confident _____ _____ _____ _____ _____ _____ _____ No Confidence

APPENDIX D

SEMANTIC DIFFERENTIAL SCALE

Please use the following adjedtive scales to describe your perceptions of ______________________ during the experiment. Simply check one of the spaces between each pair of adjectives.

Warm	____	____	____	____	____	____	____	Cold
Aloof	____	____	____	____	____	____	____	Friendly
Businesslike	____	____	____	____	____	____	____	Informal
Distant	____	____	____	____	____	____	____	Close
Caring	____	____	____	____	____	____	____	Indif-ferent
Facilitative	____	____	____	____	____	____	____	Uncon-cerned

APPENDIX E

TABLES

TABLE V

ANCOVA, ANOVA AND A POSTERIORI COMPARISONS TABLE FOR EFFECT OF WARM VS. COLD EXPERIMENTERS ON DFB PERFORMANCE MEASURE

ANCOVA Summary Table

(A) Source (adjusted for Rm. Temp.)	df	con. df.	MS	F
Between Subjects	22			
A (W-C)	1		39.446	2.72
C (Sex)	1		3.544	< 1
A x C	1		0.312	< 1
Subjects with groups	19		14.515	
Within Subjects	71			
B (Day)	3	1	22.373	4.68*
A x B	3	1	5.542	1.16
B x C	3	1	5.184	1.08
A x B x C	3	1	3.122	< 1
B x Subjects w. groups	59	19	4.786	

* $p < .05$

ANOVA Summary Table

(B) Source	df	con. df.	MS	F
Between Subjects				
A (W - C)	1		38.077	2.27
C (Sex)	1		5.891	< 1
A x C	1		0.069	< 1
Subjects w. groups	20		16.786	

TABLE V (Continued)

ANOVA summary Table (Continued)

(B) Source	df	con. df	MS	F
Within Subjects				
B (Day)	3	1	23.293	4.64*
A x B	3	1	6.100	1.21
B x C	3	1	4.940	< 1
A x B x C	3	1	3.360	< 1
B x Subjects w. groups	60	20	5.021	

$^{*}p < .05$

(C) A POSTERIORI COMPARISONS WITH ADJUSTED MEANS USING NEWMAN KEULS PROCEDURE

	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}_4$
(Day 1) $\bar{X}_1 = -2.6044$	-	-2.271	-3.485	-5.258**
(Day 2) $\bar{X}_2 = -1.5901$	-	-	-1.213	-2.986
(Day 3) $\bar{X}_3 = -1.0482$	-	-	-	-1.773
(Day 4) $\bar{X}_4 = -0.2565$	-	-	-	-

$^{**}p < .01$

TABLE VI

ANCOVA, ANOVA AND A POSTERIORI COMPARISONS TABLE
FOR EFFECT OF WARM VS. COLD EXPERIMENTERS
ON PIP PERFORMANCE MEASURE

ANCOVA Summary Table

(A) Source (adjusted for Rm. Temp.)	df	con. df	MS	F
Between Subjects	22			
A (W-C)	1		6.438	< 1
C (Sex)	1		32.460	2.91
A x C	1		13.682	3.23
Subjects w. groups	19		11.152	
Within Subjects	71			
B (day)	3	1	20.280	5.44*
A x B	3	1	4.627	1.24
B x C	3	1	4.431	1.19
A x B x C	3	1	4.773	1.28
B x Subjects w. groups	59	19	3.730	

* $p < .05$

ANOVA Summary Table

(B) Source	df	con. df	MS	F
Between Subjects				
A (W-C)	1		6.000	< 1
C (Sex)	1		37.500	3.13
A x C	1		12.042	1.01
B x Subjects w. groups	20		11.979	

TABLE VI (Continued)

ANOVA Summary Table (Continued)

(B)

Source	df	con. df	MS	F
Within Subjects				
B (day)	3	1	21.958	5.64*
A x B	3	1	5.194	1.33
B x C	3	1	4.361	1.11
A x B x C	3	1	5.736	1.47
B x Subjects w. groups	60	20	3.896	

* $p < .05$

(C) A POSTERIORI COMPARISONS WITH ADJUSTED MEANS USING NEWMAN KEULS PROCEDURE

	$\overline{X}_1$	$\overline{X}_2$	$\overline{X}_3$	$\overline{X}_4$
(Day 1) $\overline{X}_1 = 5.0133$	-	3.519*	3.876*	5.787**
(Day 2) $\overline{X}_2 = 6.4006$	-	-	.357	2.268
(Day 3) $\overline{X}_3 = 6.5412$	-	-	-	1.912
(Day 4) $\overline{X}_4 = 7.2949$	-	-	-	-

*$p < .05$

**$p < .01$

TABLE VII

ANOVA SUMMARY TABLE FOR CONFIDENCE RATINGS OF HI-LO PERFORMANCE SUBJECTS ON THE PIP MEASURE

Source	df	con. df	MS	F
Between Subjects	15			
A (Hi-Lo)	1		81	17.40**
C (W-C)	1		1.563	< 1
A x C	1		.562	< 1
Subjects w. groups	12		4.656	
Within Subjects	48			
B (days)	3	1	1.083	1.44
A x B	3	1	1.417	1.88
B x C	3	1	.729	1
A x B x C	3	1	1.729	2.29
B x subjects w. groups	36	12	.754	

**$p < .01$

TABLE VIII

ANCOVA AND ANOVA TABLE FOR DIFFERENCES BETWEEN BRT'S AND RT'S

ANCOVA Summary Table

(A) Source (adjusted for Rm. Temp.)	df	con. df	MS	F
Between Subjects				
A (W-C)	1		80.157	4.03
C (Sex)	1		493.840	24.77**
A x C	1		63.815	3.20
Subjects w. groups	19		19.933	
Within Subjects				
B (day)	3	1	1.341	< 1
A x B	3	1	.407	< 1
B x C	3	1	2.662	< 1
A x B x C	3	1	2.585	< 1
B x Subjects w. groups	59	19	10.564	

$^{**}p < .01$

ANOVA Summary Table

(B) Source	df	con. df	MS	F
Between Subjects				
A (W-C)	1		76.648	2.64
C (Sex)	1		536.855	18.48**
A x C	1		56.090	1.93
B x Subjects w. groups	20		29.053	

TABLE VIII (Continued)

ANOVA Summary Table (continued)

(B) Source	df	con. df	MS	F
Within Subjects				
B (Day)	3	1	2.731	< 1
A x B	3	1	.599	< 1
B x C	3	1	2.437	< 1
A x B x C	3	1	1.300	< 1
B x Subjects w. groups	60	20	11.044	

$^{**}p < .01$

TABLE IX

ANOVA TABLE FOR SUBJECTS' WARM-COLD RATINGS OF THEIR EXPERIMENTER

Source	df	MS	F
A (W-C)	1	10.270	7.00**
B (Sex)	1	.350	< 1
A x B	1	.350	< 1
Error	20	1.467	

**$p < .01$

VITA[2]

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