AN ABSTRACT OF THE THESIS

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Title: VISUAL ANOLOGUE BIOFEEDBACK IN THE CONTROL OF PERIPHERAL FINGER TEMPERATURE WITH HEARING IMPAIRED CHILDREN

Abstract approved: Stephen F. Davis

This study was concerned with the effects of biofeedback, via a visual mode of feedback display, on finger temperature increases with hearing impaired children. Ten hearing impaired children served as subjects, with hearing impairments ranging from .55 decibels to profound. All subjects received two baseline sessions and six sessions of biofeedback training. Attempts were made to control for confounding variables. There were no significant differences on all pre-test measures (baseline finger temperature monitoring). However, all subjects showed a significant increase in finger temperature with biofeedback training. It was concluded that hearing impaired children can learn voluntary control of visceral activity via biofeedback in a visual display mode.

VISUAL ANALOGUE BIOFEEDBACK IN THE CONTROL OF PERIPHERAL FINGER TEMPERATURE WITH HEARING IMPAIRED CHILDREN

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INTRODUCTION

Biofeedback is the use of instrumentation to provide psychophysiological processes of which the individual is not normally aware and which may be brought under voluntary control, Brown (1977). The individual is getting immediate ongoing information about a physiologic function, such as muscle tension, skin surface temperature, brain wave activity, galvanic skin response, blood pressure, and heart rate. The technique is essentially one in which a selected physiological activity is monitored by an instrument which senses by electrodes or transducers signals of biological conditions, Brown (1977). Information is usually fed back by a meter with visual and auditory modes such as light or sound. The sensed information reflects immediate changes in the measured physiologic activity. Biofeedback training is using the information to change and control voluntarily the specific process or response being monitored.

Currently there are four major psychophysiological processes which are measured by biofeedback instrumentation, Hume, (1981).

1. Muscle tension and relaxation can be measured and fed back by electroymography (EMG). Sensors placed on the skin over a selected muscle will provide electrical activity of that muscle. More electrical firings indicate greater tension or activity. With biofeedback training an individual can learn when tension begins and how to relax. The selection of site of EMG training depends on the type of symptom which is being treated. The use of EMG biofeedback is applied mostly in general relaxation training and neuromuscular reeducation.

2. Arousal changes due primarily to the sympathetic nervous system are measured by the galvanic skin response, GSR. GSR measures changes in sweat response on the surface of the skin, usually the hand. The use of GSR biofeedback provides the individual with ongoing information of their own arousal system. GSR biofeedback application has been successful in work with phobias, guided imagery, and stuttering.

3. Brian wave patterns can be measured and analyzed by an electroencephalograph (EEG). The EEG measures small microvoltages of electrical activity of the brain cortex by use of sensors placed on the scalp. The measurement is converted into particular brainwave frequencies and

amplitude. There are four major frequencies categorized: Beta, Alpha, Theta, and Delta. There are different subjective experiences associated with these major groups ranging from attentiveness or anxiousness (Beta), to more meditative and daydreaming associations (Alpha), to passive problem-solving and creativity (Theta), and sleep (Delta). However, an individual is never in any one state but a predominance of one frequency and associated subjective experience. EEG biofeedback can be used in treating certain disorders such as insomnia, pain, or enhancing creativity.

4. Peripheral blood flow can be measured by measuring the temperature of the surface of the skin by use of temperature biofeedback. Changes in dilation or constriction of the peripheral vessels lead to changes in blood flow. In a constant environment, skin surface temperature of the hands can fluctuate between 60 and 90 °F. Minute changes in the skin temperature are measured by a thermistor placed on the surface of the skin and fed back to the individual. Temperature biofeedback has been applied successfully in conditions such as migraine headaches, peripheral vascular dysfunction, and general

relaxation. Other psychophysiological processes applied to biofeedback include blood pressure and heart rate.

Biofeedback technology began to evolve during the 1960s with the purpose of providing methods of learning volitional control over physiological functions which were believed to be involuntary, Black and Cott (1977); Kimmel (1967, 1974). It was generally accepted that physiological changes in heart rate, blood pressure, electrodermal response, or brain wave activity were brought about in a reflex action. Pavlovian conditioning where the organism is essentially passive, automatically responding to stimulation, was seen as the mechanism of visceral learing. The classical conditioning model shows that an electrical shock may elicit an increase in heart rate. If the shock is consistently paired with a tone, the tone will begin to elicit the same response. The response is evoked involuntarily in a reflex manner, initially by the shock and subsequently by the tone. By using such procedures, any physiological change that could be elicited involuntarily by a specific stimulus as an unconditioned reflex also could be elicited by a neutral stimulus as a conditioned reflex, Orne (1979). Early theorists assumed thoughts

could serve as conditional stimuli and thereby provide a method of volitional control over involuntary physiological functions, Blizard, Cowings and Miller (1975).

The learning of volitional behavior was explained in terms of operant or instrumental conditioning. The process depends upon reinforcing the organism when it is producing a desired response, whereas in classical conditioning, the organism's response involves a change elicited involuntarily and is a reflex in operant conditioning. The response is a behavior within the organism's normal repertoire. In this sense reinforcement in this type of conditioning makes it worthwhile for the organism to do something that is already within its normal behavioral capabilities, Orne (1979).

During the 1960s investigators began to apply the operant model as a means of modifying visceral activity, Shapiro, Crider (1964) and Tursk (1964). Engel (1972) began to train patients to control their heart rate with electronic equipment monitoring that function. When subjects raised their heart rate by a slight amount, a signal light was turned on. With the light serving as a reward, subjects learned to alter their heart rate.

Studies have shown that, contrary to previous belief, biofeedback technology can train individuals to acquire volitional control over a number of automatic functions, Kimmel, H.D. (1967). Further, this control seems to involve considerable specificity and could not be explained simply as the result of thinking arousing thoughts, Kimmel (1980).

Miller (1969) reported studies demonstrating that visceral responses could be brought under operant control. Using curarized animals to eliminate the possibility of mediation by skeletal muscle activity, rats were trained to control heart rate and blood pressure independently of each other. The specificity of responses was great enough to train rats to increase blood flow in one ear while simultaneously decreasing it in the other ear, Miller, DiCara (1980). Another study by DiCara (1970) has supported operant procedures in the training of volitional control of visceral autonomic functions. Seven of 43 curarized rats trained to slow their heart rate died from apparent heart failure while none of the 41 rats trained to increase their heart rate showed such an effect. This research provided the scientific legitimacy needed for the emerging biofeedback

technology.

The earliest applications of biofeedback were in the field of rehabilitation, the retraining of muscles after injury or a paralytic disease. The application of biofeedback technique to lower the overall level of muscle tension did not develop until the late 1960s. Stoyva and Budzinsky (1974) reported that frontalis muscle feedback could be used to train people in general relaxation. The electromyograph (EMG) feedback initially specific in its effects, soon generalized so that as the level of frontalis muscle tension was reduced, individuals became progressively more relaxed, indicated by a lower level of muscle tension in their muscle groups as well as in the subjects' verbal reports. This type of biofeedback training has been widely applied in the treatment of tension headaches.

Another parameter used for biofeedback training is finger temperature. It has been recognized that anxiety leads to peripheral vasoconstriction, such as the cold hands of a frightened individual. In self-regulation of hand temperature the individuals actually learn to control blood volume. The blood volume that is being regulated is directly proportional to the diameter of blood vessels.

When blood vessels increase in diameter, blood volume increases and within seconds the temperature of the finger begins to rise, Cook, Gerkovich, Graham, Cohen, and Anderson, (1979). Objective psychophysiological studies have shown that finger temperature and forehead temperature vary inversely so that increasing finger temperature and decreasing forehead temperature are associated with increased relaxation and decreased anxiety. Finger temperature, therefore, may be assumed to be associated with a more general total relaxed state than the specificity of electroymograph (EMG) biofeedback, Orne (1979).

The most important independent variable in biofeedback research is the display to the subject of the physiological function under investigation. Regarding the nature and form of feedback, studies have shown that reinforcing feedback appears to be more effective than information feedback, and that the choice of feedback should be based on the functional properties of the control system that underlies the physiological process to be modified, Kimmel (1980). The type of feedback displays have varied greatly; however, they fall into three categories: Visual, auditory, and digital, and, in a few instances, tactual. Within the visual modalities, the possibilities for displaying feedback are numerous.

The most common type of visual display involves the use of a scale with the midpoint representing average baseline level and deviations to the left and right representing decreases and increases in performance. Another type of visual display illustrated by Lubar and Bohler (1976) utilized lights which were illuminated progressively each time cortical activity reached a specific criterion.

Digital feedback displays represent the level of activity by numbers. Manuch, Levenson, Kinrichson, and Gryll (1975) represented heart-rate changes by a changing display of the numbers 2 through 8. However, numerical displays proved to be hard to teach and confused the subjects, Manuch, et al. (1975).

Auditory feedback seems to have been more commonly used than visual feedback. Auditory feedback takes the form of either a change in pitch as a function of change in activity or a change in click rate. Kinsman, O'Banion, Robinson, and Staudenmayer (1975) presented feedback in the form of two clicks per second when frontalis muscle activity was absent, while one click, corresponding to

one EMG count, was given whenever the EMG signal reached a specific criterion.

Several studies have investigated the relative effectiveness of different feedback modulation, such as visual versus auditory. Blanchard and Young (1972) compared feedback display in the auditory (varying tone) and visual (meter reading) modalities in the control of increases and decreases of heart rate and found no difference in their effectiveness in the control of increases, both being superior to a no feedback control group. Budzynski and Stoyva (1973) trained subjects to reduce muscle activity under conditions of auditory feedback and visual feedback; no difference in effectiveness were apparent between the two modalities. Schandler and Gringe (1976) found tactile feedback to be superior to visual; however, no differences were reported between tactile and auditory feedback. The results of these studies still leave the question of one type of feedback being superior to another. The relative effectiveness of different modalities of feedback display may depend on the function of the response being controlled.

There have been further studies on the conditions under which the effect of biofeedback may be maximized. Calgar (1977) found analogue feedback of heart rate to be superior to binary feedback. An example of visual analogue feedback is a dial and a moving needle. The physiological level is translated directly and continuously into a slowly moving voltage level, which is displayed as a dial reading. Auditory analogue feedback uses a system which converts the physiological activity into a continuous voltage which is then fed into a voltage to frequency converter so that the output is a tone, the frequency which is proportional to the input, and thus raised with the physiological level. Binary feedback requires the definition of a specific level of phsyiological activity. When the specific level is exceeded, a constant signal is either turned on or off. Visual binary feedback usually incorporates a light which comes on when the specific level is exceeded, while auditory binary feedback uses a constant tone. Elder, Longarce, Welsh, and McAfee (1977) found continuous feedback to be superior to intermittent for the control of blood pressure. Some research in the area of biofeedback and relaxation have used various combinations of technique to obtain the best results. However, there is little

evidence that combination methods are more effective than specific technique (Tarler & Benlalo, 1978).

There have been discrepancies in the area of biofeedback and self-control of peripheral finger temperature. Roberts, Kewman, and MacDonald (1973) used hypnotic suggestion plus auditory analogue feedback to alter the difference in temperature between the hands, such as warming one hand and cooling the other. They used six subjects who were experienced in hypnotic and meditative technique and who were given a series of trials using cold and warm pads; subjects practiced awareness of warm and cold sensations. After three sessions with feedback, significant increases and decreases in temperature of both hands were observed. The results of the study, while significant, clearly condounded the biofeedback procedure with hypnotic suggestions. Raskin, Bali, and Peeke (1980), comparing EMG biofeedback, transcendental meditation, and relaxation therapy in treating chronic anxiety, found no indications that one treatment was more effective than another. However, they clearly confounded the biofeedback treatment by instructing the subjects in modified progressive relaxation techniques, and also using visual imagery to induce relaxation.

Rivera and Omizo (1980) studied the effects of relaxation and biofeedback on attention to task and impulsivity of hyperactive male children. They reported significant differences, with the treatment group improving attention to task scores and decreasing impulsivity scores. However, the biofeedback treatment was confounded by the taped relaxation program, "Peace, Harmony and Awareness" (Lupin, 1977). The study still provides a viable clinical application in the treatment of hyperactive children.

Lynch, Hama, Kohn, and Miller (1976) confounded feedback with reinforcement in their study of differential peripheral finger temperature control in children. They provided visual meter feedback of temperature differential and a digital counter display which indicated how much money the child had earned. The children's ages ranged from 10 to 11½ years, and the task was presented as a game called "moving the needle." Three of the four children were able to warm one hand relative to the other.

There is also evidence that sex differences exist in baseline levels of peripheral temperature, with females tending to have colder extremities than males (Boudewyne, 1976; Sheridan, Boehm, Ward, & Justesen, 1976). Differences in mood states also have shown rapid changes

in peripheral finger temperature. Taub, Emurian, and Howell (1975) have stressed the importance of a personal factor. Their results showed that when the experimenter adopted an impersonal attitude toward the subject, only 2 of 22 subjects in their study succeeded in bringing peripheral finger temperature under voluntary control, whereas 20 of 21 subjects succeeded when a more informal, warm, and friendly approach was adopted.

Hadfield (1920) reported a patient of his could produce large differential changes in hand temperature rapidly whenever it was suggested that he do so. Feedback was not provided. More recent studies have produced results which suggest that peripheral finger temperature changes may result from experimental procedures not involving the use of feedback. Boudewyns (1976) found that training in relaxation alone led to a significant increase in finger temperature, while subjecting the same subjects to a stressful situation produced a decrease in temperature. These results support earlier results by Mittleman and Wolff (1939), who found large decreases in temperature when difficult problems were attempted or the subjects discussed personal problems. Dugan and Sheridan (1976) found that instructing subjects to imagine their hands in very warm water or in ice-cold

water, but with no feedback available, produced significant increases and decreases in peripheral finger temperature, respectively. Dugan and Sheridan (1976) also reported the production of differences between corresponding fingers of the two hands is a much more difficult task than increasing or decreasing temperature alone.

Herzfeld and Taub (1977) using a small number of subjects produced evidence suggesting that a combination of suggestions of warmth or cold by various means in combination with biofeedback is more successful than biofeedback alone in obtaining voluntary control of finger temperature. Hunter, Russel, Russel, and Zimmerman (1976) attempted to control for imagery by instructions given to the children who were subjects but confounded feedback and reinforcement. They trained 30 learning disabled children of low average intelligence and 30 matched "normal" controls to produce increases in finger temperature in the presence of feedback, a variable intensity lamp, and reinforcment; a train which ran whenever and increase of 0.5 °F was obtained. The children were adapted to room temperature for 20 minutes and given instructions to "think your fingers warm." Both groups received continuous feedback in the first

training. In the remaining sessions, half of the subjects in each group received continuous feedback whereas the other half received inconsistent feedback. Overall, both groups showed an increase of 0.38 °F, and consistent feedback produced a significantly greater rise in temperature than inconsistant feedback.

Sheridan et al. (1976) randomly assigned their subjects to one of four training conditions: an autogenic training group, a group given autogenic training and feedback, a feedback only group, and a control group given neither feedback nor autogenic training. All groups were trained to increase peripheral finger temperatures. All three experimental groups were more successful than the control group at acquiring control, but no significant differences were apparent from the experimental groups.

Gillespie and Peck (1980) in a very carefully controlled study investigated the effects of biofeedback and guided imagery on finger temperature. Twelve subjects were randomly allocated to one of two groups: finger temperature biofeedback or guided imagery. All subjects received equal baseline and treatment sessions during which stimulus presentations were carefully controlled. The biofeedback group established an ability to increase

finger temperature, whereas the guided imagery group was consistently associated with temperature decreases.

The literature in biofeedback is certainly inconsistent and many feedback studies are seriously confounded. Several studies cited confounded biofeedback with relaxation techniques, guided imagery, or some type of reinforcement.

Hearing impaired children were used in the present study for several reasons. Computerized literature reviews exploring biofeedback with hearing impaired children or relaxation techniques for hearing impaired children revealed no apparent data to date. It may be possible that hearing impaired children could also benefit in treating of disorders in the same way as any hearing children via visual display of biofeedback modes. Specifically in the treatment of hyperactivity. Since the hyperactive child has difficulty conforming to structured situations, the problem is amplified in a school setting where demands for conformity accentuate the problem, Whalen and Henker (1976).

The present study was done to investigate control of peripheral finger temperature with hearing impaired children. Skin temperature biofeedback was used to train subjects; a visual display mode of feedback was

provided. The experimental design employed was to test the significance of a difference between means based on repeated measurements taken on the same subjects. The pre-experimental level of performance (baseline) on the variable under study (peripheral finger temperature) was obtained as well as the level of performance following the introduction of the experimental manipulation (biofeedback-treatment). Attempts were made to control for confounding biofeedback with relaxation technique, guided imagery or reinforcement.

It was predicted that subjects would show a significant increase in peripheral finger temperature with biofeedback training as compared to baseline sessions. It was also predicted that subjects would show no significant increases in peripheral finger temperature with baseline one and two.

CHAPTER 2

METHOD

Subjects

Subjects consisted of three males and seven females, ranging from 9 to 14 years of age. Subjects were all hearing impaired, ranging from .55 decibel loss to profound. Subjects were voluntarily recruited from an organization of parents of hearing impaired children. Table 1 provides biographical data on each child at the time he or she entered the study.

Apparatus

A Systec Temperature Feedback Trainer (Type 75-3-1346 T2-F) was used to measure temperature and provide a visual biofeedback mode of finger temperature. The biofeedback equipment is a precision medium range thermometer with the capabilities of measuring absolute and differential temperature. It measures absolute temperature from 60 °F to 104 °F with a meter scale range of ±25 °F and 2.5 °F, and is accurate within a °.05 °F in the 2.5 degree mode.

Procedure

An interpreter was used to aid communicating procedures of the study to the subjects. Subjects were told

Table 1

Biographical Data

Subject	Sex	Age	Hearing Impairment (db-decibel loss)
1	F	11	.95
2	M	9	.80
3	F	10	Profound
4	F	11	.75
5	F	10	.65
6	F	11	.65
7	F	13	.70
8	M	14	.55
9	M	11	.60
10	F	14	.55

that the study was investigating the way in which people attain self-control of their hand temperature. A visual mode of biofeedback was used to accommodate the special needs of the subjects. Baseline and treatment sessions were conducted in a quiet room, with subjects seated in comfortable chairs. All sessions were run at the same hour for individual subjects; this timing was intended to control for 24-hour temperature rhythm. At the beginning of each baseline and each treatment session the thermistor probe was attached to the central whorl print of the middle finger of the dominant hand. The probe lead was secured with a micropore dermical tape. All subjects received two baseline monitoring sessions and six sessions of biofeedback training (treatment). Each baseline and treatment session lasted 10 minutes following stabilization and comprised 20 thirty-second trials.

Criterion in relation to determination of temperature was no more than 0.4 °F change over two consecutive 30-second intervals. Temperature was monitored until the stability point temperature had been achieved prior to all baseline and treatment data; this monitoring was intended to control for temperature changes resulting from the difference in room temperature and finger temperature of the subjects. Stability point temperature monitoring was not less than five minutes and not greater than 20 minutes for all baseline and treatment sessions.

Finger temperature was monitored and recorded in 30-second intervals throughout all the baseline and treatment sessions. Subjects were praised for their performance at the end of each session.

The treatment sessions were procedurally similar to the baseline sessions with the following differences:

1. The visual feedback display monitoring finger temperature was provided to the subjects during treatment.

2. The function and use of the biofeedback treatment were explained and demonstrated: a meter deflection to the right is a temperature increase, a deflection to the left is a temperature decrease.

3. The typed instructions.

Length of sessions and number of trials remained constant for baseline and treatment. Thus, factors other than the independent variable (biofeedback training) that may be responsible for any temperature changes were controlled.

Baseline

Subjects were seated; thermistor probes were attached; and the stability criterion was achieved: no more than 0.4 °F change over 2 consecutive thirty-second intervals. Temperature stability point monitoring was not less than five minutes. Each subject received two

baseline sessions lasting 10 minutes and comprising 20 thirty-second trials. Temperatures were recorded throughout the sessions in thirty-second intervals. Each subject received the following typed and signed instructions:

> During this session all you are required to do is sit in the chair and remain still. Try not to move around too much, just remain sitting. Do you understand the instructions? Do you have any questions?

Treatment

After the collection of baseline data, the function and use of the biofeedback instrument were explained and demonstrated. Subjects were seated and instructed to hold the thermistor probe lightly between the index finger and thumb and observe the visual feedback mode: a meter deflection to the right is an increase in temperature; a release of thermistor to expose probe to room temperature and observe a meter deflection to the left, a temperature decrease. Subjects were allowed to experiment with the instrument briefly. Following stabilization (no more than 0.4 °F change over two consecutive thirty-second intervals) treatment sessions lasted ten minutes and comprised 20 thirty-second trials.

Subjects were not exposed to the biofeedback visual display made during stabilization. Each subject received six sessions of biofeedback training. Temperatures were recorded throughout the sessions in thirty-second intervals. All subjects received the following typed and signed instructions:

> During this session you are required to raise the reading on the meter which is a measure of your finger temperature. A deflection to the right is an increase in your finger temperature. People find their own ways to do this often using some form of mental control. Pay attention to how your body feels and how the meter reads. Use the feedback from the meter to increase your successful efforts. Try to remain still throughout but do not concentrate too hard. Remember, try to raise the meter reading. Do you have any questions?

Subjects were praised for their performance at the end of each session. All sessions took place in a quiet, dimly lit room with temperature constant ± 2.0 °F. Length of sessions and number of trials remained constant for baseline and treatment. The major difference was the stimulus arousal properties of the biofeedback treatment. Thus factors other than the independent variable

(biofeedback) that could be responsible for any temperature change were controlled.

CHAPTER 3

RESULTS

Scoring System

The method of calculating temperature change in all sessions was modeled after that described by Taub and Emurian (1976). Temperature at the end of each trial was deducted from the stability point temperature for that session, thus providing the temperature change only for each trial. Each baseline session and each treatment session were then converted to one mean change score. Data for each subject consisted of two baseline mean change scores and six treatment mean change scores. Baseline and treatment mean change scores were then converted to one baseline mean change score and one treatment mean change score for each subject. A repeated measurement design was employed utilizing a t-test for non-independent groups with a level of significance at $p < .05$. The study included baseline measures and biofeedback training (treatment phase) as outlined in Table 2. A t-test was performed on pre-experimental (baseline) measures to note any significant differences during baseline, level of significance at $p < .05$. Raw data for each subject, including pre-experimental (baseline measures two sessions per subject) and experimental

Table 2

Experimental Design

	Sessions							
	1	2	3	4	5	6	7	8
Subjects								
1	B	B	Bf	Bf	Bf	Bf	Bf	Bf
2	B	B	Bf	Bf	Bf	Bf	Bf	Bf
3	B	B	Bf	Bf	Bf	Bf	Bf	Bf
4	B	B	Bf	Bf	Bf	Bf	Bf	Bf
5	B	B	Bf	Bf	Bf	Bf	Bf	Bf
6	B	B	Bf	Bf	Bf	Bf	Bf	Bf
7	B	B	Bf	Bf	Bf	Bf	Bf	Bf
8	B	B	Bf	Bf	Bf	Bf	Bf	Bf
9	B	B	Bf	Bf	Bf	Bf	Bf	Bf
10	B	B	Bf	Bf	Bf	Bf	Bf	Bf

Note. B--Pre-experimental, base-line measures.

Bf--Biofeedback training, treatment phase.

(treatment; biofeedback training, six sessions per subject) scores are provided in Appendix A.

Data analysis of pre-experimental (baseline) measures included a t-test for non-independent groups to compare mean temperature changes for baseline 1 and baseline 2. Calculations for mean difference ($\bar{D}$), standard error ($S\bar{D}$), and t are provided in Appendix B. Baseline mean change score differences were not significant (t (9) = $p > .05$), with a critical value, (9df), at .05 level = 2.2622. Figure 1 provides mean changes in finger temperatures across subjects for baseline one and two.

Data analysis of experimental (treatment) measures included a t-test for non-independent groups to compare baseline mean change scores and treatment (biofeedback) mean change scores. Calculations for mean difference ($\bar{D}$), standard error ($S\bar{D}$), and t are provided in Appendix C. Baseline mean change scores and treatment mean change scores were significantly different ($t(9) = 8.37$, $p < .01$), with a critical value, (9df), at .01 level = 3.2498. Mean changes in finger temperature for baseline measures and biofeedback training are provided in Figure 2. Mean changes in finger temperature for baseline one, baseline two, baseline one and two mean and treatment mean are provided in Table 3. Figures 3 through 12 provide mean

changes in finger temperature across sessions for baseline 1 and 2 (control) and biofeedback training (treatment), ten subjects.

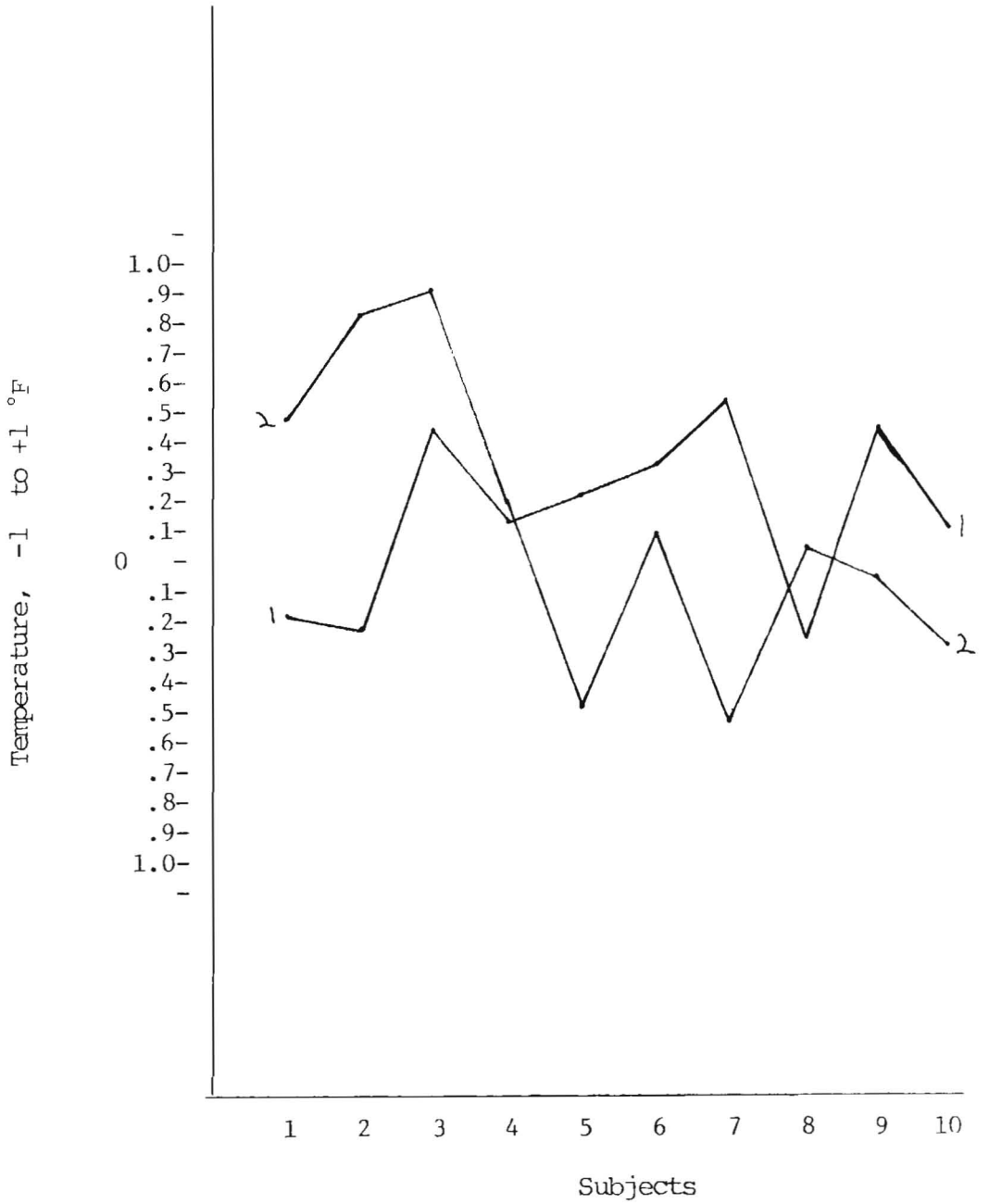

Figure 1. Mean changes in finger temperature across subjects for baseline 1 and 2.

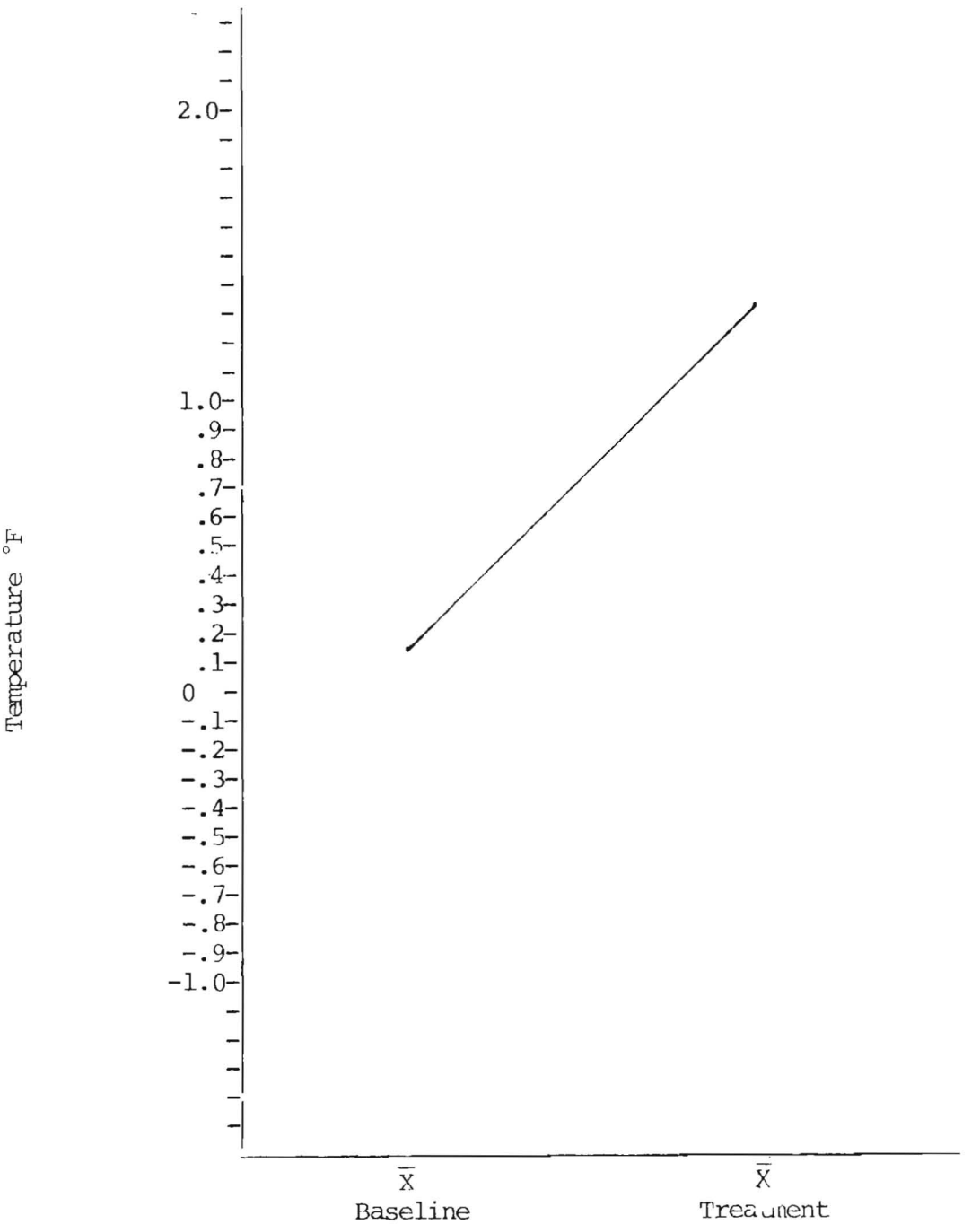

Figure 2 . Mean change in finger temperature for baseline measures and biofeedback training, (treatment).

Table 3

Mean Changes in Finger Temperature

	Subjects									
	1	2	3	4	5	6	7	8	9	10
Baselines										
1	-.1675	-.1825	.435	.135	.2125	.3375	.585	-.2225	.45	.0725
2	.4925	.835	.8725	.1375	-.4975	.0425	-.55	.055	-.0875	-.245
1-2 $\bar{X}$	.1625	.326	.6537	.136	-.1425	.19	.0175	-.0837	.18125	-.082
Treatment	1.46	1.7595	1.885	.789	1.783	1.737	1.393	.3770	.8966	1.3116

Note. Temperature °F.

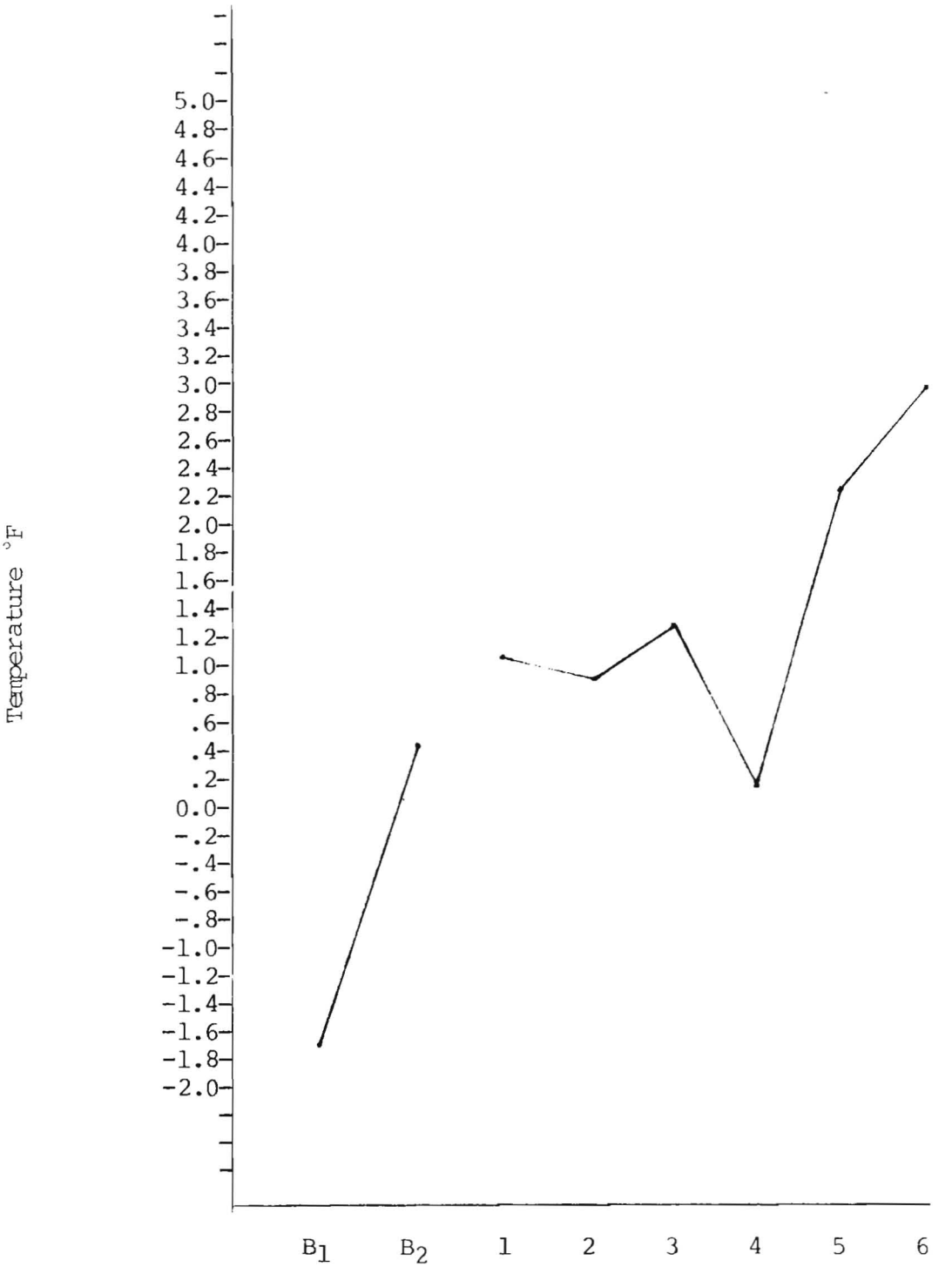

Figure 3. Mean changes in finger temperature of Subject 1 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

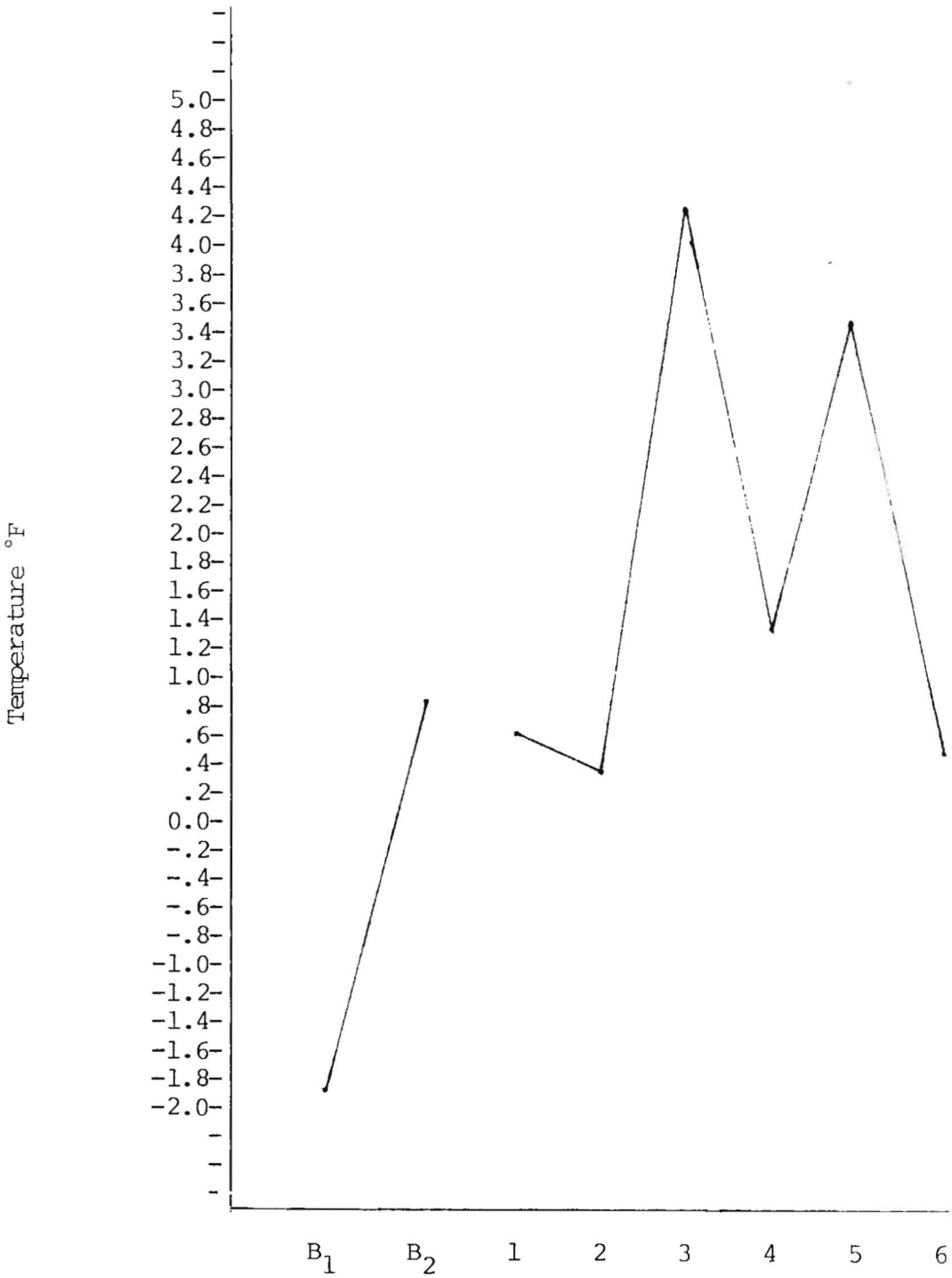

Figure 4. Mean changes in finger temperature of Subject 2 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

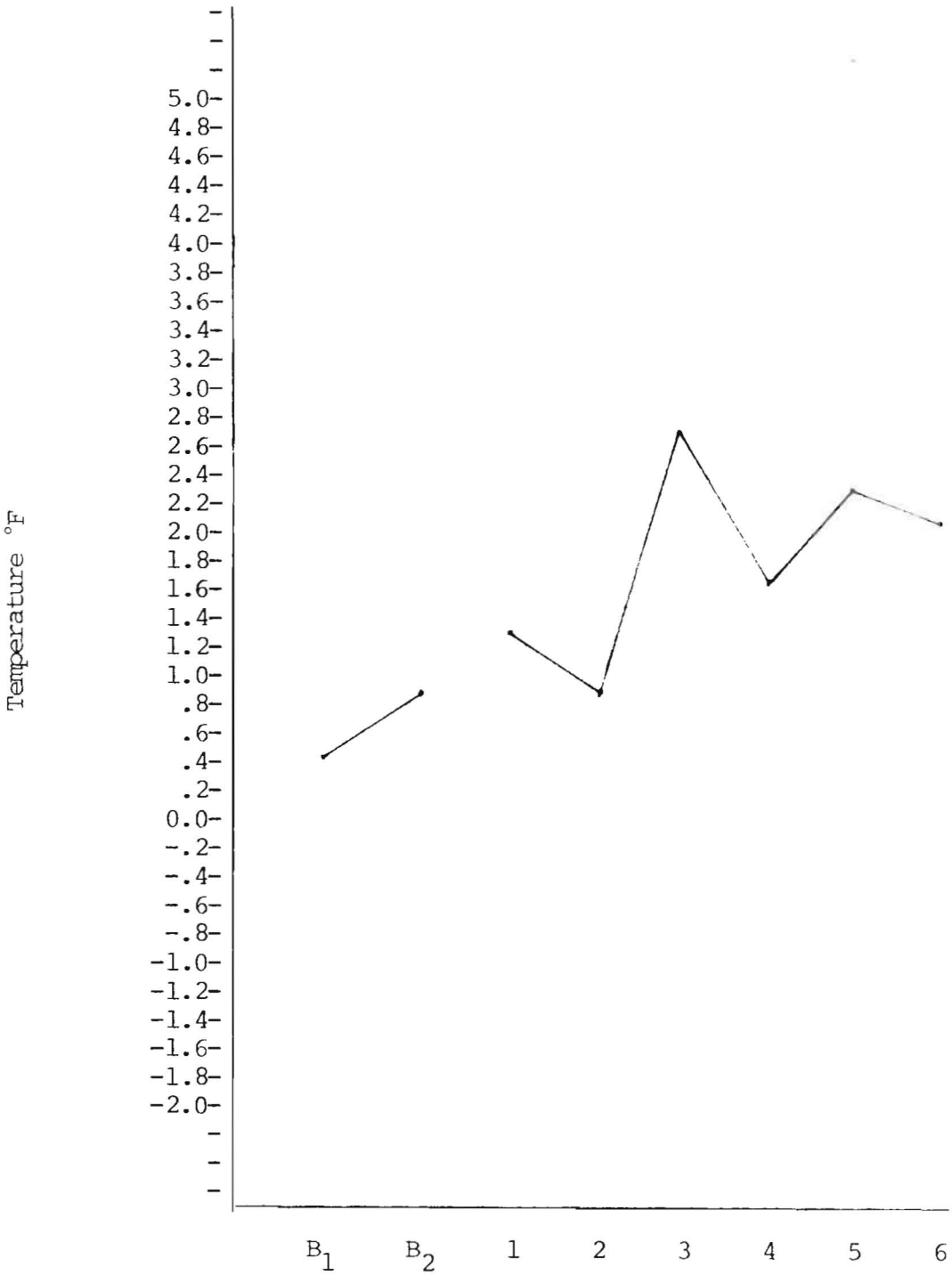

Figure 5. Mean changes in finger temperature of Subject 3 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

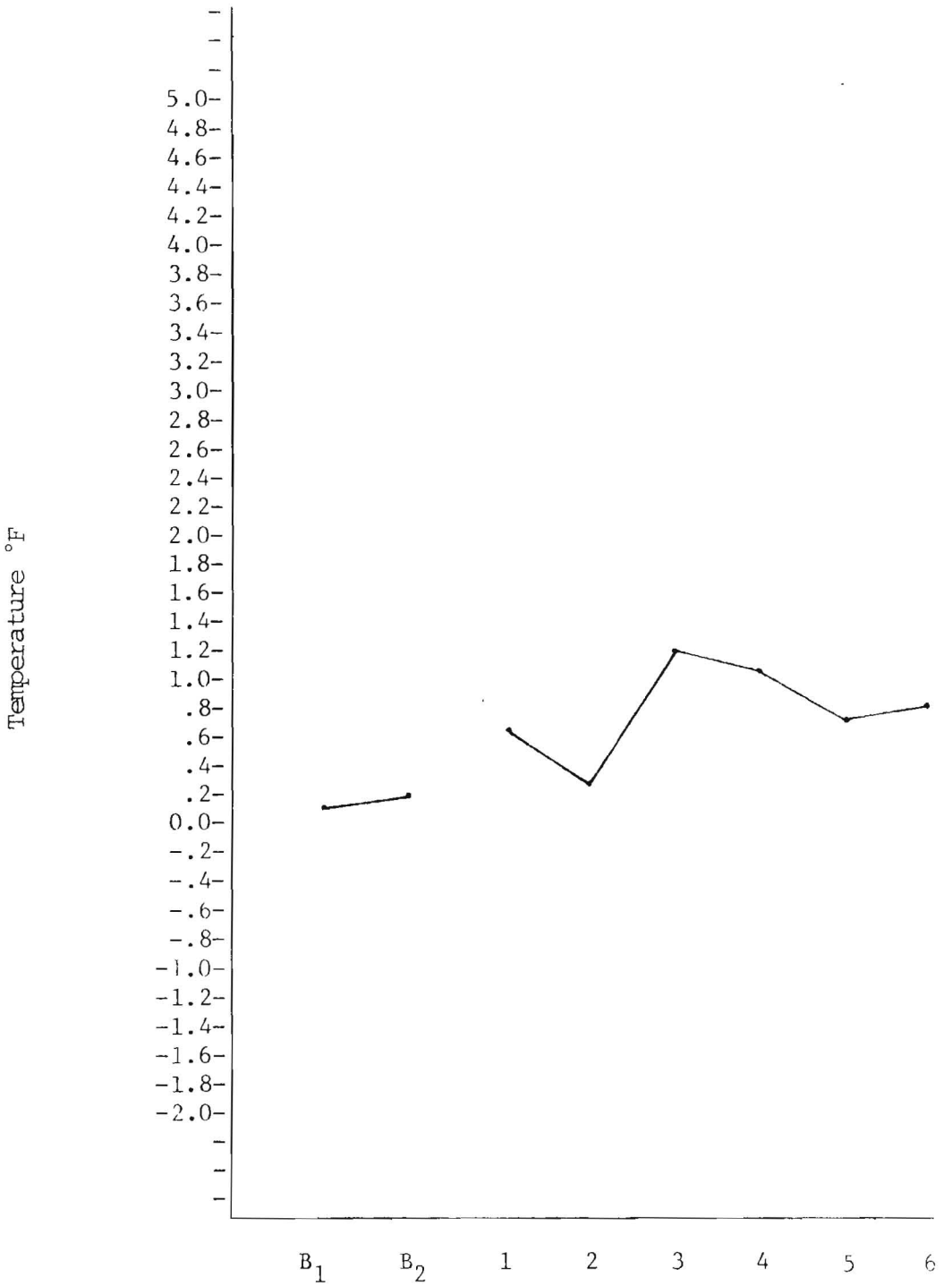

Figure 6. Mean changes in finger temperature of Subject 4 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

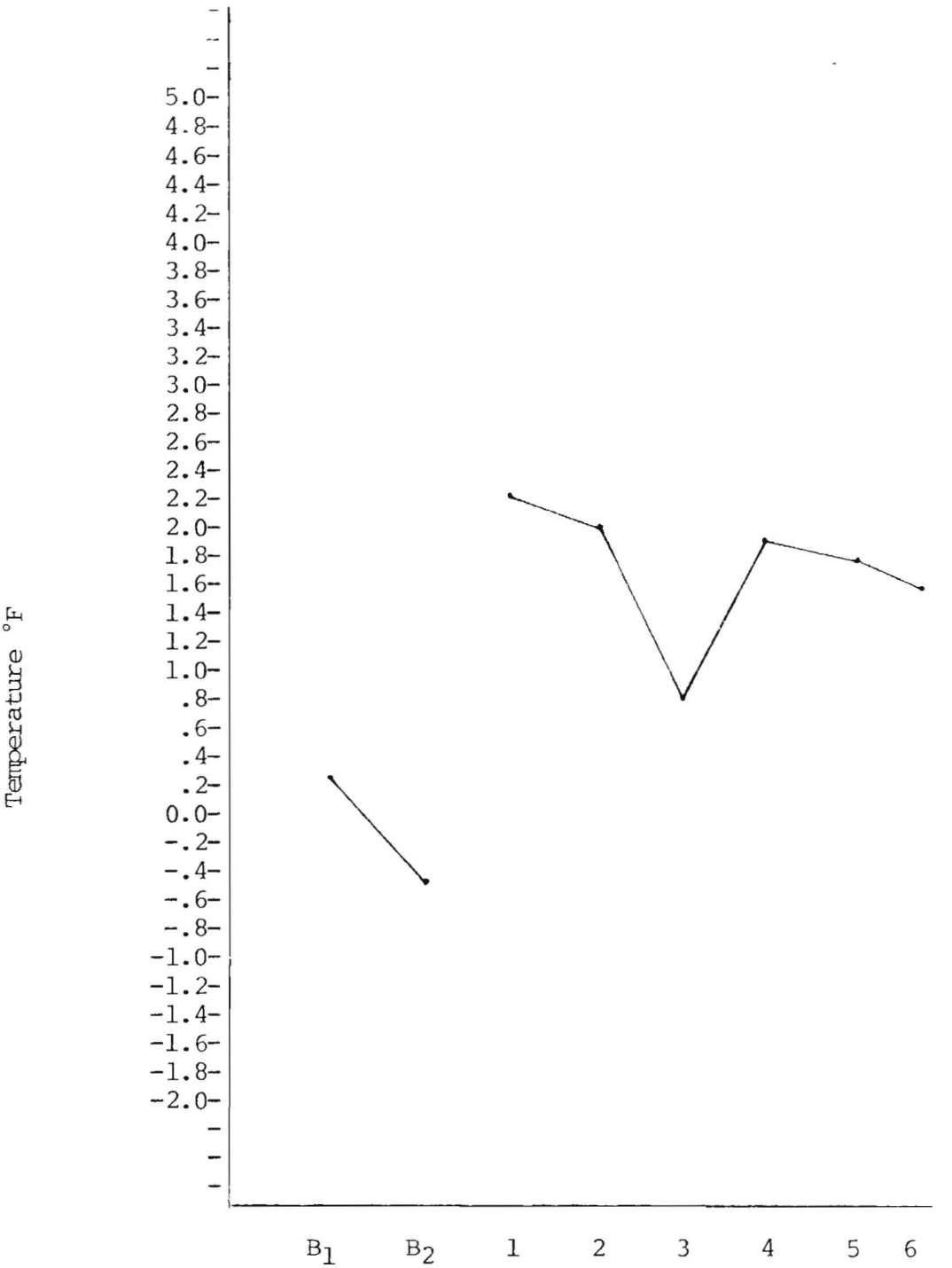

Figure 7. Mean changes in finger temperature of Subject 5 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

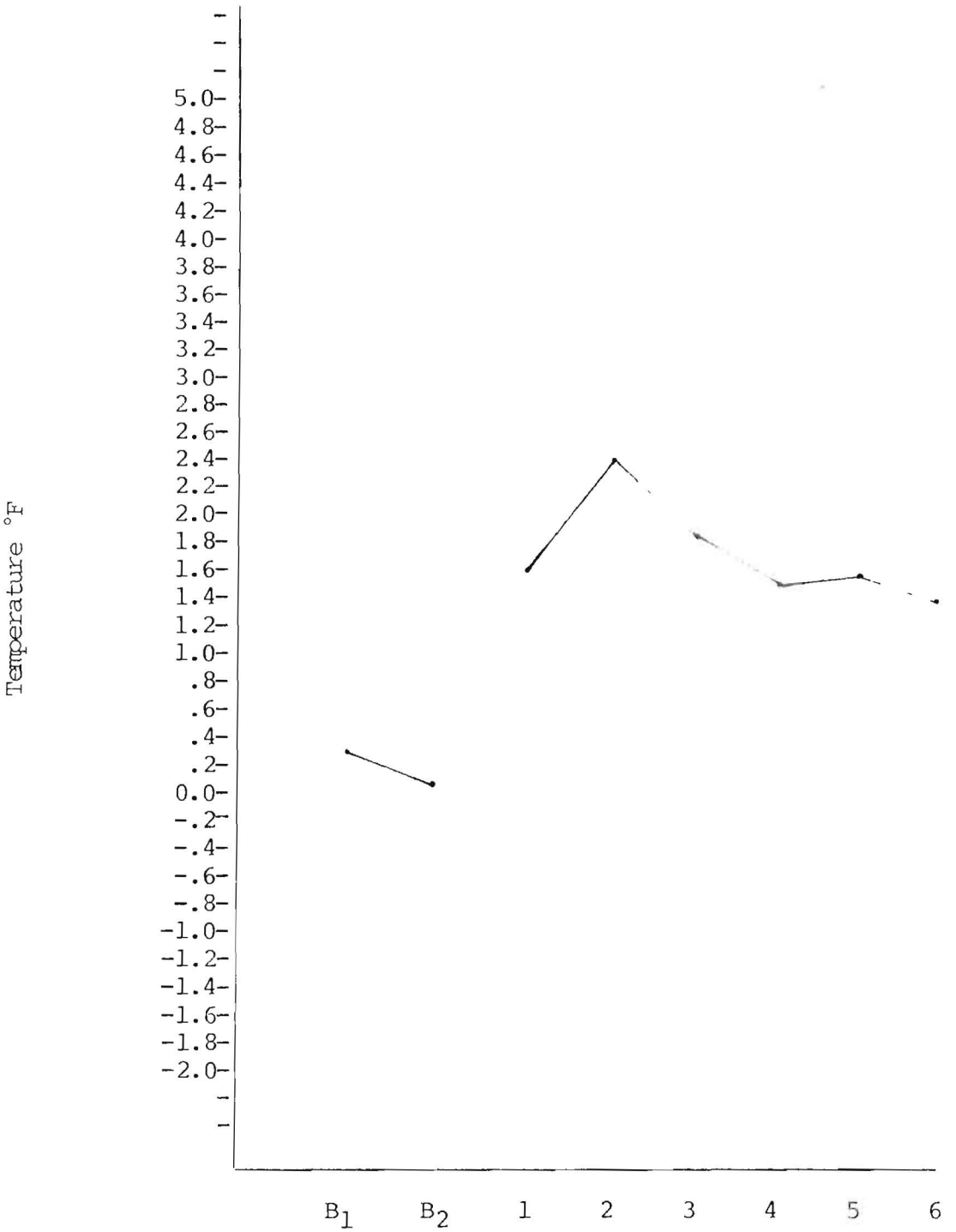

Figure 8. Mean changes in finger temperature of Subject 6 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

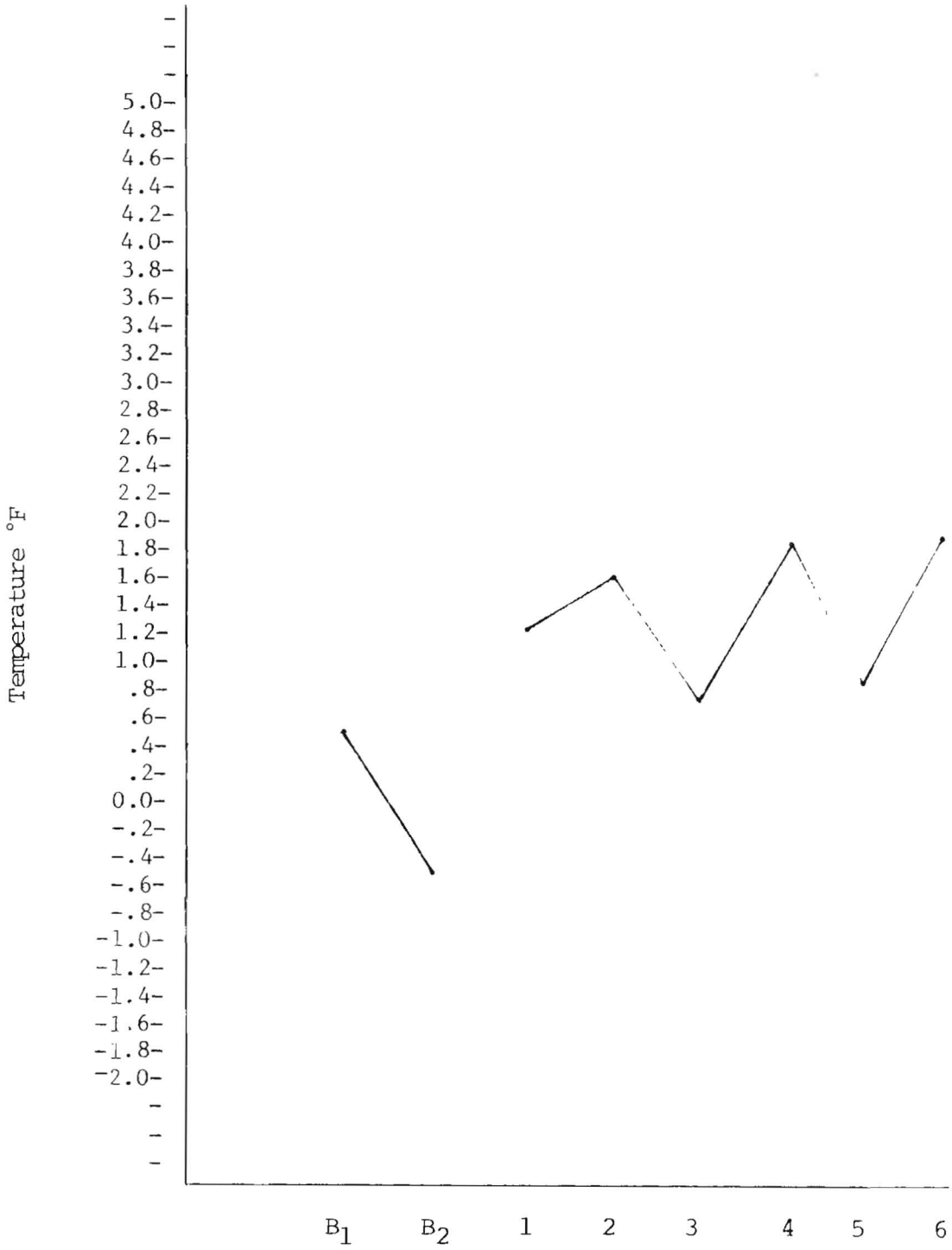

Figure 9. Mean changes in finger temperature of Subject 7 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

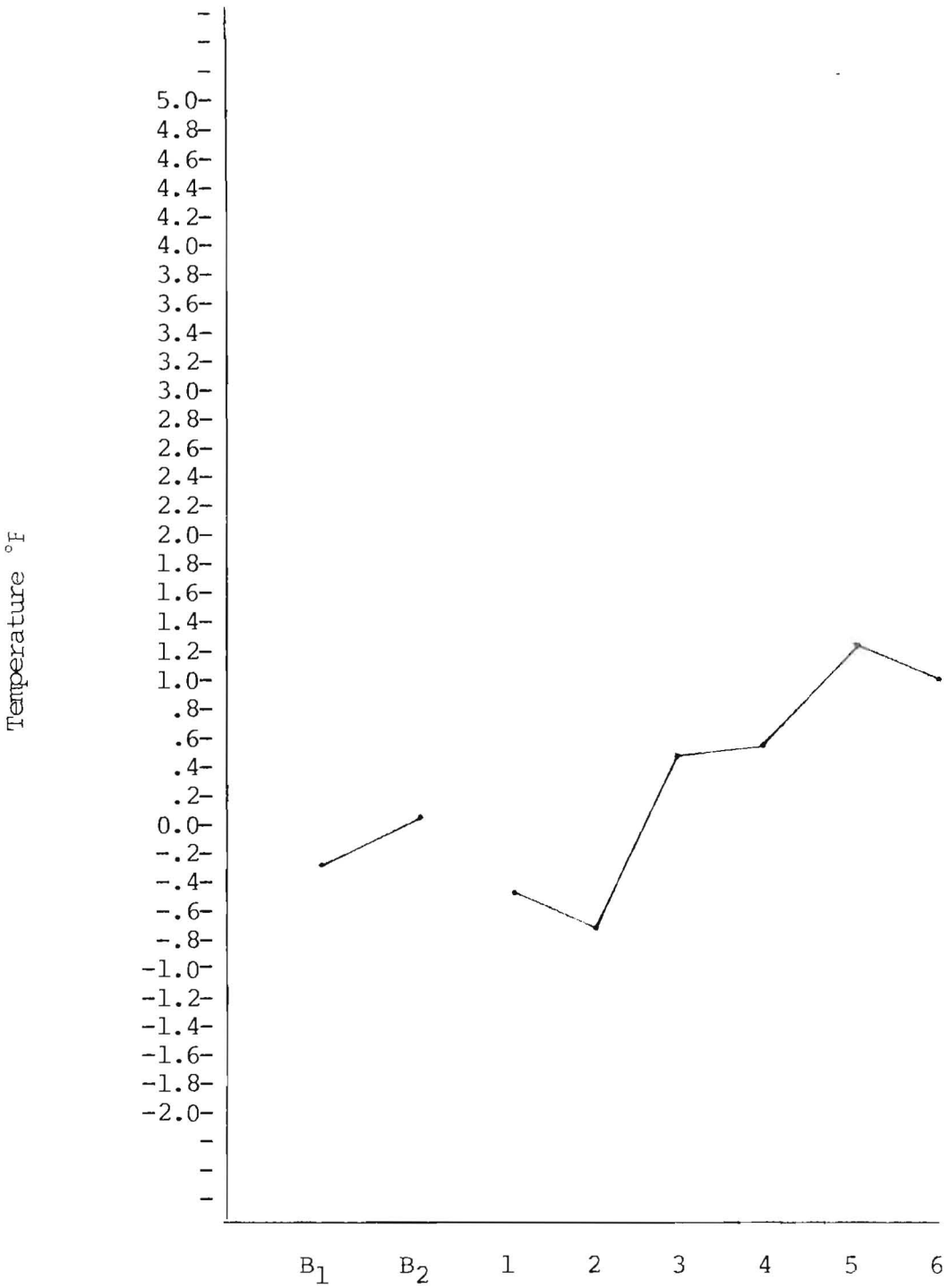

Figure 10. Mean changes in finger temperature of Subject 8 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

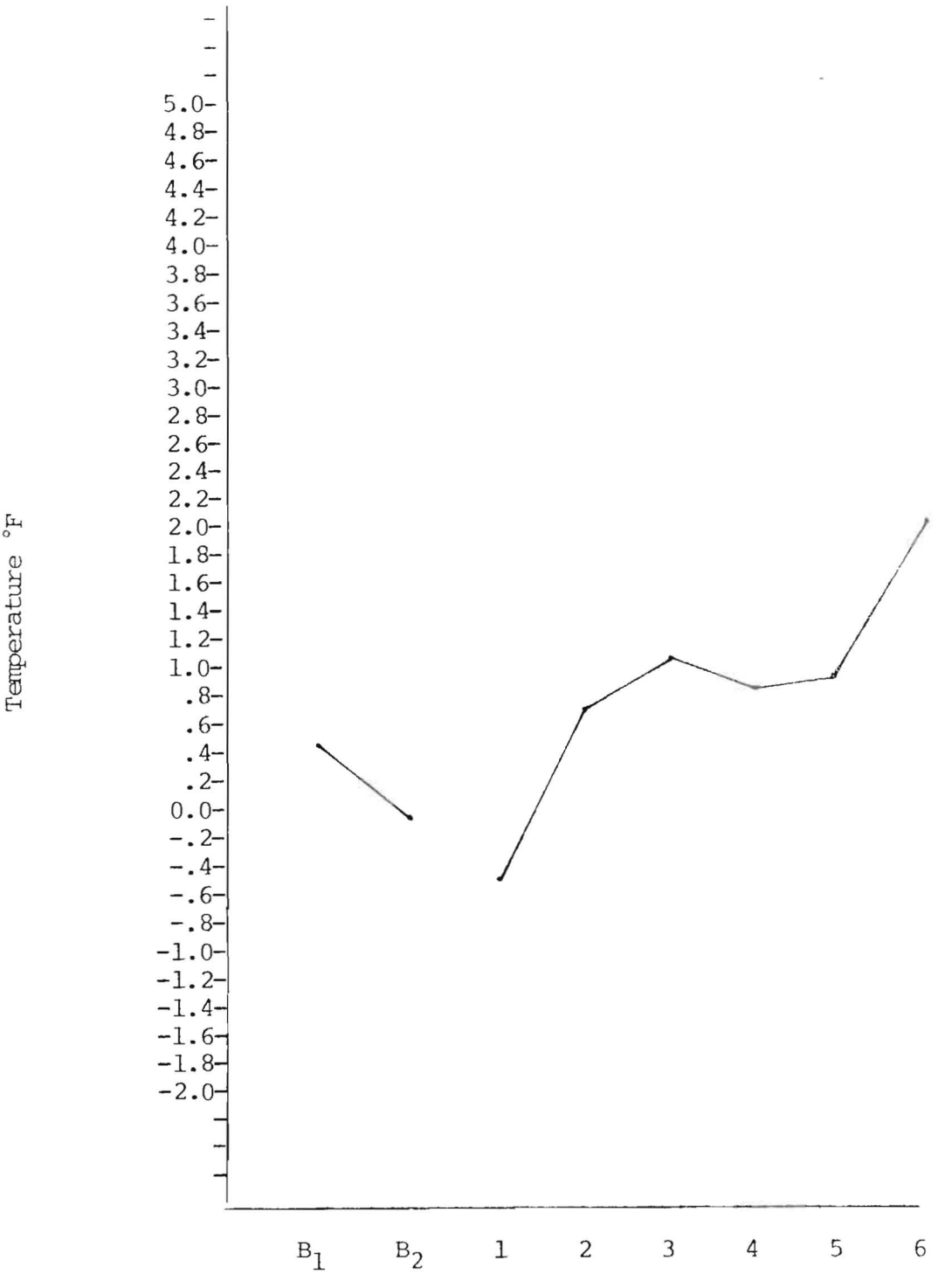

Figure 11. Mean changes in finger temperature of Subject 9 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

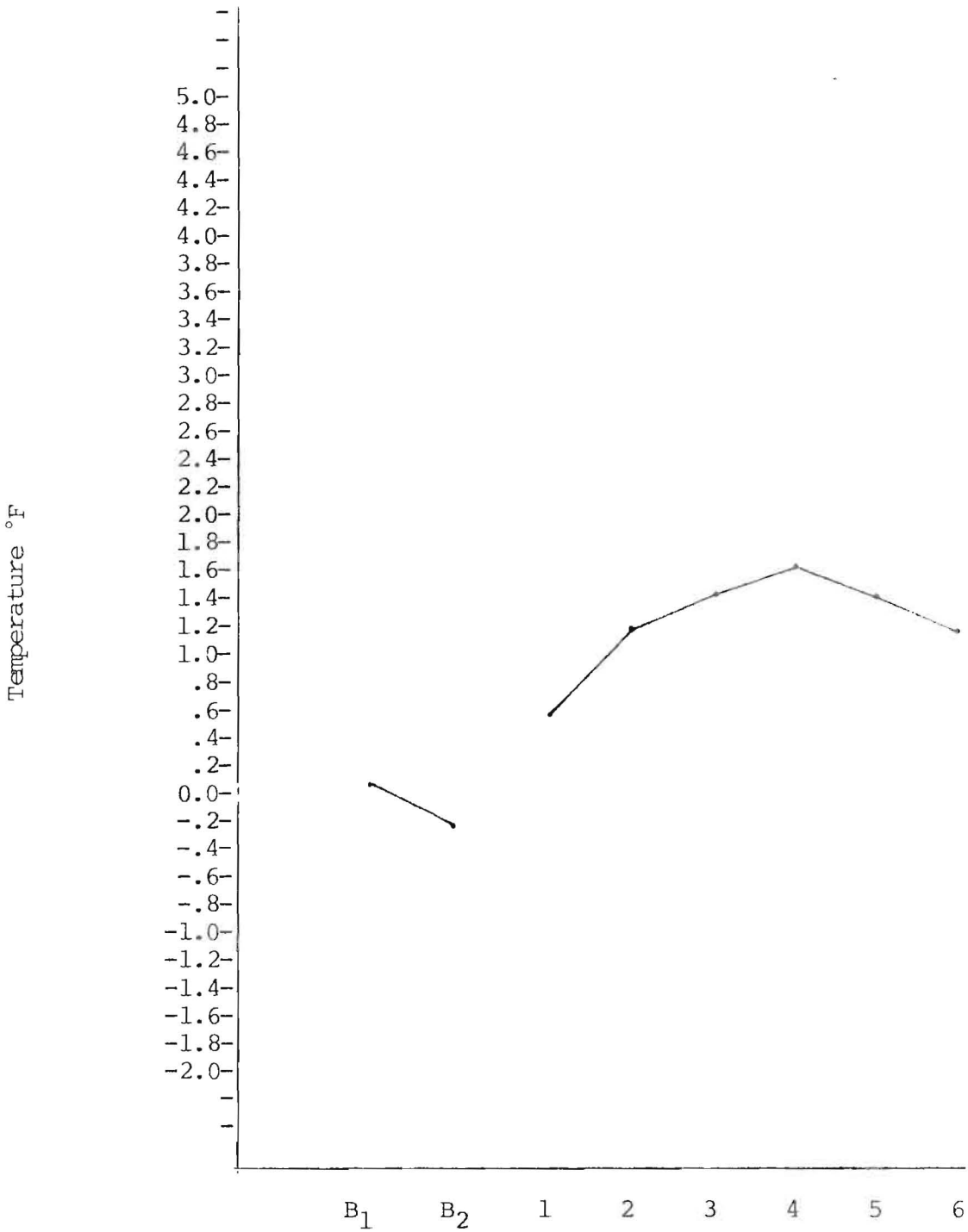

Figure 12. Mean changes in finger temperature of Subject 10 over sessions for baseline 1,2 (control) and biofeedback training (treatment).

CHAPTER 4

DISCUSSION

It was predicted that subjects would show no significant increases in finger temperature during pre-experimental (baseline finger temperature monitoring) measures. The t-test calculations in Appendix B indicate that this hypothesis was support as the mean changes in finger temperature were not significantly different.

It was also predicted that subjects would show a significant increase in peripheral finger temperature with biofeedback training as compared to pre-experimental baseline measures. The t-test calculations in Appendix C indicate that this hypothesis was supported. The mean changes in finger temperature were significantly different. All subjects showed an increase in peripheral finger temperature with biofeedback training. Mean change increases in finger temperature ranged from Subject 5, 1.64, to Subject 8, .293 (see Table 4).

The overall temperature change across subjects was an average increase of 1.339 °F. The low level of temperature change obtained with biofeedback in this study is consistent with several recent reports (King & Montgomery,

Table 4

Mean Change Increase in Finger Temperature across Subjects for Baseline and Treatment

Subject	Baseline	Treatment	Mean Increase	Rank
1	.1625	1.46	.29	5
2	.326	1.7595	1.433	3
3	.6537	1.885	1.231	6
4	.136	.789	.653	9
5	-.1425	1.783	1.64	1
6	.19	1.737	1.54	2
7	.0175	1.393	1.37	4
8	-.0837	.3770	.293	10
9	.18125	.8966	.715	8
10	-.0862	1.3116	1.225	7

Note. Temperature F.

Rank 1-10 from greatest increase to least increase, respectively.

1980; Surwit, Shapiro, & Feld (1976). Felder, Russ, Montgomery, & Horwitz (1954) have shown that once skin temperature reaches 34 °C (93.2 °F), further small increases in the skin temperature require considerable increases in blood flow. Thus subjects with high basal skin temperature will be less able to produce large scale increases.

Research has indicated that a wide range of stimuli (including instructions) may produce a decrease in finger temperature, a response incompatible with the goal of biofeedback studies requiring a temperature increase. One application of this finding is that small changes (or no change) may still demonstrate the acquisition of temperature control, since under comparable experimental conditions but without biofeedback, temperature would likely decrease (Gillespie & Peck (1981). Surwit, et al. (1976) have supported that this decrease in temperature and the common finding that temperature decreases are easier to obtain than increases may be accounted for by reference to the concept of the orienting reflex (OR). The OR refers to widespread psychophysiological reactions, which occur in response to the presentation of stimuli, of which an important factor is vasoconstruction. Surwit, et al. (1976) also examined the influence of basal finger temperature or

acquisition of control by setting room temperature at 22.5 °C for some subjects or 19.5 °C for others and reported that the lower temperature was not associated with improved performance which might have been expected if a "ceiling effect" was an important determinant of the acquisition of control. Ceiling effect refers to the difficulty of increasing finger temperature above 34 °C, which is close to a physiological ceiling. In the present study any effects of room temperature were controlled by the criteria in relation to determination of temperature stability point (see Procedure, page 21). Thus factors other than the main independent variable (biofeedback) that could account for temperature changes were decreased.

A common observation by experimenters or clinicians conducting biofeedback studies is that they are unable to provide the subjects or patients with precise instructions as to how control may be achieved over the function under study. Following completion of treatment on subjects, it was commonly observed that subjects were unable to describe what they did to achieve control. In the present study the experimenter attempted to control for providing subjects with any type of relaxation strategies

to avoid confounding biofeedback. Self-report strategies of the subjects at the conclusion of biofeedback ranged from mental imagery, i.e., imagining their hands in warm water or a bathtub to subjects unable to describe how control was achieved.

In regard to non-clinical studies of biofeedback procedures, it is reasonably established that visceral responses (heart rate, selected muscles, blood pressure, skin temperature, and EEG alpha activity) can be brought under voluntary control, Kimmel, (1967). Whether the feedback itself is necessary and sufficient for this control is still under question (Hume, 1976). Techniques of biofeedback that have the potential for being specific in their action, modifying one visceral response without altering other closely related viceral responses, have rarely functioned in this manner when applied clinically, Orne (1979). Therapeutic effects associated with biofeedback seem to be accompanied by general relaxation and decreased arousal. Clinical application where disorders have apparently responded to biofeedback procedures include tension headaches, hypertension, hyperactivity, and neuromuscular reeducation. However, few controlled comparative studies have not demonstrated biofeedback to be superior to other existing relaxation methods, Hume (1981).

One application of the present study provides a mode for a hearing impaired individual to benefit from relaxation techniques, via biofeedback. Because of the disability such a person is unable to respond to traditional relaxation requiring vocal or audible stimulation.

Further directions in research in this area should examine other modes of biofeedback, such as EMG (selected muscles), autonomic function, and EEG activity with hearing impaired subjects. Other areas of interest should be the visual feedback presentation to hearing impaired subjects. It is also recommended that future research studies in this area should pay attention to the potential confounding biofeedback with stimulus presentation of relaxation techniques. The main conclusion of the study is that hearing impaired children can learn voluntary control of visceral activity via biofeedback in a visual display mode.

The children clearly displayed an ability to increase their finger temperature with biofeedback. However, the effects may be questionable. That is, did the children learn a technique for relaxation? Suggestions for further research would be Electroencephlogram monitoring of relaxed states compared or associated with increases in finger temperature.

References

REFERENCES

Blanchard, E.B., & Young, L.D. (1972). The relative efficacy of visual and auditory feedback for self-control of heart rate. Journal of General Psychology, 87, 195-202.

Blizard, D., Cowings, P. & Miller, N.E. (1975). Visceral responses to opposite types of autogenic training imagery. Biological Psychology, 3, 49-55.

Boudewyns, P.A. (1976). A comparison of the effects of stress vs. relaxation instruction on the finger temperature response. Behavior Therapy, 7, 54-67.

Brown, B.B. (1977). Stress and The Art of Biofeedback, Harper and Row, New York.

Budzynski, R.H., & Stoyva, J. (1973). An electromyograph feedback technique for teaching voluntary relaxation of the masseter. Journal of Dental Research, 52, 116-119.

Calgar, J. (1977). Role of feedback in voluntary control of heart rate. Paper presented to the Biofeedback Research Society, Colorado Springs.

Cook, M.R., Gerkovich, M.M., Graham, C., Cohen, M.D. and Anderson, F.L. (1979). Effects of cognitive and physical stimuli on finger temperature. Psychophysiology, 16, 176-177 (abstract).

DiCara, L.V. (1970). Learning in the autonomic nervous system. Scientific American, 222, 30-39.

Dugan, M., & Sheridan, C. (1976). Effects of instructed imagery on temperature of the hands. Perceptual and Motor Skills, 42, 14.

Elder, S.T., Longarce, A., Welsh, D.M., & McAfee, R.D. (1977). Apparatus and procedure for training subjects to control their blood pressure. Psychophysiology, 14, 68-72.

Engel, B.T. (1972). Operant conditioning of cardiac function: A status report. Psychophysiology, 9, 161-177.

Felder, D., Russ, E., Montgomery, H., & Horwitz, O. (1954). Relationship in the toe of skin surface temperature to measure blood flow with a plethysomogram. Clinical Science, 13, 251-257.

Gillespie, C.L., & Peck, D.F. (1980). The effects of bio-feedback and guided imagery on finger temperature. Biological Psychology, 11, 235-247.

Hadfield, A. (1920). The influence of suggestion on body temperature. Lancet, 2, 68-69.

Herzfeld, G.M., & Taub, E. (1976). Suggestions as an aid to self-regulation of hand temperature. Paper presented to the Biofeedback Research Society, Colorado Springs.

Hume, W.I. (1976). Biofeedback. Vol. 2. Annual Research Review, Chrchill-Livingston, Edinburgh.

Hume, W.I. (1981). Biofeedback. Vol. 3. Human Science Press.

Hunter, S.H., Russel, E.D., Russel, C.H. & Zimmerman, C.L. (1976). The ability of elementary school children to learn autoregulation of fingertip skin temperature. Biofeedback Research Society Meeting Abstract, Colorado, Springs.

Kimmel, H.D. (1967). Instrumental conditioning of autonomically mediated behavior. Psychology Bulletin, 67, 337-345.

Kimmel, H.D. (1974). Instrumental conditioning of autonomically mediated responses in human beings. American Psychologist, 29, 325-335.

Kimmel, H.D. (1980). The relevance of experimental studies to clinical applications of biofeedback. Biofeedback and Self-Regulation, Vol. 6, 263-271.

King, N.J., & Montgomery, R.B. (1980). Biofeedback induced control of human peripheral temperature. Psychological Bulletin, 88, 738-752.

Kinsman, R.A., O'Banion, K., Robinson, S., & Staudenmayer, H. (1975). Continuous biofeedback and discrete posttrial verbal feedback in frontalis muscle relaxation training. Psychophysiology, 12, 30-35.

Lubar, J.F., & Bohler, W.W. (1976). Behavioral management of epileptic seizures following EEG biofeedback training of the sensorimotor rhythm. Biofeedback and Self-Regulation, 1, 77-104.

Lupin, M. (1977). Peace, Harmony, and Awareness. Austin: Learning Concepts.

Lynch, W.C., Hama, H., Kohn, L., & Miller, N.E. (1976). Instrumental control of peripheral vasomotor responses in children. Psychophysiology, 13, 219-221.

Manuch, S.B., Levenson, R.W., Kinrichson, J.J., & Gryll, S.L. (1975). Role of feedback in voluntary control of heart rate. Perceptual and Motor Skills, 40, 747-752.

Miller, N.E. (1969). Learning of visual and glandular responses. Science, 163, 434-435

Miller, N.E., & DiCara, L.V. (1968). Instrumental learning of vasomotor responses by rats: Learning to respond differentially in the two ears. Science, 159, 1485-1486.

Mittleman, B., & Wolff, H.G. (1939). Affective states of skin temperature. Psychosomatic Medicine, 1, 271-292.

Orne, M.T. (1979). The efficacy of biofeedback therapy. Annual Review of Medicine, 30, 489-503.

Raskin, M., Bali, L.R., & Peeke, H.V. (1980). Muscle biofeedback and transcendental meditation. Archives General Psychiatry, 37, 93-97.

Rivera, E., & Omizo, M.M. (1980). The effects of relaxation and biofeedback on attention to task and impulsivity among male hyperactive children. The Exceptional Child, 27(1).

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

Schandler, S.L., & Gringe, W.W. (1974). A system for providing tactile EMG feedback. Behavior Research Methods and Instrumentation, 6, 541-542.

Shapiro, D., Crider, A.B. & Tursky, B. (1964). Differentiation of an autonomic response through operant reinforcement. Psychonomics Science. 1, 147-148.

Sheridan, C.L., Boehm, M.B., Ward, L.B., & Justensen, D.R. (1976). Autogenic biofeedback, autogenic phrases, and biofeedback compared. Paper presented at annual meeting of Biofeedback Research Society.

Stoyva, J., Budzynski, T. (1974). Cultivated low arousal--An anti-stress response? In C.V. DiCara (Ed.). Limbic and Autonomic Nervous System Research, (pp. 369-394). New York: Plenum.

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

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

Taub, E., Emurian, C., & Howell, P. (1975). Further progress in training self-regulation of skin temperature. Journal of Altered States of Consciousness, 2, 201-202.

Taub, E. & Emurian, C. (1976). Feedback aided self-regulation of skin temperature with a single feedback locus. 1. Acquisition and reversal training. Biofeedback and Self-Regulation, 1, 147-168.

Whalen, C.K. & Henker, B. (1976). Psychostimulants and children: A review and analysis. Psychological Bulletin, 83, 113-1130.

APPENDIX A

Temperature Change Scores

APPENDIX A

BASELINE I

SUBJECTS

	1	2	3	4	5	6	7	8	9	10
1	0	.05	.05	.5	0	0	.2	0	0	.1
2	-.35	.1	.05	.5	-.2	.2	.3	-.2	-	.1
3	0	.25	.1	.15	-.5	.2	.4	-.2	0	0
4	.05	.25	.15	.2	.5	.25	.4	-.25	0	0
5	.35	.2	.1	.25	.45	.2	.45	-.4	.05	.05
6	.4	-.15	.1	.3	.7	.2	.7	-.65	.3	.1
7	.5	-.4	-.05	.3	.8	.3	.7	-.65	.35	.15
8	.1	-.35	0	.35	.9	.5	.8	-.7	.5	.1
9	-1.0	-.1	-.1	.3	.9	.45	.7	-.7	.5	.05
10	-.1	0	.05	.3	.1	.4	.4	-.75	.55	0
11	-.4	0	.5	.35	.2	.5	.6	-.7	.6	0
12	-.2	-.1	.55	.3	-.2	.4	.6	-.5	.65	.1
13	-.7	-.1	.6	.3	-.3	.3	.65	-.4	.6	.15
14	-.1	-.35	1.0	.2	-.3	.4	.5	-.3	.6	0
15	.4	-.3	1.0	.05	.2	.5	.6	-.1	.7	-.1
16	-.6	-.4	1.0	-.1	.1	.7	.7	.3	.75	0
17	-.4	-.7	.9	-.2	.1	.4	.65	.4	.8	.1
18	-.7	-.8	.85	-.4	-.2	.35	.7	.4	.8	.15
19	-1.0	-.5	.9	-.5	.2	.3	.8	.45	.75	.2
20	.4	-.25	.95	-.45	.4	.2	.85	.5	6	.2

$\Sigma B_{11} = -3.35$ $\Sigma B_{21} = -3.65$ $\Sigma B_{31} = 8.7$ $\Sigma B_{41} = 2.7$

$\bar{X}_{11} = -.1675$ $\bar{X}_{21} = -.1825$ $\bar{X}_{31} = .435$ $\bar{X}_{41} = .135$

$\Sigma B_{51} = 4.25$ $\Sigma B_{61} = 6.75$ $\Sigma B_{71} = 11.7$ $\Sigma B_{81} = -4.45$

$\bar{X}_{51} = .2125$ $\bar{X}_{61} = .3375$ $\bar{X}_{71} = .585$ $\bar{X}_{81} = -.2225$

$\Sigma B_{91} = 9.0$ $\Sigma B_{101} = 1.45$

$\bar{X}_{91} = .45$ $\bar{X}_{101} = .0725$

APPENDIX A

BASELINE II

SUBJECTS

	1	2	3	4	5	6	7	8	9	10
1	.1	0	.05	0	-.1	0	-.2	0	-.1	0
2	.1	0	.05	.1	-.3	-.05	-.4	.2	-.2	.05
3	.2	.05	.1	.2	-.2	.05	-.5	.25	-.4	.05
4	.25	.2	.2	.15	-.1	.1	-.35	.2	-.4	0
5	.5	.1	.5	.1	-.3	.2	-.5	.2	-.4	-.05
6	.2	.2	.5	.15	-.3	-.1	-.7	.1	-.35	-.1
7	.15	.3	.5	.2	0	-.15	-.9	0	-.4	-.1
8	.25	.8	.55	.2	-.6	-.2	-.7	-.05	-.4	-.15
9	.3	-.7	.5	.2	-.9	-.1	-.6	-.1	-.5	-.2
10	.35	.9	.8	.25	-1.0	-.05	-.5	-.1	-.45	-.25
11	.5	1.2	1.3	.3	-.7	0	-.4	-.05	-.45	-.3
12	.7	1.3	1.1	.2	-.6	0	-.5	0	-.1	-.35
13	.8	1.3	1.2	.1	-.5	.1	-.55	0	0	-.4
14	.8	1.4	1.5	.1	-.7	.2	-.5	0	.2	-.4
15	.7	1.4	1.6	.1	-.4	.2	-.55	.1	.4	-.4
16	.9	1.4	1.6	.1	-.7	.2	-.45	.1	.4	-.4
17	1.1	1.45	1.5	.15	-.7	.25	-.7	.15	.3	-.45
18	1.1	1.4	1.4	.1	-.55	.05	-.9	.15	.2	-.45
19	.85	1.2	1.3	.05	-.6	.05	-.8	.15	.4	-.5
20	0	1.4	1.2	0	-.7	.1	-.3	-.2	.5	-.5

$\Sigma B_{12} = 9.85$ $\Sigma B_{22} = 16.7$ $\Sigma B_{32} = 17.45$ $\Sigma B_{42} = 2.75$

$\bar{X}_{12} = .4925$ $\bar{X}_{22} = .835$ $\bar{X}_{32} = .8725$ $\bar{X}_{42} = .1375$

$\Sigma B_{52} = -9.95$ $\Sigma B_{62} = .85$ $\Sigma B_{72} = -11.0$ $\Sigma B_{82} = 1.1$

$\bar{X}_{52} = -.4975$ $\bar{X}_{62} = .0425$ $\bar{X}_{72} = -.55$ $\bar{X}_{82} = .055$

$\Sigma B_{92} = -1.75$ $\Sigma B_{102} = -4.9$

$\bar{X}_{92} = -.0875$ $\bar{X}_{102} = -.245$

APPENDIX A

TREATMENT SESSIONS

Subject 1

	#1	#2	#3	#4	#5	#6
1	0	.1	1.0	.1	.3	.7
2	.4	.2	1.5	.1	.4	.9
3	.6	.3	1.9	.25	.6	1.8
4	.95	.4	.2	0	.8	2.4
5	1.0	.5	.5	0	1.2	2.65
6	1.5	.6	.55	.5	1.7	3.1
7	1.9	.6	.35	0	2.0	3.35
8	2.0	.7	.6	-.3	2.3	3.5
9	2.0	.8	.95	-.7	2.2	3.7
10	1.85	.9	1.25	-.5	2.6	3.8
11	2.0	.95	1.5	-.5	2.7	3.9
12	1.8	1.1	1.7	-.15	3.1	3.9
13	1.7	1.2	1.75	.05	3.2	4.0
14	1.6	1.25	2.0	.3	3.3	3.7
15	1.1	1.3	2.0	.5	3.25	3.8
16	1.0	1.4	1.85	.65	3.3	3.6
17	.5	1.35	1.75	.8	3.5	4.0
18	-.2	1.4	.8	.9	3.5	3.8
19	-.1	1.5	1.0	.95	3.5	3.8
20	-.5	1.55	1.3	1.0	4.0	3.6

$\Sigma T_{11}=21.1$ $\Sigma T_{12}=18.1$ $\Sigma T_{13}=24.45$ $\Sigma T_{14}=3.95$ $\Sigma T_{15}=47.45$ $\Sigma T_{16}=60.1$

$\bar{X}=1.055$ $\bar{X}=.905$ $\bar{X}=1.225$ $\bar{X}=.1975$ $\bar{X}=2.3725$ $\bar{X}=3.005$

$\Sigma S_1 T\bar{X}=8.76$

$S_1 T\bar{X}=\underline{1.46}$

APPENDIX A

TREATMENT SESSIONS

Subject 2

	#1	#2	#3	#4	#5	#6
1	.2	-.5	0	0	.8	.3
2	.4	-.1	.5	.5	1.0	.4
3	.6	-.2	1.4	.6	1.2	.3
4	.65	-.1	2.1	.55	.55	.45
5	.9	.15	3.8	.65	1.0	.35
6	1.0	.35	3.95	.85	2.0	.1
7	1.0	.45	3.6	.95	2.15	.3
8	1.1	.45	3.55	1.6	2.25	.9
9	1.15	.4	4.1	1.65	2.55	.7
10	1.15	.5	4.6	1.6	2.9	.6
11	.95	.6	4.8	1.75	3.1	.3
12	1.0	.7	6.4	1.45	3.55	.3
13	.5	.7	4.1	1.25	3.8	.1
14	.3	.9	6.1	1.25	4.3	-.05
15	.2	.6	6.3	1.4	4.9	-.2
16	.6	.2	6.5	1.85	4.9	.2
17	.5	.35	6.6	1.9	5.8	.4
18	.4	.45	6.3	2.2	5.9	.2
19	.45	.25	5.8	2.3	6.4	.4
20	.4	.5	6.1	2.45	6.8	.9

$\Sigma T_{21}=13.45$ $\Sigma T_{22}=6.65$ $\Sigma T_{23}=86.6$ $\Sigma T_{24}=26.75$ $\Sigma T_{25}=70.75$ $\Sigma T_{26}=6.95$

$\bar{X}= .6725$ $\bar{X}= .3325$ $\bar{X}= 4.33$ $\bar{X}= 1.3375$ $\bar{X}= 3.5375$ $\bar{X}= .3475$

$\Sigma S_2 T\bar{X}= 10.5575$

$S_2 T\bar{X}= 1.7595$

APPENDIX A

TREATMENT SESSIONS

Subject 3

	#1	#2	#3	#4	#5	#6
1	.2	.2	.2	.2	.2	0
2	.4	.3	.4	.2	.3	.15
3	.55	.35	.7	.4	.35	.2
4	.7	.5	1.3	.7	.5	.5
5	.9	.6	1.9	1.1	1.0	1.1
6	.95	.75	1.9	1.3	1.9	1.5
7	1.0	.7	2.4	1.4	2.2	2.0
8	1.0	.85	2.7	1.6	2.4	2.1
9	1.1	1.05	3.0	1.8	2.6	2.3
10	1.25	1.0	3.15	1.9	2.75	2.45
11	1.45	1.05	3.3	1.95	2.9	2.5
12	1.5	1.1	3.4	2.0	3.0	2.55
13	1.7	1.15	3.7	2.1	3.1	2.6
14	1.9	1.1	3.8	2.2	3.2	2.6
15	2.0	.95	3.8	2.3	3.3	2.7
16	2.15	1.0	3.8	2.45	3.4	2.8
17	2.15	1.0	3.8	2.4	3.45	3.0
18	2.2	1.35	3.9	2.4	3.5	3.05
19	2.15	1.25	3.95	2.45	3.5	3.15
20	2.3	1.2	4.1	2.5	3.65	3.2

$T_{31}=27.55$ $\Sigma T_{32}=17.45$ $\Sigma T_{33}=55.2$ $\Sigma T_{34}=35.8$ $\Sigma T_{35}=47.2$ $\Sigma T_{36}=43.05$

$\bar{X}=1.3775$ $\bar{X}= .8725$ $\bar{X} = 2.76$ $\bar{X} = 1.79$ $\bar{X} = 2.36$ $\bar{X} = 2.1525$

$S_3T\bar{X} = 11.3125$

$S_3T\bar{X} = 1.8854167$

APPENDIX A

TREATMENT SESSIONS

SUBJECT 4

	#1	#2	#3	#4	#5	#6
1	.1	0	.3	0	0	.4
2	.2	.05	.4	.2	.15	.4
3	-.1	-.2	.5	.4	.25	.4
4	-.5	-.3	.6	.45	.3	.5
5	-.5	.1	.65	.5	.4	.5
6	-.55	0	.9	.6	.45	.5
7	0	-.1	1.0	.7	.5	.55
8	.05	-.1	1.0	.8	.5	.6
9	.2	.15	1.1	.9	.6	.65
10	.4	.25	1.2	1.0	.6	.7
11	.5	.45	1.3	1.2	.7	.8
12	.8	.5	1.35	1.4	.9	.7
13	1.0	.45	1.55	1.5	.8	.75
14	1.2	.5	1.55	1.7	.9	.9
15	1.4	.6	1.7	1.7	.9	.8
16	2.0	.65	1.8	1.75	1.0	.9
17	2.0	.5	1.9	2.0	1.0	.9
18	2.0	.6	2.0	2.1	1.2	.9
19	1.7	.8	2.1	2.0	1.2	1.0
20	1.5	.9	2.0	2.3	1.4	1.0

$\Sigma T_{41} = 13.4$ $\Sigma T_{42} = 5.8$ $\Sigma T_{43} = 24.7$ $\Sigma T_{44} = 23.2$ $\Sigma T_{45} = 13.75$ $\Sigma T_{46} = 13.85$

$\bar{X} = .67$ $\bar{X} = .29$ $\bar{X} = 1.235$ $\bar{X} = 1.16$ $\bar{X} = .6875$ $\bar{X} = .6925$

$\Sigma S_4 T\bar{X} = 4.735$

$S_4 T\bar{X} = \underline{.7891667}$

APPENDIX A

TREATMENT SESSIONS

Subject 5

	#1	#2	#3	#4	#5	#6
1	0	.5	0	-.1	.2	0
2	.8	.8	-.1	-.2	.4	.15
3	.9	.8	0	.4	.6	.4
4	1.1	1.0	.2	.5	.8	.5
5	1.4	1.5	.5	.8	1.5	.9
6	1.5	1.6	.6	.9	2.0	1.3
7	1.6	1.8	.7	1.5	2.0	1.45
8	2.0	2.0	.8	1.8	2.2	1.8
9	2.3	2.0	1.0	2.0	2.4	2.0
10	2.2	2.2	1.0	2.5	2.4	2.5
11	2.6	2.2	1.1	2.5	1.9	2.1
12	2.7	2.3	1.0	2.7	1.8	2.1
13	2.7	2.3	1.0	3.0	2.4	2.2
14	2.9	2.5	1.1	3.0	2.45	2.1
15	3.15	2.6	1.2	3.2	2.5	2.0
16	3.2	3.1	1.4	3.3	2.6	2.2
17	3.3	3.2	1.2	3.25	2.6	2.1
18	3.4	3.3	1.3	3.1	2.6	2.15
19	3.3	3.3	1.0	2.9	2.8	2.1
20	3.3	3.3	1.3	3.0	2.7	2.1

ΣT_{51}= 44.35 ΣT_{52}= 42.3 ΣT_{53}= 16.3 ΣT_{54}= 40.05 ΣT_{55}= 38.85 ΣT_{56}= 32.15

$\bar{X}$= 2.2175 $\bar{X}$= 2.115 $\bar{X}$= .815 $\bar{X}$= 2.0025 $\bar{X}$= 1.9425 $\bar{X}$= 1.6075

$S_5 T\bar{X}$= 10.7

$S_5 T\bar{X}$= 1.7833

APPENDIX A

TREATMENT SESSIONS

Subject 6

	#1	#2	#3	#4	#5	#6
1	.1	0	.2	0	.2	.1
2	.2	1.5	.8	.5	.4	1.25
3	.3	1.8	1.0	.9	.8	1.5
4	.4	2.6	1.2	1.2	.9	1.5
5	.55	2.7	1.5	1.5	1.0	1.6
6	.6	2.1	2.0	1.6	1.2	1.7
7	1.4	2.1	2.0	1.8	1.6	1.75
8	2.0	1.9	2.0	1.8	1.9	2.0
9	2.4	2.0	2.0	1.8	1.9	1.9
10	2.2	2.1	2.2	1.8	1.95	1.8
11	2.6	2.1	2.2	1.6	2.0	1.5
12	2.7	2.0	2.4	1.7	2.0	1.6
13	2.7	2.0	2.5	1.6	2.0	1.65
14	2.5	1.6	1.7	1.7	1.7	1.1
15	2.9	2.8	1.95	1.8	1.75	1.3
16	2.8	3.4	2.3	1.85	1.65	.8
17	2.5	3.8	2.3	1.9	1.7	1.4
18	1.6	3.9	2.2	2.0	1.8	1.5
19	1.2	3.95	2.2	2.0	1.85	1.6
20	1.5	3.9	2.2	2.0	1.7	1.6

T_{61}= 33.15 ΣT_{62}= 48.25 ΣT_{63}= 36.85 ΣT_{64}= 31.05 ΣT_{65}= 30.00 ΣT_{66}= 29.15

$\bar{X}$ = 1.6575 $\bar{X}$ = 2.4125 $\bar{X}$ = 1.8425 $\bar{X}$ = 1.5525 $\bar{X}$ = 1.5 $\bar{X}$ = 1.4575

$S_6T\bar{X}$ = 10.4225

$S_6T\bar{X}$ = 1.7370833

TREATMENT

SESSIONS

Subject 7

	#1	#2	#3	#4	#5	#6
1	.2	0	0	.2	0	.2
2	.85	.3	.3	.6	.2	.4
3	.7	1.5	.35	1.2	.5	1.0
4	1.2	2.2	.4	1.4	.55	1.4
5	1.4	1.0	.2	1.8	1.1	1.5
6	1.6	1.5	.1	2.0	1.2	1.8
7	1.6	1.7	.2	2.0	1.35	2.0
8	1.6	1.5	.1	2.1	1.0	2.0
9	1.55	1.65	.8	2.0	1.0	2.1
10	1.2	1.4	.9	2.1	1.0	2.2
11	1.15	1.3	1.0	2.15	0	2.2
12	1.1	1.9	1.2	2.15	.4	2.4
13	1.0	2.1	1.25	2.2	.9	2.5
14	1.3	2.2	1.25	2.25	1.0	2.5
15	1.5	2.3	1.0	2.3	1.1	2.6
16	1.55	2.2	1.2	2.35	1.1	2.65
17	1.6	2.2	1.1	2.35	1.05	2.5
18	1.6	2.0	.9	2.4	1.1	2.6
19	1.6	1.95	1.0	2.4	1.0	2.5
20	1.65	1.9	1.0	2.3	1.0	2.4

$T_{71} = 25.95$ $\Sigma T_{72} = 32.8$ $\Sigma T_{73} = 14.25$ $\Sigma T_{74} = 38.25$ $\Sigma T_{75} = 16.55$ $\Sigma T_{76} = 39.45$

$\bar{X} = 1.2975$ $\bar{X} = 1.64$ $\bar{X} = .7125$ $\bar{X} = 1.9125$ $\bar{X} = .8275$ $\bar{X} = 1.9725$

$S_7 T\bar{X} = 8.3625$

$S_7 T\bar{X} = 1.39375$

APPENDIX A

TREATMENT SESSIONS

Subject 8

	#1	#2	#3	#4	#5	#6
1	0	-.1	.3	0	.1	0
2	-.2	-.3	.6	-.1	.2	0
3	-.2	-.5	1.0	.2	.4	.05
4	-.3	-.6	1.2	.4	.5	.1
5	-.35	-.7	1.4	.5	.7	.2
6	-.4	-1.0	1.4	.6	1.0	.3
7	-.45	-1.6	1.5	.65	1.0	.4
8	-.65	-1.4	1.4	.5	1.1	.6
9	-.8	-1.0	1.1	.4	1.3	.9
0	-.9	-1.1	1.0	.5	1.4	1.2
1	-.9	-1.0	.6	.3	1.5	1.3
2	-.9	-1.0	.2	0	1.5	1.5
3	-.6	-1.0	0	-.2	1.6	1.7
4	-.65	-.7	-.1	.1	1.6	1.75
5	-.65	-.7	-.2	.2	1.7	2.0
6	-.55	-.5	0	.4	1.8	2.0
7	-.4	-.5	-.1	.5	2.0	2.2
8	-.25	-.5	-.4	1.0	2.1	2.3
9	-.2	-.6	-.5	2.1	2.4	2.4
0	-.1	-.65	-.4	2.5	2.5	2.3

$_{81}$= -9.45 ΣT_{82}= -15.45 ΣT_{83}= 10.00 ΣT_{84}= 10.55 ΣT_{85}= 26.4 ΣT_{86}= 23.2

= -.4725 $\bar{X}$ = -.7725 $\bar{X}$ = .5 $\bar{X}$ = .5275 $\bar{X}$ = 1.32 $\bar{X}$ = 1.16

$_8T\bar{X}$ = 2.2625

$_8T\bar{X}$ = .3770833

APPENDIX A

TREATMENT SESSIONS

Subject 9

	#1	#2	#3	#4	#5	#6
1	-.1	.2	0	.1	0	.2
2	-.2	.5	.1	.1	.2	.5
3	-.4	.6	.5	.3	.4	1.0
4	-.5	.7	.5	.4	.5	1.2
5	-.8	.7	.5	.5	.8	1.5
6	-1.0	.5	.4	.7	1.0	1.6
7	-1.2	.4	.5	.5	1.2	2.0
8	-1.4	.4	.7	.7	1.1	2.2
9	-1.3	.4	.8	.8	1.2	2.4
10	-1.2	.6	.9	1.0	1.2	2.5
11	-1.0	.7	1.0	1.2	1.3	2.8
12	-.8	.8	1.5	1.2	1.3	2.9
13	-.6	.8	1.7	1.1	1.2	3.0
14	-.5	.7	1.8	1.2	1.1	3.0
15	-.4	.7	2.0	1.3	1.2	3.1
16	-.1	.8	1.9	1.4	1.2	3.2
17	.1	.9	2.0	1.5	1.3	3.3
18	.2	1.0	2.0	1.6	1.0	3.3
19	.3	1.1	1.95	1.65	1.1	3.2
20	.3	1.2	2.0	1.6	1.0	3.0

$\Sigma T_{91} = -10.6$ $\Sigma T_{92} = 14.4$ $\Sigma T_{93} = 22.75$ $\Sigma T_{94} = 18.85$ $\Sigma T_{95} = 19.3$ $\Sigma T_{96} = 42.9$

$\bar{X} = -.53$ $\bar{X} = .72$ $\bar{X} = 1.1375$ $\bar{X} = .9425$ $\bar{X} = .965$ $\bar{X} = 2.145$

$S_9 T\bar{X} = 5.38$

$S_9 T\bar{X} = .8966$

APPENDIX A
TREATMENT
SESSIONS

Subject 10

	#1	#2	#3	#4	#5	#6
1	0	-.1	-.05	-.1	-.05	-.1
2	.3	0	.5	-.15	0	-.3
3	.5	.5	.9	.4	.2	.4
4	.5	.8	1.0	.7	.5	.5
5	.5	.9	1.2	1.0	.9	.7
6	.6	1.0	1.3	1.2	1.0	.9
7	.6	1.1	1.4	1.4	1.2	1.0
8	.6	1.3	1.5	1.6	1.4	1.1
9	.65	1.4	1.5	1.8	1.5	1.3
10	.7	1.45	1.55	1.9	1.5	1.4
11	.7	1.5	1.6	2.0	1.6	1.6
12	.8	1.55	1.65	2.1	1.9	1.65
13	.8	1.6	1.7	2.2	2.0	1.75
14	.85	1.7	1.75	2.4	2.0	1.85
15	.9	1.7	1.8	2.4	2.2	2.0
16	.9	1.75	1.85	2.5	2.3	2.0
17	.9	1.8	1.85	2.55	2.3	2.0
18	.95	1.9	1.9	2.6	2.4	2.0
19	1.0	1.9	1.85	2.6	2.4	2.05
20	1.0	1.9	1.9	2.65	2.45	2.1

$\Sigma T_{101} = 13.75$ $\Sigma T_{102} = 25.65$ $\Sigma T_{103} = 28.65$ $\Sigma T_{104} = 33.75$ $\Sigma T_{105} = 29.7$ $\Sigma T_{106} = 25.$

$\bar{X}_{101} = .6875$ $\bar{X}_{102} = 1.2825$ $\bar{X}_{103} = 1.4325$ $\bar{X}_{104} = 1.6875$ $\bar{X}_{105} = 1.485$ $\bar{X}_{106} = 1.$

$\Sigma S_{10}{}^{T\bar{X}} = 7.87$

$S_{10}{}^{T\bar{X}} = 1.3116$

APPENDIX B

Baseline 1 and 2 Data Analysis

APPENDIX B

PRE-TEST MEASURE
T-TEST FOR NON-INDEPENDENT GROUPS (BASELINE 1 AND 2)

Subject	Baseline 1	Baseline 2	Difference (D)	D^2
1	-.1675	.4925	-.66	.4356
2	-.1825	.835	-1.0175	1.035
3	.435	.8725	-.4375	.1914
4	.135	.1375	-.0025	.0000063
5	.2125	-.4975	-.285	.0812
6	.3375	.0425	.295	.0870
7	.585	-.55	.035	.0012
8	-.2225	.055	-.2775	.0770
9	.45	-.0875	.3625	.1314
10	.0725	-.245	-.1725	.0297
			$\Sigma D = -2.16$	$\Sigma D^2 = 2.0695$

$\bar{D} = -.216$

$$\Sigma d^2 = \Sigma D^2 - \frac{(\Sigma D)^2}{N}$$

$$= 2.0695 - \frac{(-2.16)^2}{10} = 2.0695 - \frac{4.6656}{10}$$

$$= 2.0695 - -.4665$$

$$= 1.603$$

$$S^2_D = \Sigma d^2/(N-1)$$

$$= 1.603/10-1$$

$$= .1781$$

$$S_D = \sqrt{.1781}$$

$$= .4220$$

$$S_{\bar{D}} = SD/\sqrt{N}$$

$$= .422/3.162$$

$$= .1334$$

$$t = \bar{D}/S_{\bar{D}}$$

$$= -.216/.1334$$

$$= -1.6191$$

$(t(9) = 2.2622_1P_1.05)$ critical value$_1$

$t(9) = 1.62\ {}_1P > .05$

APPENDIX C

Baseline and Treatment Data Analysis

APPENDIX C

T-TEST FOR NON-INDEPENDENT GROUPS (BASELINE AND TREATMENT)

Subject	Pre Exp. (Control)	Exp. (Treatment)	Difference (D)	D^2
1	.1625	1.46	-1.2975	1.8635
2	.326	1.7595	-1.4335	2.0549
3	.6537	1.885	-1.2313	1.5160
4	.136	.789	-.653	.4264
5	-.1425	1.783	-1.9255	3.707
6	.19	1.737	-1.547	2.3932
7	.0175	1.393	-1.3755	1.8920
8	-.0837	.3770	-.4607	.2122
9	.18125	.8966	-.7153	.5117
10	-.0862	1.3116	-1.3978	1.9538
			$\Sigma D = -12.037$	$\Sigma D^2 = 16.3507$
			$\bar{D} = -1.2037$	

$$\Sigma d^2 = \Sigma D^2 - \frac{(\Sigma D)^2}{N}$$

$$= 16.3507 - \frac{(-12.037)^2}{10}$$

$$= 16.3507 - -14.4889$$

$$= 1.8618$$

$$S^2_D = \Sigma d^2/(N-1)$$

$$= .2068$$

$$SD = \sqrt{.2068}$$

$$= .4548$$

$$S_{\bar{D}} = S_D/\sqrt{N}$$

$$= .4548/3.1622$$

$$= .1438$$

$$t = \bar{D}/S_{\bar{D}}$$

$$= -1.2037/.1438$$

$$= 8.3706$$

$(t(9) = 2.2622\ P_1.05)$

critical value$_1$

$(t(9) = 8.37_1 P<.01$